UltraSIL Polymer-Housed Evolution Distribution Class Surge Arrester Certified Test Report

UltraSIL Polymer-Housed Evolution Distribution-Class Surge Arrester

CERTIFICATION

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

Mike Ramarge
Arrester Engineering Manager

INTRODUCTION

This test report certifies that the UltraSIL polymer-housed Evolution surge arrester was successfully tested to IEEE Std C62.11™-2005 standard "*IEEE Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits*".

TEST PROGRAM

OBJECTIVE

To demonstrate the UltraSIL polymer-housed Evolution surge arrester meets all performance requirements.

PROCEDURE

The following design tests were performed on a sufficient number of samples to demonstrate all performance requirements are met.

DESIGN TESTS

A. Insulation Withstand……………… ....Per IEEE Std C62.11™-2005 standard, Para. 8.1.2.1
B. Discharge Voltage Current Characteristics..Per IEEE Std C62.11™-2005 standard, Para. 8.3
C. Discharge Voltage Time Characteristics......Per IEEE Std C62.11™-2005 standard, Para. 8.3.2.2
D. Impulse Protective Level Voltage-Time Characteristic Test…………………………......Per IEEE Std C62.11™-2005 standard, Para. 8.4
E. Accelerated Aging Procedure…………… ....Per IEEE Std C62.11™-2005 standard, Para. 8.5
F. High Current, Short Duration……………….Per IEEE Std C62.11™-2005 standard, Para. 8.12
G. Low Current, Long Duration… ....Per IEEE Std C62.11™-2005 standard, Para. 8.13.2
H. Duty Cycle…………………………...............Per IEEE Std C62.11™-2005 standard, Para. 8.14
I. Internal Ionization and RIV………… ....Per IEEE Std C62.11™-2005 standard, Para. 8.10
J. Short Circuit Test (Design B)………….........Per IEEE Std C62.11™-2008 standard, Amendment 1, Para. 8.24
K. Disconnector Test…………………… ....Per IEEE Std C62.11™-2005 standard, Para. 8.21
L. Contamination Test…………………… ....Per IEEE Std C62.11™-2005 standard, Para. 8.8
M. Temporary Overvoltage (TOV)…… ....Per IEEE Std C62.11™-2005 standard, Para. 8.15
N. Accelerated Aging Tests of External Polymeric Insulating Systems……… ....Per IEEE Std C62.11™-2005 standard, Para. 8.6
O. Seal Integrity…………………………… ....Per IEEE Std C62.11™-2005 standard, Para. 8.9
P. 1000 Hours Accelerated Aging Test with Exposure to Salt Fog……………………… ...Per IEEE Std C62.11™-2005 standard, Para. 8.7 & Per IEC 60099-4, Para. 10.8.14.2.1 Edition 2004
Q. 5000 Hours Weather Aging Test… ....Per IEEE Std C62.11™-2005 standard, Annex C & Per IEC 60099-4, Para. 10.8.14.2.2 Edition 2004

ADDENDUM

R. Water Immersion Test…………………….....Per IEEE Std. C62.11™-2005, Para 8.22.3.3
S. High Humidity Test…………………….........Per Cooper Power Systems Internal Specification 5A1-340-1

Chart 1...Evolution Arrester Discharge Voltages **including 3rd Party Front-of-Wave Sparkover Testing on Standard Production 10 kV, 18 kV & 27 kV arresters**
Chart 2...TOV Recovery Capabilities of Evolution Arresters
Graph 1 ....Evolution Arrester TOV Curve per IEEE Std C62.11™ standard
Graph 2 ....Disconnector Time-Current Characteristic Plot

RESULTS

The UltraSIL polymer-housed Evolution surge arresters met all performance requirements.

TEST A
INSULATION WITHSTAND

OBJECTIVE

To verify that assembled insulating members of the arrester withstand impulse and power frequency voltage tests in accordance with IEEE Std C62.11™-2005 standard, Para. 8.1.2.1.

PROCEDURE

- New clean arrester housings of all ratings, including the longest and highest stressed designs were assembled over insulator cores. The samples were mounted in several configurations, including short and long insulating hangers with and without NEMA brackets and base mountings. Test samples were subjected to positive and negative 1.2 x 50 µs voltage impulses to obtain insulation withstand levels. Test voltages were determined by multiplying the maximum discharge voltage for a 20 kA 8/20 µs current impulse by a factor of 1.42. See Note 1 below.
- A 60 Hertz Voltage was applied between the arrester and grounded NEMA bracket while wet for 10 seconds in order to demonstrate a wet withstand voltage greater than 1.36 times the claimed 10 second TOV capability of the arrester. See Note 2 below.
- A 60 Hertz voltage equal to 1.5 x MCOV was applied between the arrester ground terminal and the grounded NEMA bracket while the hanger bracket was wet for 10 seconds. This test was performed on all available hanger models for all ratings.

RESULTS

Arrester samples met the requirements of the Insulation Withstand Test by demonstrating no evidence of flashovers.

