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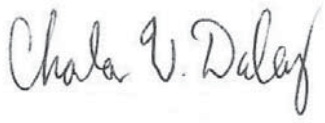
UltraSIL™ Polymer-Housed VariSTAR™ Type US, UH, UX Station Class Surge Arresters certified test report

Powering Business Worldwide

UltraSIL™ Polymer-Housed VariSTAR™ Type US, UH, UX Station Class Surge Arresters

CERTIFICATION

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



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INTRODUCTION

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™-2020 standard "IEEE Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits".

TEST PROGRAM

OBJECT

To demonstrate that the UltraSIL Polymer-Housed VariSTAR Surge Arresters meet 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

	Test Description	Per IEEE Std C62.11™-2020 section
A.	Insulation Withstand	8.1.2.4
B.	Discharge Voltage Current Characteristics	8.2
C.	Discharge Voltage Time Characteristics	8.4
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L.	Partial Discharge (PD) Test	8.11

RESULTS

UltraSIL Polymer-Housed VariSTAR Station Class Surge Arresters met all performance requirements.

TEST A
INSULATION WITHSTAND

OBJECTIVE

To verify that the assembled insulating members of UltraSIL Polymer-Housed VariSTAR Type US, UH, and UX Station Class Surge Arresters withstand impulse and power frequency voltage tests in accordance with IEEE Std C62.11™-2020 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 IEEE Std C62.11™-2020: Table 4.
- These samples were also subjected to both wet and dry 60 Hertz withstand voltages which exceeded theminimum values in IEEE Std C62.11™-2020: Table 4.

Arresters rated >54 kV:

- For each arrester rating the maximum 8 x 20, 20 kA discharge voltage was determined. This value wasmultiplied 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 andnegative 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 seconds; wet 60 Hzwithstand voltage in rms volts for each arrester.
- Arrester samples of each rating having the internal parts removed, were wetted and subjected to 10seconds 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™-2020 standard. The insulation withstand voltages for UltraSIL Polymer-Housed VariSTAR Surge Arresters are shown in Tables 3.

OBJECT

To verify that the assembled insulating members of the UltraSIL Polymer-Housed VariSTAR Surge Arresters withstand impulse and power frequency voltage tests.

PROCEDURE

- 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 50µs 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 eacharrester.
- Arrester samples of each rating having the internal parts removed, were wetted and subjected to 10

seconds of 60 Hz rmsvoltages exceeding the minimum withstand voltages as calculated above.

RESULTS

The samples did not flash over during the tests performed. Table 3 shows the insulation withstand voltages for UltraSIL Polymer-Housed VariSTAR Station Class Surge Arresters

TEST B
DISCHARGE VOLTAGE CURRENT CHARACTERISTICS

OBJECTIVE

To determine the maximum discharge voltage characteristics of the UltraSIL Polymer-Housed 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™-2020 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

Tables 4 - 6 shows the maximum 8 x 20 discharge voltages for the UltraSIL Polymer-Housed VariSTAR Station Class Surge Arresters

TEST C
DISCHARGE VOLTAGE TIME CHARACTERISTICS

OBJECTIVE
To obtain the front-of-wave and switching impulse protective levels of the UltraSIL Polymer-Housed VariSTAR Type US, UH, and UX Station Class Surge Arresters in accordance with IEEE Std C62.11™-2020 standard.

PROCEDURE
Determination of FOW discharge voltage:
- A current of 10 kA was used to determine the front-of-wave protective level.
- The samples were impulsed using front time of 1 µs
- The samples were impulsed using front time of 8 µs (Test B)
- A metal block was impulsed using front time of 1 µs.
- For each sample, the voltage trace of the metal block was subtracted from the voltage trace measured onthe sample
- The normalized FOW discharge voltage for each sample was determined by dividing the maximum voltage of the sample with 1 µs front time (excluding inductive voltage) by the 8 usec front time voltage.Switching Impulse Protective Level:
- Currents of 500, 1,000 and 2,000 Amperes crest were used to determine the switching impulse protectivelevel.
- The arresters were impulsed with switching impulse current waves having a time to actual crest of 45 to60 µs.
- The discharge voltage crest was measured.

