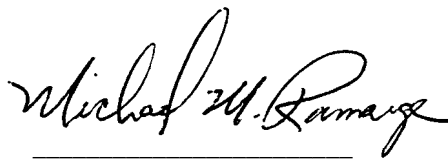


**10 kA Class 3**  
**Certified Test Report**  
**IEC 60099-4 2009**

**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.*



**Michael M. Ramarge**  
**Arrester Engineering Manager**

## INTRODUCTION

This test report certifies that the UltraSIL VariSTAR arresters 10kA- Class 3 were successfully tested to IEC 60099-4:2009 “Metal-Oxide surge arresters without gaps for a.c. systems”.

## TEST PROGRAM

### OBJECT

To demonstrate that the UltraSIL VariSTAR Arresters 10kA– Class 3 meet all performance requirements.

### PROCEDURE

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

### TYPE TESTS

- A. Insulation Withstand Test
  - a) Lightning Impulse Voltage Test ..... Per IEC 60099-4 Section 10.8.2.6
  - b) Switching Impulse Voltage Test ..... Per IEC 60099-4 Section 10.8.2.7
  - c) Power Frequency Voltage Test..... Per IEC 60099-4 Section 10.8.2.8
- B. Residual Voltage Test
  - a) Steep Current Impulse Residual Voltage Test ... Per IEC 60099-4 Section 10.8.3.1
  - b) Lightning Impulse Residual Voltage Test ..... Per IEC 60099-4 Section 10.8.3.2
  - c) Switching Impulse Residual Voltage Test ..... Per IEC 60099-4 Section 10.8.3.3
- C. Long Duration Current Impulse  
Withstand Test ..... Per IEC 60099-4 Section 10.8.4.2
- D. Switching Surge Operating Duty Test..... Per IEC 60099-4 Section 10.8.5.5
- E. Power Frequency Voltage vs. Time ..... Per IEC 60099-4 Section 6.10, Annex D
- F. Short Circuit Tests ..... Per IEC 60099-4 Section 10.8.7
- G. Internal Partial Discharge Tests ..... Per IEC 60099-4 Section 10.8.8
- H. Test of the Bending Moment
  - a) Mechanical/Thermal Pre-conditioning..... Per IEC 60099-4 Section 10.8.9.3.1
  - b) Terminal Torque Pre-conditioning..... Per IEC 60099-4 Section 10.8.9.3.1.1
  - c) Thermo Mechanical Pre-conditioning..... Per IEC 60099-4 Section 10.8.9.3.1.2
  - d) Thermal Pre-conditioning ..... Per IEC 60099-4 Section 10.8.9.3.1.3
  - e) Water Immersion Test..... Per IEC 60099-4 Section 10.8.9.3.2
  - f) Test Evaluation ..... Per IEC 60099-4 Section 10.8.9.4
- I. Weather Aging Tests
  - a) Test Series A: 1000 hr ..... Per IEC 60099-4 Section 10.8.14.2.1
- J. Accelerated Ageing Test of the Resistor Blocks.....Per IEC 60099-4 Section 10.8.5.2
- K. Radio Intereference Voltage (RIV) Test.....Per IEC60099-4 Section 10.8.12

### RESULTS

The UltraSIL VariSTAR arresters met all performance requirements of IEC 60099-4:2009.

**TEST A:  
INSULATION WITHSTAND**

Test Report Number: K-015943-RC-001-R00  
Certifying Laboratory: Kinectrics

Object: To demonstrate the voltage withstand capability of the external insulation of the arrester housing.

*Lightning Impulse Voltage Test*

Procedure: The sample was clean and dry. The sample was subject to fifteen positive and negative 1.2 X 50  $\mu$ s impulses.

Results: The sample passed with less than two discharges at the positive and negative voltage values. No internal discharges occurred.

*Switching Impulse Voltage Test*

Procedure: The sample was subject to fifteen consecutive positive and negative impulses.