NOTE 1: Housing insulation withstand levels for all ratings of the Evolution arrester are well above maximum discharge voltages for both FOW Sparkover Levels and 8x20 µs current impulses using a 1.42 multiplication factor. Housing Withstand Levels and arrester FOW Sparkover Levels for all ratings are provided in Table 4 & 5 of catalog section 235-99.

NOTE 2: The 10 second wet withstand levels for each individual housing are provided in Table 4 of catalog section 235-99.

TEST B
DISCHARGE VOLTAGE
CURRENT CHARACTERISTICS

OBJECTIVE

To determine maximum discharge voltage characteristics of the arrester at 1.5, 3, 5, 10, 20 and 40 kA crest in accordance with IEEE Std C62.11™-2005 standard, Para. 8.3.1.

PROCEDURE

- Sample arresters were impulsed using an 8 x 20 µs wave shape at 1.5, 3, 5, 10, 20 and 40 kA crest.
- The discharge voltage crest was measured.

RESULTS

Maximum discharge voltages were establish in accordance with standards and are provided in Chart 1.

TEST C
DISCHARGE VOLTAGE
TIME CHARACTERISTICS

OBJECTIVE

To obtain the front-of-wave protective level of the arrester based on an impulse resulting in a discharge voltage cresting in 0.5 µs in accordance with IEEE Std C62.11™-2005 standard, Para. 8.3.2.

PROCEDURE

- A classifying current of 10 kA for heavy duty/riser pole was used to determine the equivalent front-of-wave protective level.
- The arresters were impulsed using front times of 8 µs, 2 µs and 1 µs.
- The maximum discharge voltage and the time to voltage crest were measured.
- The voltage/time measurements were plotted on linear voltage versus log time paper and the maximum voltage at 0.5 µs was determined and recorded.

RESULTS

The Equivalent Front-of-Wave (EFOW) protective levels were established in accordance with IEEE Std C62.11™-2005 standard, Para. 8.3.2. and are used for comparison purposes to determine arrester Front-of-Wave Protective Levels.

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TEST D
IMPULSE PROTECTIVE LEVEL VOLTAGE-TIME CHARACTERISTIC TEST

OBJECTIVE

To determine if impulse protective levels are a function of arrester's maximum sparkover values for Front-of-Wave and 1.2/50 µs impulse wave shapes in accordance with IEEE Std. C62.11™-2005 standard, Para. 8.4.

PROCEDURE

- Determine Front-of-Wave protective levels by comparing Front-of-Wave spark over levels to classifying current discharge voltages cresting in 0.5 µs.
- A classifying current of 10 kA for Heavy-Duty/Riserpole was used to determine front-of-wave protective levels for voltage waves cresting in 0.5 µs for all ratings of the Evolution arrester.
- Front-of Wave impulse sparkover testing was performed using both positive and negative polarity impulses with a minimum of 1.2 times the arrester 10 kA classifying current discharge voltage for all ratings of the Evolution arrester as described under 8.4.2.1.
- The maximum discharge voltage and the time to voltage crest were measured for five (5) discharges of positive and negative polarity voltage waveforms.
- The maximum discharge voltage recorded during testing of the positive and negative polarity impulses was compared to the classifying current discharge voltage cresting in 0.5 µs.
- The FOW Sparkover Level exceeded the 0.5 µs discharge voltage at a classifying current of 10 kA so the FOW Impulse Sparkover Test was performed.
- The FOW Impulse Sparkover Test as described under Para. 8.4.2.1.2 was performed using positive and negative polarity impulses with sparkovers occurring before 90% of the crest value of the voltage waveform. The nominal rate of rise for the voltage waveform was equivalent to 100 kV/µs for each 12 kV duty-cycle voltage rating as described in Table 8 under Para. 8.4.2.1.1.
- The maximum front-of-wave sparkover level was recorded for all ratings of the Evolution arrester. See Note 1.
- Determine if arrester sparkover voltage for a 1.2/50 µs lightning impulse exceeds the discharge voltage from an 8/20 µs current discharge at the classifying current of 10 kA.
- The 1.2/50 µs impulse sparkover determination test was performed using five (5) positive and negative voltage waveforms as described under Para. 8.4.2.2.1. The magnitude of the test waveforms were a minimum of 1.2 times the arrester discharge voltage using a classifying current of 10 kA.
- The maximum discharge voltage recorded was less than the classifying current discharge voltage at 10 kA.
- The Slow-front (switching surge) impulse protective level test is not required for the Evolution arrester as referenced in Table 7 under Para. 8.3.2.2.2.

RESULTS

Front-of-wave sparkover levels were established as the front-of-wave protective levels and the classifying current discharge voltages were established as the 1.2/50 µs impulse protective levels in accordance with IEEE Std. C62.11™-2005 standard, Para. 8.4.

NOTE : Maximum front-of-wave sparkover levels are provided in Chart 1 of the Certified Test Report, which includes 3rd party supporting data.

