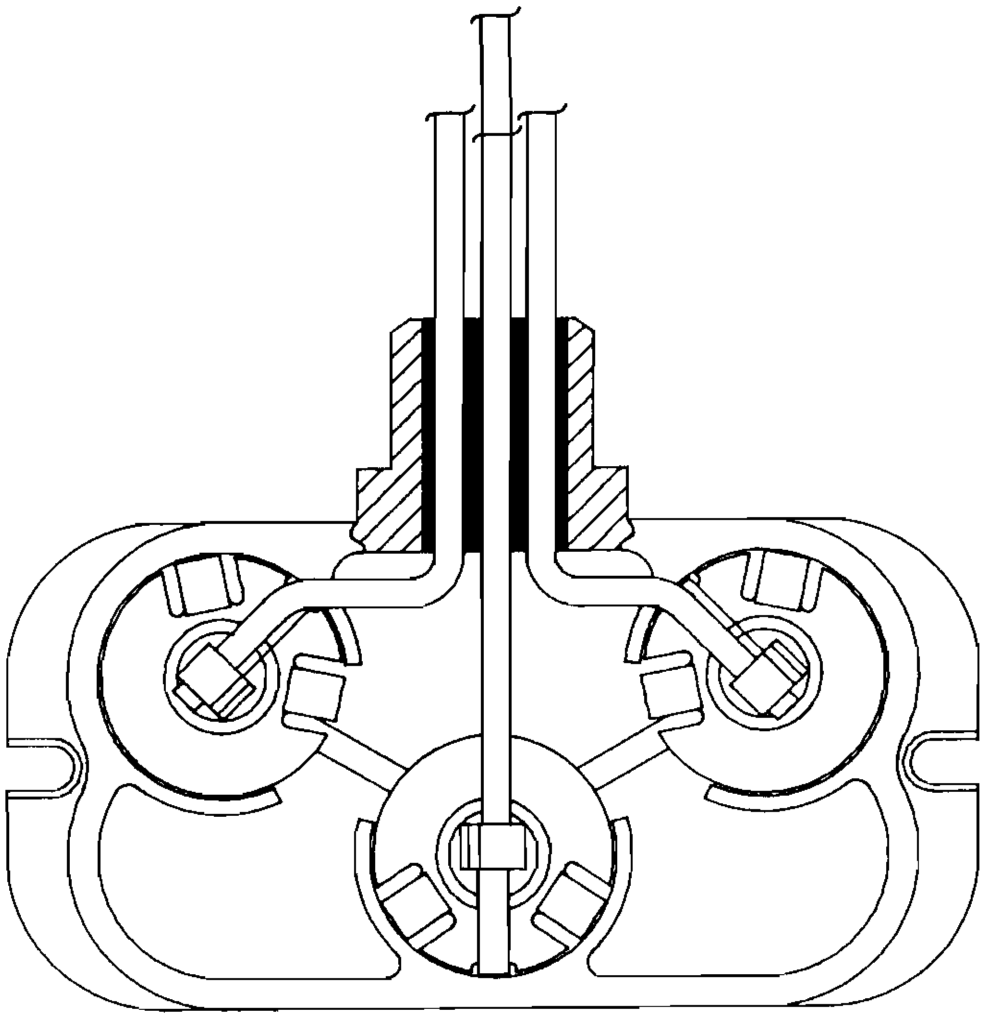
Surge Arresters

COOPER POWER SYSTEMS

VariSTAR® MOV Storm Trapper® Secondary Surge Arrester Certified Design Test Report



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SECTION 1 - GENERAL INFORMATION

1.1 Purpose and Objectives Statement

The purpose of this document is to present certified design test data and a summary of physical and electrical characteristics of the McGraw-Edison® MOV Storm Trapper® Secondary Surge Arrester.

1.2 Certification Statement

The design tests conducted and the data recorded in this document are presented in accordance with the sections of ANSI/IEEE Standard C62.11-1987 relevant to Secondary Metal Oxide Surge Arresters.

The McGraw-Edison surge arresters rated 175 volts to 650 volts meet or exceed all applicable requirements of the above referenced standard as reported in the following sections of this document.

1.3 Summary Data

Tabulated below are summaries of the electrical and physical characteristics of the McGraw-Edison Storm Trapper surge arresters rated 175 volts to 650 volts.

TABLE 1
Protective Characteristics

Rating	MCOV	Maximum Discharge Voltage (kV crest) 8/20 µs Current Wave				
V rms	V rms	1.5 kA*	3 kA*	5 kA*	10 kA*	10 kA**
175	175	1.1	1.2	1.4	1.7	3.1
350	350	1.6	1.7	1.9	2.3	3.5
650	650	2.2	2.4	2.7	3.1	4.0

