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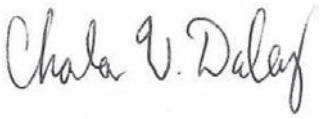
COOPER POWER SERIES

UltraSIL™ Polymer-Housed VariSTAR™ Type US, UH, and UX Station-Class Surge Arresters Certified Test Report

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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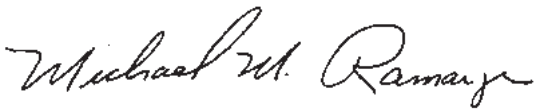

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Introduction

This test report certifies that the UltraSIL Polymer-Housed VariSTAR Type US, UH, and UX Station-Class Surge Arresters were successfully tested to IEEE Std C62.11™-2005 standard, *IEEE Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits*. The Pressure Relief Test was performed in accordance with IEEE Std C62.11a™-2008 standard.

Test Program

Object

To demonstrate that the UltraSIL Polymer-Housed VariSTAR Type US, UH, and UX Station-Class Surge Arresters meet all performance requirements.

Procedure

The design tests listed in Table 1 were performed on a sufficient number of samples to demonstrate that all performance requirements are met.

Results

UltraSIL Polymer-Housed VariSTAR Type US, UH, and UX Station-Class Surge Arresters met all performance requirements.

Table 1. Design Tests

Designation	Description	Per IEEE Std
Test A	Insulation Withstand	C62.11™-2005 standard, Section 8.1.2.4
Test B	Discharge Voltage Current Characteristics	C62.11™-2005 standard, Section 8.3.1
Test C	Discharge Voltage Time Characteristics	C62.11™-2005 standard, Section 8.4
Test D	Accelerated Aging Procedure	C62.11™-2005 standard, Section 8.5
Test E	High-current, Short-duration	C62.11™-2005 standard, Section 8.12
Test F	Transmission-line Discharge Test	C62.11™-2005 standard, Section 8.13.1
Test G	Duty Cycle	C62.11™-2005 standard, Section 8.14
Test H	Short Circuit Test (Design B)	C62.11a™-2008 standard, Section 8.21
Test I	Contamination Test	C62.11™-2005 standard, Section 8.8
Test J	Temporary Overvoltage (TOV)	C62.11™-2005 standard, Section 8.15
Test K	Accelerated Aging by Exposure to Salt Fog	C62.11™-2005 standard, Section 8.7
Test L	Maximum Design Cantilever Test for Polymer-Housed Arresters	C62.11™-2005 standard, Section 8.22
Test M	Moisture Ingress Test for Polymer-Housed Arresters	C62.11™-2005 standard, Section 8.22
Test N	Partial Discharge (PD) Test	C62.11™-2005 standard, Section 8.11

Test A: Insulation Withstand

Object

To verify that the assembled insulating members of the VariSTAR Type US, UH, and UX Station-Class Surge Arresters withstand impulse and power frequency voltage tests in accordance with IEEE Std C62.11™-2005 standard.

Procedure

Arresters rated 3-48 kV:

- New, clean arresters of each rating, with internal parts rendered inoperative, were subjected to positive and negative 1.2 x 50 µs voltage impulses which exceeded the minimum values in Table 4 of IEEE Std C62.11™-2005 standard.
- These samples were also subjected to both wet and dry 60 Hertz withstand voltages which exceeded the minimum values in Table 4 of IEEE Std C62.11™-2005 standard.

Arresters rated ≥ 54 kV:

- For each arrester rating the maximum 8 x 20, 20 kA discharge voltage was determined. This value was multiplied by a factor of 1.42. This calculated value established the minimum 1.2 x 50 µs impulse withstand level.
- New, clean arrester samples of each rating, with internal parts removed, were subjected to positive and negative 1.2 x 50 µs voltage impulses which exceeded the minimum withstand levels as calculated above.
- For each arrester rating, the maximum switching impulse discharge voltage was determined. This value was multiplied by a factor of 0.82. This calculated value established the minimum 10 second, wet 60 Hz withstand voltage in rms volts for each arrester.
- Arrester samples of each rating having the internal parts removed, were wetted and subjected to 10 seconds of 60 Hz rms voltages exceeding the minimum withstand voltages as calculated above.

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. Table 2 shows the insulation withstand voltages for VariSTAR Type US, UH, and UX Station-Class Surge Arresters.

Test B: Discharge Voltage Current Characteristics

Object

To determine the maximum discharge voltage characteristics of the VariSTAR Type US, UH, and UX Station-Class Surge Arresters at 1.5, 3, 5, 10, 20 and 40 kA crest in accordance with IEEE Std C62.11™-2005 standard.

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

Table 3, Table 4, and Table 5 show the maximum 8 x 20 discharge voltages for the VariSTAR Type US, UH, and UX Station-Class Surge Arresters, respectively.

Test C: Discharge Voltage Time Characteristics

Object

To obtain the front-of-wave and switching impulse protective levels of the VariSTAR Type US, UH, and UX Station-Class Surge Arresters in accordance with IEEE Std C62.11™-2005 standard.

Procedure

Front-of-Wave Protective Level:

- A current of 10 kA was used to determine the 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.

Switching Impulse Protective Level:

- Currents of 500 and 1000 Amperes crest were used to determine the switching impulse protective level.
- The arresters were impulsed with switching impulse current waves having a time to actual crest of 45 to 60 µs.
- The discharge voltage crest was measured.