TEST E
ACCELERATED AGING PROCEDURE

OBJECTIVE

To verify K_c and K_R ratios of the arresters in accordance with IEEE Std C62.11™-2005 standard, Para. 8.5.

K_C = MCOV Ration
K_R = Duty Cycle Ratio

These ratios were determined to calculate the test values of MCOV and duty cycle voltages used during testing.

PROCEDURE

- MOV valve elements were placed in an oven at 115°C and energized at MCOV for 1,000 hours.
- The watts loss was measured at the MCOV and duty cycle voltage levels within two to five hours after the start of the test.
- The watts loss was measured at 1,000 hours at MCOV and duty cycle voltage levels.

$$K_C = \frac{Watts\ Loss @ 1{,}000 Hrs @ MCOV}{Watts\ Loss @ 2-5 Hrs @ MCOV}$$

$$K_R = \frac{Watts\ Loss @ 1{,}000 Hrs @ Rated\ Voltage}{Watts\ Loss @ 2-5 Hrs @ Rated\ Voltage}$$

If K_C and K_R ≤ 1, then K_C and K_R are equal to 1.

RESULTS

MOV disks met requirements of the Accelerated Aging Procedure by demonstrating K_C and K_R < 1, which is in accordance with IEEE Std C62.11™-2005 standard, Para. 8.5.

TEST F
HIGH-CURRENT, SHORT-DURATION

OBJECTIVE

To demonstrate that arresters meet the high-current, short-duration requirements in accordance with IEEE Std C62.11™-2005 standard, Para. 8.12.

PROCEDURE

- Three 10 kV rated equivalent thermal sections, with isolators, were used for this test.
- Each sample was impulsed with a 100 kA (heavy duty/riser pole) crest current wave with a wave shape of 4 x 10 µs.
- The samples were allowed to cool to ambient temperature.
- Each sample was impulsed a second time.
- Within five minutes following the second impulse, the samples were energized at the thermal recovery voltage per IEEE Std C62.11™-2005 standard, paragraph 7.2.2 (MCOV x K_W x K_C) for 30 minutes to verify thermal recovery.
- The samples were inspected after testing to make sure that there was not any physical damage.

RESULTS

Arrester samples met the requirements of the High-Current, Short-Duration test (HCSD) by demonstrating the ability to handle two 100kA impulses and undergoing thermal recovery with no physical damage.

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TEST G
LOW-CURRENT, LONG-DURATION

OBJECTIVE

To demonstrate that arresters meet the low-current, long-duration requirements in accordance with IEEE Std C62.11™-2005 standard, Para. 8.13.2.

PROCEDURE

- Three 10kV rated equivalent thermal sections, with isolators were used for this test.
- Each sample was impulsed with a 10 kA (heavy duty and riser pole) crest, 8 x 20 µs wave and the discharge voltage measured.
- Each sample was impulsed using a 250 amp (heavy duty/riser pole) by 2,000 µs square wave six times, once every 50 to 60 seconds. The samples were allowed to cool to room temperature. This procedure was repeated two more times.
- Immediately after the 18th shot, the samples were placed into an oven until they stabilized at 60°C.
- The samples were impulsed two more times within 5 minutes after removal from the oven.
- Immediately after the 20th shot, the samples were energized at the thermal recovery voltage per IEEE Std C62.11™-2005 standard, paragraph 7.2.2 (MCOV x K_W x K_C) for 30 minutes minimum to verify thermal recovery.
- Each sample was impulsed with a 10 kA (heavy duty/riser pole) crest 8 x 20 µs wave and the discharge voltage measured. The discharge voltage was compared to the discharge voltage taken prior to the low-current, long-duration testing to make sure that it did not vary by more than ±10%.
- The samples were inspected after testing to assure that no physical damage occurred.

RESULTS

Arrester samples met the requirements of the Low-Current, Long-Duration test (LCLD) by demonstrating the ability to handle 20 impulses, undergoing thermal recovery, demonstrating <10% change in discharge voltage with no physical damage.

TEST H
DUTY CYCLE

OBJECTIVE

To demonstrate arresters meet the duty cycle requirements in accordance with IEEE Std C62.11™-2005 standard, Para. 8.14.

PROCEDURE

- Three 10 kV prorated equivalent thermal sections, with isolators were used for this test.
- Each sample was impulsed with a 10 kA (heavy duty/riser pole) crest, 8 x 20 µs wave and the discharge voltage measured.
- Each sample was energized at K_R times the duty cycle voltage (K_R=1), for the duration of time needed to allow 20 impulses.
- Each sample was impulsed with a 10 kA (heavy duty/Riserpole) crest surge of 8 x 20 µs wave shape.
- The impulse occurred at approximately 60° before the crest on the power frequency wave.
- Each sample was impulsed once every 50 to 60 seconds for 20 consecutive impulses.
- After the 20th impulse, the samples were de-energized and placed into an oven until they stabilized at 60°C.
- Each sample was removed from the oven and immediately energized at the thermal recovery voltage per IEEE Std C62.11™-2005 standard, paragraph 7.2.2 **(**MCOV x K_W x K_C) and impulsed twice more at a 40 kA crest within one minute.
- Samples remained energized at the thermal recovery voltage for 30 minutes minimum to verify thermal recovery.
- Each sample was impulsed with a 10 kA (heavy duty/riser pole) crest 8 x 20 µs wave and the discharge voltage measured. The discharge voltage was compared to the discharge voltage taken prior to duty cycle to make sure that it did not vary by more than ± 10%.
- The samples were inspected after testing to assure that no physical damage occurred.

