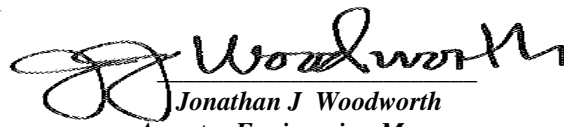


UNS 5kA Arrester
Certified Test Report
IEC 60099-4 2004

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
Chief Engineer


Jonathan J Woodworth
Arrester Engineering Manager

INTRODUCTION

This test report certifies that the UltraSIL VariSTAR arresters UNS Class 1 – 5kA were successfully tested to IEC 60099-4:2004 “Metal-Oxide surge arresters without gaps for a.c. systems”.

TEST PROGRAM

OBJECT

To demonstrate that the UltraSIL VariSTAR Arresters Class 1 –5kA 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 8.2.6
 - b) Power Frequency Voltage Test..... Per IEC 60099-4 Section 8.2.8
- B. Residual Voltage Test
 - a) Steep Current Impulse Residual Voltage Test .. Per IEC 60099-4 Section 8.3.1
 - b) Lightning Impulse Residual Voltage Test Per IEC 60099-4 Section 8.3.2
- C. Long Duration Current Impulse Withstand Test Per IEC 60099-4 Section 8.4.3
- D. High Current Impulse Operating Duty Test Per IEC 60099-4 Section 8.5.4
- E. Power Frequency Voltage vs. Time Per IEC 60099-4 Section 6.10, Annex D
- F. Characteristics of an Arrester Short Circuit Tests .. Per IEC 60099-4 Section 6.11
- G. Internal Partial Discharge Tests Per IEC 60099-4 Section 8.8
- H. Moisture Ingress Test
 - a) Terminal Torque Pre-conditioning..... Per IEC 60099-4 Section 10.8.13.2.1
 - b) Thermo Mechanical Pre-conditioning..... Per IEC 60099-4 Section 10.8.13.2.2
 - c) Water Immersion Test..... Per IEC 60099-4 Section 10.8.13.3
 - d) Verification Tests Per IEC 60099-4 Section 10.8.13.4
- I. Weather Aging Tests
 - a) Test Series A: 1000 hr Per IEC 60099-4 Section 10.8.14.2.1
 - b) Test Series B: 5000 hr Per IEC 60099-4 Section 10.8.14.2.2
- J. Mechanical Tests
 - a) Test of the Bending Moment Per IEC 60099-4 Section 8.9
 - b) Sulphur Dioxide Test Per IEC 60099-4 Section 8.10.3.2
 - c) Salt Mist Test Per IEC 60099-4 Section 8.10.3.3
- K. Disconnecter Operation Per IEC 60099-4 Section 8.6.3

RESULTS

The UltraSIL VariSTAR arresters met all performance requirements of IEC 60099-4:2004.

**TEST A:
INSULATION WITHSTAND**

Test Report Number: AT-96023133
Certifying Laboratory: CESI

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 μ s 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 0.88 times the lightning impulse protection level for a period of 1 minute.

Results: The sample passed with no discharges during the one-minute period.

**TEST B:
RESIDUAL VOLTAGE TESTS**

Test Report Number: AT-96007051
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 μ s to 1.1 μ s and the virtual time to half-value on the tail was not longer than 20 μ 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 μ s to 9 μ s and the virtual time to half-value on the tail was between 18 μ s to 22 μ s.

Result:

U _R Arrester Rating (kV, rms)	U _C COV (kV, rms)	Steep Current Residual Voltage (kV, crest)	Lightning Impulse Residual Voltage (kV, crest)					
			8/20 μs Current Wave					
			1.5 kA	3 kA	5kA	10kA	20kA	40kA
3	2.55	10.9	9.0	9.7	10.4	11.4	13.0	15.1
6	5.10	21.8	17.9	19.4	20.8	22.7	26.0	30.2
9	7.65	31.4	25.8	28.0	30.0	32.8	37.4	43.5
10	8.40	32.7	26.9	29.1	31.2	34.1	38.9	45.3
12	10.2	41.1	33.8	36.5	39.2	42.9	48.9	56.9
15	12.7	51.3	42.2	45.7	49.0	53.6	61.1	71.1
18	15.3	61.6	50.8	54.8	58.8	64.3	73.4	85.3
21	17.0	65.4	53.7	58.2	62.4	68.2	77.9	90.6
24	19.5	76.3	62.7	67.8	72.8	79.6	90.8	106.0
27	22.0	86.3	71.0	76.8	82.4	90.1	103.0	120.0
30	24.4	96.2	79.1	85.6	91.8	100.0	115.0	133.0
33	27.0	107.0	87.8	95.1	102.0	112.0	127.0	148.0
36	29.0	115.0	94.7	103.0	110.0	120.0	137.0	160.0

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

Test Report Number: AT-96004925
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 and no physical damage.

**TEST D:
HIGH CURRENT IMPULSE OPERATING DUTY TEST**

Test Report Number: AT-96004039
Certifying Laboratory: CESI

Object: To demonstrate the ability of the arrester to meet the high current impulse operating duty test requirements.