Results

Table 3, Table 4, and Table 5 show the front-of-wave and switching impulse protective levels for the VariSTAR Type US, UH, and UX Station-Class Surge Arresters, respectively.

Test D: Accelerated Aging Procedure

Object

To verify the K_C and K_R ratios of the VariSTAR Type US, UH, and UX Station-Class Surge Arresters in accordance with IEEE Std C62.11™-2005 standard.

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

- Samples 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 re-measured at 1,000 hours at MCOV and duty cycle voltage levels.

- $K_C = \dfrac{\text{Watts Loss @ 1,000 Hrs @ MCOV}}{\text{Watts Loss @ 2-5 Hrs @ MCOV}}$
- $K_R = \dfrac{\text{Watts Loss @ 1,000 Hrs @ Rated Voltage}}{\text{Watts Loss @ 2-5 Hrs @ Rated Voltage}}$

If the maximum power ratio is ≤ 1, then K_C and K_R are equal to 1.

Results

K_C and K_R = 1.

Test E: High-current, Short-duration

Object

To demonstrate that the VariSTAR Type US, UH, and UX Station-Class Surge Arresters meet the high-current, short-duration requirements in accordance with IEEE Std C62.11™-2005 standard.

$K_W = V_{WI}/V_{WN}$

Procedure

- Three prorated equivalent thermal sections were used for this test.
- Each sample was impulsed with a 100 kA crest current with a wave shape of 4 x 10 µs. This exceeded the required crest current of 65 kA.
- The samples were allowed to cool to ambient temperature.
- Each sample was impulsed a second time.
- Immediately following the second impulse, the samples were energized at the thermal recovery voltage per IEEE Std C62.11™-2005 standard (MCOV x K_W x K_C) for 30 minutes to verify thermal recovery.
- The samples were inspected after testing to verify that there was no physical damage.
- $K_W = V_{WI}/V_{WN}$

Results

VariSTAR Type US, UH, and UX Station-Class Surge Arresters met the high-current, short-duration requirements of two impulses, thermal recovery, and no physical damage.

Test F: Transmission-line Discharge Test

Object

To demonstrate that the VariSTAR Type US, UH, and UX Station-Class Surge Arresters meet the transmission-line discharge test in accordance with IEEE Std C62.11™-2005 standard.

Procedure

- Three prorated equivalent thermal sections were used for this test.
- Each sample was impulsed with a 10 kA crest, 8 x 20 µs wave and the discharge voltage was measured.
- Each sample was subjected to three groups of six consecutive Transmission-Line Discharge (TLD) operations timed to occur 50 to 60 seconds apart. The TLD operations were as defined in IEEE Std C62.11™-2005 standard.
- The samples were permitted to cool after each group of six impulses.
- After the 18th impulse the samples were heated to 60 degrees centigrade and allowed to thermally stabilize.
- Within two minutes upon removal from the oven, two additional TLD impulses were applied 50 to 60 seconds apart.
- Within one minute the appropriate 60 Hz voltage was applied and the watts loss was monitored for a minimum of 30 minutes to verify thermal recovery.
- Each sample was subjected to a final 10 kA crest, 8 x 20 µs impulse 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

VariSTAR Type US, UH, and UX Station-Class Surge Arresters met the Transmission-Line Discharge test requirements of 20 impulses, <10% change in discharge voltage, and no physical damage.

Test G: Duty Cycle

Object

To demonstrate that the VariSTAR Type US, UH, and UX Station-Class Surge Arresters meet the duty cycle requirements in accordance with IEEE Std C62.11™-2005 standard.

Procedure

- Three prorated equivalent thermal sections were used for this test.
- Each sample was impulsed with 10 kA 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 10 kA crest surges of 8 x 20 µs wave shape.
- Each 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 K_C times the MCOV (K_C = 1) and impulsed twice more with a 10 kA crest, 8/20 µs wave within one minute.
- Samples remained energized at the thermal recovery voltage per IEEE Std C62.11™-2005 standard (MCOV x K_W x K_C) for 30 minutes minimum to verify thermal recovery.
- Each sample was then impulsed with a 10 kA 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

VariSTAR Type US, UH, and UX Station-Class Surge Arresters met the duty cycle test requirements of 22 impulses, thermal recovery, <10% change in discharge voltage, and no physical damage.

Test H: Short Circuit Test (Design B)

Object

To verify that the pressure-relief capability of VariSTAR Type US, UH, and UX Station-Class Surge Arresters meet the requirements in accordance with IEEE Std C62.11a™-2008 standard.

Procedure

- 60-kV rated samples were used in the testing for the US design and 72-kV rated samples were used for the UH and UX designs, which represent the highest voltage rating in a single unit housing.
- The arrester samples were mounted to simulate service conditions as specified by IEEE Std C62.11a™-2008 standard.

High-Current Pressure-Relief Testing:

- Samples were pre-failed by power frequency overvoltage.
- The test circuit was adjusted to produce a 60 Hz, 63 kA (rms) current for a minimum of 0.2 seconds.
- The above noted current was initiated within 5° of the applied 60 Hz voltage zero.
- The arresters were monitored to assure venting occurred without violent shattering.

Low-Current Pressure-Relief Testing:

- Samples were pre-failed by power frequency overvoltage.
- The test circuit was adjusted to produce a 60 Hz current of 600 A determined by the average for the duration of the current flow.
- The current duration lasted until the arrester vented up to a maximum of 1 second or until venting occurs.