RESULTS

The arrester samples met the requirements of the Duty Cycle Test withstanding 22 impulses, demonstrating thermal recovery with <10% change in discharge voltage and no physical damage.

TEST I
INTERNAL IONIZATION AND RIV

OBJECTIVE

To verify that arresters do not generate unacceptable levels of internal ionization current or RIV noise in accordance with IEEE Std C62.11™-2005 standard, Para. 8.10.

PROCEDURE

- A 1.05 x MCOV power frequency voltage was applied across the line and ground terminals of arresters with different voltage ratings.
- RIV and ionization voltage measurements were taken at 1.0M Hertz.

RESULTS

The arrester samples met the requirements of the RIV test by demonstrating ionization voltages much lower than 10 µV.

NOTE: All production arresters are 100% tested for RIV noise using a partial discharge tester (Pd $\leq$ 5pC).

TEST J
SHORT-CIRCUIT TEST
(DESIGN B)

OBJECTIVE

To verify that failed arresters are able to conduct fault current without violent disintegration in accordance with IEEE Std C62.11™-2008 standard, Amendment 1, Para. 8.24.

PROCEDURE

- The tests were performed on a 36 kV sample with a polyester-insulating hanger.
- The arresters were pre-failed by thermally overloading the MOV disks using excessive power frequency voltage.
- The following test currents were applied to the arresters:

Fault Current Amplitude (kA rms)	Fault Current Duration (cycles)
0.6	60
20.0	12

RESULTS

Arrester samples met the requirements of the Short-Circuit Test by venting before a specified maximum 1-second duration and without ejecting any internal components.

NOTE: Cooper Power Systems performed the Short Circuit Test at a third party test facility on the UltraSIL Housed VariSTAR design and is representative of the UltraSIL Housed Evolution arrester.

TEST K
DISCONNECTOR TEST

OBJECTIVE

To verify that the disconnector can withstand, without operation, the arrester design tests and provide a current-time characteristic operating curve, in accordance with IEEE Std C62.11™-2005 standard, Para. 8.21.

PROCEDURE

- The arrester samples in all the electrical tests, including the following tests, were performed with disconnectors attached:

  1---High Current, Short Duration (Test E)
  2---Low Current, Long Duration (Test F)
  3---Duty Cycle (Test G)
  4---Contamination Test (Test K)
  5---TOV (Test L)
  6---Seal Integrity Test (Test N)

- A disconnector time-current curve was established using five samples at current levels of 20, 80, 200, and 800 amps rms, as shown in Graph 2.

RESULTS

The disconnector samples met the requirements of the Disconnector Test by demonstrating the arrester electrical tests did not cause disconnector operation within the disconnector time-current curve.

TEST L
CONTAMINATION TEST

OBJECTIVE

To demonstrate the ability of the arresters to withstand the electrical stresses caused by contamination on the housing, in accordance with IEEE Std C62.11™-2005 standard, Para. 8.8.

PROCEDURE

- Arrester samples were energized for a minimum of one hour at MCOV.
- The watts loss at MCOV was measured at the end of the hour.
- The samples were de-energized. Within 13 minutes, a 400-500 ΩcM slurry was applied to the housing heavily enough to form drops on the skirts.
- The samples were energized at the MCOV voltage.
- The watts loss was measured after 15 minutes.
- The samples were de-energized again and another slurry application was performed.
- The samples were energized at MCOV for 30 minute intervals and the watts loss was monitored to verify decreasing levels towards the original measurement.
- Once the samples were cleaned and dried, they were inspected for internal damage using partial discharge measurements at MCOV.

RESULTS

The arrester samples met the requirements of the Contamination Test by having stabilized lower watts loss over time and not flashing over with evidence of internal physical damage.

TEST M
TEMPORARY OVERVOLTAGE (TOV)

OBJECTIVE

To verify what levels of 60 cycle temporary overvoltage the arresters survive in accordance with IEEE Std C62.11™-2005 standard, Para. 8.15.