RESULTS
Tables 4 -6 shows the front-of-wave and switching impulse protective levels for the UltraSIL Polymer-Housed VariSTAR Station Class Surge Arresters.

TEST D
ACCELERATED AGING

OBJECTIVE

To verify the K_C and K_R ratios of the UltraSIL Polymer-Housed VariSTAR Class Station Surge Arresters in accordance with IEEE Std C62.11™2020 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 remeasured at 1,000 hours at MCOV and duty cycle voltage levels.

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

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

If KC and KR - 1, then KC and KR are equal to 1.

RESULTS

K_C and K_R = 1.

TEST E
SWITCHING SURGE ENERGY RATING TEST

OBJECTIVE

To demonstrate that the UltraSIL Polymer-Housed VariSTAR Type US, UH , and UX Station Class Surge Arresters series meets the multiple discharge switching surge energy capability withstand (Wth - thermal energy) claimed for station and intermediatearresters in accordance with IEEE Std C62.11™-2020 standard.

PROCEDURE

- Three prorated equivalent thermal sections were used for this test.
- Each sample was impulsed with the switching surge classifying current per Table 7.
- Each sample was subjected to six groups of three current impulses, each with a virtual duration of 2000 to3200 µs timed to occur 50 to 60 seconds apart. The amplitude of the impulses was in the range of Table13 for the conditioning impulses for the energy class being tested as defined in IEEE Std C62.11™-2020 standard.
- The samples were permitted to cool after each group of three impulses.
- The samples were then subjected to two 65 kA 4/10 µs impulses with a time between impulses of 50 to 60seconds apart.
- The prorated sections were placed into an oven until they stabilized at 60 °C.
- Within five minutes upon removal from the oven, two thermal recovery impulses were applied 50 to 60seconds apart. The amplitude of the impulses was in the range of Table 13 for the thermal recovery impulses for the energy class being tested as defined in IEEE Std C62.11™-2020 standard.
- Within 100 ms after the second discharge, the sample was energized at duty cycle rated voltage for 10 sec, followed by the power frequency recovery voltage was applied and the watts loss was monitored fora minimum of 30 minutes to verify thermal recovery.

RESULTS

UltraSIL Polymer-Housed VariSTAR Type US, UH, and UX Station Class Surge Arresters two shot thermal energy rating (Wth) per table 1 below demonstrated thermal recovery, no sign of physical damage, and the switching surge discharge voltage at the classifying current changed by less than 5 %.

Table 1: Energy Classification (W_{th})

Family	Energy Classification (Wth)
US (3-108kV)	C - 6 kJ/kV of MCOV
US (120-240kV)	E - 9 kJ/kV of MCOV
UH (3-108kV)	E - 9 kJ/kV of MCOV
UH (120-240kV)	G – 13 kJ/kV of MCOV
UX (3-108kV)	G – 13 kJ/kV of MCOV

TEST F
SINGLE-IMPULSE WITHSTAND RATING TEST

OBJECTIVE

To demonstrate that the UltraSIL Polymer-Housed VariSTAR Class Station Surge Arresters series meets the single impulse withstand capability. The capability expressed in Coulombs represents the maximum charge transfer of a single current impulse that the arrester can withstand multiple times without causing physical or electrical damage for station and intermediate arresters in accordance with IEEE Std C62.11™-2020 standard.

PROCEDURE

- Ten VariSTAR samples of the 41, 50, and 63 mm nominal diameter with the greatest nominal length used in the
  arrester design with the highest discharge voltage at the classifying current that is used in the design.
- Each sample was impulsed with the switching surge classifying current and the reference voltage was measured at the reference current.
- Each sample was subjected to ten groups of two current impulses, each with a virtual duration of 2000 to4,000 µs timed to occur 50 to 60 seconds apart. The charge content of the impulses were 1.1 times theSingle – impulse withstand rating claimed for the test as defined in IEEE Std C62.11™-2020 standard.
- The samples were permitted to cool after each group of two impulses.

RESULTS

VariSTAR Station Class Surge Arresters met the Single Impulse withstand rating asclaimed per table 2 with ten samples passing the requirements of 20 impulses, <5% change in discharge voltage and reference voltage, and no physical damage.