* 1.5" Leads
** 18" leads

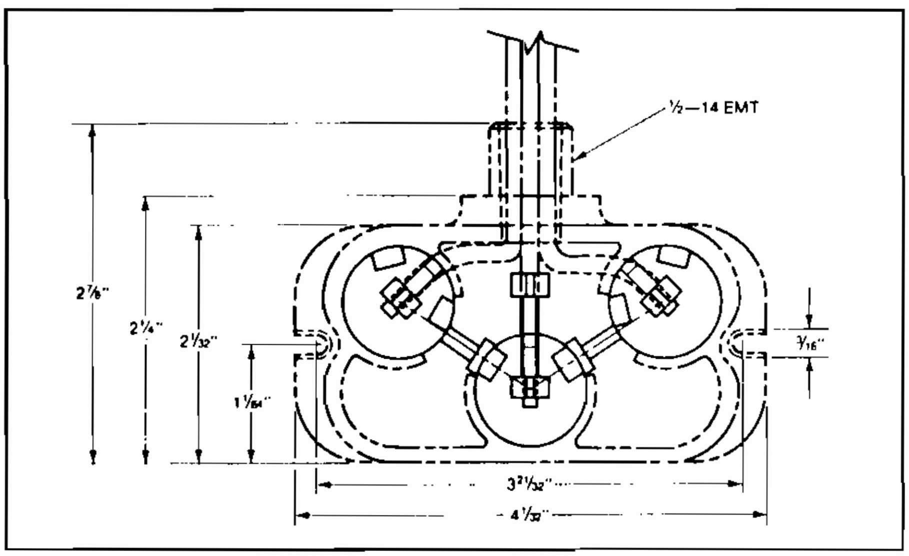

Figure 1
Arrester Diagram

TABLE 2
Insulation Withstand Voltages

Arrester Rating	1.2/50 Impulse	1 min Dry	10 sec Wet
kV rms	kV crest	kV rms	kV rms
175	10	6	6
350	10	6	6
650	10	6	6

SECTION 2 - DESIGN TEST DATA

2.0 Definition of Terms

Surge Arrester - A protective device for limiting surge voltages on equipment by diverting surge current and returning the device to its original status. It is capable of repeating these functions as specified.

Metal-Oxide Surge Arrester (MOSA) - A surge arrester utilizing valve elements fabricated from nonlinear resistance metal oxide materials.

Duty-cycle Voltage Rating -The designated maximum permissible voltage between terminals at which the arrester is designed to perform its duty cycle.

Maximum Continuous Operating Voltage (MCOV) -The maximum designated root-mean-square (rms) value of power frequency voltage that may be applied continuously between the terminals of the arrester.

Design Tests - Tests made on each design to establish the performance characteristics and to demonstrate compliance with the appropriate standards of the industry. Once made they need not be repeated unless the design is changed so as to modify performance.

Certification Tests - Tests run on a regular periodic basis to verify that selected, key performance characteristics of a product or representative samples thereof have remained within performance specifications.

Routine Tests - Tests made by the manufacturer on every device or representative samples, or on parts or materials, as required, to verify that the product meets the design specifications.

Waveshape Designation - The wave shape of an impulse (other than rectangular) of a current or voltage is designated by a combination of two numbers. The first, an index of the wave front, is the virtual duration of the wave front in microseconds. The second, an index of the wave tail, is the time in microseconds from the virtual zero to the instant at which one-half of the crest value is reached on the wave tail. Examples are 1.2/50 and 8/20 µs waves.

Reference Current -The reference current (Iref) of an arrester is the peak value of the resistive component of the power frequency current used to determine the reference voltage (Vref) of an arrester. The reference current is high enough to make the effects of stray capacitance on the measured voltage negligible.

Reference Voltage - The reference voltage of an arrester is the highest peak value of the power frequency voltage, independent of polarity, divided by the square root of two, measured at the reference current of the arrester.

2.1 Arrester Insulation Withstand Tests ANSI/IEEE C62.11-1987; Section 8.1

2.1.1 INSULATION WITHSTAND TEST DESCRIPTION

The voltage withstand tests of arrester insulation demonstrate that the insulation of the arrester is above the minimum specified levels given in Table 2 of the referenced section of the ANSI/IEEE C62.11-1987 standard.

2.1.2 INSULATION WITHSTAND TEST PROCEDURE

New, clean arresters of each rating were subjected to positive and negative 1.2/50 µs withstand tests and 60 Hz wet and dry withstand tests. The voltage was applied to the lead wire of a functional arrester while external grounding was attached to the housing.

2.1.3 INSULATION WITHSTAND TEST EVALUATION

Table 3 lists the actual withstand voltage values. All values meet or exceed those listed in Table 2 of the above referenced standard section for all arrester ratings.

TABLE 3
Insulation Withstand Voltages

Arrester Rating	1.2/50 Impulse	1 min Dry	10 sec Wet
kV rms	kV crest	kV rms	kV rms
175	10	6	6
350	10	6	6
650	10	6	6

2.2 Discharge Voltage Characteristics ANSI/IEEE C62.11-1987; Section 8.3

2.2.1 DISCHARGE VOLTAGE TEST DESCRIPTION

The discharge voltage tests serve to establish the relation between the voltage across the arrester terminals and the discharge current at several values of discharge current of specified waveshape.

