

Product Assurance North Carolina

**Qualification Testing of the
Surge Protective Device Everprotect 40-380**

**CTR-01-023
Revision 0**

August 28, 2001

Tested by: John Kizis
Engineering /Science Tech
Product Assurance

Prepared by: Sherif Kamel
Technical Support and Test Manager

Approved by: Phil McCartney
Quality Manager

TABLE OF CONTENTS

1.	TEST BY VISUAL INSPECTION AND INSTALLATION ON APPROVAL.....	3
2.	TEST OF EVERPROTECT 40-380 IDENTIFICATION.....	3
3.	TEST OF AIR DISTANCE AND CREEPAGE DISTANCE.....	3
4.	TEST OF PROTECTIVE LEVEL WITH NORMAL DISCHARGE CURRENT	4
4.1	DETERMINATION OF THE V-I CHARACTERISTICS	4
4.2	TEST OF PROTECTIVE LEVEL	9
5.	TEST WITH INCREASED DISCHARGE CURRENT 40 kA, 8/20 ms.....	9
6.	MAXIMUM SURGE CURRENT RATING.....	10
7.	OPERATING DUTY TEST.....	11
8.	LONG DURATION CURRENT IMPULSE TEST (ENERGY HANDLING TEST).....	13
9.	ACCELERATED AGING TEST.....	15

1. TEST BY VISUAL INSPECTION AND INSTALLATION ON APPROVAL

The Everprotect 40-380 is attached to the ground or the neutral conductor using a 1/2-20 threaded stud. The high voltage conductor is connected to the high voltage electrode using a 1/4-20 screw.

2. TEST OF EVERPROTECT 40-380 IDENTIFICATION

The following data are given on the name plate in a well legible way (name plate color is white with writing in black characters):

- Description of the product : Transient Voltage Surge Suppressant
- Type name of the manufacturer : Keyitec
- Suppressed Voltage Rating : 1200 V
- Year of manufacture : week/year
- Trade Mark : Everprotect 40-380

3. TEST OF AIR DISTANCE AND CREEPAGE DISTANCE

The following table shows a comparison between the requirements on the air distance and the creepage distance between the active parts and the ground according to E DIN VDE 0675 / part 6 (table 3) and the actual values of the device.

Rated Voltage (V)	Air distance (mm)		Creepage distance for insulating material (mm)	
	Set	Actual	Set	Actual
300 to 600	5.5	20	11	20

Table 1: Creepage and air distance as measured on the Surge Protective Device and as stipulated by the standard.

4. TEST OF PROTECTIVE LEVEL WITH NORMAL DISCHARGE CURRENT

The tests were carried out on three new units of Everprotect 40-380.

4.1 Determination of the V-I characteristics

The residual voltage at DC current in the range from 0.1 mA to 5 mA was measured on three new units. The results are shown in Table 2.

Sample	0.1 mA	0.5 mA	1 mA	5 mA
U3	674.1	743.3	760.8	818.8
U4	657.3	724.3	753.4	802.8
U5	674.8	741.2	759.1	814.2

Table 2: DC voltage-current characteristics of the surge protective device samples.

The residual voltage test with lightning impulse current was made on the same samples with positive impulse current in the range 1 kA to 100 kA (8/20 μ s except for the 65 kA which is 4/10 μ s). Table 3 shows these results.

Sample	1 kA	2.5 kA	5 kA	10 kA	20 kA	40 kA	65 kA	100 kA
U3	1174.9	1257.1	1360.1	1487.0	1648.1	1898.1	2355.1	2641.9
U4	1136.6	1220.3	1312.9	1433.5	1590.5	1833.4	2116.1	2867.2
U5	1153.7	1234.9	1327.8	1452.2	1615.3	1862.4	2218.4	2765.4

Table 3: Impulse voltage-current characteristics of the surge protective device samples.

Figures 1 to 8 show the diagrams of the measurements.