Results

VariSTAR Type US, UH, and UX Station-Class Surge Arresters passed the described high and low-current pressure-relief tests based on oscillograph recordings showing test current magnitude and duration, from the evidence of the time at which the venting occurred, and from the confinement of all components of the arrester within the specified enclosures.

Test I: Contamination Test

Object

To demonstrate the ability of the VariSTAR Type US, UH, and UX Station-Class Surge Arresters to withstand the electrical stresses caused by contamination on the housing, in accordance with IEEE Std C62.11™-2005 standard.

Procedure

- 240 kV samples were used in this test.
- 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 10 minutes, a 400-500 Ωm slurry was applied to the lower half of the arrester housing heavily enough to form drops on the skirts.
- The samples were energized within 3 minutes of contamination at MCOV.
- 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

VariSTAR Type US, UH, and UX Station-Class Surge 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.

Test J: Temporary Overvoltage (TOV)

Object

To verify what levels of 60 cycle temporary overvoltage the VariSTAR Type US, UH, and UX Station-Class Surge Arresters survive in accordance with IEEE Std C62.11™-2005 standard.

Procedure

- Prorated equivalent thermal sections were used for this test.
- Each sample was impulsed with a 10 kA 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 TOV was applied for all five samples at the time ranges specified.
- Within 1 second, each sample was energized at the thermal recovery voltage per IEEE Std C62.11™-2005 standard (MCOV x K_W x K_C) for 30 minutes. Sample current and temperature were monitored for thermal runaway.
- Each sample was impulsed with a 10 kA 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.
- The above test procedures were repeated with "prior duty" energy applied to the arrester before the TOV is applied.
- The "prior duty" energy applied to the arrester before the TOV was the energy generated in two transmission line discharges.
- The "prior duty" energy applied to Type US (3-108 kV) arresters was 3.9 kJ/kV of MCOV and 6.2 kJ/kV of MCOV for 120-240 kV Type US arresters. For Type UH (3-108 kV) arresters, the energy was 6.2 kJ/kV of MCOV and 10 kJ/kV of MCOV for 120-240 kV Type UH arresters. For Type UX arresters, the energy was 10 kJ/kV of MCOV.

Results

Graph 1 and Table 6 show the performance results

Test K: Accelerated Aging by Exposure to Salt Fog

Object

The purpose of this test is to demonstrate the ability of the VariSTAR Type US, UH, and UX Station-Class Surge Arresters to withstand electrical stresses on the arrester housing caused by exposure to salt fog, in accordance with IEEE Std C62.11™-2005 standard.

Procedure

- Complete 72 kV Samples were used for this test.
- The Reference Voltage at specified Reference Current and Partial Discharge at 1.05 x MCOV were recorded.
- Samples were mounted vertically in a moisture-sealed corrosion-proof chamber.
- The fog should continually fill the chamber.
- The samples were energized at MCOV for time duration of 1,000 hours.
- The samples were inspected after testing to assure no physical damage occurred.
- The Reference Voltage at specified Reference Current and Partial Discharge at 1.05 x MCOV were recorded.

Results

VariSTAR Type US, UH, and UX Station-Class Surge Arresters met the Accelerated Aging by Exposure to Salt Fog requirements of no tracking occurring, erosion did not penetrate through housing material, sheds and housing were not punctured, reference voltage did not decrease by more than 5% from initial measurements, and partial discharge did not exceed 10pc before and after testing.

Test L: Maximum Design Cantilever Test for Polymer-Housed Arresters

Object

To evaluate the Maximum Design Cantilever Load (MDCL-Static) specified by the manufacturer for polymer-housed arresters in accordance with IEEE Std C62.11™-2005 standard.

Procedure

- The sample consisted of the longest mechanical unit of the design family consisting of an end casting and top terminal assembly.
- Power loss at 80-100% MCOV (noting ambient temperature) and Nominal Discharge Current at 1.5 kA measurements are recorded.
- Terminal torque levels of 100 ft-lbs were applied to samples using 20-mm top studs and 150 ft-lbs for samples using 1.0" top studs for time durations of 30s.
- Thermomechanical Preconditioning:
  - The sample is subject to the Maximum Design Cantilever Load with variations in load direction and temperature according to IEEE Std C62.11™-2005 standard, Figure 4.
  - Maximum Design Cantilever Load is 6,000 in-lbs for Type US (3-108 kV); 8,000 in-lbs for Type UH (3-108 kV) and US (120-240 kV); 14,000 in-lbs for Type UX (3-108 kV) and UH (120-240 kV) arresters.
  - Each temperature shall be maintained for a minimum of 16 hours and no longer than 24 hours.

    The sample is subject to:
    - 0° load direction at 60 ° ±3 °C
    - 180° load direction at -25 ° ±3 °C
    - 270° load direction at 45 ° ±3 °C
    - 90° load direction at -40 ° ±3 °C

    The deflection at each direction shall be noted.
  - The sample is then subjected to loads at each direction in ambient temperature for a period of 24 hrs per direction. The deflection at each direction shall be noted.
- Power loss at 80-100% MCOV (noting ambient temperature) and Nominal Discharge Current at 1.5 kA measurements are recorded.

Results

VariSTAR Type US, UH, and UX Station-Class Surge Arresters met Maximum Design Cantilever test requirements of the power loss and did not increase by more than 20% from the initial measurement. The residual voltage at 1.5 kA did not deviate more than 5% from the initial measurement. The oscillograms did not reveal any voltage or current breakdown, and partial discharge at 1.05 x MCOV did not exceed 10pC.