2.2.2 DISCHARGE VOLTAGE TEST PROCEDURES

Discharge voltage measurements were made on new arresters randomly selected and subjected to an 8/20 µs current wave at 1.5, 3, 5 and 10 kA. Each test was performed in compliance with the referenced section of the ANSI/IEEE C62.11-1987 standard.

2.2.3 DISCHARGE VOLTAGE TEST EVALUATION

Table 4 presents the tabulated values for the maximum discharge voltage for each arrester rating.

The curves in Figure 2 show the maximum discharge voltage versus impulse current for 175, 350 and 650 volt arrester ratings.

Figures 3 & 4 show typical test current and measured voltage oscillograms for discharge voltage tests at 1.5 and 5 kA for a 175 volt Storm Trapper arrester.

TABLE 4
Protective Characteristics-Maximum values

Rating	MCOV	Maximum Discharge Voltage (kV crest) 8/20 µs Current Wave				
V rms	V rms	1.5 kA*	3 kA*	5 kA*	10 kA*	10 kA**
175	175	1.1	1.2	1.4	1.7	3.1
350	350	1.6	1.7	1.9	2.3	3.5
650	650	2.2	2.4	2.7	3.1	4.0

* 1.5" Leads
** 18" leads

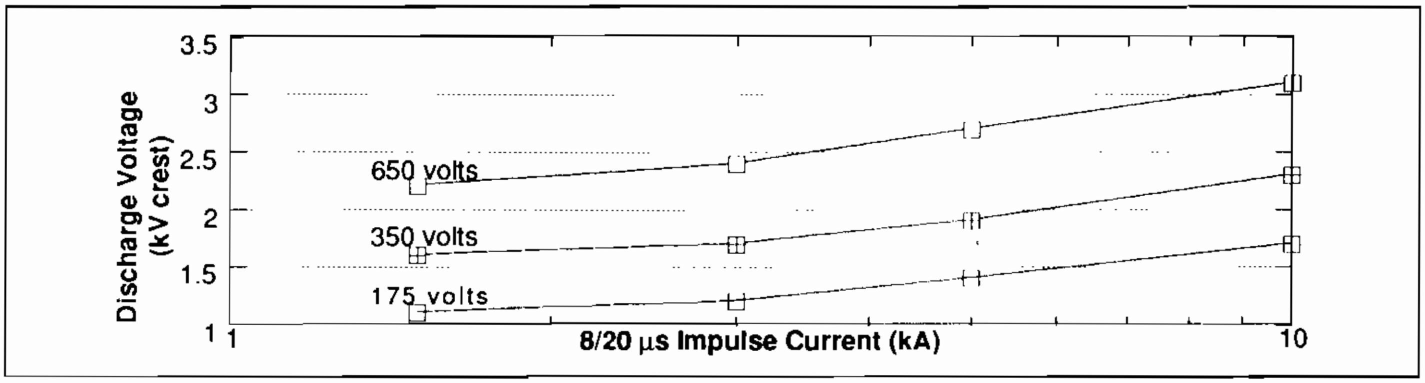

Figure 2
Maximum Discharge Voltage vs 8/20 Impulse Currents

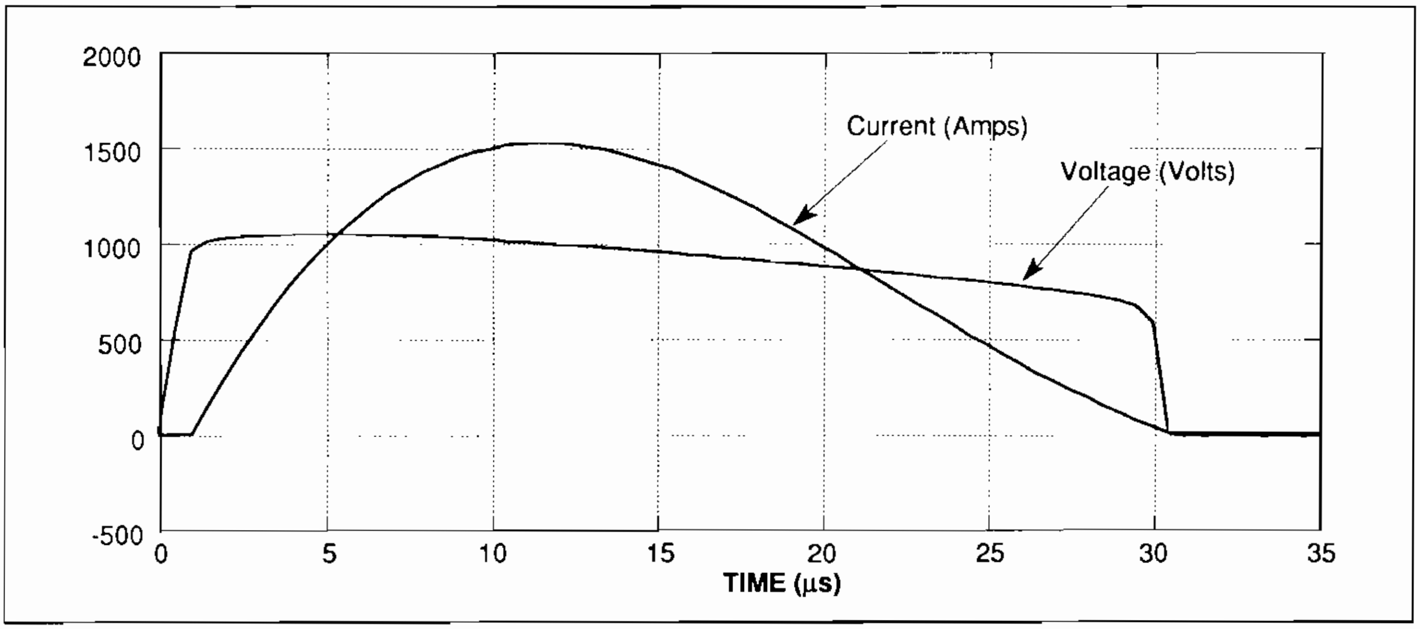

Figure 3
Typical 1.5 kA, 8/20 μs Discharge Voltage for a 175 volt Storm Trapper Arrester

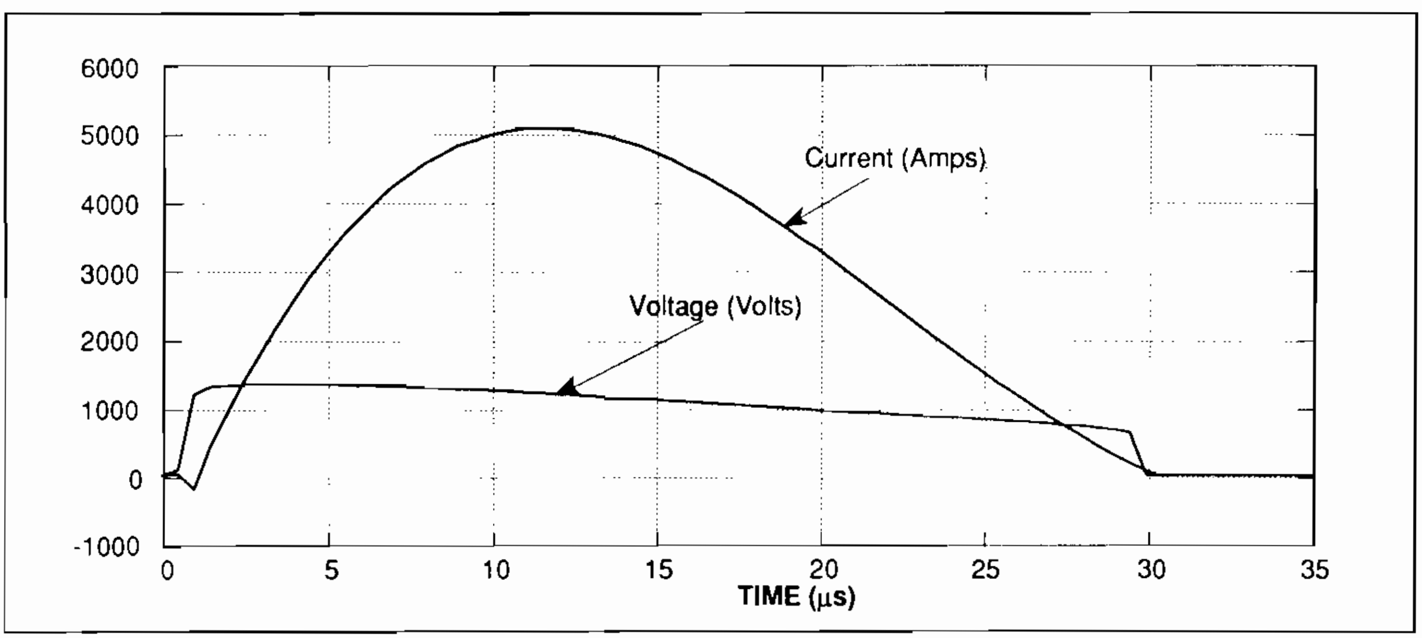

Figure 4
Typical 5 kA, 8/20 μs Discharge Voltage for a 175 volt Storm Trapper Arrester

2.3 Accelerated Aging Procedure ANSI/IEEE C62.11-1987; Section 8.5

2.3.1 ACCELERATED AGING TEST DESCRIPTION

The accelerated aging test procedure provides a method to simulate the long-term effect of voltage and temperature on design parameters significant to the arrester performance. It is not a test in itself and has no evaluation procedure. It is an aging procedure from which voltage ratios are obtained for use in duty-cycle and discharge current withstand tests to simulate the performance of arresters as if they had been in service for an extended period equivalent to the test period of 1000 hrs. at 115 °C.

2.3.2 ACCELERATED AGING TEST PROCEDURE

Two typical Storm Trapper Surge Arrester MOV elements were heated to 115 °C and energized at their MCOV for 1000 hrs. The maximum watts loss of each specimen was measured at MCOV and rated voltage during the first two to five hours of the test and at the conclusion of the 1000 hours of continuous testing.

2.3.3 ACCELERATED AGING TEST EVALUATION

If the voltage ratios determined during this test are greater than 1.0, then the voltages used for duty-cycle and discharge current withstand tests must be adjusted accordingly.

