COOPER Power Systems

Certified Test Report File Ref: Cat. Sec. 235-35

UltraSIL Polymer-Housed VariSTAR Normal-Duty, Heavy-Duty and Riser Pole Distribution-Class Arresters

Bulletin 95062
September 2012 • Supersedes 04/09

UltraSIL Polymer-Housed VariSTAR Normal-Duty, Heavy-Duty and Riser Pole Distribution-Class Arresters

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
Engineering Manager

INTRODUCTION

This test report certifies that the UltraSIL Polymer-Housed VariSTAR arresters were successfully tested to IEEE Std C62.11-2005™ standard "*IEEE Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits*".

TEST PROGRAM

OBJECT

To demonstrate that the UltraSIL Polymer-Housed VariSTAR Arresters meet all performance requirements.

PRODEDURE

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. Accelerated Aging Procedure…………………......Per IEEE Std C62.11-2005™ standard, Para. 8.5
E. High Current, Short Duration………………… ......Per IEEE Std C62.11-2005™ standard, Para. 8.12
F. Low Current, Long Duration…………………........Per IEEE Std C62.11-2005™ standard, Para. 8.13.2
G. Duty Cycle…………………………………….........Per IEEE Std C62.11-2005™ standard, Para. 8.14
H. Internal Ionization and RIV………………….........Per IEEE Std C62.11-2005™ standard, Para. 8.10
I. Short Circuit Test (Design B)…………………… Per IEEE Std C62.11-2008™ standard, Amendment 1, Para. 8.24
J. Disconnector Test………………………… ....Per IEEE Std C62.11-2005™ standard, Para. 8.21
K. Contamination Test…………………………….......Per IEEE Std C62.11-2005™ standard, Para. 8.8
L. Temporary Overvoltage (TOV)……………… ....Per IEEE Std C62.11-2005™ standard, Para. 8.15
M. Accelerated Aging Tests of External Polymeric Insulating Systems………………………… ....Per IEEE Std C62.11-2005™ standard, Para. 8.6
N. Seal Integrity……………………………………… .Per IEEE Std C62.11-2005™ standard, Para. 8.9
O. 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 2004-05
P. 5000 Hours Weather AgingTest……………….....Per IEEE Std C62.11-2005™ standard , Annex C & Per IEC 60099-4, Para. 10.8.14.2.2 Edition 2004-05

ADDENDUM

Q. Water Immersion Test ....Per IEC 60099-4, Para. 10.8.13 Edition 2004

Chart 1, 2, & 3 ....Normal-Duty, Heavy-Duty and Riser Pole Arrester Discharge Voltages

Chart 4..VariSTAR TOV Recovery Capability

Graph 1 ....VariSTAR TOV Curve per ANSI C62.11

Graph 2 ....Disconnector Time-Current Characteristic Plot

RESULTS

The UltraSIL VariSTAR arresters met all performance requirements.

TEST A
INSULATION WITHSTAND

OBJECT

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 power frequency 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 power frequency 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.

RESULTS

None of the samples flashed over during any of the above tests in accordance with the insulation withstand requirements of IEEE Std C62.11-2005™ standard, Para. 8.1.2.1.

NOTE 1: Housing withstand levels and arrester protective levels are provided in Tables 4, 5, 6 & 7 in catalog section 235-35 for comparison purposes.

NOTE 2: The 10 second wet withstand levels for each individual housing are provide in Table 4 of catalog section 235-35 for comparison purposes to the 10 second arrester TOV capability.

TEST B
DISCHARGE VOLTAGE
CURRENT CHARACTERISTICS

OBJECT

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

Chart 1 shows the maximum discharge voltages for the normal-duty arresters. Chart 2 shows the maximum discharge for the heavy-duty arresters. Chart 3 shows the maximum discharge voltages for the riser pole arresters.

TEST C
DISCHARGE VOLTAGE
TIME CHARACTERISTICS

OBJECT

To obtain the front-of-wave protective level of the arrester based on an impulse that results 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 5 kA crest for normal-duty and 10 kA for heavy-duty and 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

Chart 1 shows front-of-wave protective levels for the normal-duty arresters. Chart 2 shows front-of-wave protective levels for the heavy-duty arresters. Chart 3 shows front-of-wave protective levels for the riser pole arresters.