PROCEDURE

- Each sample was impulsed with a 10 kA (heavy duty/riser pole) crest, 8 x 20 µs wave and the discharge voltage measured.
- Samples were preheated to 60°C.
- Each sample was removed from the oven and immediately energized at the overvoltage.
- The overvoltage was removed after the guaranteed duration.
- Within 1 S, each sample was energized at the thermal recovery voltage per IEEE Std C62.11™-2005 standard, paragraph 7.2.2 (MCOV x K_W x K_C) for 30 minutes. Sample and temperature were monitored for thermal runaway.
- Each sample was impulsed with a 10 kA (heavy duty/riser pole) crest 8 x 20 µs wave and the discharge voltage measured. The discharge voltage was compared to the discharge voltage taken prior to the Temporary Overvoltage testing to make sure that it did not vary by more than ±10%.
- The samples were inspected after testing to assure that no physical damage occurred.
- Temporary overvoltage test points were plotted.

RESULTS

Temporary over voltage capability has been established in accordance with IEEE Std C62.11™-2005 standard, Para. 8.15. Results are provided in Chart 2 and Graph 1.

TEST N
ACCELERATED AGING TESTS OF EXTERNAL POLYMERIC INSULATING SYSTEMS

OBJECTIVE

To demonstrate a high performance level of the external polymer insulating system of the arresters when exposed to accelerated light and electrical stress in accordance with IEEE Std C62.11™-2005 standard, Para. 8.6.

PROCEDURE

- The arrester housing and hanger bracket materials were subjected to UV testing per ASTM G154-00a (Replaces G53-96) for over 1,000 hours without any cracking of the surfaces.
- The discharge voltage of three full arrester samples was measured using an 8 x 20 µs impulse with a 10 kA (heavy duty/riser pole) crest.
- The hanger brackets of the samples were grounded at their mounting hole.
- The following test cycle was performed for 1,000 hours:
  -Dip sample into a 400-500 Ωcm slurry bath.
  -Remove sample from slurry and energize for two minutes at MCOV.
  -De-energize sample and dip into 400-500 Ωcm slurry bath.
- After 1,000 hours of cycling the discharge voltage of the samples was measured using an 8 x 20 µs duration impulse with a 10 kA (heavy duty/riser pole) crest.
- With the arrester samples effectively shorted, the maximum system voltage was applied across the hanger bracket for 20 hours using the cycle described above.

RESULTS

The samples passed the Accelerated Aging Test by demonstrating no evidence of flashovers or surface tracking and the arrester discharge voltage did not change more than ±10% from the initial value.

TEST O
SEAL INTEGRITY

OBJECTIVE

To verify that the seal design of the UltraSIL arrester is robust in accordance with IEEE Std C62.11™-2005 standard, Para. 8.9.

PROCEDURE

- Three samples were subjected to all of the following tests.
- The RIV and watts loss was measured at the duty cycle rating.
- An AWG No. 1 solid wire was installed on the top and bottom terminals and torqued to 20 ft Ibs.
- The samples were temperature conditioned by heating them to 70°C for 14 days.
- Once the samples returned to ambient temperature, they were heated to 60°C for one hour.
- The samples were then placed in a 4°C cold-water bath for two hours.
- The 60° to 4°C cycle was repeated 10 times.
- Within 24 hours of the last cycle, the RIV and watts loss were measured at the duty cycle voltage to verify that the RIV did not increase more than 20 µV and the watts loss did not increase more than 50% than the initial value.
- The samples were internally inspected to verify that there was no moisture present.

RESULTS

The arrester samples successfully met the test requirements of the Seal Integrity Test by demonstrating less than 20 µV increase in RIV and less than 50% increase in watts loss from initial value.

TEST P
1000 HOURS ACCELERATED AGING TEST WITH EXPOSURE TO SALT FOG

OBJECTIVE

To verify the ability of the arrester to withstand continuous salt fog conditions and endure surface arcing and heating in accordance with IEEE Std C62.11™-2005 standard Para. 8.7.

PROCEDURE

- One sample of the longest electrical section with the highest rated voltage was subjected to pre-test measurements as prescribed by standards.
- Sample was placed in the vertical position inside an enclosure with salt fog mist of 10kg/m^3 salinity level and energized at Uc for duration of 1000 hours.
- Post-tests were conducted to verify measured values did not exceed levels specified by the standard.
- Sample was inspected to assure that no physical damage had occurred.

RESULTS

The arrester samples successfully met the test requirements of the 1,000 Hour Accelerated Aging Test by demonstrating no housing punctures or erosion of the housing, no internal breakdowns; no surface tracking was evidenced by physical examination. Measured post-test values did not exceed levels specified by the standard.

NOTE: Cooper Power Systems performed the 1,000 Hours Accelerated Aging Test with Exposure to Salt Fog in our A2LA Accredited test facility in Olean, NY on the UltraSIL Housed VariSTAR arrester and is representative of the UltraSIL Housed Evolution arrester.

TEST Q
5000 HOURS WEATHER AGING TEST

OBJECTIVE

To verify the ability of the arrester to endure surface arcing and heating while subject to humidification, thermal cycling, rain, simulated solar radiation (UV) and salt fog. Testing was performed in accordance with IEEE Std C62.11™-2005 standard, Annex C.