Since all final watts loss values were lower than the initial watts loss values the voltage ratios (Kc & Kr) are equal to 1.0, therefore no test voltage adjustments need to be made for duty-cycle or discharge current withstand tests.

Figure 6 illustrates the watts loss curves for the two Storm Trapper Surge Arrester MOV elements at MCOV for the 1000 hr. duration of the accelerated aging test. The data is also tabulated in Table 5. Note that in the case of the Storm Trapper Surge Arrester MCOV = Rating, therefore Kc = Kr = 1

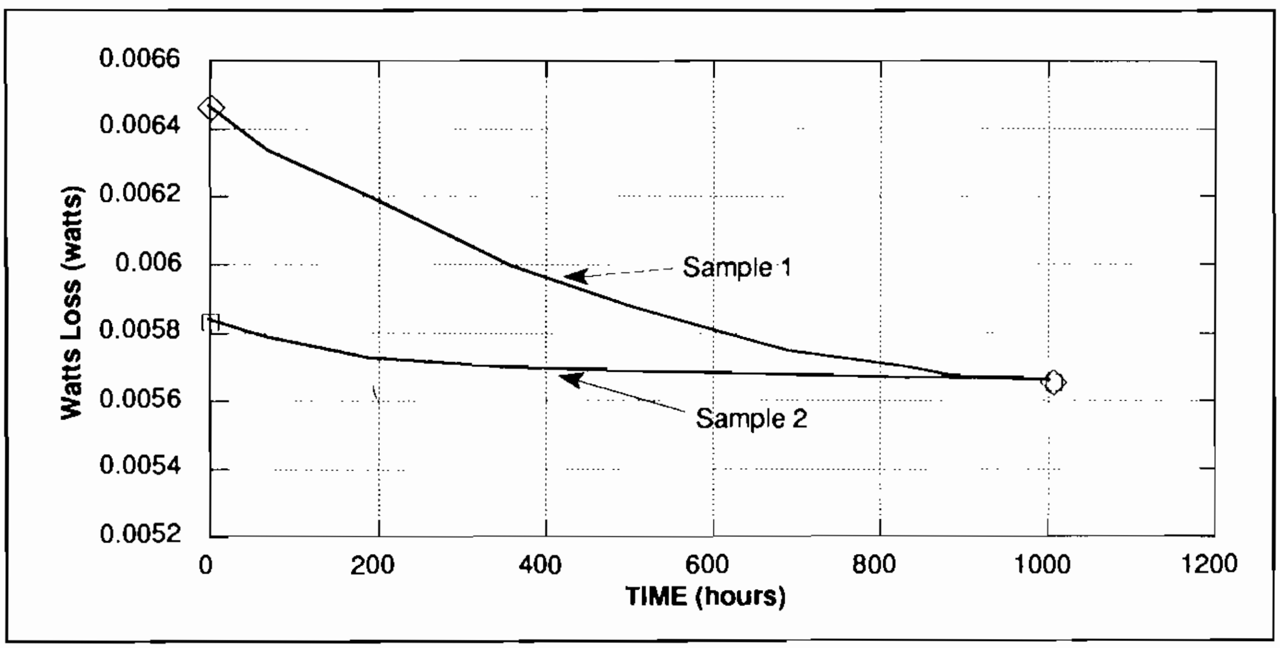

Figure 5
Typical Accelerated Aging Test at MCOV - Watts Loss vs. Time at 115 °C

TABLE 5
Accelerated Aging Test Summary at 115 °C

Test Voltage	MCOV		Rated	
Disk Number	1	2	1	2
Watts @ 2.5 hr.	.0065	.0058	.0065	.0058
Watts @ 1000 hr.	.0057	.0057	.0057	.0057
K Value	Kc=1		Kr=1	

Section 2.4 Discharge-Current Withstand Tests ANSI/IEEE C62.11-1987; Section 8.6

2.4.1 DISCHARGE-CURRENT WITHSTAND TEST DESCRIPTION

The discharge current withstand test, consisting of a high-current, short-duration test, serves to demonstrate the adequacy of the electrical, mechanical and thermal design of the arrester.

2.4.2 DISCHARGE-CURRENT WITHSTAND TEST PROCEDURES

2.4.2.1 High-Current, Short-Duration

Three 175 volt and three 650 volt Storm Trapper surge arresters were subjected to two 4/10 μs impulse current waves having 10 kA-crest amplitude. Within five minutes of the second discharge each arrester was energized at MCOV and the power monitored for thirty (30) minutes as prescribed in Section 8.6.1.2 of the referenced standard. An applied voltage greater than MCOV was not necessary since the voltage ratios determined in the accelerated aging tests were less than 1.0.

The discharge voltage of each arrester measured with a 1.5 kA-crest, 8/20 μs current wave was determined before and after the high-current, short-duration current withstand test.

2.4.3 DISCHARGE-CURRENT WITHSTAND TEST EVALUATION

2.4.3.1 High-Current, Short-Duration

The oscilligrams in Figures 6 and 7 show the typical pairs of current and voltage traces for the first and second high current, short-duration operations for a 175 volt Storm Trapper surge arrester.