TEST D
ACCELERATED AGING PROCEDURE

OBJECT

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 Ratio
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 remeasured 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 $K_R \leq 1$, then K_C and K_R are equal to 1.

RESULTS

K_C and $K_R < 1$ for normal-duty, heavy-duty and riser pole arresters.

TEST E
HIGH-CURRENT, SHORT-DURATION

OBJECT

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 65 kA (normal-duty) or 100 kA (heavy-duty and 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

The arresters met the high-current, short-duration requirements of two impulses, thermal recovery, and no physical damage.

TEST F
LOW-CURRENT, LONG-DURATION

OBJECT

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 10 kV rated equivalent thermal sections, with isolators were used for this test.
- Each sample was impulsed with a 5 kA (normal-duty) or 10 kA (heavy-duty and riser pole) crest, 8 x 20 µs wave and the discharge voltage measured.
- Each sample was impulsed using a 75 amp (normal-duty) or 250 amp (heavy-duty and 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 five 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 5 kA (normal-duty) or 10 kA (heavy-duty and 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 $\pm$10%.
- The samples were inspected after testing to assure that no physical damage occurred.

RESULTS

The arresters met the low-current, long-duration requirements of 20 impulses, thermal recovery, <10% change in discharge voltage, and no physical damage.

TEST G
DUTY CYCLE

OBJECT

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 5 kA (normal-duty) or 10 kA (heavy-duty and 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 5 kA (normal duty) or 10 kA (heavy-duty pole) 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 heavy-duty or riser pole 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.
- Each normal-duty sample was removed from the oven and immediately energized at (MCOV x K_W x K_C) impulsed twice more at a 5 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 5 kA (normal-duty) or 10 kA (heavy-duty or 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 arresters met the duty cycle test requirements of 22 impulses, thermal recovery, <10% change in discharge voltage, and no physical damage.

TEST H
INTERNAL IONIZATION AND RIV

OBJECT

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

All of the arresters had measured RIV and ionization voltages much lower than 10 µV which was in accordance with IEEE Std C62.11-2005™ standard, Para. 8.10.

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

TEST I
SHORT-CIRCUIT TEST
(DESIGN B)

OBJECT

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 normal-duty, heavy-duty and riser pole arresters with hanger bracket. Normal-duty samples were rated 36 kV and heavy-duty and riser pole arresters were rated 60 kV.
- The arresters were pre-failed by shunting the MOV disks using a fuse wire and 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 of 1 second and without ejecting any internal components in accordance with IEEE Std C62.11-2008™ standard, Amendment 1, Para. 8.24.

TEST J
DISCONNECTOR TEST

OBJECT

To verify that the 3/8” or 12 mm 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 performance of the arrester electrical tests did not cause any disconnectors to operate and the disconnector time-current curve was determined in accordance with IEEE Std C62.11-2005™ standard, Para. 8.21.

TEST K
CONTAMINATION TEST

OBJECT

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

- Normal-duty, heavy-duty and riser pole 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 passed the test by having stabilized lower watts loss over time, by not flashing over and by not having any internal physical damage in accordance with IEEE Std C62.11-2005™ standard, Para. 8.8.

TEST L
TEMPORARY OVERVOLTAGE (TOV)

OBJECT

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 5 kA (normal-duty) or 10 kA (heavy-duty and 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 5 kA (normal-duty) or 10 kA (heavy-duty and 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

Graph 1 and Chart 4 show the performance results.

TEST M
ACCELERATED AGING TESTS OF EXTERNAL POLYMERIC INSULATING SYSTEMS

OBJECT

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 5 kA (normal-duty) or 10 kA (heavy-duty and 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.
  - Deenergize sample and dip into 400-500 Ωcm slurry bath.
- After completion of the 1,000 hour energized test cycle the discharge voltage of the samples was measured using an 8 x 20 µs duration impulse with a 5 kA (normal-duty) or 10 kA (heavy-duty and riser pole) crest.
- With the arrester samples effectively shorted, the maximum system voltage was applied across the hanger bracket for 20 hours using the above described cycle.