Results: The sample passed with less than two discharges at the positive and negative voltage values. No internal discharges occurred.

*Power Frequency Voltage Test*

Procedure: The sample was clean and tested under wet conditions. The sample was subject to a power frequency voltage of 1.06 times the switching impulse protection level for a period of sixty seconds.

Results: The sample passed with no discharges during the sixty-second period.

**TEST B:  
RESIDUAL VOLTAGE TESTS**

Test Report Number: B2002837  
Certifying Laboratory: CESI

Object: To determine the maximum discharge voltage for each discharge current.

*Steep Current Impulse Residual Voltage Test*

Procedure: One steep current impulse was applied to each sample with a peak value equal to the nominal discharge current of the arrester. The current impulse had a front time between 0.9 $\mu$ s to 1.1 $\mu$ s and the virtual time to half-value on the tail was not longer than 20 $\mu$ s.

*Lightning Impulse Residual Voltage Test*

Procedure: A lightning current impulse was applied to each sample for approximately 0.5, 1, and 2 times the nominal discharge current. The current impulse had a front time between 7 $\mu$ s to 9 $\mu$ s and the virtual time to half-value on the tail was between 18 $\mu$ s to 22 $\mu$ s.

*Switching Impulse Residual Voltage Test*

Procedure: One switching current impulse was applied to each sample at 125 A and 500 A. The current impulse had a front time greater than 30 $\mu$ s and less than 100 $\mu$ s and a virtual time to half-value of approximately twice the virtual front time.

Results:

Arrester Rating $U_R$ (kV, rms)	Arrester COV $U_C$ (kV, rms)	Steep Current Residual Voltage (kV, crest)	Lightning Impulse Residual Voltage (kV, crest) 8/20 $\mu$ s Current Wave						Switching Impulse Residual Voltage (kV, crest) 30/60 Current Wave			
			1.5 kA	3 kA	5 kA	10 kA	20 kA	40 kA	125 A	250 A	500 A	1000 A
3	2.55	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	16.3	13	13.7	14.3	15.6	16.8	18.8	11.4	11.7	12.1	12.6
9	7.65	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	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	32.6	26	27.4	28.6	31.1	33.6	37.5	22.8	23.4	24.1	25.1
15	12.7	40.6	32.4	34.1	35.6	38.7	41.9	46.7	28.4	29.1	30.0	31.2
18	15.3	48.9	39	41.1	42.9	46.6	50.4	56.3	34.2	35.1	36.2	37.6
21	17	54.4	43.3	45.6	47.7	51.7	56	62.5	38	39	40.2	41.8
24	19.5	62.4	49.7	52.3	54.7	59.3	64.2	71.7	43.6	44.7	46.1	47.9
27	22	70.3	56	59	61.7	66.9	72.5	80.9	49.1	50.4	52	54
30	24.4	78	62.1	65.5	68.4	74.2	80.4	89.7	54.5	55.9	57.7	59.9
33	27.5	87.9	70	73.8	77.1	83.6	90.6	102	61.4	63	65	67.5
36	29	92.7	73.8	77.8	81.3	88.2	95.5	107	64.8	66.4	68.6	71.2
39	31.5	101	80.2	84.5	88.3	95.8	104	116	70.3	72.2	74.5	77.3
42	34	109	86.6	91.2	95.3	104	112	125	75.9	77.9	80.4	83.5
45	36.5	117	92.9	97.9	103	111	121	135	81.5	86.3	89.6	94.6
48	39	125	99.3	105	110	119	129	144	87.1	89.3	92.2	95.7
54	42	135	107	113	118	128	139	155	93.8	96.2	99.3	104
60	48	154	123	129	135	146	159	177	108	110	114	118
66	53	170	135	143	149	162	175	195	119	122	126	131
72	57	183	146	153	160	174	188	210	128	131	135	140
78	62	199	158	167	174	189	205	228	139	142	147	153
84	68	218	174	183	191	207	224	250	152	156	161	167
90	72	231	184	194	202	219	238	265	161	165	171	177
96	76	243	194	204	214	232	251	280	170	174	180	187
	77	247	196	207	216	235	254	284	172	177	182	189
108	84	269	214	226	236	256	277	309	188	193	199	207
120	98	314	250	263	275	298	323	361	219	225	232	241
132	106	339	270	285	298	323	349	390	237	243	251	261
138	111	355	283	298	312	338	366	408	248	255	263	273
144	115	368	293	309	323	350	379	423	257	264	272	283
150	120	384	306	322	337	365	396	442	268	275	284	295
162	130	416	331	349	365	396	429	478	291	298	308	319
168	131	419	334	352	368	399	432	482	293	300	310	322
172	140	448	357	376	393	426	461	515	313	321	331	344
180	144	461	367	387	404	438	475	530	322	330	341	354
192	152	486	387	408	427	463	501	559	340	348	360	373
198	160	512	408	430	449	487	527	589	358	367	378	393
204	165	528	420	443	463	502	544	607	369	378	390	405
216	174	556	443	467	488	529	573	640	389	399	412	427
228	180	576	459	483	505	548	593	662	402	413	426	442
240	190	608	484	510	533	578	626	699	424	435	449	467