The arresters pass this design test based on the performance criteria listed below:

1. Each arrester exhibited thermal recovery by demonstrating continuously decreasing power values over the thirty (30) minute monitoring after the current withstand test. This is illustrated in Table 6.
2. There was no evidence of physical or electrical deterioration caused by the current withstand tests.
3. The 1.5 kA (8/20 μs) discharge voltage changed by less than 10%.

TABLE 6
High-Current, Short-Duration Test Summary

Arrester	10 kA Discharge Voltage(4/10 μs)		Watts Loss @ MCOV	
Rating	1st shot	2nd shot	Initial	30 Min.
kV rms	kV crest	kV crest	Watts	Watts
175	2.7	2.7	.001	.001
175	2.7	2.8	.002	.001
175	2.7	2.7	.001	.001
650	2.9	3.1	.015	.009
650	2.9	3.0	.044	.026
650	2.4	2.5	.020	.010

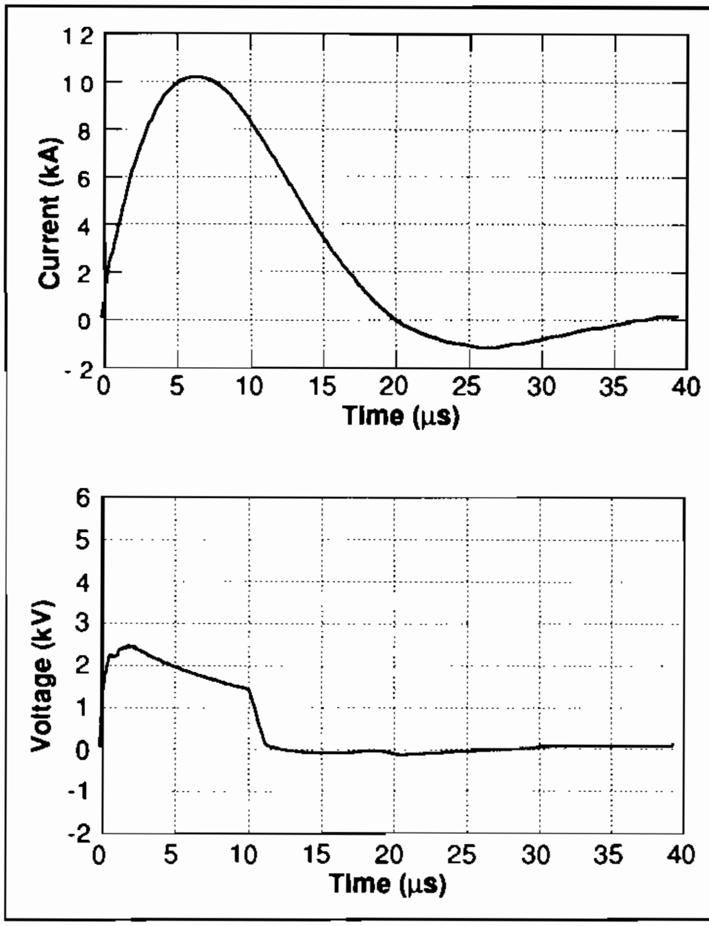

Figure 6
1st High-Current, Short Duration (10kA) Operation

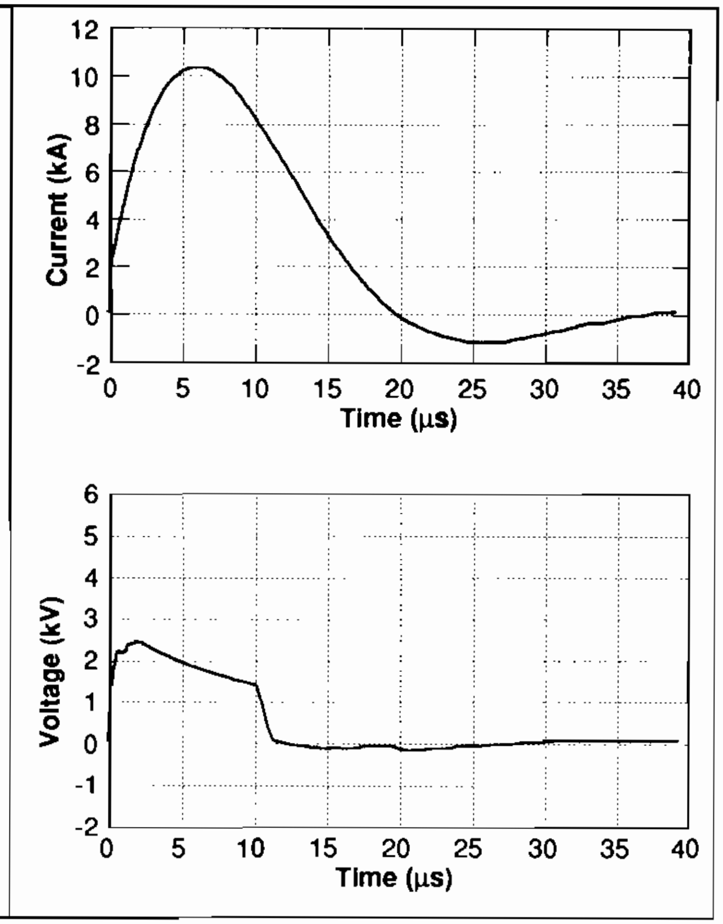

Figure 7
2nd High-Current, Short Duration (10kA) operation

2.5 Duty-Cycle Test

ANSI/IEEE C62.11-1987; Section 8.7

2.5.1 DUTY-CYCLE TEST DESCRIPTION

The duty-cycle test serves to establish the ability of the arrester to discharge impulse current repeatedly while energized at duty-cycle voltage and thermally recover at MCOV.