RESULTS

The samples passed by not having any evidence of flashovers or surface tracking and the arrester discharge voltage did not change more than ± 10% from the initial value in accordance with IEEE Std C62.11-2005™ standard, Para. 8.6.

TEST N
SEAL INTEGRITY

OBJECT

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 met the test requirements in accordance with IEEE Std C62.11-2005™ standard, Para. 8.9.

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

OBJECT

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-tests consisting of Reference Voltage and Partial Discharge measurements. The Reference Voltage was measured at a peak resistive current of 3mA for normal-duty and 4mA for heavy-duty. Partial Discharge was measured at a test voltage of 1.05 x Uc.
- Sample was placed in the vertical position inside an enclosure with salt fog mist of 10kg/m³ salinity level and energized at Uc for duration of 1000 hours.
- Post-tests were conducted for Reference Voltage and Partial Discharge 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 sample tested successfully met the test requirements of IEEE Std C62.11-2005™ standard, Para. 8.7. There were no housing punctures or erosion of the housing, no internal breakdowns; no surface tracking was evidenced by physical examination. The arrester reference voltage did not decrease by more than 5% and the partial discharge level did not exceed 10pC.

TEST P
5000 HOURS WEATHER AGING TEST

OBJECT

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-tests consisting of Reference Voltage and Partial Discharge measurements. The Reference Voltage was measured at a peak resistive current of 3mA for normal-duty and 4mA for heavy-duty. Partial Discharge was measured at a test voltage of 1.05 x Uc.
- 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 conducted for Reference Voltage and Partial Discharge 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 IEEE Std C62.11-2005™ standard, Annex C. 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. The arrester reference voltage did not decrease by more than 5% and the partial discharge level did not exceed 10pC.

ADDENDUM

TEST Q
WATER IMMERSION TEST

OBJECTIVE

To demonstrate the resistance of a composite wrapped module to moisture ingress. This test was completed in accordance with standard IEC 60099-4, Ed 2 2004.

PROCEDURE

- One 36 kV 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 5kA, 8 x 20 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 52 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, 8 x 20 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 standard IEC 60099-4, Para 10.8.13 Ed 2 2004.

NOTE: Cooper Power Systems does not claim cantilever strength for the UltraSIL Polymer-Housed VariSTAR arresters certified to the IEEE Std C62.11 standard and is why data was omitted from the Certified Test Report for thermo mechanical preconditioning. A third party test report, which includes the thermo mechanical preconditioning, is available upon request.

Chart 1
Normal-Duty VariSTAR Arrester Discharge Voltages

Duty Cycle Voltage Rating (kV)	MCOV (kV)	Equivalent Front-of-Wave (kV)*	Maximum Discharge Voltage (kV crest) 8/20 µs Current Wave						Switching Surge (kV)**	
			1.5 kA	3 kA	5 kA	10 kA	20 kA	40 kA	125 A	500 A
3	2.55	11.0	9.0	9.7	10.4	11.4	13.0	15.1	7.9	8.5
6	5.1	22.0	18.0	19.4	20.8	22.7	26.0	30.2	15.7	16.9
9	7.65	31.7	26.0	28.0	30.0	32.8	37.4	43.5	22.7	24.4
10	8.4	33.0	27.0	29.1	31.2	34.1	38.9	45.3	23.6	25.4
12	10.2	41.5	33.9	36.6	39.2	42.9	48.9	56.9	29.6	31.9
15	12.7	51.8	42.4	45.7	49.0	53.6	61.1	71.1	37.0	39.9
18	15.3	62.2	50.9	54.9	58.8	64.3	73.4	85.3	44.4	47.9
21	17	66.0	54.0	58.2	62.4	68.2	77.9	90.6	47.2	50.8
24	19.5	77.0	63.0	67.9	72.8	79.6	90.8	106	55.0	59.3
27	22	87.2	71.4	76.9	82.4	90.1	103	120	62.3	67.1
30	24.4	97.1	79.5	85.7	91.8	100	115	133	69.4	74.7
33	27	108	87.8	95.1	102	112	127	148	77.1	83.1
36	29	116	95.3	103	110	120	137	160	83.1	89.6

* Based on a 5 kA current impulse that results in a discharge voltage cresting in 0.5 µs.
** Based on a 30/60 µs current impulse.