**TEST C:  
LONG DURATION CURRENT IMPULSE WITHSTAND TEST**

Test Report Number: B2011153  
Certifying Laboratory: CESI

Object: To demonstrate the ability of the arrester to meet the long duration current impulse withstand test requirements.

Procedure: The sample was subject to eighteen impulses, divided into six groups of three operations, with 50-60 seconds between impulses. The samples cooled to ambient temperature between impulses.

Results: The samples met test requirements with less than 5% change in residual voltage the physical integrity was verified by the oscillogram of the 19<sup>th</sup> impulse.

**TEST D:  
SWITCHING SURGE OPERATING DUTY TEST**

Test Report Number: B2012759  
Certifying Laboratory: CESI

Object: To demonstrate the ability of the arrester to meet the switching surge operating duty test requirements.

Procedure: The sample was subject to twenty 8/20 lightning current impulses with a peak value equal to the nominal discharge current of the arrester with the sample at  $1.2 * U_C'$ . The impulses were divided into four groups of five impulses, with 50-60 s between impulses and 25-30 minutes between groups. The sample was then subject to two 100kA  $\pm$  10kA high current impulses. The sample was then subject to two long duration current impulses at an elevated temperature of  $60 \pm 3$  °C with 50-60 s between impulses. Within 100ms of the second impulse, the sample shall be energized at  $U_R'$  for 10s and  $U_C'$  for 30 minutes.

Results: The samples met test requirements with less than 5% change in residual voltage, achieving thermal stability. After the test, the two additional long duration current impulse were applied which demonstrated physical integrity and no damage occurred.

