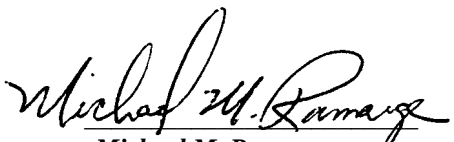
10kA Class 3

Certified Test Report

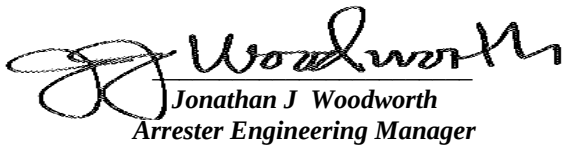
IEC 60099-4 2004

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 3 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 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 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-A4007441
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	8.8	6.7	7.0	7.3	7.9	8.8	10.1	5.9	6.0	6.2	6.4
6	5.10	17.0	13.3	14.0	14.6	15.6	17.3	19.6	11.7	12.0	12.4	12.9
9	7.65	25.3	19.9	21.0	21.8	23.4	25.8	29.1	17.6	18.1	18.6	19.3
10	8.40	27.8	21.9	23.0	23.9	25.7	28.3	31.9	19.4	19.8	20.4	21.2
12	10.2	33.6	26.6	28.0	29.0	31.1	34.3	38.6	23.5	24.1	24.8	25.7
15	12.7	41.8	33.1	34.8	36.2	38.7	42.7	47.9	29.3	30.0	30.9	32.0
18	15.3	50.2	39.9	41.9	43.5	46.6	51.4	57.6	35.3	36.1	37.2	38.5
21	17.0	55.8	44.3	46.6	48.4	51.8	57.0	63.9	39.2	40.2	41.3	42.8
24	19.5	63.9	50.8	53.5	55.5	59.4	65.4	73.2	44.9	46.1	47.4	49.1
27	22.0	72.0	57.3	60.3	62.6	67.0	73.7	82.5	50.7	52.0	53.4	55.4
30	24.4	79.9	63.6	66.9	69.4	74.3	81.8	9134	56.2	57.6	59.3	61.4
33	27.5	89.9	71.7	75.4	78.2	83.7	92.1	103	63.4	65.0	66.8	69.2
36	29.0	94.8	75.6	79.5	82.5	88.3	97.1	109	66.8	68.5	70.4	73.0
39	31.5	103	82.1	86.3	89.6	95.9	106	118	72.6	74.4	76.5	79.3
42	34.0	112	88.6	93.2	96.7	104	114	127	78.3	80.3	82.6	85.6
45	36.5	119	95.1	100	104	111	122	137	84.1	86.2	88.7	91.9
48	39.0	128	102	107	111	119	131	146	89.9	92.1	94.7	98.2
54	42.0	137	109	115	119	128	141	157	96.8	99.2	102	106
60	48.0	157	125	132	137	146	161	179	111	113	117	121
66	53.0	173	138	145	151	161	178	199	122	125	129	133
72	57.0	187	149	156	162	174	191	213	131	135	138	144
78	62.0	203	162	170	176	189	208	232	143	147	151	156
84	68.0	222	177	186	193	207	228	254	157	161	165	171
90	70.0	229	182	192	199	213	234	262	161	165	170	176
96	76.0	248	198	208	216	231	254	284	175	180	185	191
108	84.0	275	219	230	239	256	281	314	194	198	204	211
120	98.0	319	255	269	279	298	328	366	226	232	238	247
132	106	347	276	290	302	323	355	396	244	250	258	267
138	111	363	289	304	316	338	372	415	256	262	270	280
144	115	376	300	315	327	350	385	430	265	272	279	290
162	130	425	339	356	370	396	435	486	300	307	316	327
168	131	428	341	359	373	399	438	489	302	309	318	330
172	140	457	365	384	398	426	468	523	323	331	340	352
180	144	470	375	395	410	438	482	538	332	340	350	362
192	152	497	396	417	432	463	509	568	350	359	369	383
198	160	523	417	439	455	487	536	598	369	378	389	403
204	165	539	430	452	469	502	552	617	380	390	401	415
216	174	567	453	477	495	529	582	650	401	411	423	438
228	182	594	474	499	518	554	609	680	419	430	442	458
240	190	620	495	521	540	578	636	709	438	449	462	478

TEST C:
LONG DURATION CURRENT IMPULSE WITHSTAND TEST

Test Report Number: AT-A4007442
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-A4007443
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.

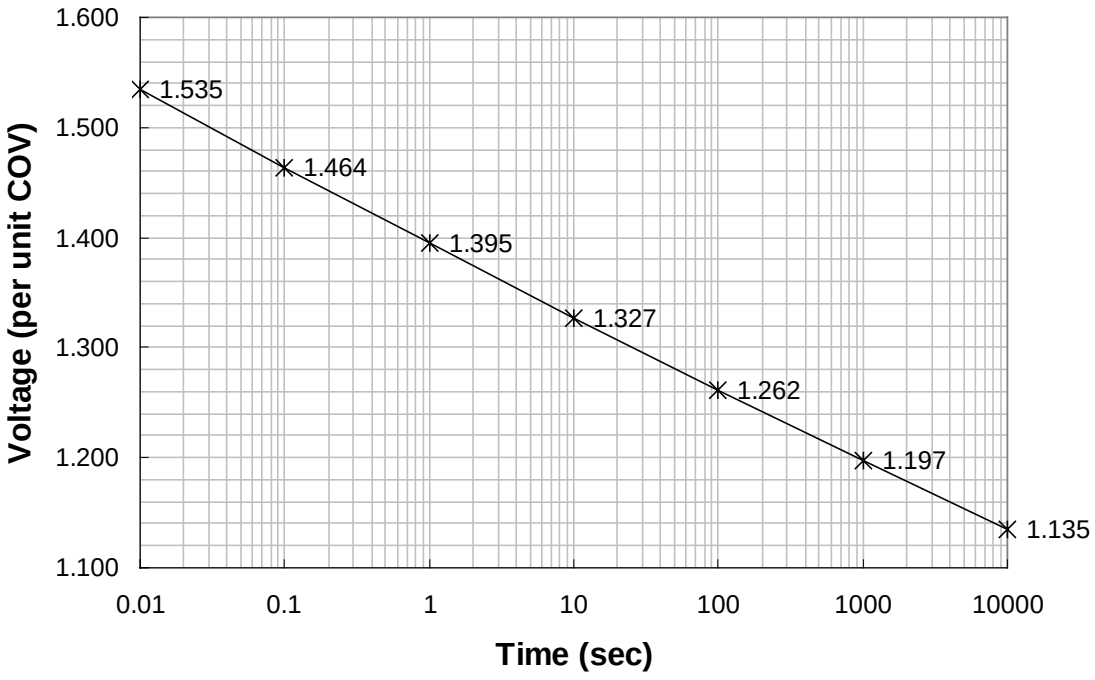
TEST E:
POWER FREQUENCY VOLTAGE VS. TIME

Test Report Number: AT-A4007444
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 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. The 60kV arrester tested at reduced voltage met low current test requirements of 600A.

TEST G:
INTERNAL PARTIAL DISCHARGE TESTS

Test Report Number: AT-A4008727
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 $\leq$ 10pC.

TEST H:
MOISTURE INGRESS TEST

Test Report Number: AT-A4007731
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: 10631
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: T04-1327
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-A4007732
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-A4007445
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.