

***CERTIFIED
TEST REPORT***

Cooper Power Systems

25 kV Class – 200 Amp

15.2/26.3 kV

**SEPARABLE CONNECTOR
SYSTEM**

Includes Cooper POSI-BREAK™

**Loadbreak Elbow and
Insulated Protective Cap**

Cooper Power Systems
25 kV Class – 200 Amp
15.2/26.3 kV
SEPARABLE CONNECTOR SYSTEM

CERTIFICATION

*Statements made and data shown are, to the best of our knowledge and belief,
correct and within the usual limits of commercial testing practice.*

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INTRODUCTION

15.2/26.3 kV

The Cooper Power Systems 25 kV Class 200 Amp Separable Connectors are designed as a fully shielded and insulated termination system for connecting high voltage extruded underground cable to transformers, switchgear and other apparatus.

The POSI-BREAK elbow and insulated protective cap are designed with an increased strike distance along the 200 amp interface. This feature eliminates flashovers which may occur due to the "partial vacuum effect" created when an elbow or cap is separated from an energized 200 amp bushing.

This report certifies that all system component parts were installed according to the applicable installation instructions and tested to the design tests required by the IEEE Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V, designated as IEEE Standard 386-1995.

TEST PROGRAM

15.2 / 26.3 kV

OBJECT

To demonstrate that the Cooper Power Systems 25 kV Class 200 Amp Separable Connector System meets the requirements of IEEE Standard 386-1995 and the requirements of the Cooper Power Systems "Multi-Stress" and "Partial Vacuum Switching" tests.

PROCEDURE

Design tests were performed on the number of samples as specified in Table 4 of IEEE Standard 386-1995. The 25 kV 200 Amp Separable Connector parts were randomly selected from finished goods inventory and dimensionally checked to ensure that the interfaces were in compliance with the applicable figures of IEEE Standard 386-1995. The 25 kV 200 Amp Separable Connector System consists of the products listed below. Each product was tested to all of the applicable Design Tests as specified in Table 4 of IEEE Standard 386-1995 and Cooper Power Systems "Multi-Stress" and "Partial Vacuum Switching" tests.

PRODUCT LIST

25 kV Class 200 Amp Separable Connector System Products:

- | | |
|---------------------------------------|-----------------|
| 1. Loadbreak Elbow Connector | LE225, PLE225 |
| 2. Insulated Protective Cap | LPC225, PLPC225 |
| 3. Loadbreak Bushing Insert | LBI225 |
| 4. Long Loadbreak Bushing Insert | LBI225L |
| 5. Loadbreak Feedthru Insert | 2637881C01M |
| 6. Loadbreak Junctions (2, 3 & 4-Way) | 2637166C |
| 7. Bushing Well | 2603973B |
| 8. Bushing Well Plug | 2604231B |
| 9. Insulated Standoff Bushing | 2625064B |
| 10. Grounding Elbow | 2604128B |

DESIGN TESTS - IEEE Std. 386-1995

| | | |
|----|----------------------------------------------------------|--------------------|
| A. | Corona Voltage Level | Section 7.4 |
| B. | Alternating Current Withstand Voltage | Section 7.5.1 |
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| D. | Impulse Withstand Voltage | Section 7.5.3 |
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| K. | Cable Pull Out..... | Section 7.13 |
| L. | Operating Force Test..... | Section 7.14 |
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| N. | Test Point Cap Operating Force Test..... | Section 7.16.1 |
| O. | Test Point Cap Operating Withstand Test..... | Section 7.16.2 |
| P. | Test Point Capacitance Test..... | Section 7.17.1 |
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| R. | Shielding Test..... | Section 7.18 |
| S. | Switching and Fault Close Interchangeability Tests | Sections 7.7 & 7.8 |

Design Tests - Cooper Power Systems

| | | |
|----|--------------------------|------------|
| T. | Multi-Stress Test..... | Appendix A |
| U. | Partial Vacuum Test..... | Appendix B |

Summary

The representative Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products met all requirements as specified in the IEEE Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V, designated as IEEE Std. 386-1995.

In addition, the Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products met all requirements as specified for the Cooper Power Systems "Multi-Stress" and "Partial Vacuum Switching" tests.

Test A
15.2/26.3 kV
CORONA VOLTAGE LEVEL TEST
Section 7.4

Object

To demonstrate that the Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products meet or exceed the IEEE Standard 386-1995, Section 7.4, minimum corona voltage level of 19 kV rms.

Procedure

Ten of each of the applicable separable connector system products were tested with mating parts for a 25 kV class minimum corona voltage level of 19kV rms. The test voltage is gradually increased to 20% above the 19 kV corona level (22.8 kV). If the corona exceeds 3 pC, the voltage is decreased to the corona voltage level of 19 kV and maintained between 3 and 60 seconds. The corona shall not exceed 3 pC at the specified 19 kV corona voltage level.