Chart 2
Heavy-Duty VariSTAR Arrester Discharge Voltages

Arrester Rating (kV rms)	MCOV (kV rms)	Front-of-Wave Protective Level* (kV crest)	Maximum Discharge Voltage (kV crest) 8/20 µs Current Wave						Switching Surge (kV)**	
			1.5 kA	3 kA	5 kA	10 kA	20 kA	40 kA	125 A	500 A
3	2.55	11.0	8.2	8.7	9.1	9.9	10.9	12.3	7.1	7.6
6	5.10	21.9	16.3	17.4	18.2	19.8	21.9	24.7	14.1	15.1
9	7.65	33.0	24.6	26.1	27.3	29.8	33.0	37.1	21.3	22.7
10	8.40	35.0	26.0	27.7	29.0	31.6	34.9	39.4	22.6	24.1
12	10.2	43.9	32.7	34.8	36.4	39.7	43.9	49.5	28.3	30.3
15	12.7	53.1	39.6	42.1	44.0	48.0	53.1	59.8	34.3	36.6
18	15.3	66.0	49.1	52.3	54.7	59.6	65.9	74.2	42.6	45.5
21	17.0	70.0	52.1	55.4	58.0	63.2	69.9	78.7	45.1	48.2
24	19.5	80.9	60.2	64.1	67.0	73.1	80.8	91.1	52.2	55.8
27	22.0	94.0	70.0	74.5	77.9	84.9	93.9	106	60.6	64.8
30	24.4	102	76.1	81.0	84.7	92.4	102	115	66.0	70.5
33	27.0	116	86.5	92.1	96.3	105	116	131	75.0	80.1
36	29.0	123	91.5	97.3	102	111	123	138	79.3	84.7
39	31.5	133	98.9	105	110	120	133	149	85.7	91.6
42	34.0	144	107	114	119	130	144	162	92.8	99.2
45	36.5	155	115	123	128	140	155	174	100	107
48	39.0	166	124	132	138	150	166	187	107	114
54	42.0	182	135	144	150	164	181	204	117	125
60	48.0	201	150	160	167	182	201	227	130	139

* Based on a 10 kA current impulse that results in a discharge voltage creating in 0.5 µs.
** Based on a 30/60 µs current impulse.