Test M: Moisture Ingress Test for Polymer-Housed Arresters

Object

To evaluate the mechanical load specified by the manufacturer and the seal for polymer-housed arresters in accordance with IEEE Std C62.11™-2005 standard.

Procedure

- Three Complete 72 kV samples were used in this test, one of each type.
- Power loss at 80-100% MCOV (noting ambient temperature) and Nominal Discharge Current at 1.5 kA measurements are recorded.
- Terminal torque levels of 100 ft-lbs were applied to samples using 20-mm top studs and 150 ft-lbs for samples using 1.0" top studs for time durations of 30s.
- Thermomechanical Preconditioning.
  - The sample is subject to the Maximum Design Cantilever Load with variations in load direction and temperature per IEEE Std C62.11™-2005 standard, Figure 4.
  - Maximum Design Cantilever Load is 6,000 in-lbs for Type US (3-108 kV); 8,000 in-lbs for Type UH (3-108 kV) and US (120-240 kV); 14,000 in-lbs for Type UX (3-108 kV) and UH (120-240 kV) arresters.
  - Each temperature shall be maintained for a minimum of 16 hours and no longer than 24 hours.

    The sample is subject to:
    - 0° load direction at 60° ±3 °C
    - 180° load direction at -25° ±3 °C
    - 270° load direction at 45° ±3 °C
    - 90° load direction at -40° ±3 °C

    The deflection at each direction was noted.
  - The sample is then subjected to loads at each direction in ambient temperature for a period of 24 hrs per direction. The deflection at each direction shall be noted.
- The arrester shall be immersed in boiling water (100 °C) with 1 kg/m^3 of NaCl for 42 hours OR the arrester shall be immersed in water at a minimum temperature of 80 °C for a period of 168 hours (1 week).
- Power loss at 80-100% MCOV (noting ambient temperature) and Nominal Discharge Current at 1.5 kA measurements are recorded.

Evaluation

VariSTAR Type US, UH, and UX Station-Class Surge Arresters met Moisture Ingress test requirements of the power loss did not increase by more than 20% from the initial measurement. The residual voltage at 1.5 kA did not deviate more than 5% from the initial measurement. The oscillograms did not reveal any voltage or current breakdown, and partial discharge at 1.05 x MCOV did not exceed 10pC.

Test N: Partial Discharge (PD) Test

Object

The purpose of this test is to verify that the VariSTAR Type US, UH, and UX Station-Class Surge Arresters do not generate unacceptable levels of partial discharge according to IEEE Std C62.11™-2005 standard.

Procedure

- The samples were 240 kV arresters, one of each type.
- The corrected Rated and MCOV voltages were calculated based on the correction factor of $V_{ref\ measured}/V_{ref\ minimum}$.
- The voltage was raised to rated voltage for 2 seconds, then lowered to 1.05 x corrected MCOV.
- The partial discharge was measured at this level voltage.

Evaluation

VariSTAR Type US, UH, and UX Station-Class Surge Arresters met Partial Discharge test requirements. Partial discharge at 1.05 x corrected MCOV did not exceed 10pC.

Table 2. Insulation Withstand Voltages - VariSTAR Type US, UH, and UX Station-Class Surge Arresters with Standard Creep Housings