Table 2: Single Impulse Withstand Rating (Q_{rs})

Family	Single Impulse Rating (Qrs)
US (3-108kV)	1.2 C
US (120-240kV)	1.6 C
UH (3-108kV)	1.6 C
UH (120-240kV)	3.6 C
UX (3-108kV)	3.6 C

TEST G
SHORT CIRCUIT TEST
(DESGIN B)

OBJECTIVE

To verify arrester internal fault is not likely to create an explosive event in accordance with IEEE Std C62.11™-2020standard.

PROCEDURE

- Samples were pre-failed by power frequency overvoltage.
- 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.

High-Current Short Circuit Testing:

- 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 Short Circuit 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 currentflow.
- The current duration lasted until the arrester vented up to a maximum of 1 second or until venting occurred.

RESULTS

UltraSIL Polymer-Housed VariSTAR Station Class Surge Arresters passed the described high and low-current tests based on oscillograph recordings showing test current magnitude and duration, from the evidence of the time at which the ventingoccurred, and from the confinement of all components of the arrester within the specified enclosures.

TEST H
CONTAMINATION TEST

OBJECTIVE

To demonstrate the ability of the UltraSIL Polymer-Housed VariSTAR Station Class Surge Arresters to withstand the electrical stresses caused by contamination on the housing.

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 13 minutes, a 400-500 Ωcm slurry was applied to the lower half of the arresterhousing 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 levelstowards the original measurement.
- Once the samples were cleaned and dried, they were inspected for internal damage using partial discharge measurementsat MCOV.

RESULTS

UltraSIL Polymer-Housed VariSTAR Station Class Surge Arresters samples passed the test by having stabilized lower watts loss over time,by not flashing over and by not having any internal physical damage.

TEST I
TEMPORARY OVERVOLTAGE (TOV)

OBJECTIVE
To verify what levels of power frequency temporary overvoltage the UltraSIL Polymer-Housed VariSTAR Station Class Surge Arresters survive in accordance with IEEE Std C62.11™-2020 standard.

PROCEDURE
- Prorated equivalent thermal sections were used for this test.
- Each sample was impulsed with a 10kA 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 before sample failure.
- Within 1 second, each sample was energized at the thermal recovery voltage per IEEE Std C62.11™-2020 standard (MCOV x KW x KC) for 30 minutes. Sample current and power loss were monitored for thermal runaway.
- Each sample was impulsed with a 10kA 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 TOVis applied.
- The "prior duty" energy applied to the arrester before the TOV was the energy generated in two switching surge discharges defined by the Switching Surge Energy Rating claimed.
- The "prior duty" energy applied, as defined by the Switching Surge Energy Rating (Wth- two-shot thermal) per Table 1.

RESULTS
Figure 1 shows the performance results.

TEST J
ACCELERATED AGING BY EXPOSURE TO SALT FOG

OBJECTIVE

The purpose of this test is to demonstrate the ability of the UltraSIL Polymer-Housed VariSTAR Station Class Station Surge Arresters to withstand electrical stresses on the arrester housing caused by exposure to salt fog.

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 continually filled the chamber. The starting value of the salt content of the water was 10 kg/m^3.
- The samples were energized at MCOV for time duration of 1000 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

UltraSIL Polymer-Housed VariSTAR Station Class Surge Arresters met the Accelerated Aging by Exposure to Salt Fog requirements of notracking 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 andafter testing. No trips or interruptions occurred during testing.

TEST K
MAXIMUM DESIGN CANTILEVER TEST FOR POLYMER-HOUSED ARRESTERS

OBJECTIVE
To evaluate the Maximum Design Cantilever Load (MDCL-Static) specified by the manufacturer for polymer housed arresters.

PROCEDURE
- The sample consisted of the longest mechanical unit of the design family consisting of an end casting and top terminalassembly.
- Power loss at 80-100% MCOV (noting ambient temperature) and Nominal Discharge Current at 1.5 kA measurements arerecorded.
- Terminal torque levels of 100 ft-lbs were applied to samplesusing 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 continuous cantilever load with variations in load direction and temperatureaccording to IEEE Std C62.11™-2020 standard, Figure 5.
  - 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
  - The sample is subject to 180° load direction at -25° ±3 °C
  - The sample is subject to 270° load direction at 45° ±3 °C
  - The sample is subject to 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 directionaccording to IEEE Std C62.11™-2020 standard, Figure 4. 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 arerecorded.