Chart 3
Riser Pole VariSTAR Arrester Discharge Voltages

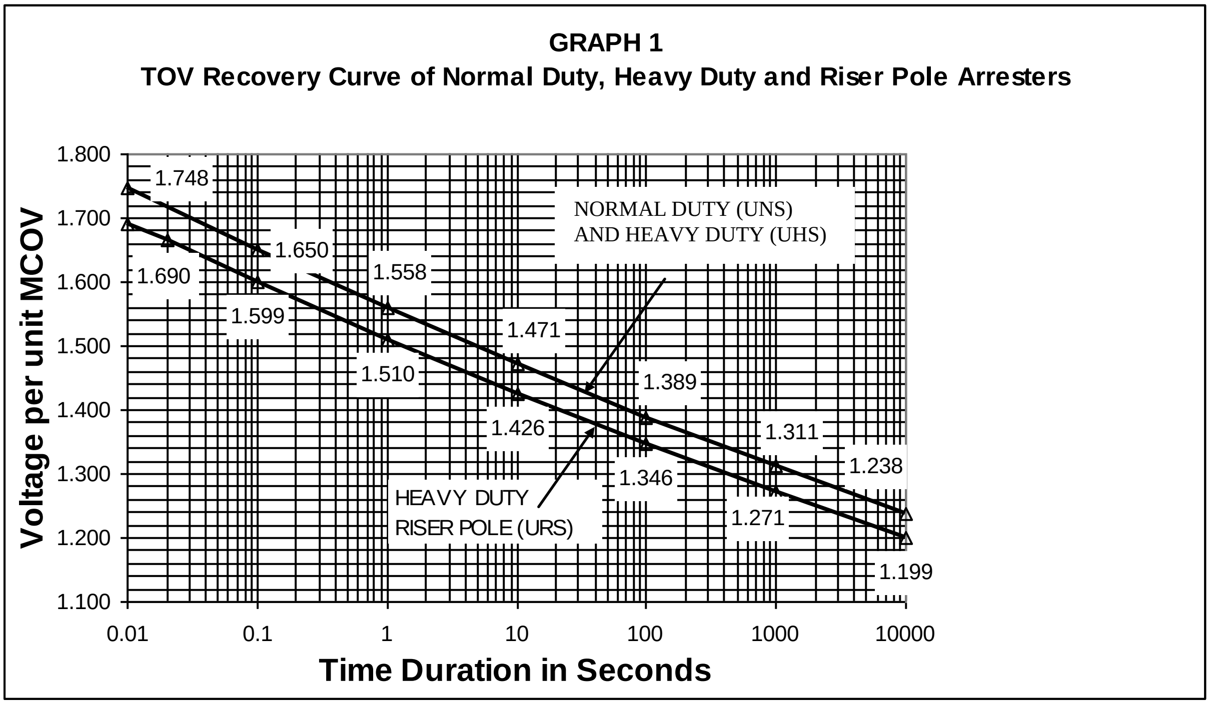
Duty Cycle Voltage Rating (kV)	MCOV (kV rms)	Equivalent Front-of-Wave* (kV)	Maximum Discharge Voltage (kV crest) 8/20 µs Current Wave						30/60 Switch Surge (kV)**	
			1.5 kA	3 kA	5 kA	10 kA	20 kA	40 kA	125 A	500 A
3	2.55	10.3	7.7	8.2	8.6	9.4	10.3	11.7	6.7	7.1
6	5.1	20.7	15.5	16.4	17.2	18.7	20.7	23.3	13.3	14.3
9	7.65	29.8	22.3	23.7	24.7	27.0	29.8	33.6	19.2	20.6
10	8.4	31.0	23.2	24.6	25.7	28.1	31.0	35.0	20.0	21.4
12	10.2	39.1	29.2	31.1	32.4	35.4	39.1	44.1	25.2	27.0
15	12.7	48.7	36.4	38.7	40.4	44.1	48.8	54.9	31.4	33.6
18	15.3	58.4	43.7	46.4	48.5	52.9	58.5	65.9	37.7	40.4
21	17	62.0	46.4	49.3	51.5	56.2	62.1	70.0	40.0	42.8
24	19.5	72.3	54.1	57.5	60.0	65.5	72.4	81.6	46.7	50.0
27	22	81.4	60.9	64.7	67.6	73.8	81.6	91.9	52.6	56.3
30	24.4	91.0	68.1	72.4	75.6	82.5	91.2	103	58.8	62.9
33	27	100	75.0	79.7	83.3	90.9	100	113	64.7	69.3
36	29	108	80.6	85.6	89.4	97.6	108	122	69.5	74.4

* Based on a 10 kA current impulse that results in a discharge voltage cresting in 0.5 µs.