Arrester Rating (kV, rms)	Arrester MCOV (kV, rms)	Creepage Distance (inches)			Insulation Withstand Voltages											
					1.2/50 Impulse (kV, Crest)			Switching Surge Impulse (kV, Crest)			60 Hz, dry 60 Seconds (kV, rms)			60 Hz, wet 10 Seconds (kV, rms)		
		US	UH	UX	US	UH	UX	US	UH	UX	US	UH	UX	US	UH	UX
3	2.55	30.7	30.7	30.7	115	119	126	N/A	N/A	N/A	80	77	82	64	63	60
6	5.1	38.4	38.4	38.4	134	137	138	N/A	N/A	N/A	94	90	90	75	75	71
9	7.65	38.4	38.4	38.4	134	137	138	N/A	N/A	N/A	94	90	90	75	75	71
10	8.4	38.4	38.4	38.4	134	137	138	N/A	N/A	N/A	94	90	90	75	75	71
12	10.2	46.1	46.1	46.1	155	158	159	N/A	N/A	N/A	109	104	104	88	88	84
15	12.7	46.1	46.1	46.1	155	158	159	N/A	N/A	N/A	109	104	104	88	88	84
18	15.3	53.7	53.7	53.7	176	178	179	N/A	N/A	N/A	123	118	117	101	101	97
21	17.0	53.7	53.7	53.7	176	178	179	N/A	N/A	N/A	123	118	117	101	101	97
24	19.5	61.4	61.4	61.4	201	201	206	N/A	N/A	N/A	140	140	135	113	113	116
27	22.0	61.4	61.4	61.4	201	201	206	N/A	N/A	N/A	140	140	135	113	113	116
30	24.4	69.1	69.1	69.1	217	218	220	N/A	N/A	N/A	151	146	144	126	128	123
33	27.5	69.1	69.1	69.1	217	218	220	N/A	N/A	N/A	151	146	144	126	128	123
36	29.0	69.1	69.1	69.1	217	218	220	N/A	N/A	N/A	151	146	144	126	128	123
39	31.5	84.4	84.4	84.4	252	258	262	N/A	N/A	N/A	172	166	168	152	156	154
42	34.0	84.4	84.4	84.4	252	258	262	N/A	N/A	N/A	172	166	168	152	156	154
45	36.5	92.1	92.1	92.1	275	279	281	N/A	N/A	N/A	188	188	184	162	167	162
48	39.0	99.8	99.8	99.8	294	298	300	N/A	N/A	N/A	201	201	202	173	186	176
54	42.0	99.8	99.8	99.8	294	298	300	N/A	N/A	N/A	201	201	202	173	186	176
60	48.0	107.5	107.5	107.5	316	319	321	N/A	N/A	N/A	212	215	211	187	192	188
66	53.0	138.2	115.2	115.2	434	340	342	N/A	N/A	N/A	302	230	224	252	206	201
72	57.0	138.2	122.8	122.8	434	361	364	N/A	N/A	N/A	302	246	237	252	213	210
78	62.0	153.5	153.5	153.5	469	476	482	N/A	N/A	N/A	323	312	312	278	284	277
84	68.0	168.9	168.9	168.9	504	516	524	N/A	N/A	N/A	344	332	336	304	312	308
90	72.0	176.6	176.6	176.6	527	537	543	N/A	N/A	N/A	360	354	352	314	323	316
96	76.0	184.3	184.3	184.3	550	558	562	N/A	N/A	N/A	376	376	368	324	334	324
108	84.0	199.6	199.6	199.6	588	596	600	N/A	N/A	N/A	402	402	404	346	372	352
120	98.0	215	215	-	638	642	-	N/A	N/A	-	430	422	-	384	376	-
132	106	230.3	230.3	-	680	684	-	N/A	N/A	-	460	448	-	412	402	-
138	111	245.7	245.7	-	722	728	-	N/A	N/A	-	492	474	-	426	420	-
144	115	245.7	245.7	-	722	728	-	N/A	N/A	-	492	474	-	426	420	-
162	130	307.1	307.1	-	915	921	-	N/A	N/A	-	617	615	-	564	540	-
168	131	314.8	314.8	-	936	942	-	N/A	N/A	-	631	624	-	570	552	-
172	140	322.4	322.4	-	957	963	-	N/A	N/A	-	646	637	-	584	565	-
180	144	330.1	330.1	-	978	985	-	972	1029	-	662	650	-	591	574	-
192	152	337.8	337.8	-	999	1006	-	994	1052	-	677	663	-	605	587	-
198	160	353.2	353.2	-	1041	1049	-	1040	1083	-	707	685	-	618	608	-
204	165	360.8	360.8	-	1062	1070	-	1062	1106	-	722	698	-	632	621	-
216	174	406.9	406.9	-	1213	1221	-	1197	1296	-	818	817	-	750	716	-
228	180	422.2	422.2	-	1255	1263	-	1247	1320	-	846	835	-	762	740	-
240	190	429.9	429.9	-	1276	1284	-	1272	1332	-	860	844	-	768	752	-

Table 3. Protective Characteristics of the UltraSIL Polymer-Housing Station-Class Arrester Type US