2.5.2 DUTY-CYCLE TEST PROCEDURE

Three 175 volt and three 650 volt storm trapper Surge Arresters were subjected to twenty (20) operations of a 1.5 kA- crest, 8/20 µs current wave while being continuously energized at rated power frequency voltage. The current wave initiaion was approximately 60 degrees before the crest of the power frequency voltage and was applied at one minute intervals.

Following the twentieth operation each section was heated to 60 °C,energized at rated voltage and subjected to two 1.5 kA, 8/20 µs current waves with a one minute interval between operations. After the last two 1.5 kA operations the arrester remained energized at rated voltage and the power was monitored for thirty (30) minutes.

The 1.5 kA-crest, 8/20 µs discharge voltage was measured before the operating duty-cycle test and again when the sections had returned to ambient temperature subsequent to the operating duty-cycle test.

2.5.3 DUTY-CYCLE TEST EVALUATION

Figures 8 and 9 show typical oscillograms of the corresponding pairs of the current and voltage traces after the first and twentieth 1.5 kA duty-cycle operations respectively for a 650 volt arrester.

Figures 10 and 11 present similar data for the last two 1.5 kA duty-cycle operations.

The data presented in the above figures is also in Table 7 for both the 1.5 kA duty-cycle tests.

The arresters pass this design test based on the performance criteria listed below:

1. Each section exhibited thermal recovery by demonstrating continuously decreasing power values over the thirty (30) minute monitoring after the operating duty-cycle test. This is illustrated in Table 7.

2. There was no evidence of physical or electrical deterioration caused by the operating duty-cycle test.

3. The 1.5 kA (8/20 μs) discharge voltages measured after the duty-cycle test remained essentially unchanged from the initial values.

TABLE 7
Operating Duty-Cycle Test Summary

Arrester Rating	Leakage Current After Specified 1.5 kA Discharge Peak Current (μA)					
kV rms	Initial	1st Discharge	20th Discharge	21st Discharge	22nd Discharge	After 30 min.
175	58.6	56.0	61.2	67.4	69.0	51.2
175	56.8	56.2	64.2	63.2	69.8	54.4
175	58.2	56.4	62.8	68.0	70.6	57.6
650	167	164	179	188	188	167
650	144	141	148	159	164	143
650	141	139	144	155	160	141