RESULTS
UltraSIL Polymer-Housed VariSTAR 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 than5% 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 K
MOISTURE INGRESS TEST FOR POLYMER-HOUSED ARRESTERS

OBJECTIVE

To evaluate the mechanical load specified by the manufacturer and the seal for polymer-housed arrester.

PROCEDURE

- Three Complete 72 kV samples were used in this test.
- Power loss at 80-100% MCOV (noting ambient temperature) and Nominal Discharge Current at 1.5 kA measurements arerecorded.
- Terminal torque of 35 ft-lbs was applied to the sample for the time duration of 30s.
- Thermomechanical Preconditioning
  - The sample is subject to the maximum continuous cantilever load with variations in load direction and temperature perIEEE Std C62.11™-2020 standard, Figure 4.
  - Maximum Design Cantilever Load per table 3.
  - 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.
  - The sample is subject to 180° load direction at 25 ° ±3 °C
  - The sample is subject to 270° load direction at 45 ° ±3 °C
  - The sample is subject to 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. Thedeflection at each direction shall be noted.
- 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 arerecorded.

RESULTS

UltraSIL Polymer-Housed VariSTAR Station Class Surge Arresters met Moisture Ingress test requirements of the power loss did not and increase by more than 20% from the initial measurement. The residual voltage at 1.5 kA did not deviate more than 5% fromthe 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 L
PARTIAL DISCHARGE (PD) TEST

OBJECTIVE

The purpose of this test is to verify that the UltraSIL Polymer-Housed VariSTAR Station Class Surge Arresters do not generate unacceptable levels of partial discharge according to IEEE Std C62.11™-2020 standard.

PROCEDURE

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

RESULTS

UltraSIL Polymer-Housed VariSTAR Station Class Surge Arresters met Partial Discharge test requirements. Partial discharge at 1.05 x corrected MCOV did not exceed 10pC.

