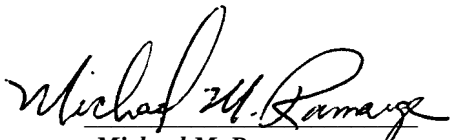
10kA Class 2

Certified Test Report

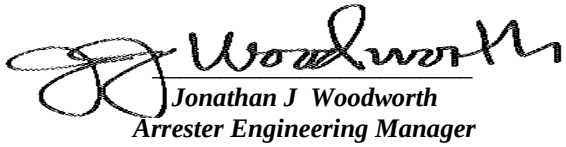
IEC 60099-4 2004

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 10kA- Class 2 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 10kA– Class 2 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) Switching Impulse Voltage Test …… Per IEC 60099-4 Section 8.2.7
   c) 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) Switching Impulse Residual Voltage Test …… Per IEC 60099-4 Section 8.3.3

C. Long Duration Current Impulse
   Withstand Test …… Per IEC 60099-4 Section 8.4.2

D. Switching Surge Operating Duty Test……. Per IEC 60099-4 Section 8.5.5

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, Annex O

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. Accelerated Ageing Test of the Resistor Blocks……..Per IEC 60099-4 Section 8.5.2

RESULTS

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

TEST A:
INSULATION WITHSTAND

Test Report Number: 10559-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 μs 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: AT-A4007446
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 0.9μs to 1.1μs and the virtual time to half-value on the tail was not longer than 20μs.

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 7μs to 9μs and the virtual time to half-value on the tail was between 18μs to 22μs.

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 30μs and less than 100μs 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 μs Current Wave						Switching Impulse Residual Voltage (kV, crest) 30/60 Current Wave			
			1.5 kA	3 kA	5kA	10kA	20kA	40kA	125 A	250 A	500 A	1000A
3	2.55	9.2	7.0	7.4	7.7	8.4	9.4	11.0	6.1	6.3	6.5	6.7
6	5.10	17.9	13.9	14.7	15.4	16.7	18.6	21.4	12.2	12.6	13.0	13.5
9	7.65	26.8	20.9	22.0	23.1	25.0	27.7	31.7	18.3	18.9	19.5	20.2
10	8.40	29.3	23.0	24.2	25.4	27.4	30.4	34.8	20.1	20.7	21.4	22.2
12	10.2	35.6	27.9	29.4	30.8	33.3	36.9	42.1	24.4	25.2	26.0	26.9
15	12.7	44.2	34.7	36.6	38.3	41.4	45.9	52.2	30.4	31.3	32.4	33.5
18	15.3	53.0	41.8	44.0	46.2	49.8	55.2	62.8	36.6	37.7	39.0	40.4
21	17.0	58.9	46.4	48.9	51.3	55.4	61.3	69.7	40.7	41.9	43.4	44.9
24	19.5	67.5	53.3	56.1	58.8	63.5	70.3	79.9	46.7	48.1	49.8	51.5
27	22.0	76.1	60.1	63.3	66.3	71.6	79.3	90.0	52.7	54.3	56.1	58.1
30	24.4	84.4	66.6	70.2	73.6	79.4	87.9	100	58.4	60.2	62.3	64.4
33	27.5	95.0	75.1	79.1	82.9	89.5	99.1	112	65.9	67.8	70.2	72.6
36	29.0	100	79.2	83.4	87.4	94.4	105	119	69.5	71.5	74.0	76.6
39	31.5	109	86.0	90.6	95.0	103	113	129	75.4	77.7	80.4	83.1
42	34.0	118	92.8	97.8	103	111	122	139	81.4	83.9	86.8	89.7
45	36.5	126	100	105	110	119	131	149	874.4	90.0	93.1	96.3
48	39.0	135	107	112	118	127	140	159	93.4	96.2	100	103
54	42.0	145	115	121	127	137	151	171	101	104	107	111
60	48.0	165	131	138	145	156	173	196	115	118	123	127
66	53.0	184	145	153	160	173	191	217	127	131	135	140
72	57.0	198	156	164	172	186	205	233	137	141	145	151
78	62.0	214	169	178	187	202	223	253	149	153	158	164
84	68.0	235	186	196	205	221	245	278	163	168	174	179
90	70.0	248	197	207	217	234	259	294	172	178	184	190
96	76.0	262	208	219	229	247	274	310	182	188	194	201
108	84.0	290	229	242	253	273	302	343	201	207	214	222
120	98.0	338	268	282	295	319	353	399	235	242	250	259
132	106	367	290	305	320	345	382	433	254	261	270	280
138	111	384	303	319	335	361	400	453	266	274	283	293
144	115	397	314	331	347	374	414	469	275	284	293	304
162	130	449	355	374	392	423	468	530	311	321	332	343
168	131	452	358	377	395	426	472	534	314	323	334	346
172	140	483	382	403	422	455	504	571	335	345	357	370
180	144	497	393	414	434	468	518	587	345	355	368	380
192	152	526	415	437	458	495	547	620	364	375	388	401
198	160	553	437	460	482	521	576	653	383	395	408	422
204	165	570	451	475	497	537	594	673	395	407	421	436
216	174	601	475	501	525	566	626	710	417	429	444	459
228	182	628	497	524	549	592	655	742	436	449	464	480
240	190	656	519	547	573	618	684	774	455	469	485	502

TEST C:
LONG DURATION CURRENT IMPULSE WITHSTAND TEST

Test Report Number: AT-A4007437
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:
SWITCHING SURGE OPERATING DUTY TEST

Test Report Number: AT-A4007439
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 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 ^{o}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, and no physical damage.