The products tested were 1-9 of the Product List on page 4.

Results

For all ten samples of each product tested the corona level was less than 3 pC at the specified minimum corona extinction voltage level of 19 kV rms.

Conclusion

The representative Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products met or exceeded the IEEE Standard 386-1995, Section 7.4, minimum corona voltage level of 19 kV rms.

TEST B
15.2/26.3 kV
ALTERNATING CURRENT WITHSTAND VOLTAGE TEST
Section 7.5.1

Object

To demonstrate that the Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products meet the IEEE Standard 386-1995, Section 7.5.1, 60 Hz, one minute ac withstand level of 40 kV rms.

Procedure

Ten of each of the applicable separable connector system products were tested with mating parts by raising the 60 Hz ac test voltage to 40 kV rms in less than 30 seconds, then maintaining the voltage at 40 kV rms for one minute.

The products tested were 1-9 of the Product List on page 4.

Results

All samples of each product withstood a 40 kV rms, 60 Hz ac one minute voltage withstand without a puncture or flashover.

Conclusion

The representative Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products met the IEEE Standard 386-1995, Section 7.5.1, 60 Hz, one minute ac voltage withstand level of 40kV rms without a puncture or flashover.

TEST C
15.2/26.3 kV
DIRECT CURRENT WITHSTAND VOLTAGE TEST
Section 7.5.2

Object

To demonstrate that the Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products meet the IEEE Standard 386-1995, Section 7.5.2, 15 minute dc withstand level of 78 kV.

Procedure

Ten of each of the applicable separable connector system products were tested with mating parts by connecting the negative dc voltage terminal to the test specimen and raising the test voltage to 78kV, then holding the voltage at 78 kV for 15 minutes.

The products tested were 1-9 of the Product List on page 4.

Results

All samples of each product withstood a 78 kV rms 15 minute dc withstand without a puncture or flashover.

Conclusion

The representative Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products met the IEEE Standard 386-1995, Section 7.5.2, 15 minute dc voltage withstand level of 78 kV without a puncture or flashover.

TEST D
15.2/26.3 kV
IMPULSE WITHSTAND VOLTAGE TEST (BIL)
Section 7.5.3

Object

To demonstrate that the Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products meet the IEEE Standard 386-1995, Section 7.5.3, impulse level of 125 kV.

Procedure

Ten of each of the applicable separable connector system products were tested with mating parts and subjected to an impulse voltage having 1.2/50 microsecond wave and crest value of 125 kV BIL. Each sample was subjected to three positive and three negative full wave impulses with the following wave shape.

| WAVE SHAPE | |
|------------------------------------|---------------------|
| <i>Measured Quantity</i> | <i>Tolerance ±%</i> |
| Crest Value | 3 |
| Front Time | 30 |
| Time to Half Value | 20 |
| Nominal Rate of Rise of Wave Front | 20 |

The products tested were 1-9 of the Product List on page 4.

Results

All samples of each product withstood three positive and three negative full wave impulses with 125 kV crests without a puncture or flashover.

Conclusion

The representative Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products met the IEEE Standard 386-1995, Section 7.5.3, impulse withstand voltage level of 125 kV without a puncture or flashover.

TEST E
15.2/26.3 kV
SHORT-TIME CURRENT TEST
Section 7.6

Object

To demonstrate that the Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products meet the IEEE Standard 386-1995, Section 7.6, short-time current requirements for 200 Amp connectors.

Procedure

Four samples of each of the applicable separable connector system products were connected in a manner approximating service conditions and subjected to short-time currents with magnitudes and durations of 3,500 amperes rms symmetrical for 3 seconds (180 cycles) and 10,000 amperes rms symmetrical for 0.17 seconds (10 cycles). The rms value of the first major loop of the current wave exceeded 1.3 times the specified current magnitude measured in accordance with IEEE Standard C37.09-1979.

The products tested were 1, 3-7 and 10 of the Product List on page 4.

Results

All samples of each product withstood short-time currents with magnitudes and durations of 3,500 amperes rms symmetrical for 3 seconds (180 cycles) and 10,000 amperes rms symmetrical for 0.17 seconds (10 cycles) without any separation of the interfaces or impairing the connector's ability to meet the other requirements of IEEE Standard 386-1995.

Conclusion

The representative Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products met the short-time current requirements of IEEE Standard 386-1995, Section 7.6.

TEST F
15.2/26.3 kV
CPS/CPS Switching Test
Section 7.7

Object

To demonstrate that the Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products are capable of closing and interrupting 200 Amps at 26.3 kV phase-to-phase when tested per the switching test requirements as specified in Section 7.7 of IEEE Standard 386-1995.