Table 3: 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	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	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	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	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	99.8	99.8	99.8	294	298	300	N/A	N/A	N/A	201	201	202	173	186	176
54	42	99.8	99.8	99.8	294	298	300	N/A	N/A	N/A	201	201	202	173	186	176
60	48	107.5	107.5	107.5	316	319	321	N/A	N/A	N/A	212	215	211	187	192	188
66	53	138.2	115.2	115.2	434	340	342	N/A	N/A	N/A	302	230	224	252	206	201
72	57	138.2	122.8	122.8	434	361	364	N/A	N/A	N/A	302	246	237	252	213	210
78	62	153.5	153.5	153.5	469	476	482	N/A	N/A	N/A	323	312	312	278	284	277
84	68	168.9	168.9	168.9	504	516	524	N/A	N/A	N/A	344	332	336	304	312	308
90	72	176.6	176.6	176.6	527	537	543	N/A	N/A	N/A	360	354	352	314	323	316
96	76	184.3	184.3	184.3	550	558	562	N/A	N/A	N/A	376	376	368	324	334	324
108	84	199.6	199.6	199.6	588	596	600	N/A	N/A	N/A	402	402	404	346	372	352
120	98	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 4: 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	3.36	3.19	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	6.73	6.38	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	10.1	9.6	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	11.1	10.5	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	13.5	12.8	34.9	27.2	28.8	30.3	33.1	36.3	41.4	23.5	24.1	25	26.1
15	12.7	16.8	15.9	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	20.2	19.1	52.4	40.8	43.1	45.4	49.7	54.5	62.1	35.3	36.2	37.5	39.1
21	17	22.4	21.3	58.2	45.3	47.9	50.4	55.2	60.5	69	39.2	40.2	41.6	43.5
24	19.5	25.7	24.4	66.7	51.9	55	57.8	63.3	69.4	79.1	44.9	46.1	47.8	49.8
27	22	29	27.5	75.3	58.6	62	65.2	71.4	78.3	89.2	50.7	52	53.9	56.2
30	24.4	32.2	30.5	83.5	65	68.8	72.3	79.2	86.8	98.9	56.2	57.7	59.8	62.4
33	27.5	36.3	34.4	94.1	73.2	77.5	81.5	89.3	97.9	112	63.3	65	67.3	70.3
36	29	38.3	36.3	99.2	77.2	81.7	86	94.2	104	118	66.8	68.6	71	74.1
39	31.5	41.5	39.4	108	83.9	88.8	93.4	103	113	128	72.5	74.5	77.1	80.5
42	34	44.8	42.5	117	90.5	95.8	101	111	121	138	78.3	80.4	83.2	86.9
45	36.5	48.1	45.6	125	97.2	103	109	119	130	148	84	86.3	89.4	93.3
48	39	51.4	48.8	134	104	110	116	127	139	159	89.8	92.2	95.5	99.6
54	42	55.4	52.5	144	112	119	125	137	150	171	96.7	99.3	103	108
60	48	63.3	60	165	128	136	143	156	171	195	111	114	118	123
66	53	69.9	66.3	182	142	150	158	172	189	215	122	126	130	136
72	57	75.2	71.3	195	152	161	169	185	203	232	132	135	140	146
78	62	81.8	77.5	213	165	175	184	202	221	252	143	147	152	159
84	68	89.7	85	233	181	192	202	221	242	276	157	161	167	174
90	72	95	90	247	192	203	214	234	257	292	166	171	177	184
96	76	100.2	95	260	203	215	226	247	271	309	175	180	186	195
108	84	110.8	105	288	224	237	249	273	299	341	194	199	206	215
120	98	129.3	122.5	314	250	263	275	298	323	361	219	225	232	241
132	106	139.8	132.5	339	270	285	298	323	349	390	237	243	251	261
138	111	146.4	138.8	355	283	298	312	338	366	408	248	255	263	273
144	115	151.7	143.8	368	293	309	323	350	379	423	257	264	272	283
162	130	171.5	162.5	416	331	349	365	396	429	478	291	298	308	319
168	131	172.8	163.8	419	334	352	368	399	432	482	293	300	310	322
172	140	184.7	175	448	357	376	393	426	461	515	313	321	331	344
180	144	189.9	180	461	367	387	404	438	475	530	322	330	341	354
192	152	200.5	190	486	387	408	427	463	501	559	340	348	360	373
198	160	211	200	512	408	430	449	487	527	589	358	367	378	393
204	165	217.6	206.3	528	420	443	463	502	544	607	369	378	390	405

216	174	229.5	217.5	556	443	467	488	529	573	640	389	399	412	427
228	180	237.4	225	582	464	488	511	554	600	669	407	417	430	447
240	190	250.6	237.5	608	484	510	533	578	626	699	424	435	449	467