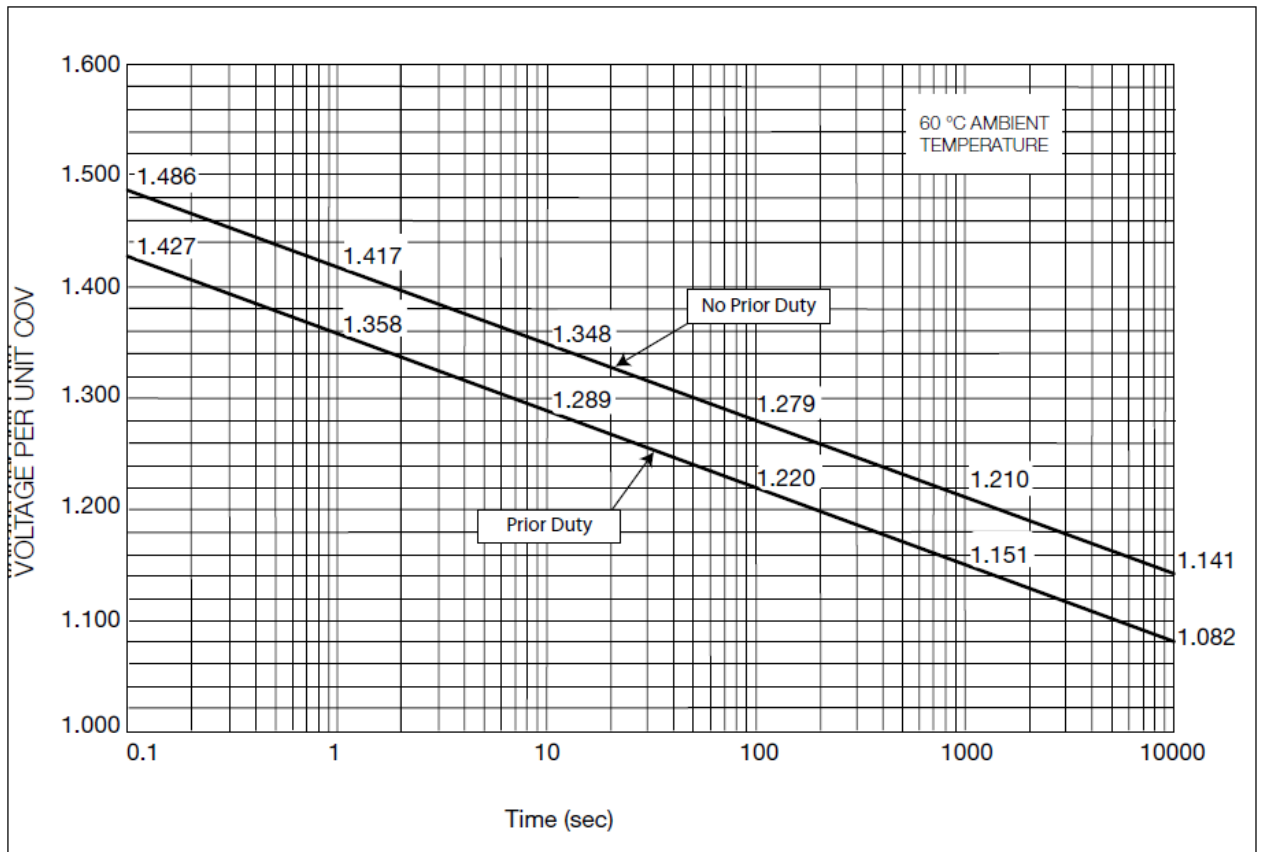
**TEST E:  
POWER FREQUENCY VOLTAGE VS. TIME**

Test Report Number: B2002847  
Certifying Laboratory: CESI

Object: To determine the over voltage values and time durations for the arrester design.

Procedure: The sample was subjected to two long duration current impulses at an elevated temperature of  $60 \pm 3^\circ\text{C}$  with 50-60 s between impulses. The sample was then subject to an over voltage at for the specified time range. The recovery voltage of  $U_c'$  was applied to the sample for thirty minutes.

Results:



**TEST F:  
SHORT CIRCUIT TEST**

Test Report Number: C112-01-K3  
Certifying Laboratory: KEMA

Object: To verify arrester internal fault is not likely to create an explosive event.

Procedure: The sample was thermally pre-killed using an over voltage applied for  $5 \pm 3$  minutes. One 72kV arrester was tested at high current of 63kA, low current of 800 Amps and two reduced currents of 25kA and 12kA respectively.

Results: The 72kV arresters tested met the evaluation criteria of no violent shattering, no parts found outside of the test enclosure except for soft polymeric parts, and self-extinguished within 2 minutes.