Procedure

Thirty (30) Cooper Power Systems 25 kV Class, 200 Amp loadbreak bushing inserts (LBI225) were installed into a bushing well (2603973B) and mated with Cooper Power Systems 25 kV Class, 200 Amp loadbreak elbows (LE225), which were assembled onto properly prepared XLPE insulated cables.

Each insert/elbow assembly tested was mounted in a fixture with all normally grounded parts grounded in a manner approximating normal service conditions. Adjacent grounds consisting of a bushing well, insert and elbow assembly were mounted on each side of the connector being tested and appropriately grounded. The center-to-center spacing of the test assembly sample to each adjacent ground assembly was 4.0 inches.

Each insert/elbow assembly was subjected to 10 complete 200 Amp switching operations at 26.3 kV phase-to-phase under the conditions listed in Figure 19 (circuit diagram A) and Table 6 of the IEEE Standard 386-1995 for connectors with a voltage rating of 15.2/26.3 kV. A complete switching operation consists of closing and opening the connector.

Switching operations were performed manually in a series circuit with live-line tools. Successive switching operations were performed at time intervals greater than 1 minute. Before each closing operation took place, a minimum dwell time of 5 seconds was maintained after the probe was positioned in the arc extinguishing area of the insert. Each closing and opening operation was made with a positive continuous motion with adequate time between the closing and interrupting of the test connectors to allow for steady-state voltage and current conditions.

Appropriate ground-fault detection equipment was incorporated into the test set-up. The last switching operation for each sample was recorded on an oscillogram.

The loadbreak bushing insert (LBI225) test results apply to the long insert (LBI225L), feedthru insert (2637881C01M) and junctions (2637166C) which employ the same contact design. The loadbreak elbow (LE225) test results apply to the POSI-BREAK elbow which employs the same probe.

Results

The connector samples exceeded the switching requirement of ten consecutive samples without a flashover to ground.

Conclusion

The representative Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products met the 200 Amp, 26.3 kV phase-to-phase switching requirements as specified in Section 7.7 of IEEE Standard 386-1995.

TEST G
15.2/26.3 kV
CPS/CPS Fault-Closure Test
Section 7.8

Object

To demonstrate that the Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products are capable of closing on a 10,000 Amp, 0.17 second (10 cycle) fault at 26.3 kV phase-to-phase, when tested per the fault-closure requirements specified in Section 7.8 of IEEE Standard 386-1995.

Procedure

The insert/elbow assemblies which passed the 10 switching operations in Test F, Section 7.7, of this report were used for the fault-closure test. The insert/elbow sets were fault-close tested in the same sequence as was done in the switching test. The mounting preparation for the fault-close test was the same as specified in the switching test (Test F, Section 7.7) of this report.

The switched assemblies were subjected to one 10 kA, 0.20 second (12 cycle), 26.3 kV phase-to-phase fault-closure under the conditions as listed in Table 8 and shown in Figure 20 (circuit A) of IEEE Standard 386-1995 for connectors with a voltage rating of 15.2/26.3 kV. Before each fault-closing operation, a 5 second dwell time was maintained after the probe was positioned in the arc extinguishing area of the insert.

Fault-closure testing continued until at least 10 consecutive assemblies passed the criteria of having no external ground current shown on the oscillograms, all component parts remaining within the closed connector assembly and at least one connector was closed when the voltage was 80% or more of the peak voltage value.

Results

Of the successful switching assemblies, ten consecutive samples passed the 10 kA, 0.20 second (12 cycle), 26.3 kV phase-to-phase fault-closure with no external ground current, all component parts remained within the closed connector assembly and at least one connector was closed when the voltage was 80% or more of the peak test voltage.

Conclusion

The representative Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products met the 10 kA, 0.17 second (10 cycle), 26.3 kV phase-to-phase fault-closure requirements as specified in Section 7.8 of IEEE Standard 386-1995.

TEST H
15.2/26.3 kV
Accelerated Thermal Test
Section 7.10.1

Object

To demonstrate that the Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products are capable of meeting the accelerated thermal test temperature and resistance requirements as specified in Section 7.10.1 of IEEE Standard 386-1995.

Procedure

Four assemblies each consisting of a loadbreak elbow (LE225), loadbreak bushing insert (LBI225) and a bushing well (2603973B) were prepared for testing and set up as described in IEEE Standard 386-1995, Section 7.10.1. The connectors were assembled in series on AWG No. 1/0, 260 mil XLPE insulated cable 36 inches long with a CopperTop compression connector (2639043A06). Thermocouples were placed at the following current transfer points:

- a) elbow probe to compression lug
- b) elbow probe to female contact
- c) bushing insert female contact structure to metallic housing
- d) the connection between the bushing insert and bushing well

Once the test set-up was completed, current cycle testing was conducted at an ambient temperature between 15°C and 35°C in a draft free environment.