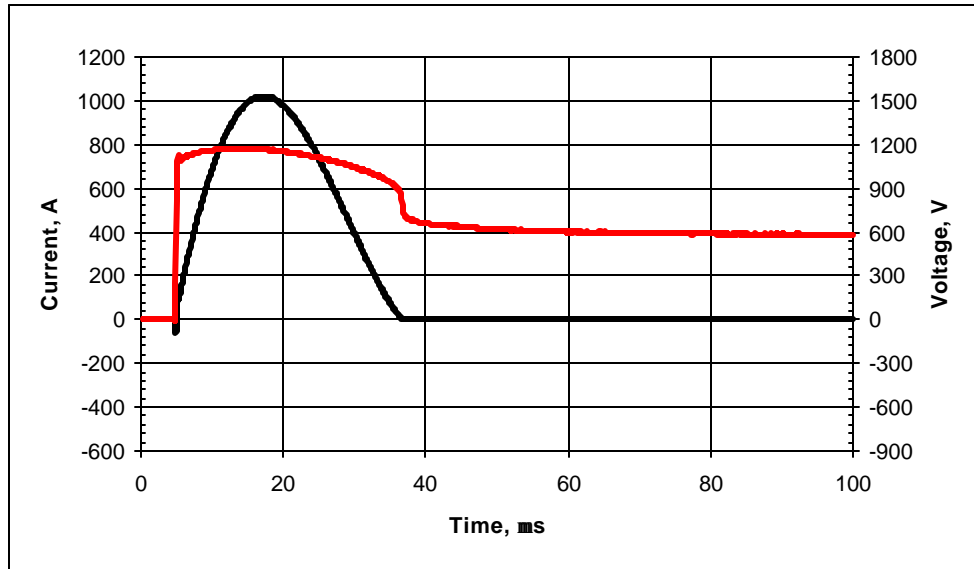


Figure 1: Voltage and current oscillograms ($I = 1 \text{ kA}$).

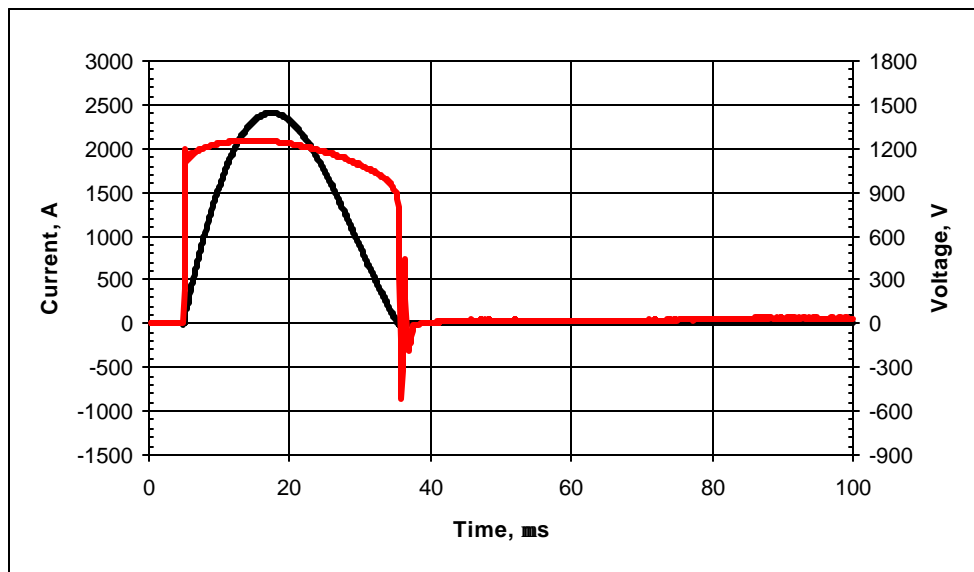


Figure 2: Voltage and current oscillograms ($I = 2.5 \text{ kA}$).