Procedure: The sample was subject to twenty 8/20 lighting current impulses with a peak value equal to the nominal discharge current of the arrester with the sample at 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 $65K_a \pm 10kA$ high current impulses. Within 100ms of the second impulse, the sample shall be energized at U_R' for 10 s and U_C' for 30 minutes.

Results: The samples met test requirements with less than 5% change in residual voltage, achieving thermal stability, and no physical damage.

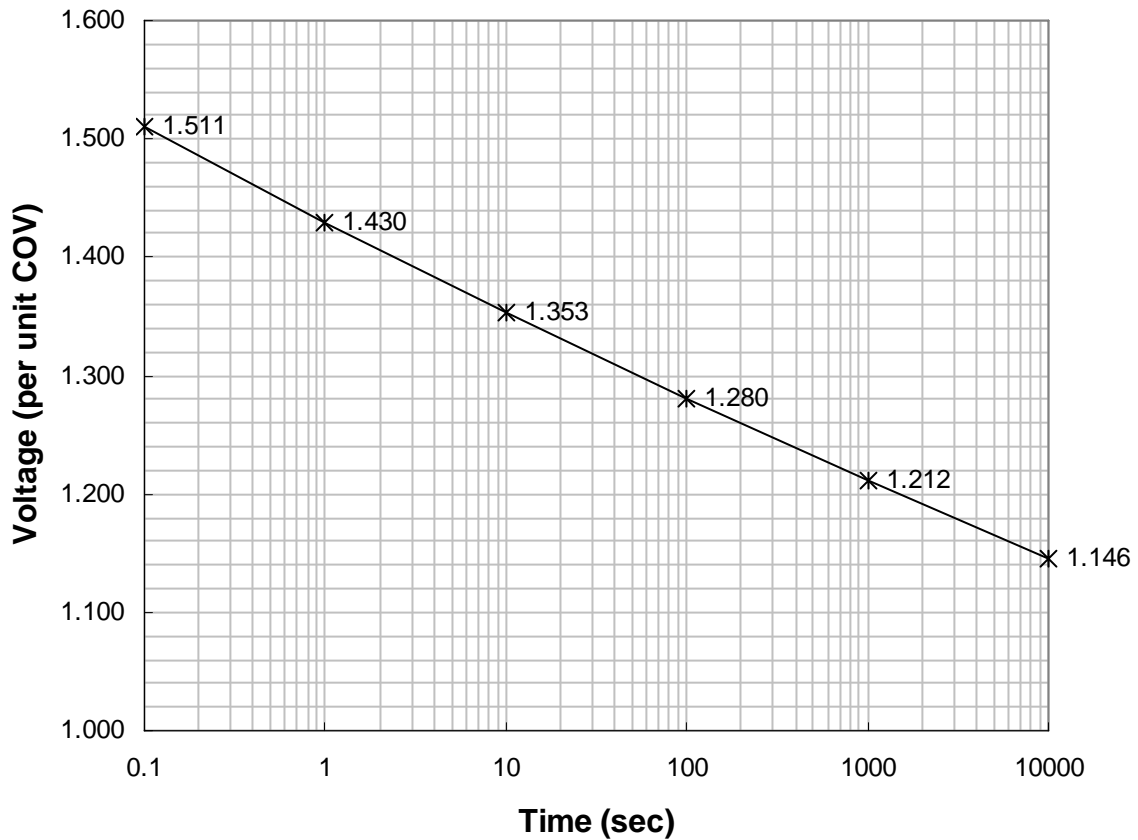
**TEST E:
POWER FREQUENCY VOLTAGE VS. TIME**

Test Report Number: AT-96004044
Certifying Laboratory: CESI

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

Procedure: The sample was subject to one high current impulse, $4 \times 10 \mu\text{s}$, at the elevated temperature $60^\circ \pm 3^\circ\text{C}$. The sample was then subject to each over voltage at each specified time range. The recovery voltage of U_C' was applied to the sample for thirty minutes.

Results:



**TEST F:
CHARACTERISTICS OF AN ARRESTER: SHORT CIRCUIT TEST**

Test Report Number: S2-03135-A
Certifying Laboratory: KEMA

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

Procedure: Samples were pre-killed using an over voltage applied for 5 ± 3 minutes. Two 36kV arresters were then tested at full voltage and two 36kV arrester was tested at a reduced voltage.

Results: The 36kV arresters tested at full voltage met high current test requirements of 20kA The 60kV arresters tested at reduced voltage met low current test requirements of 600A.