**TEST G:  
INTERNAL PARTIAL DISCHARGE TESTS**

Test Report Number: B2006463  
Certifying Laboratory: CESI

Object: To verify the arrester design does not generate excessive partial discharge.

Procedure: The sample was energized to the rated voltage for 2 seconds. The voltage was then lowered to  $1.05 * U_C$  and the partial discharge level was recorded.

Results: The samples met test requirements with partial discharge  $\leq 10\text{pC}$ .

**TEST H:  
TEST OF THE BENDING MOMENT**

Test Report Number: B2002856  
Certifying Laboratory: CESI

Object: To verify the arrester design's ability to withstand the manufacturer's declared value for bending loads. The test also evaluates the design will not decrease in performance under thermo-mechanical and moisture conditions.

Procedure: The samples were subjected to a series of preconditioning tests including power loss, internal partial discharge, residual voltage, terminal torque, and thermo-mechanical preconditioning. The specified long term load (SLL) of 920 Nm was applied for 1000 cycles and validated on all three samples. Two samples were then subjected to the specified short term load (SSL) of 1150 Nm, while the other sample was subjected to thermal mechanical pre-conditioning which included thermal variations of two 48 hour cycles of heating and cooling with the direction of the SLL changing every 24 hours. The samples were then immersed in 80°C de-ionized water with 1kg/m<sup>3</sup> of NaCl for a period of 52 hours. The samples remained in the water until the temperature cooled to 50 °C. After the samples reached ambient temperature they were tested for changes in power loss, internal partial discharge and residual voltage.

Results: All samples showed no signs of physical damage, the slope of the force-deflection curve remains positive up to the SSL value except for dips not exceeding 5% of the SSL magnitude, demonstrated less than a 20% change in power loss, the internal partial discharge did not exceed 10pC, and there was a less than 5% deviation in residual voltage with no signs of breakdown seen in the voltage and current oscillograms.

**TEST I:  
WEATHER AGING TESTS**

**TEST SERIES A: 1000 HR**

Test Report Number: H – 12035  
Certifying Laboratory: CESI

Object: To verify the ability of the arrester to withstand continuous salt fog conditions and endure surface arcing and heating.

Procedure: The samples were placed in an enclosure filled with a salt fog mist. The samples were energized at  $U_C$  for a period of 1000 hours. The samples underwent pre and post testing consisting of partial discharge and reference voltage.

Results: All samples met the test requirements of: no housing punctures or housing erosion, 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 10 pC.



**TEST J:  
ACCELERATED AGEING TEST OF THE RESISTOR BLOCKS**

Test Report Number: B2002850  
Certifying Laboratory: CESI

Object: To determine the voltage values  $U_C'$  and  $U_R'$  for operating duty testing.

Procedure: Samples of the resistor blocks in composite wrap material were at  $115^{\circ}\text{C} \pm 4 \text{ K}$  for 1000 hours. Power losses were monitored for the duration of the test.

Results: The power loss ratio between the start of the test and the end power loss was less than 1.0 for all samples. No correction factor during operating duty testing must be applied.

**TEST K:  
RADIO INTERFERENCE VOLTAGE (RIV) TEST**

Test Report Number: B2004637  
Certifying Laboratory: CESI

Object: To verify that under normal operating conditions the surge arrester does not generate external partial discharges resulting in radio influence voltage exceeding a stated level.

Procedure: The 240kV rated surge arrester was increased to 1.15 x COV, then lowered to 1.05\*COV and maintained there for 5 minutes. The voltage was then decreased in approximately 19 kV steps to 0.5\*COV and then raised again to 1.05 x COV and maintained for 5 minutes. At each step the RIV was measured, recorded and plotted versus the applied voltage.

Results: All measured values did not exceed the 2500  $\mu$ V and therefore the test results were positive.

REVISION NO.	DATE	WHAT WAS ADDED/CHANGED
1	01/20/2014	Page 8 Weather Aging Test Report Number corrected

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