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 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	3.36	3.19	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	6.73	6.38	16.3	13	13.7	14.3	15.6	16.8	18.8	11.4	11.7	12.1	12.6
9	7.65	10.1	9.6	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	11.1	10.5	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	13.5	12.8	32.6	26	27.4	28.6	31.1	33.6	37.5	22.8	23.4	24.1	25.1
15	12.7	16.8	15.9	40.6	32.4	34.1	35.6	38.7	41.9	46.7	28.4	29.1	30	31.2
18	15.3	20.2	19.1	48.9	39	41.1	42.9	46.6	50.4	56.3	34.2	35.1	36.2	37.6
21	17	22.4	21.3	54.4	43.3	45.6	47.7	51.7	56	62.5	38	39	40.2	41.8
24	19.5	25.7	24.4	62.4	49.7	52.3	54.7	59.3	64.2	71.7	43.6	44.7	46.1	47.9
27	22	29	27.5	70.3	56	59	61.7	66.9	72.5	80.9	49.1	50.4	52	54
30	24.4	32.2	30.5	78	62.1	65.5	68.4	74.2	80.4	89.7	54.5	55.9	57.7	59.9
33	27.5	36.3	34.4	87.9	70	73.8	77.1	83.6	90.6	102	61.4	63	65	67.5
36	29	38.3	36.3	92.7	73.8	77.8	81.3	88.2	95.5	107	64.8	66.4	68.6	71.2
39	31.5	41.5	39.4	101	80.2	84.5	88.3	95.8	104	116	70.3	72.2	74.5	77.3
42	34	44.8	42.5	109	86.6	91.2	95.3	104	112	125	75.9	77.9	80.4	83.5
45	36.5	48.1	45.6	117	92.9	97.9	103	111	121	135	81.5	83.6	86.3	89.6
48	39	51.4	48.8	125	99.3	105	110	119	129	144	87.1	89.3	92.2	95.7
54	42	55.4	52.5	135	107	113	118	128	139	155	93.8	96.2	99.3	104
60	48	63.3	60	154	123	129	135	146	159	177	108	110	114	118
66	53	69.9	66.3	170	135	143	149	162	175	195	119	122	126	131
72	57	75.2	71.3	183	146	153	160	174	188	210	128	131	135	140
78	62	81.8	77.5	199	158	167	174	189	205	228	139	142	147	153
84	68	89.7	85	218	174	183	191	207	224	250	152	156	161	167
90	72	95	90	231	184	194	202	219	238	265	161	165	171	177
96	76	100.2	95	243	194	204	214	232	251	280	170	174	180	187
108	84	110.8	105	269	214	226	236	256	277	309	188	193	199	207
120	98	129.3	122.5	297	242	253	263	284	303	334	214	219	226	234
132	106	139.8	132.5	321	262	274	285	307	328	361	232	237	244	253
138	111	146.4	138.8	336	274	287	298	321	343	378	243	248	256	265
144	115	151.7	143.8	348	284	297	309	333	356	392	251	257	265	274
162	130	171.5	162.5	394	321	336	349	376	402	443	284	291	300	310
168	131	172.8	163.8	397	323	339	352	379	405	446	286	293	302	312
172	140	184.7	175	424	346	362	376	405	433	477	306	313	323	334
180	144	189.9	180	436	355	372	387	417	445	491	315	322	332	343
192	152	200.5	190	460	375	393	408	440	470	518	332	340	350	362
198	160	211	200	485	395	413	430	463	495	545	350	358	369	382
204	165	217.6	206.3	500	407	426	443	477	510	562	361	369	380	393

216	174	229.5	217.5	527	429	450	467	503	538	593	380	389	401	415
228	180	237.4	225	551	449	470	489	526	563	620	398	407	419	434
240	190	250.6	237.5	575	469	491	510	550	587	647	415	425	438	453

a: Temporary Overvoltage with Prior Duty.

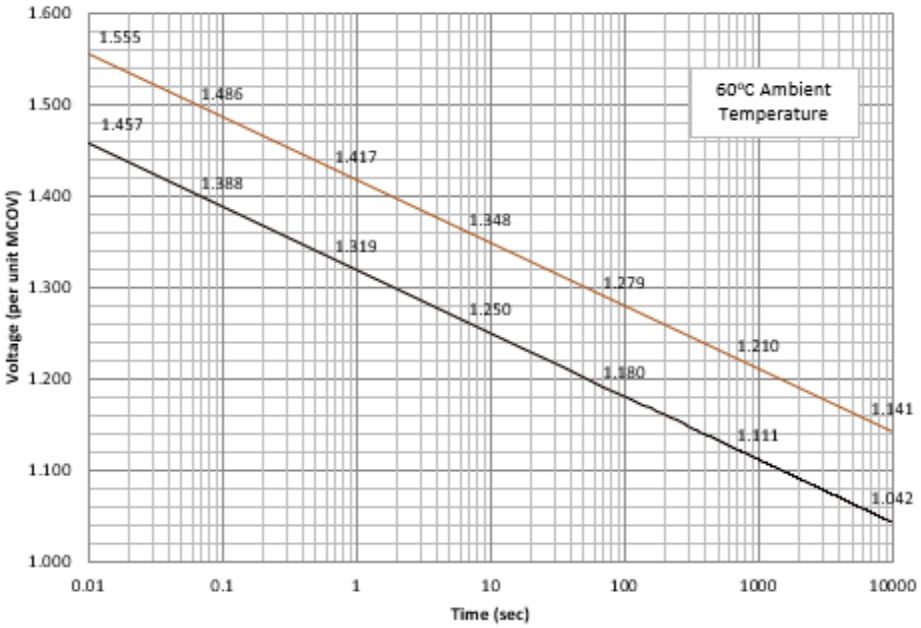
b: Based on a 10 kA current impulse that results in a discharge voltage cresting in 0.5 µs.c: Contact manufacturer for alternate electrical builds.