Arrester Rating (kV, rms)	Arrester MCOV (kV, rms)	TOV[a]		Front-of-Wave Protective Level[b] (kV Crest)	Maximum Discharge Voltage (kV Crest)[c] 8/20 µs Current Wave						Switching Surge Protective Level[d] (kV Crest)			
		1 Sec	10 Sec		1.5kA	3kA	5kA	10kA	20kA	40kA	125A	250A	500A	1000A
3	2.55	3.5	3.3	8.8	6.8	7.2	7.6	8.3	9.1	10.4	5.9	6.1	6.3	6.6
6	5.1	6.9	6.6	17.5	13.6	14.4	15.2	16.6	18.2	20.7	11.8	12.1	12.5	13.1
9	7.65	10.4	9.9	26.2	20.4	21.6	22.7	24.9	27.3	31.1	17.7	18.1	18.8	19.6
10	8.4	11.4	10.8	28.8	22.4	23.7	24.9	27.3	29.9	34.1	19.4	19.9	20.6	21.5
12	10.2	13.9	13.1	34.9	27.2	28.8	30.3	33.1	36.3	41.4	23.5	24.1	25	26.1
15	12.7	17.2	16.4	43.5	33.8	35.8	37.7	41.3	45.2	51.5	29.3	30.1	31.1	32.5
18	15.3	20.8	19.7	52.4	40.8	43.1	45.4	49.7	54.5	62.1	35.3	36.2	37.5	39.1
21	17.0	23.1	21.9	58.2	45.3	47.9	50.4	55.2	60.5	69	39.2	40.2	41.6	43.5
24	19.5	26.5	25.1	66.7	51.9	55	57.8	63.3	69.4	79.1	44.9	46.1	47.8	49.8
27	22.0	29.9	28.4	75.3	58.6	62	65.2	71.4	78.3	89.2	50.7	52	53.9	56.2
30	24.4	33.1	31.5	83.5	65	68.8	72.3	79.2	86.8	98.9	56.2	57.7	59.8	62.4
33	27.5	37.3	35.4	94.1	73.2	77.5	81.5	89.3	97.9	112	63.3	65	67.3	70.3
36	29.0	39.4	37.4	99.2	77.2	81.7	86	94.2	104	118	66.8	68.6	71	74.1
39	31.5	42.8	40.6	108	83.9	88.8	93.4	103	113	128	72.5	74.5	77.1	80.5
42	34.0	46.2	43.8	117	90.5	95.8	101	111	121	138	78.3	80.4	83.2	86.9
45	36.5	49.6	47.0	125	97.2	103	109	119	130	148	84	86.3	89.4	93.3
48	39.0	53.0	50.3	134	104	110	116	127	139	159	89.8	92.2	95.5	99.6
54	42.0	57.0	54.1	144	112	119	125	137	150	171	96.7	99.3	103	108
60	48.0	65.2	61.9	165	128	136	143	156	171	195	111	114	118	123
66	53.0	72.0	68.3	182	142	150	158	172	189	215	122	126	130	136
72	57.0	77.4	73.5	195	152	161	169	185	203	232	132	135	140	146
78	62.0	84.2	79.9	213	165	175	184	202	221	252	143	147	152	159
84	68.0	92.3	87.7	233	181	192	202	221	242	276	157	161	167	174
90	72.0	97.8	92.8	247	192	203	214	234	257	292	166	171	177	184
96	76.0	103.2	98.0	260	203	215	226	247	271	309	175	180	186	195
108	84.0	114.1	108.3	288	224	237	249	273	299	341	194	199	206	215
120	98.0	133.1	126.3	314	250	263	275	298	323	361	219	225	232	241
132	106	143.9	136.6	339	270	285	298	323	349	390	237	243	251	261
138	111	150.7	143.1	355	283	298	312	338	366	408	248	255	263	273
144	115	156.2	148.2	368	293	309	323	350	379	423	257	264	272	283
162	130	176.5	167.6	416	331	349	365	396	429	478	291	298	308	319
168	131	177.9	168.9	419	334	352	368	399	432	482	293	300	310	322
172	140	190.1	180.5	448	357	376	393	426	461	515	313	321	331	344
180	144	195.6	185.6	461	367	387	404	438	475	530	322	330	341	354
192	152	206.4	195.9	486	387	408	427	463	501	559	340	348	360	373
198	160	217.3	206.2	512	408	430	449	487	527	589	358	367	378	393
204	165	224.1	212.7	528	420	443	463	502	544	607	369	378	390	405
216	174	236.3	224.3	556	443	467	488	529	573	640	389	399	412	427
228	180	244.4	232.0	582	464	488	511	554	600	669	407	417	430	447
240	190	258.0	244.9	608	484	510	533	578	626	699	424	435	449	467

Notes

a: Temporary Overvoltage with Prior Duty.

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

c: Contact manufacturer for alternate electrical builds.

d: 45-60 µs rise time for a 500 A peak current surge.

Table 4. Protective Characteristics of the UltraSIL Polymer-Housing Station-Class Arrester Type UH

Arrester Rating (kV, rms)	Arrester MCOV (kV, rms)	TOV[a]		Front-of-Wave Protective Level[b] (kV Crest)	Maximum Discharge Voltage (kV Crest)[c] 8/20 µs Current Wave						Switching Surge Protective Level[d] (kV Crest)			
		1 Sec	10 Sec		1.5kA	3kA	5kA	10kA	20kA	40kA	125A	250A	500A	1000A
3	2.55	3.5	3.3	8.2	6.5	6.9	7.2	7.8	8.4	9.4	5.7	5.9	6.1	6.3
6	5.1	6.9	6.6	16.3	13	13.7	14.3	15.6	16.8	18.8	11.4	11.7	12.1	12.6
9	7.65	10.4	9.9	24.5	19.5	20.6	21.5	23.3	25.2	28.2	17.1	17.6	18.1	18.8
10	8.4	11.4	10.8	26.9	21.4	22.6	23.6	25.6	27.7	30.9	18.8	19.3	19.9	20.7
12	10.2	13.9	13.1	32.6	26	27.4	28.6	31.1	33.6	37.5	22.8	23.4	24.1	25.1
15	12.7	17.2	16.4	40.6	32.4	34.1	35.6	38.7	41.9	46.7	28.4	29.1	30	31.2
18	15.3	20.8	19.7	48.9	39	41.1	42.9	46.6	50.4	56.3	34.2	35.1	36.2	37.6
21	17.0	23.1	21.9	54.4	43.3	45.6	47.7	51.7	56	62.5	38	39	40.2	41.8
24	19.5	26.5	25.1	62.4	49.7	52.3	54.7	59.3	64.2	71.7	43.6	44.7	46.1	47.9
27	22.0	29.9	28.4	70.3	56	59	61.7	66.9	72.5	80.9	49.1	50.4	52	54
30	24.4	33.1	31.5	78	62.1	65.5	68.4	74.2	80.4	89.7	54.5	55.9	57.7	59.9
33	27.5	37.3	35.4	87.9	70	73.8	77.1	83.6	90.6	102	61.4	63	65	67.5
36	29.0	39.4	37.4	92.7	73.8	77.8	81.3	88.2	95.5	107	64.8	66.4	68.6	71.2
39	31.5	42.8	40.6	101	80.2	84.5	88.3	95.8	104	116	70.3	72.2	74.5	77.3
42	34.0	46.2	43.8	109	86.6	91.2	95.3	104	112	125	75.9	77.9	80.4	83.5
45	36.5	49.6	47.0	117	92.9	97.9	103	111	121	135	81.5	83.6	86.3	89.6
48	39.0	53.0	50.3	125	99.3	105	110	119	129	144	87.1	89.3	92.2	95.7
54	42.0	57.0	54.1	135	107	113	118	128	139	155	93.8	96.2	99.3	104
60	48.0	65.2	61.9	154	123	129	135	146	159	177	108	110	114	118
66	53.0	72.0	68.3	170	135	143	149	162	175	195	119	122	126	131
72	57.0	77.4	73.5	183	146	153	160	174	188	210	128	131	135	140
78	62.0	84.2	79.9	199	158	167	174	189	205	228	139	142	147	153
84	68.0	92.3	87.7	218	174	183	191	207	224	250	152	156	161	167
90	72.0	97.8	92.8	231	184	194	202	219	238	265	161	165	171	177
96	76.0	103.2	98.0	243	194	204	214	232	251	280	170	174	180	187
108	84.0	114.1	108.3	269	214	226	236	256	277	309	188	193	199	207
120	98.0	133.1	126.3	297	242	253	263	284	303	334	214	219	226	234
132	106	143.9	136.6	321	262	274	285	307	328	361	232	237	244	253
138	111	150.7	143.1	336	274	287	298	321	343	378	243	248	256	265
144	115	156.2	148.2	348	284	297	309	333	356	392	251	257	265	274
162	130	176.5	167.6	394	321	336	349	376	402	443	284	291	300	310
168	131	177.9	168.9	397	323	339	352	379	405	446	286	293	302	312
172	140	190.1	180.5	424	346	362	376	405	433	477	306	313	323	334
180	144	195.6	185.6	436	355	372	387	417	445	491	315	322	332	343
192	152	206.4	195.9	460	375	393	408	440	470	518	332	340	350	362
198	160	217.3	206.2	485	395	413	430	463	495	545	350	358	369	382
204	165	224.1	212.7	500	407	426	443	477	510	562	361	369	380	393
216	174	236.3	224.3	527	429	450	467	503	538	593	380	389	401	415
228	180	244.4	232.0	551	449	470	489	526	563	620	398	407	419	434
240	190	258.0	244.9	575	469	491	510	550	587	647	415	425	438	453