**TEST G:
INTERNAL PARTIAL DISCHARGE TESTS**

Test Report Number: A4-003924
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:
MOISTURE INGRESS TEST**

Test Report Number: A4-003910
Certifying Laboratory: CESI

Object: To verify the arrester 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 samples were then immersed in boiling de-ionized water with 1kg/m^3 of NaCl for a period of 42 hours. The samples remained in the water until the temperature cooled to $50\text{ }^\circ\text{C}$. 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, 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: T04-1373
Certifying Laboratory: STRI

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 SERIES B: 5000 HR

Test Report Number: TESTING IN PROGRESS
Certifying Laboratory: STRI

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

Procedure: One 60kV surge arrester was placed under various environmental stresses in a cyclic manner while energized at U_C for a period of 5000 hours. These stresses included solar radiation simulation, artificial rain, dry heat, damp heat, high dampness at room temperature, and salt fog at low concentration. The sample underwent pre and post testing consisting of partial discharge and reference voltage.

**TEST J:
MECHANICAL TESTS**

TEST OF BENDING MOMENT:

Test Report Number: A4-003917
Certifying Laboratory: CESI

Object: To verify the arrester could withstand cantilever and environmental stresses.

Procedure: The maximum permissible static load (180 Nm) was applied to the upright arrester for a period of 60 – 90 seconds. The sample was then immersed in a vessel, boiled in de-ionized water with 1 kg/m^3 of NaCl for 42 hours. At the end of the boiling, the sample remained in the vessel until the water cooled to $50 \text{ }^\circ\text{C}$. The sample underwent pre and post testing consisting of power loss, partial discharge and residual voltage.

Results: The sample showed no physical damage, the power loss did not increase by more than 20 % of the initial measurement, the partial discharge did not exceed 10 pC at $1.05*U_c$, and the residual voltage at the same discharge current did not deviate by more than 5%.

SULPHUR DIOXIDE AND SALT MIST TESTS:

Test Report Number: 13-7351-20-04-3A-rev2
Certifying Laboratory: Thomas A. Edison Technical Center

Object: To verify the arrester could withstand cantilever and environmental stresses.

Procedure: The arrester was placed in an airtight box with sulphur dioxide gas for a period of 21 days. The sample was then placed in a chamber with a salt mist atmosphere for a period of 96 hours. The sample underwent pre and post testing of partial discharge.

Results: The sample showed no physical damage and the partial discharge did not exceed 10 pC at $1.05 \cdot U_c$.

**TEST K:
DISCONNECTOR OPERATION**

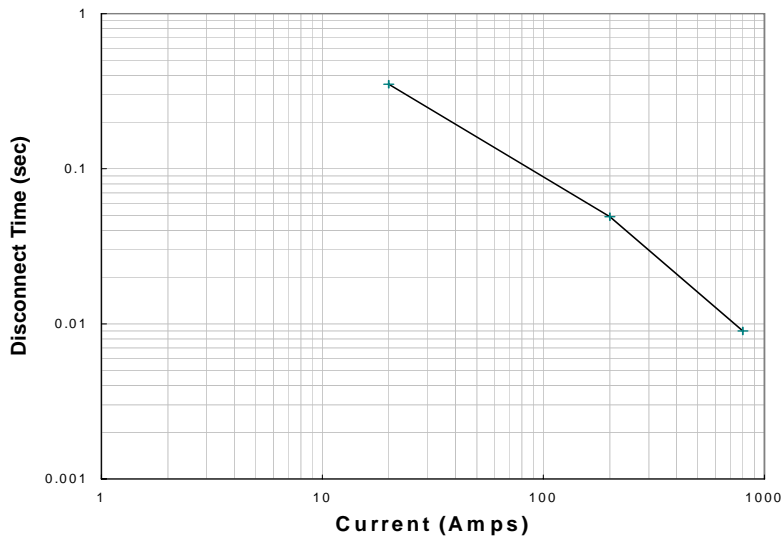
Test Report Number: A4-000660
Certifying Laboratory: CESI

Object: To verify the disconnecter was effective and permanently disconnected from arrester.

Procedure: Five disconnectors were tested without the surge arrester at 20A, 200A, and 800 A. The applied voltage was approximately 2700 V.

Results: In each test, the samples disconnected and the separation was permanent.

Disconnect Curve




Certificate of Compliance

Certified Test Report Summary CP0504 is compliant with IEC 60099-4:2004. All tests were completed per IEC 60099-4:1991 and IEC 60099-4:2001 at independent third party testing laboratories. All testing results meet the test requirements stated in the latest revision of the standard IEC 60099-4:2004.

Type Tests	IEC 60099-4 Revision		
	1991	2001	2004
Insulation Withstand Test	X	✓	✓
Residual Voltage Test	X	✓	✓
Long Duration Current Impulse	X	✓	✓
High Current Impulse Operating Duty Test	X	✓	✓
Power Frequency Voltage vs. Time	X	✓	✓
Characteristics of an Arrester Short Circuit Tests		INFO	INFO
Internal Partial Discharge Tests		X	✓
Moisture Ingress Test		X	✓
Weather Aging Tests		X	✓
Mechanical Tests		X	✓
Disconnecter Operation		X	✓

Definitions: "X" = Test revision required
 "✓" = Same test required as previous revision
 "INFO" = Informative optional test


 Michael M Ramarge
 Chief Engineer


 Jonathan J Woodworth
 Arrester Engineering Manager