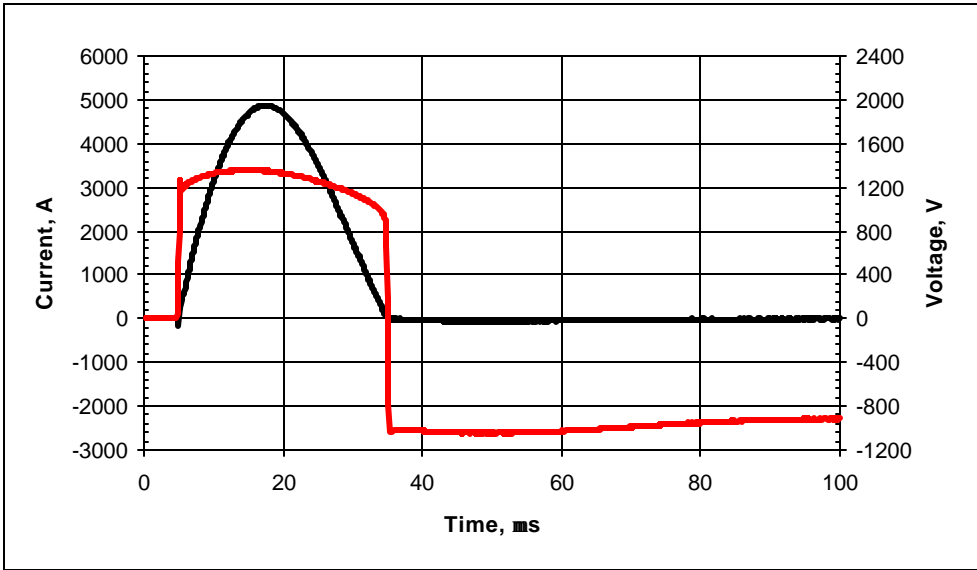


Figure 3: Voltage and current oscillograms ($I = 5 \text{ kA}$).

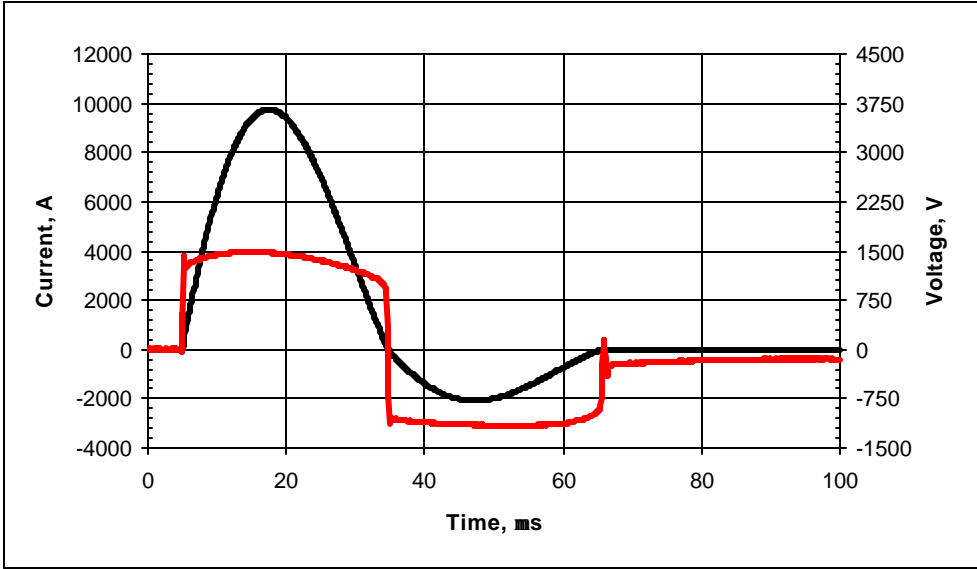


Figure 4: Voltage and current oscillograms ($I = 10 \text{ kA}$).