Notes

a: Temporary Overvoltage with Prior Duty.

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

c: Contact manufacturer for alternate electrical builds.

d: 45-60 µs rise time for a 500 A peak current surge.

Table 5. Protective Characteristics of the UltraSIL Polymer-Housing Station-Class Arrester Type UX

Arrester Rating (kV, rms)	Arrester MCOV (kV, rms)	TOV[a]		Front-of-Wave Protective Level[b] (kV Crest)	Maximum Discharge Voltage (kV Crest)[c] 8/20 µs Current Wave						Switching Surge Protective Level[d] (kV Crest)			
		1 Sec	10 Sec		1.5kA	3kA	5kA	10kA	20kA	40kA	125A	250A	500A	1000A
3	2.55	3.5	3.3	7.8	6.3	6.6	6.9	7.4	7.9	8.7	5.6	5.7	5.9	6.1
6	5.1	6.9	6.6	15.5	12.6	13.2	13.7	14.8	15.8	17.4	11.2	11.4	11.8	12.2
9	7.65	10.4	9.9	23.2	18.9	19.8	20.6	22.2	23.7	26.1	16.7	17.1	17.6	18.3
10	8.4	11.4	10.8	25.5	20.8	21.7	22.6	24.3	26	28.6	18.4	18.8	19.4	20.1
12	10.2	13.9	13.1	30.9	25.2	26.4	27.4	29.5	31.6	34.8	22.3	22.8	23.5	24.3
15	12.7	17.2	16.4	38.5	31.4	32.8	34.1	36.8	39.3	43.3	27.8	28.4	29.3	30.3
18	15.3	20.8	19.7	46.3	37.8	39.5	41.1	44.3	47.3	52.1	33.4	34.2	35.2	36.5
21	17.0	23.1	21.9	51.5	42	43.9	45.6	49.2	52.6	57.9	37.1	38	39.2	40.5
24	19.5	26.5	25.1	59.1	48.1	50.4	52.3	56.4	60.3	66.4	42.6	43.6	44.9	46.5
27	22.0	29.9	28.4	66.6	54.3	56.8	59.1	63.6	68	74.9	48.1	49.2	50.7	52.4
30	24.4	33.1	31.5	73.9	60.2	63	65.5	70.6	75.4	83.1	53.3	54.6	56.2	58.2
33	27.5	37.3	35.4	83.3	67.8	71	73.8	79.5	85	93.7	60.1	61.5	63.3	65.5
36	29.0	39.4	37.4	87.8	71.5	74.9	77.8	83.9	89.6	98.8	63.3	64.8	66.8	69.1
39	31.5	42.8	40.6	95.4	77.7	81.3	84.5	91.1	97.4	108	68.8	70.4	72.5	75.1
42	34.0	46.2	43.8	103	83.9	87.8	91.2	98.3	106	116	74.2	76	78.3	81
45	36.5	49.6	47.0	111	90	94.2	97.9	106	113	125	79.7	81.6	84	87
48	39.0	53.0	50.3	119	96.2	101	105	113	121	133	85.1	87.2	89.8	92.9
54	42.0	57.0	54.1	128	104	109	113	122	130	143	91.7	93.9	96.7	101
60	48.0	65.2	61.9	146	119	124	129	139	149	164	105	108	111	115
66	53.0	72.0	68.3	161	131	137	143	154	164	181	116	119	122	127
72	57.0	77.4	73.5	173	141	148	153	165	177	195	125	128	132	136
78	62.0	84.2	79.9	188	153	161	167	180	192	212	136	139	143	148
84	68.0	92.3	87.7	206	168	176	183	197	211	232	149	152	157	162
90	72.0	97.8	92.8	218	178	186	194	209	223	246	158	161	166	172
96	76.0	103.2	98.0	230	188	197	204	220	235	259	166	170	175	181
108	84.0	114.1	108.3	255	208	217	226	243	260	286	184	188	194	201