A current level of 309 Amps created a steady-state temperature rise of 100°C to 105°C on the control conductor in the first five current cycles. This current was used for the duration of the test.

The test consisted of 50 current cycles with the current-on 4 hours and current-off 2 hours for each cycle. At the end of each current-on cycle the assemblies were de-energized and within 3 minutes submerged in 5°C ± 5°C water for the remainder of the current-off cycle.

At the end of the 10th, 25th and 40th cycles (± 2 cycles) and after the samples returned to room ambient temperature, a short time ac current of 3500 ± 300 rms amperes was applied to each assembly for 3 seconds.

For each assembly, a dc resistance measurement between the elbow cable equalizer and bushing well stud was made at the end of the 10th, 20th, 30th, 40th and 50th cycles (± 2 cycles) after the assemblies had stabilized at room ambient temperature.

The room ambient temperature was measured within 2 feet of the test loop and recorded at the same time as the dc resistance measurements. All the resistances were corrected to 20°C.

Results

The temperatures at each transfer point did not exceed the temperature of the control conductor during the test.

A condition of temperature stability was maintained from the fifth cycle to the end of the test as exhibited by temperature differences between the control conductor and connector not exceeding 10°C from the average of the measured differences for each transfer point.

Stability of the corrected dc resistance measurements was exhibited by the dc resistance measurements varying less than $\pm 5\%$ from the average of all the measurements within the measurement interval.

Conclusion

The representative Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products met the accelerated thermal test temperature and resistance requirements as stated in Section 7.10.1 of IEEE Standard 386-1995.

TEST I
15.2/26.3 kV
Thermal Test with Off-Axis Operation
Section 7.10.2

Object

To demonstrate that the Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products are capable of meeting the mechanical and current cycling requirements as specified in Section 7.10.2 of IEEE Standard 386-1995.

Procedure

Four connector assemblies consisting of a loadbreak elbow (LE225), loadbreak bushing insert (LBI225) and a bushing well (2603973B) were assembled to a prepared 36 inch piece of AWG No. 1/0, 260 mil XLPE insulated cable, with a CopperTop compression connector (2639043A06). These products were then assembled in a series circuit described in Section 7.10.2 of IEEE Standard 386-1995.

Each connector assembly was then subjected to 6 cycles consisting of a mechanical operation and current cycling as described:

Mechanical Operation

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

The connector system was then opened 5 times with the force applied to a half inch wide pulling band as shown in Figure 21 of IEEE Standard 386-1995 and closed 5 times with the force applied to the operating eye. The force used to open and close the elbow was parallel to the axis of the probe. Sufficient force was used to completely close and latch the connector.

Current Cycling

A 72 inch long control cable of the same type and size as used to join the connectors was installed in the current-cycling loop between two equalizers.

The test current was adjusted to create a temperature on the conductor of the control cable of $90^{\circ}\text{C} \pm 5^{\circ}\text{C}$. The current, 265 Amps, was applied for eight continuous cycles, each cycle consisting of 3 hours current-on and 3 hours current-off.

The current-cycling test was conducted at an ambient temperature of 15°C to 35°C in a draft free environment.

Temperatures were measured by thermocouples located at:

- a) the compression lug
- b) the approximate midpoint of the bushing contact
- c) on the conductor surface at the midpoint of the control cable

Results

The temperatures measured at the compression lug and bushing contact midpoint of the four connector assemblies did not exceed the temperature of the conductor of the control cable throughout the duration of the test.

Conclusion

The representative Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products met the mechanical and current carrying requirements as specified in Section 7.10.2 of IEEE Standard 386-1995.

TEST J
15.2/26.3 kV
Accelerated Seal Life Test
Section 7.12

Object

To demonstrate that the Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products are capable of meeting the long term sealing requirements specified in the Accelerated Seal Life Test of IEEE Standard 386-1995, Section 7.12.

Procedure

Four connector assemblies consisting of a loadbreak elbow (LE225), a loadbreak bushing insert (LBI225) and a bushing well (2603973B) were assembled using proper installation techniques for each product. A plastic mandrel made of acetal resin (DuPont Delrin) was used to simulate the test cable during the oven aging portion of the test.

The four assemblies were placed in an oven having a 121°C temperature for three weeks.

After the three week oven aging, the four assemblies were removed from the oven and operated once by using the operating eye of the elbow.