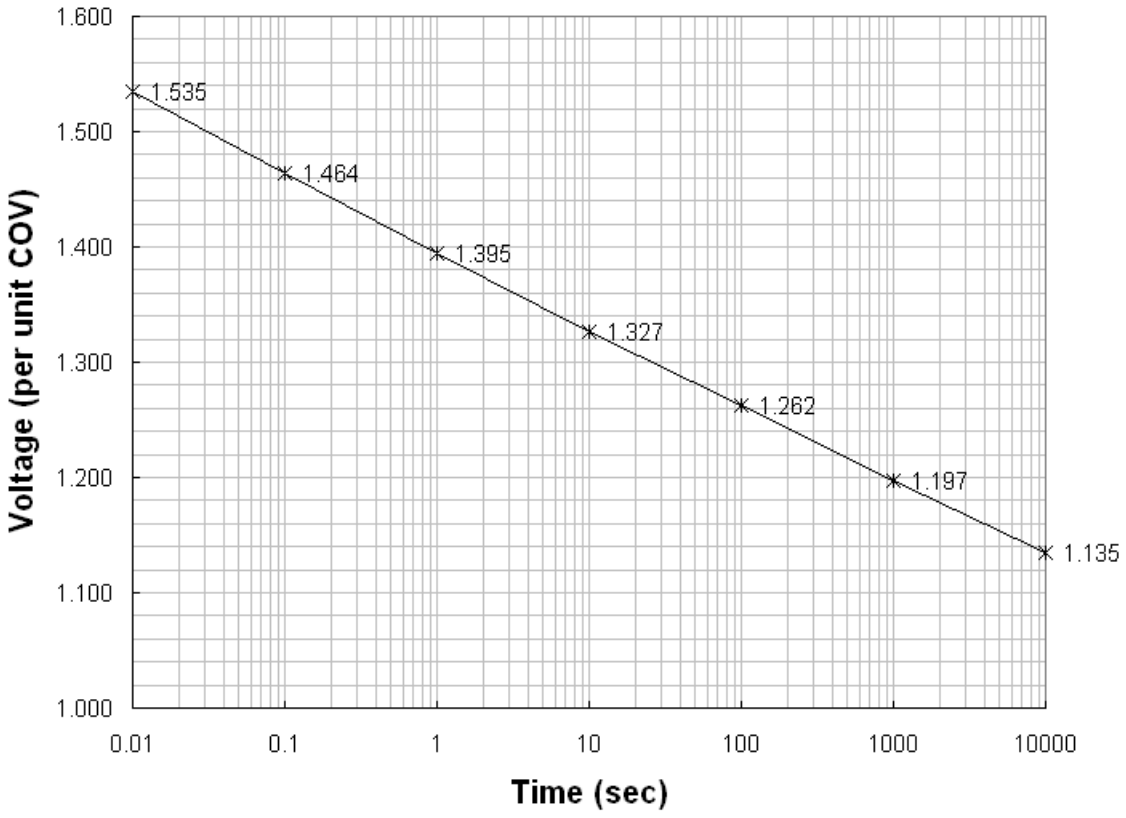
TEST E:
POWER FREQUENCY VOLTAGE VS. TIME

Test Report Number: AT-A4007440
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. 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: 53021129
Test Date: July 29, 2003
Certifying Laboratory: Hydro Quebec

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

Procedure: The samples were thermally pre-killed using an over voltage applied for 5±3 minutes. Two 60kV arresters were tested at a reduced voltage.

Results: The 60kV arrester tested at reduced voltage met high current test requirements of 40kA. The 60kV arresters tested at reduced voltage met low current test requirements of 600A.

Test Report Number: 53021129
Test Date: July 28, 2003
Certifying Laboratory: Hydro Quebec

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±3 minutes. One 60kV arrester was tested at a reduced voltage.

Results: The 60kV arrester tested at reduced voltage met high current test requirements of 80kA.

TEST G:
INTERNAL PARTIAL DISCHARGE TESTS

Test Report Number: AT-A4008725
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 ≤ 10pC.

TEST H:
MOISTURE INGRESS TEST

Test Report Number: AT-A4007728
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 ^oC. 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: 10613
Certifying Laboratory: Kinectrics

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: T04-1326
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.

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, no over current trip out, the arrester reference voltage did not decrease by more than 5%, and the partial discharge level did not exceed 5 pC.

TEST J:
MECHANICAL TESTS

TEST OF THE BENDING MOMENT:

Test Report Number: AT-A4007729
Certifying Laboratory: CESI

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

Procedure: The maximum permissible static load (680 Nm for sample 1 and 460 Nm for sample 2) 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 at 80^{o}C with 1 kg/m^3 of NaCl for 52 hours. At the end of the boiling, the sample remained in the vessel until the water cooled to 50 °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*Uc, 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: ML 169-2003-1
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*Uc.

TEST K:
ACCELERATED AGEING TEST OF THE RESISTOR BLOCKS

Test Report Number: AT-A4007446
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^{o}C $\pm$ 4 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.