PROCEDURE

- One sample of the longest electrical section with the highest rated voltage was subjected to pre-test measurements as prescribed by standards.
- Sample was placed in the vertical position inside a test chamber equipped for heating, humidity, UV-radiation, artificial rain and salt fog. The sample was subject to a multi-stress cycle as defined by IEEE Std C62.11™-2005 standard, Annex C, and Figure C.1 for duration of 5,000 hours.
- Post-tests were to verify measured values did not exceed specified levels by the standard.
- Sample was inspected to assure that no physical damage had occurred.

RESULTS

The sample fulfilled the requirements of the 5,000 Hour Weather Aging Test by demonstrating no over current trip-out occurred during the testing procedure. There was no tracking, cracking or treeing of the external housing. There were no housing punctures or internal breakdowns. Measured post-test values did not exceed levels specified by the standard.

NOTE: Cooper Power Systems performed the 5,000 Hours Weather Aging Test at a third party test facility on the UltraSIL Housed VariSTAR arrester and is representative of the UltraSIL Housed Evolution arrester.

ADDENDUM

TEST R
WATER IMMERSION TEST

OBJECTIVE

To demonstrate the resistance of an UltraSIL polymer-housed arrester with a composite wrapped module to moisture ingress. This test was completed in accordance with standards IEEE C62.11™-2005 standard, Para. 8.22.3.3.

PROCEDURE

- One 36kV rated module section encapsulated in composite weave material was used for this test.
- Pre-tests consisted of the following measurements:
  - Power loss at 100% of MCOV
  - Partial discharge tested at 1.05 x MCOV
  - Lightning impulse residual voltage using 5 kA, 8x20 µs current impulse
- Sample was immersed in deionized water with 1kg/m³ of NaCl content. Water temperature was increased to 80º C and maintained for 168 hours.
- Sample remained immersed until water-cooled to 50º C.
- Water temperature was maintained until sample was removed.
- Post-test measurements were performed to include:
  - Power loss at 100% of MCOV
  - Partial discharge at 1.05 x MCOV
  - Lightning Impulse Residual Voltage using 5 kA, 8x20 µs current impulse

RESULTS

The arrester sample met the requirements of the Water Immersion Test by demonstrating less than 20% change in power loss, less than 10pC of internal partial discharge, less than 5% change in residual voltage and no signs of physical damage according to standards IEEE C62.11™-2005 standard, Para. 8.22.3.3.

NOTE: Cooper Power Systems does not claim cantilever strength for the Evolution arrester and is the reason why data was omitted from the Certified Test Report for thermo mechanical preconditioning.

TEST S
HIGH HUMIDITY TEST

OBJECTIVE

The High Humidity test was designed to demonstrate proper function of the insulating gap assembly under extreme humidity conditions.

PROCEDURE

- This test was completed on two 10 kV UltraSIL housing distribution arresters with module assemblies incorporating insulating gap assemblies and composite weave technology.
- Pre-tests consisted of the following measurements:
  - Power Frequency Sparkover
  - Partial discharge tested at 1.05 x MCOV
- The top aluminum electrodes were drilled out to allow a direct path for moisture to penetrate the gap assemblies.
- Samples were exposed to 95% relative humidity while energized at an elevated temperature of 60º C for 1,000 hours.
- Post-tests consisted of the following measurements:
  - Power Frequency Sparkover
  - Partial discharge tested at 1.05 x MCOV

RESULTS

The arrester samples satisfy the criteria for the High Humidity test by demonstrating less than 10% change in Power Frequency Sparkover Voltage, less that 10pC internal partial discharge tested at 1.5 x MCOV and no visible signs of physical damage or dielectric breakdown of components.

Chart 1
UltraSIL Polymer-Housed Evolution Arrester Discharge Voltages

Arrester Rating (kV rms)	MCOV (kV rms)	Minimum 60HZ Sparkover (kV Crest/√2)	Front-of-Wave Protective Level* (kV crest)	3rd Party Front-of-Wave Protective Level** (kV crest)	Maximum Discharge Voltage 8/20 µs Current Wave (kV crest)						Switching Surge*** (kV Crest)
					1.5 kA	3 kA	5 kA	10 kA	20 kA	40 kA	500 A
3	2.55	4.54	20.0	-	8.1	8.7	9.3	10.2	11.6	13.5	7.6
6	5.10	9.08	23.0	-	16.1	17.4	18.6	20.3	23.3	27.0	15.2
9	7.65	13.6	32.4	-	18.9	20.3	21.8	23.8	27.3	31.6	17.8
10	8.40	15.0	32.4	24.3	20.1	21.6	23.2	25.4	29.0	33.7	19.0
12	10.2	18.2	52.4	-	25.2	27.2	29.1	31.8	36.4	42.2	23.8
15	12.7	22.6	55.4	-	30.5	32.8	35.2	38.5	44.0	51.1	28.8
18	15.3	27.2	64.8	51.1	37.8	40.8	43.7	47.8	54.6	63.4	35.7
21	17.0	30.3	64.8	-	40.1	43.2	46.3	50.6	57.9	67.2	37.8
24	19.5	34.7	87.8	-	46.4	50.0	53.6	58.6	67.0	78	43.8
27	22.0	39.2	97.2	66.9	53.9	58.0	62.2	68.0	78	90	50.8
30	24.4	43.4	117.2	-	58.6	63.2	67.7	74	85	98	55.3
33	27.0	48.1	120.2	-	66.6	71.7	77	84	96	112	62.8
36	29.0	51.6	129.6	-	70.4	76	81	89	102	118	66.4