The four assemblies were then reassembled with AWG No. 1/0 stranded aluminum, 260 mil XLPE insulated test cables and subjected to 50 cycles of the following sequence of operations:

1. The assemblies were connected in series with a 72 inch control cable and heated in air using sufficient current (260 Amps) to raise the temperature of the conductor of the control cable to 90°C ± 5°C for one hour.
2. After applying current for one hour, the assemblies were de-energized and within three minutes submerged in 25°C ± 10°C conductive water (5000 ohm-cm max) to a depth of one foot for one hour.
3. After the 50th cycle, each assembly was subjected to three positive and three negative full wave impulses with 125 kV crest values, following the test procedure as described in Section 7.5.3 of IEEE Standard 386-1995.
4. Each assembly was subjected to a test point voltage test as described in Section 7.17.2 of IEEE Standard 386-1995.

Results

Following the 50 accelerated sealing life test cycles, all four assemblies withstood three positive and three negative full wave impulses having 125 kV crest values, without a puncture or flashover.

After the impulse test, the elbow test point of each assembly indicated an energized condition with an applied voltage of 15.2 kV.

Conclusion

The representative Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products met the long term sealing requirements as specified in Section 7.12 of IEEE Standard 386-1995.

TEST K
15.2/26.3 kV
Cable Pull Out Test (Tensile Strength)
Section 7.13

Object

The purpose of this test is to determine if the connection between the cable conductor and compression lug of the connector is capable of withstanding a tensile force of 200 pounds-force as specified in IEEE Standard 386-1995, Section 7.13.

Procedure

Four Cooper Power Systems bimetallic CopperTop compression lug connectors were crimped on AWG No. 1/0 solid aluminum cable. Four of the assemblies were crimped using a BG nose crimping die with three crimps per connector. Each connector was subjected to a tensile force of 200 lbf for one minute.

Results

All four connectors withstood the applied force of 200 lbf for one minute without impairing the connectors' ability to meet the other requirements of IEEE Standard 386-1995.

Conclusion

The representative Cooper Power Systems bimetallic compression connectors meet the cable pull out requirements of IEEE Standard 386-1995, Section 7.13.

TEST L
15.2/26.3 kV
Operating Force Test
Section 7.14

Object

To demonstrate that the Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products meet the IEEE Standard 386-1995 operating force requirements of 50 to 200 pounds-force at temperatures of -20°C, +25°C and +65°C.

Procedure

Four Cooper Power Systems loadbreak elbows (LE225 and PLE225) were installed on prepared cables and four insulated protective caps (LPC225 and PLPC225) were lubricated and mated with loadbreak bushing inserts (LBI225) per the Cooper Power Systems installation instructions.

The operating force for each connector/bushing insert assembly was applied when the temperature of the components was at -20°C, +25°C and +65°C, for three separate tests. Each test consisted of closing the connector, then reopening it within 10 minutes. The force was applied to the operating eye of the connector parallel to the axis of the probe, at a rate of 5 in/min.

Results

Each set of four connector/bushing insert assemblies had operating forces between 50 lbf and 200 lbf at the -20°C, +25°C and +65°C temperatures.

Conclusion

The representative Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products met the operating force requirements of 50 to 200 pounds-force at temperatures of -20°C, +25°C and +65°C when tested per Section 7.14 of IEEE Standard 386-1995.

TEST M
15.2/26.3 kV
Operating Eye Test
Section 7.15

Object

To demonstrate that the Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products meet the IEEE Standard 386-1995 operating eye test requirements of a 120 lb-in rotational force and a 500 pounds-force static tensile pull force at ambient temperature.

Procedure

Four loadbreak elbows (LE225) and four insulated protective caps (LPC225) were subjected to the Operating Eye Test. A tensile force of 500 pounds-force was applied at the rate of 5 in/min to the operating eye parallel to the axis of the probe. Then a rotational force of 120 lb-in was applied to the operating eye with a live-line tool simulating fixture in a clockwise and then a counterclockwise direction. The corona voltage level was measured before and after these tests per the requirements of Section 7.4.

The loadbreak elbow (LE225) and insulated protective cap (LPC225) test results apply to the POSI-BREAK elbow (PLE225) and cap (PLPC225) which employ the same operating eye design.

Results

The operating eye of each elbow (LE225) and insulated protective cap (LPC225) were still serviceable after the withstand tests for tensile and rotational force. The elbow and insulated protective cap, when tested on a bushing well insert (LBI225), met the requirements of a corona voltage level of 19 kV rms before and after the mechanical tests.

Conclusion

The representative Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products met the operating eye test requirements of IEEE Standard 386-1995, Section 7.15.

TEST N
15.2/26.3 kV
Test Point Cap Operating Force Test
Section 7.16.1

Object

To demonstrate that the Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products meet the test point operating force requirements of IEEE Standard 386-1995, Section 7.16.1.