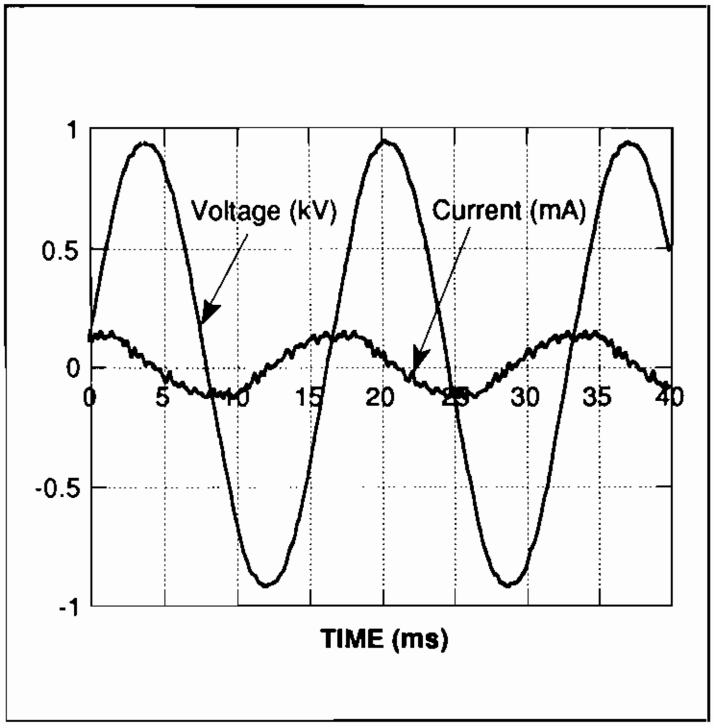

Figure 8
1st Operating Duty-Cycle Operation

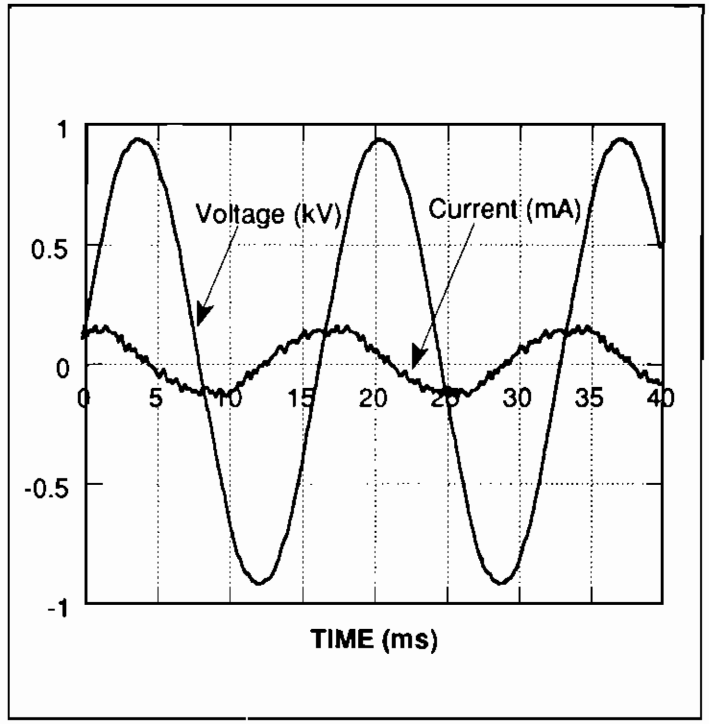

Figure 9
20th Operating Duty-Cycle Operation

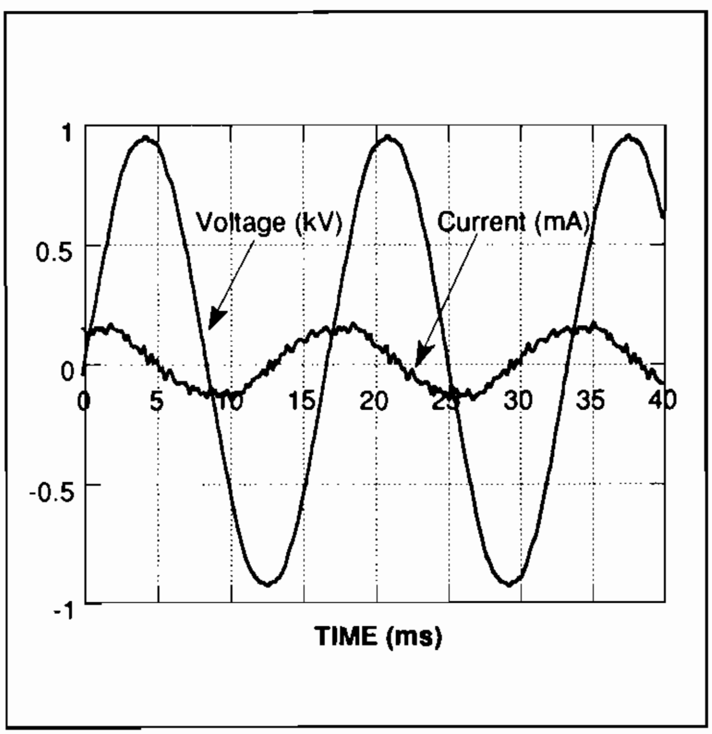

Figure 10
21st Operating Duty-Cycle Operation

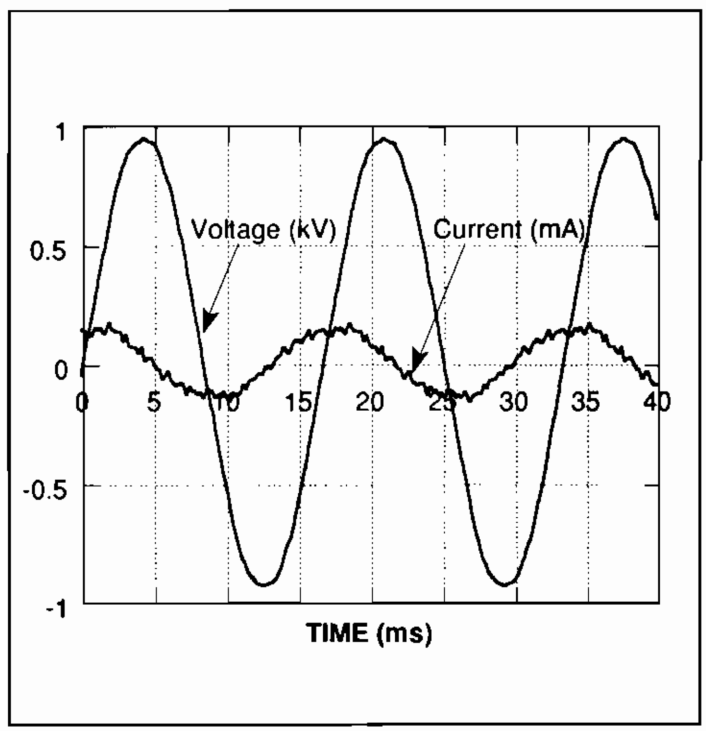

Figure 11
22nd Operating Duty-Cycle Operation