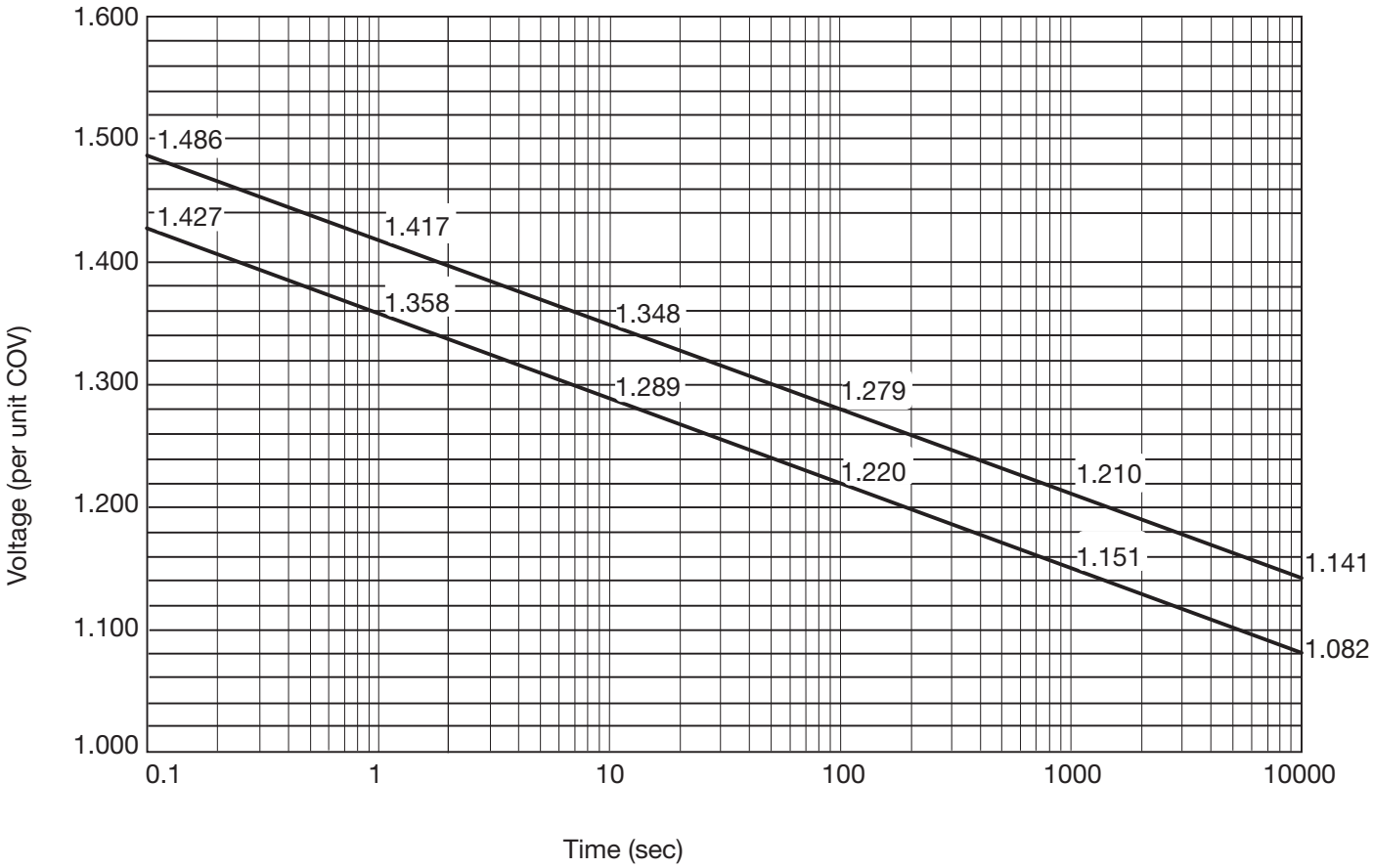
Notes

a: Temporary Overvoltage with Prior Duty.

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

c: Contact manufacturer for alternate electrical builds.

d: 45-60 µs rise time for a 500 A peak current surge..



Graph 1. TOV Recovery Curve of VariSTAR Type US, UH, and UX Station-Class Surge Arresters

Note: The energy absorbed in the prior duty test was 3.9 kJ/kV of MCOV for type US (3-108 kV) arresters.
For Type US (120-240 kV) and UH (3-108 kV), the energy was 6.2 kJ/kV of MCOV.
For Type UH (120-240 kV) and UX (3-108 kV), the energy was 10 kJ/kV of MCOV.

Table 6. TOV Recovery Capability of VariSTAR Type US, UH, and UX Station-Class Surge Arresters

	TOV (per unit MCOV)	
Time (seconds)	No Prior Duty	Prior Duty
0.1	1.486	1.427
1	1.417	1.358
10	1.348	1.289
100	1.279	1.220
1000	1.210	1.151
10000	1.141	1.082

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