Procedure

With the test point cap applied to loadbreak elbow (LE225), a tensile force was applied in a direction parallel to the axis of the probe at a rate of 5 inches per minute. Four samples were tested at each temperature of -20°C, +25°C and +65°C. The force required to separate the cap from the elbow shall be within 8 to 49 pounds-force.

Results

The test point cap operating force of each sample was within the specified requirements of 8 to 49 pounds-force at each temperature of -20°C, +25°C and +65°C.

Conclusion

The representative Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products met the test point cap operating force requirements of IEEE Standard 386-1995, Section 7.16.1.

TEST O
15.2/26.3 kV
Test Point Cap Operating Withstand Test
Section 7.16.2

Object

To demonstrate that the Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products meet the test point cap operating eye withstand requirements of IEEE Standard 386-1995, Section 7.16.2.

Procedure

A tensile force of 100 pounds-force was applied to the test point cap operating eye at a rate of 5 in/min and held for one minute. Four samples were tested at each temperature of -20°C, +25°C and +65°C.

Results

The test point cap operating eye of each sample withstood the applied tensile force of 100 pounds-force at each temperature of -20°C, +25°C and +65°C.

Conclusion

The representative Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products met the test point cap operating eye test requirements of IEEE Standard 386-1995, Section 7.16.2.

TEST P
15.2/26.3 kV
Test Point Capacitance Test
Section 7.17.1

Object

To demonstrate that the Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products meet the test point capacitance test requirements of IEEE Standard 386-1995, Section 7.17.1.

Procedure

An AWG No. 1/0 aluminum 260 mil XLPE cable was prepared per the elbow instruction sheet. Ten loadbreak elbow (LE225) samples were tested with the above cable, utilizing an HP 4261A capacitance measuring instrument.

The capacitance from test point to conductor and test point to ground shield were measured. The capacitance between the test point and conductor system shall be at least 1.0 pF. The ratio of the capacitance between test point and ground shield to the capacitance between the test point and conductor system shall not exceed 12.0.

The loadbreak elbow (LE225) test results apply to the POSI-BREAK elbow (PLE225) which employ the same test point design.

Results

The test point capacitance test verified that the capacitance between the test point and conductor was at least 1.0 pF for each of the ten elbow samples. The ratio of capacitance between test point and ground shield to the capacitance between the test point and the conductor system did not exceed 12.0 for each of the ten elbow samples.

Conclusion

The representative Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products met the test point capacitance requirements of IEEE Standard 386-1995, Section 7.17.1.

TEST Q
15.2/26.3 kV
Test Point Voltage Test
Section 7.17.2

Object

To demonstrate that the Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products meet the test point voltage requirements of IEEE Standard 386-1995, Section 7.17.2.

Procedure

An AWG No. 1/0 aluminum 260 mil XLPE cable was prepared per the elbow instruction sheet. A loadbreak bushing insert was assembled into a bushing well which had its shank submerged under oil. With a test elbow latched to the insert, a voltage of 15 kV was applied. A Ross-meter, a voltage sensing instrument specifically designed for separable connectors, was applied to the test point of ten loadbreak elbows (LE225).

Results

An energized voltage condition was detected on the test points of all ten elbows at an applied voltage of 15 kV.

Conclusion

The representative Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products met the test point voltage requirements of IEEE Standard 386-1995, Section 7.17.2.

TEST R
15.2/26.3 kV
Shielding Test
Section 7.18

Object

The purpose of this test is to demonstrate that the connector shielding material used on the Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products meet the requirements of IEEE Standard 592-1995.

Procedure

The semiconducting shield materials used on the 25 kV Separable Connector System products were subjected to the Shield Resistance Test and Fault Current Initiation Test as specified in IEEE 592-1990.

For the Shield Resistance Test, the semiconducting shield resistance was measured using the voltmeter-ammeter method with dc current. Wraparound connections were applied at the extremities of the loadbreak elbow (LE225) test specimen. The voltage was measured with the current adjusted to 1 milliamp \pm 20 percent. The resistance was then calculated.

Resistance measurements were made on four elbow samples from recent production and four samples oven aged for 168 hours at 120°C. Resistance measurements for all eight samples were made with the test specimen temperature at 20°C and 90°C.

For the Fault Current Initiation Test, four samples were assembled per Figure 1 of IEEE Standard 592-1995. A 3/8 inch diameter faulting rod threaded at one end was assembled into the compression connector through an interference fit drilled hole and seated flush with the surface of the shield. The test circuit voltage was 7 kV rms with an available short circuit current of 10,000 Amps rms symmetrical. Each test specimen was subjected to two tests that caused initiation of a fault current to ground. The samples were not disturbed between the two tests.