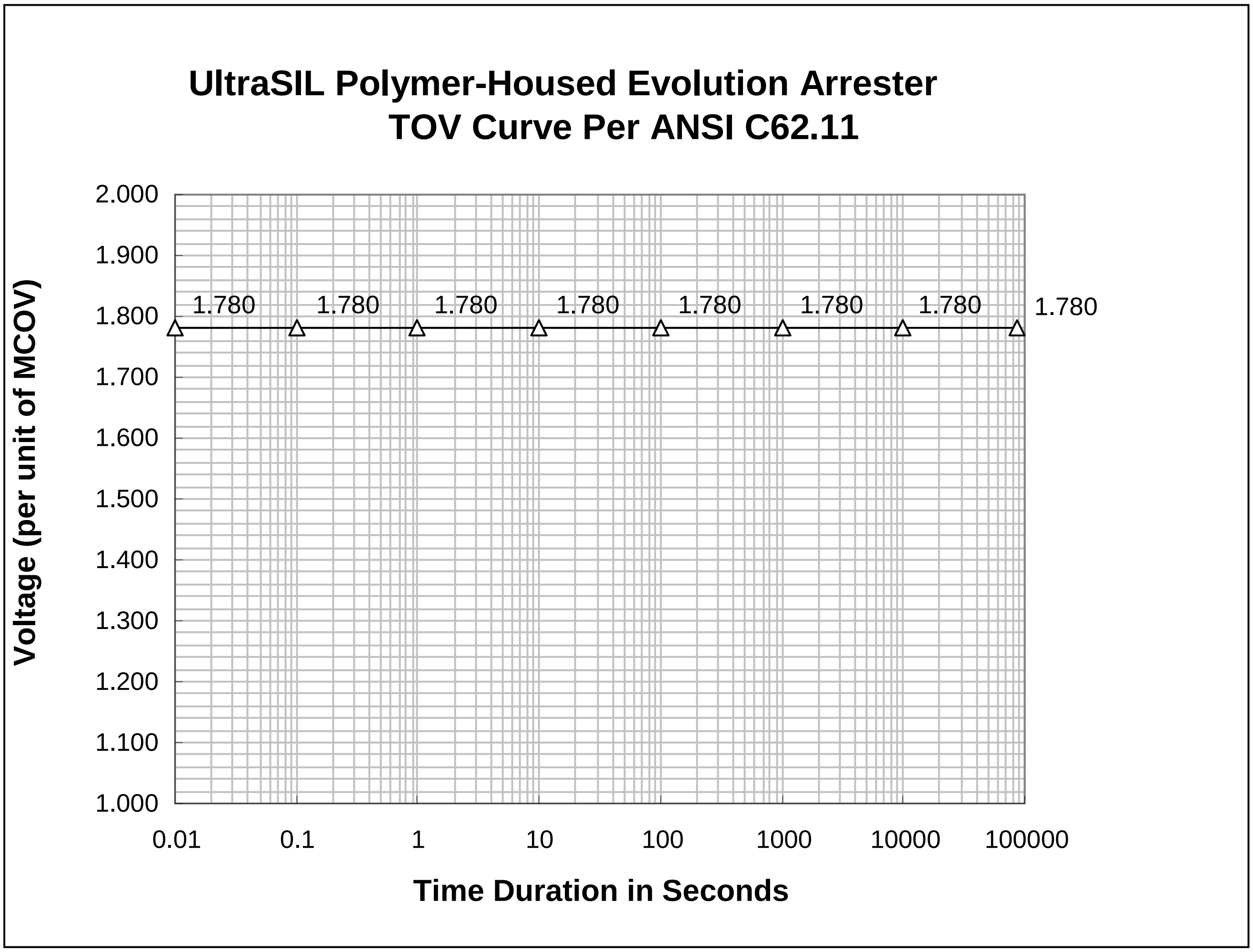
*The Front-of-Wave Sparkover Level is based on a voltage waveform having a rate of rise of 100 kV/µs for each 12 kV of arrester duty cycle rating. The FOW Sparkover Level for the Evolution arrester is the Front-of-Wave Protective Level.
**The 3rd party test report is available on the Cooper Power Systems website as CP1012 and includes the Front-of-Wave Sparkover test data for standard production 10 kV, 18 kV & 27 kV arresters.