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

Table 6: 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	3.36	3.19	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	6.73	6.38	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	10.1	9.6	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	11.1	10.5	25.5	20.8	21.7	22.6	24.3	26	28.6	18.4	18.8	19.4	20.1
12	10.2	13.5	12.8	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	16.8	15.9	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	20.2	19.1	46.3	37.8	39.5	41.1	44.3	47.3	52.1	33.4	34.2	35.2	36.5
21	17	22.4	21.3	51.5	42	43.9	45.6	49.2	52.6	57.9	37.1	38	39.2	40.5
24	19.5	25.7	24.4	59.1	48.1	50.4	52.3	56.4	60.3	66.4	42.6	43.6	44.9	46.5
27	22	29	27.5	66.6	54.3	56.8	59.1	63.6	68	74.9	48.1	49.2	50.7	52.4
30	24.4	32.2	30.5	73.9	60.2	63	65.5	70.6	75.4	83.1	53.3	54.6	56.2	58.2
33	27.5	36.3	34.4	83.3	67.8	71	73.8	79.5	85	93.7	60.1	61.5	63.3	65.5
36	29	38.3	36.3	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	41.5	39.4	95.4	77.7	81.3	84.5	91.1	97.4	108	68.8	70.4	72.5	75.1
42	34	44.8	42.5	103	83.9	87.8	91.2	98.3	106	116	74.2	76	78.3	81
45	36.5	48.1	45.6	111	90	94.2	97.9	106	113	125	79.7	81.6	84	87
48	39	51.4	48.8	119	96.2	101	105	113	121	133	85.1	87.2	89.8	92.9
54	42	55.4	52.5	128	104	109	113	122	130	143	91.7	93.9	96.7	101
60	48	63.3	60	146	119	124	129	139	149	164	105	108	111	115
66	53	69.9	66.3	161	131	137	143	154	164	181	116	119	122	127
72	57	75.2	71.3	173	141	148	153	165	177	195	125	128	132	136
78	62	81.8	77.5	188	153	161	167	180	192	212	136	139	143	148
84	68	89.7	85	206	168	176	183	197	211	232	149	152	157	162
90	72	95	90	218	178	186	194	209	223	246	158	161	166	172
96	76	100.2	95	230	188	197	204	220	235	259	166	170	175	181
108	84	110.8	105	255	208	217	226	243	260	286	184	188	194	201

Figure 1: TOV Recovery Curve of VariSTAR Type US, UH and UX Station Class Surge Arresters



Family	Energy Classification (Wth)
US (3-108kV)	C - 6 kJ/kV of MCOV
US (120-240kV)	E - 9 kJ/kV of MCOV
UH (3-108kV)	E - 9 kJ/kV of MCOV
UH (120-240kV)	G – 13 kJ/kV of MCOV
UX (3-108kV)	G – 13 kJ/kV of MCOV

Table 7: TOV Recovery Capability of VariSTAR Type US, UH and UX Station Class Surge Arresters

Time (Seconds)	TOV (Per unit MCOV)	
	No Prior Duty	Prior Duty
0.1	1.486	1.388
1	1.417	1.319
10	1.348	1.25
100	1.279	1.18
1000	1.21	1.111
10000	1.141	1.042

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REVISION TABLE

REVISION NO.	DATE	WHAT WAS ADDED/CHANGED
0	09/2021	New Report

Eaton
1000 Eaton Boulevard
Cleveland, OH 44122
United States
Eaton.com

Eaton's Power Systems Division
2300 Badger Drive
Waukesha, WI 53188
United States
Cooperpower.com

Powering Business Worldwide