Results

The shield resistance measurements between the extremities of the elbow were all less than the maximum allowable 5000 ohms. The semiconducting shield was also capable of twice initiating a 10 kA fault current to ground at 7 kV within three seconds and maintaining the fault current for 0.167 seconds (10 cycles at 60 Hz) without the original insulation surface being exposed due to burning.

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Conclusion

The representative semiconductive shield material of the Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products met the shielding requirements of IEEE Standard 386-1995, Section 7.18.

TEST S
15.2/26.3 kV
Switching and Fault Close Interchangeability Tests
Sections 7.7 and 7.8

Object

To demonstrate that the Cooper Power Systems 25 kV Class 200 Amp loadbreak elbow and loadbreak bushing insert meet the switching and fault close requirements as specified in Sections 7.7 and 7.8 of IEEE Standard 386-1995 when tested with competitive parts.

Procedure

The same procedure was used as described in Tests F and G. The following combinations of Cooper Power Systems and competitive connectors were tested at 26.3 kV phase-to-phase.

Cooper Bushing LBI225 (was 2637612C01M) with:

| <i>Competitor's Elbow</i> | <i>Catalog Number</i> |
|---------------------------|-----------------------|
| Elastimold | 273LRH240 |
| Blackburn | JT2CG10BLA |
| General Electric | 9U01BBX575 |

Cooper Elbow LE225 (was 2604740B) with:

| <i>Competitor's Bushing</i> | <i>Catalog Number</i> |
|-----------------------------|-----------------------|
| Elastimold | 2701A4 |
| Blackburn | JLB2C10 |
| General Electric | 9U02BAB004 |

The test results for Cooper Power Systems 2637612C01M bushing insert apply to the product now designated as LBI225 which employ the same contact and interface design. The test results for Cooper Power Systems 2604740B elbow apply to the product now designated as LE225 which employ the same probe and interface design.

Results

At least ten consecutive pairs of each of the above elbow/bushing combinations were successfully switched 10 times and subsequently fault closed. No external ground current occurred and all component parts remained within the closed connector assembly for all of the fault closed elbow/bushing pairs.

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Conclusion

The representative Cooper Power Systems 25 kV Class 200 Amp loadbreak elbow and loadbreak bushing insert met the switching and fault close interchangeability requirements as specified in Sections 7.7 and 7.8 of IEEE Standard 386-1995 for the six connector combinations listed above.

TEST T
15.2/26.3 kV
Multi-Stress Test
Appendix A

Object

To demonstrate that the Cooper Power Systems 25 kV Class 200 Amp Separable Connector System products are capable of meeting the requirements of Cooper's long term multi-stress accelerated aging test. The multi-stress aging test is designed to verify that the base design, materials and manufacturing processes are capable of producing connectors which meet normal requirements for longevity in use.

Standard

Cooper Power Systems Multi-Stress Test E9120 Rev. 01, 11/12/93. The connectors shall withstand the multi-stress accelerated aging conditions for a minimum of 2,500 hours without a puncture or flashover.

Procedure

Eight loadbreak elbows (LE225), eight insulated protective caps (LPC225) and four 4-way junctions (2637166C) were subjected to the multi-stress accelerated aging test. The elbows are assembled on AWG No. 1/0 aluminum 260 mil XLPE cable.

Two elbow/cable assemblies and two caps are mounted to each 4-way junction. The interfaces are lubricated in accordance to the installation instructions. The four junctions are submerged in a water filled tank. The water is supplied directly from the tap without any treatment.

The water is heated to between 85°C and 95°C using emergent resistance heater coils. The surface of the water is covered with plastic balls to reduce the rate of evaporation. Water is added regularly to maintain coverage of the test specimens.

A continuous 60 Hz ac test voltage of 1.5 times the rated line-to-ground voltage is applied to the junction assemblies. The test voltage for 25 kV Class connectors is 22.5 kV (1.5 x 15.2).

Tan delta and capacitance is measured to monitor the stability of the insulation system of each test specimen. Test elbows and caps are mounted on an unaged bushing insert for the tan delta and capacitance measurements. The tan delta and capacitance of test junctions is measured using an unaged elbow/cable assembly and three unaged caps. The same unaged

connectors are used throughout the test for measuring the capacitance and tan delta of the test specimens.

An initial tan delta and capacitance measurement of each elbow, cap and junction is taken prior to the start of the accelerated aging regimen. Periodically, the test samples are de-energized, removed from the water and allowed to cool to room ambient temperature. Tan delta and capacitance measurements are then taken. Measurements were made at 500 hour increments \pm 50 hours.