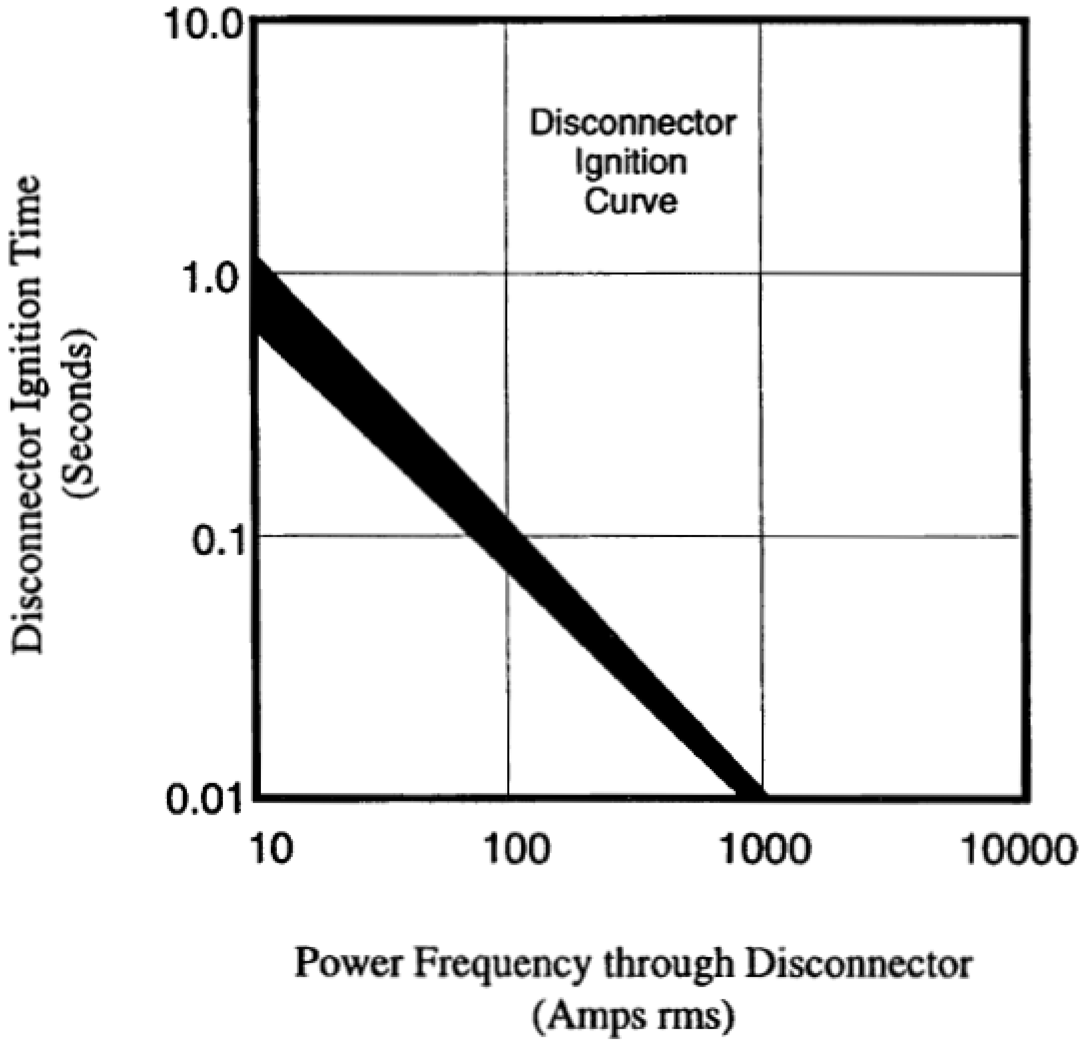
** Based on a 30/60 µs current impulse.

Chart 4
TOV Recovery Capability of the VariSTAR Arresters

Without Hanger	Per Unit of MCOV	
Time, Seconds	**Normal-Duty & Heavy-Duty**	**Riser Pole**
0.01	1.748	1.690
0.02	1.720	1.665
0.1	1.650	1.599
1	1.558	1.510
10	1.471	1.426
100	1.389	1.346
1000	1.311	1.271
10000	1.238	1.199



Graph 2
Distribution Arrester Disconnector Time-Current Characteristic Plot



REVISION TABLE

REVISION No.	DATE	WHAT WAS ADDED/CHANGED
0	April, 1996	Originated
1	December, 1996	
2	September, 2006	
3	August, 2008	Minor editorial changes
4	January, 2009	Updated Test “A”, Procedure and Results sections Updated Test “B”, Results section Updated Test “F”, Procedure section Updated Test “I”, Object, Procedure and Results sections Updated Test “O”, Procedure section Added Addendum, Test Q Corrected Chart 3
5	April, 2009	Corrected Test “F”, Results section Miscellaneous Clerical corrections
6	September, 2012	Updated Test “J”, Object section Updated Test “A”, Procedure section

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