***Based on a 30/60 µs current impulse.

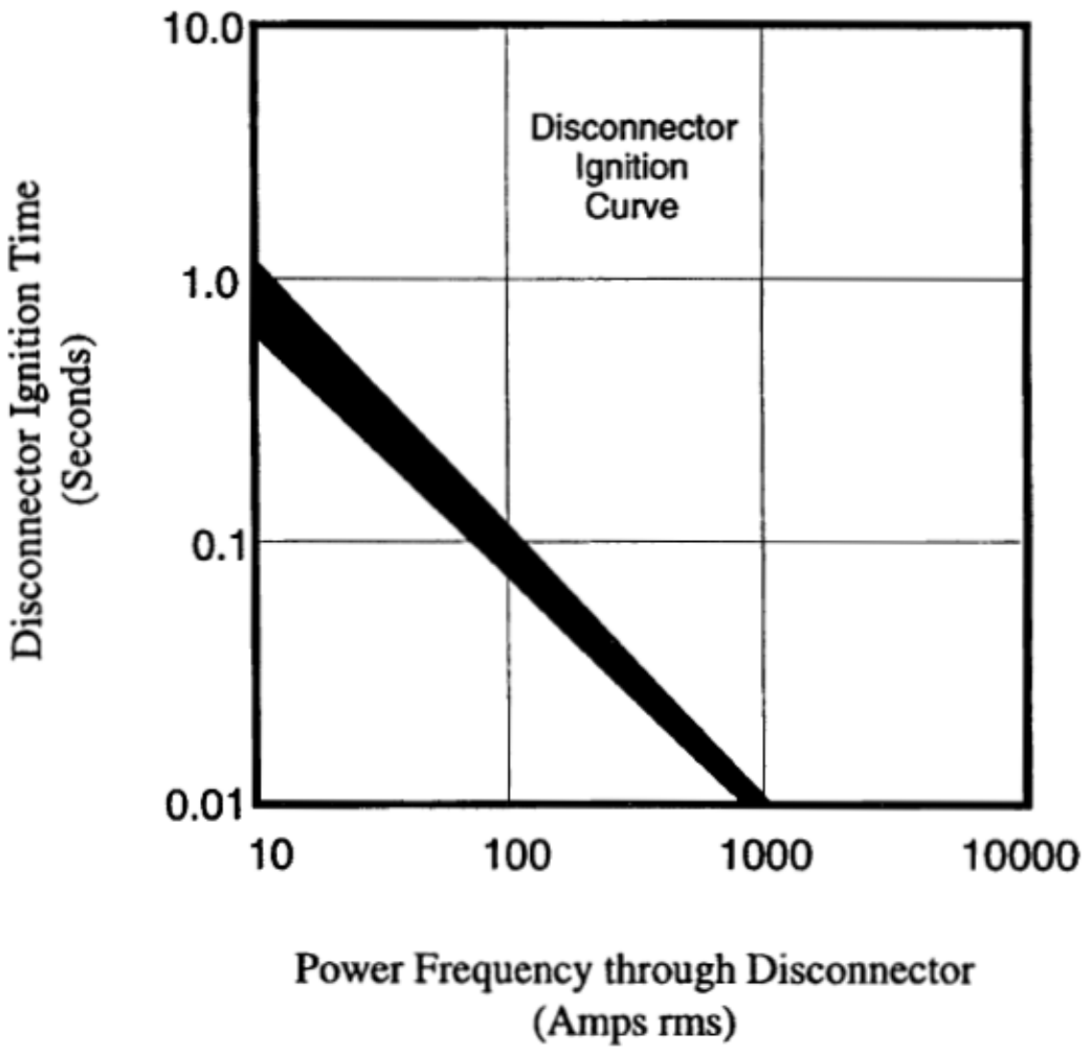
Chart 2
TOV Recovery Capability of UltraSIL Polymer-Housed Evolution Arresters

Time, Seconds	Per Unit of MCOV
	Evolution
0.01	1.78
0.02	1.78
0.1	1.78
1	1.78
10	1.78
100	1.78
1000	1.78
10000	1.78

Graph 1



Graph 2
Distribution Arrester Disconnector Time-Current Characteristic Plot



REVISION TABLE

REVISION NO.	DATE	WHAT WAS ADDED/CHANGED
1	08/10/2011	Misc format/spelling changes made Changed Design Test I IEEE standard Changed Design Test O, P and Q IEC standard Edition date Inserted Graph and Chart references Changed Test I Objective paragraph IEEE standard reference Corrected Test L Results Chart reference Inserted Test Q Results IEC 60099-4 Paragraph reference Changed Chart 4 to Chart 2 Test D added, Impulse Protective Level Voltage-Time Characteristic Test Testing update to Test A, Insulation Withstand, Procedure and Results sections Testing update to Test G, Procedure section Testing update to Test J, Procedure and Results sections Testing update to Test P, Procedure section Testing update to Test R, Objective and Results sections Addition of Test D, Impulse Protective Level Voltage-Time Characteristic Test Chart 1 edits, plus footnotes
2	10/08/2014	Corrected Test R, Water Immersion Test section

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