Results

The eight elbows, eight protective caps and four 4-way junctions withstood 2,500 hours of the multi-stress accelerated aging test without a puncture or a flashover. The tan delta and capacitance of each connector demonstrated stability throughout the duration of the test.

Conclusion

The representative Cooper Power Systems 25 kV Class 200 amp Separable Connector System products met the requirements of the Cooper Power Systems Multi-Stress Test E9120.

TEST U
15.2/26.3 kV
Partial Vacuum Switching Test
Appendix B

Object

To demonstrate that the Cooper Power Systems POSI-BREAK 25 kV Class 200 Amp Separable Connector System products are capable of being separated without a flashover when tested per the requirements of the proposed Cooper Power Systems partial vacuum switching test.

Procedure

Twelve POSI-BREAK elbows (PLE225) are assembled onto a short length of properly prepared XLPE insulated cables. The twelve POSI-BREAK elbow/cable assemblies and twelve POSI-BREAK insulated protective caps (PLPC225) are each assembled to bushing inserts (LBI225) at an ambient temperature of $25^{\circ}\text{C} \pm 5^{\circ}\text{C}$ without applying lubrication to the 200 Amp operating interface.

The connector assemblies are chilled in a cold chamber at -20°C to -25°C for a minimum of 16 hours.

A connector assembly is removed from the cold chamber and mounted to the face plate of a grounded test stand. Adjacent grounds are not required. The face plate mounting shall be equipped with threaded mounting studs and a bushing well clamp located in a manner duplicating a typical field application.

The separable connector, elbow or cap, shall be separated from the bushing within 10 minutes after removal from the cold chamber. The opening operation shall be performed with a positive continuous motion applied manually or by a mechanical actuator. The force shall be applied to the operating eye of the connector using suitable live-line tool or equivalent device.

The test circuit and circuit parameters are detailed in the following Figure A and Table B. The line-to-ground test voltage for the 15.2/26.3 kV rated connectors is 30 kV rms. Appropriate metering equipment shall be applied for ground-fault detection.

FIGURE A
Circuit Diagram

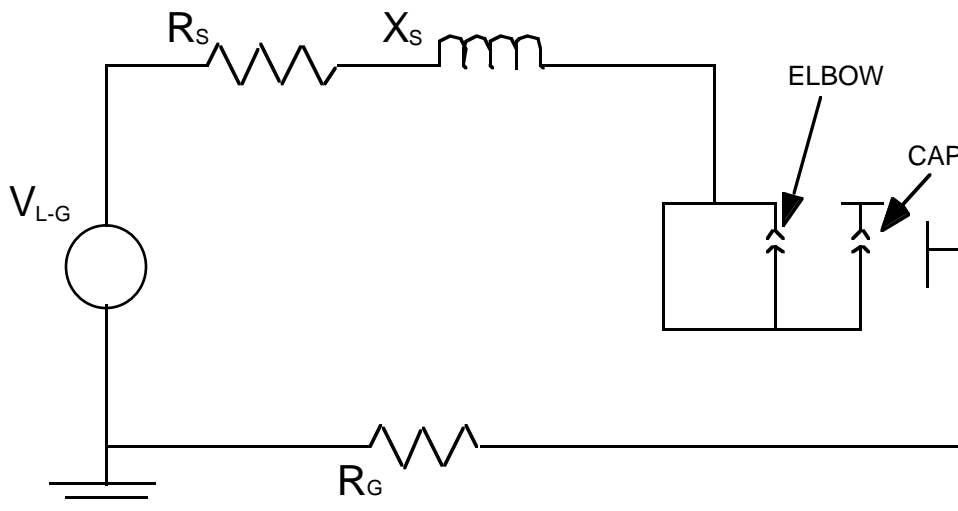


TABLE B
Circuit Parameters

$$V_{L-G} = 2 \times (\text{RATED L-G Voltage})$$

$$Z_S = X_S + R_S$$

$$X_S/R_S = 5.0 - 7.0$$

$$Z_S \geq 0.10 \times R_G$$

$$I_F = V/(Z_S + R_G) \geq 50 \text{ Amps}$$

Results

Twelve consecutive POSI-BREAK elbows and twelve consecutive POSI-BREAK insulated protective caps were successfully switched when mated with a Cooper bushing insert without a flashover to ground at a 30 kV line-to-ground test voltage.

Additionally, twelve consecutive POSI-BREAK elbows and twelve consecutive POSI-BREAK insulated protective caps were successfully switched when mated with an Elastimold bushing insert (Cat. No. 2701A4) without a flashover to ground at a 30 kV line-to-ground test voltage.

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Conclusion

The representative Cooper Power Systems POSI-BREAK 25 kV Class 200 Amp Separable Connector System products met the requirements of the proposed Cooper Power Systems partial vacuum switching test.