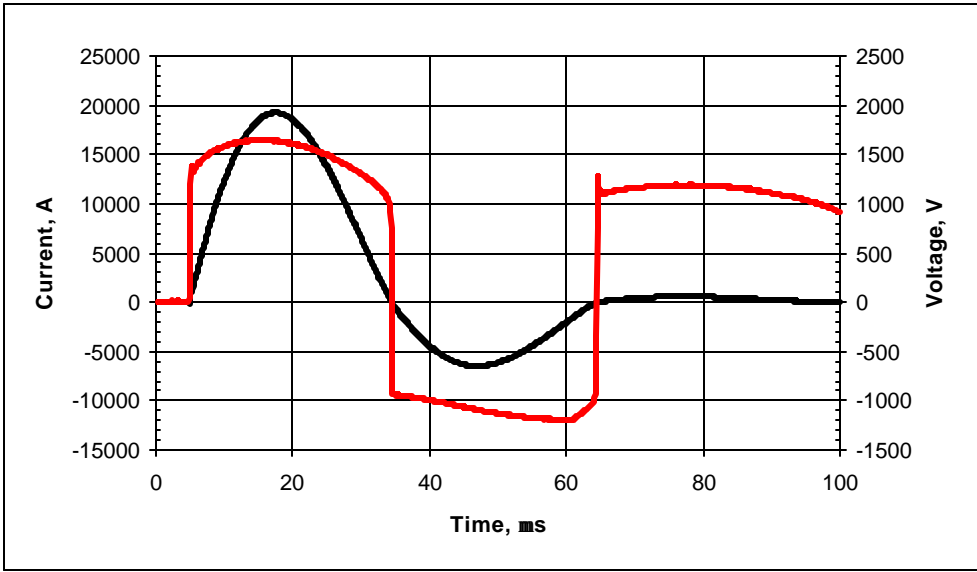


Figure 5: Voltage and current oscillograms ($I = 20 \text{ kA}$).

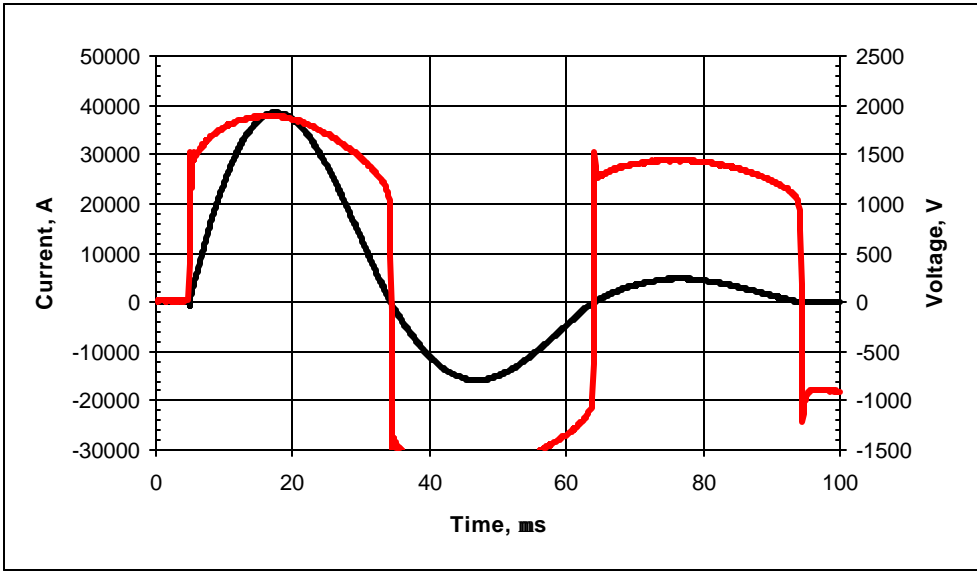


Figure 6: Voltage and current oscillograms ($I = 40 \text{ kA}$).

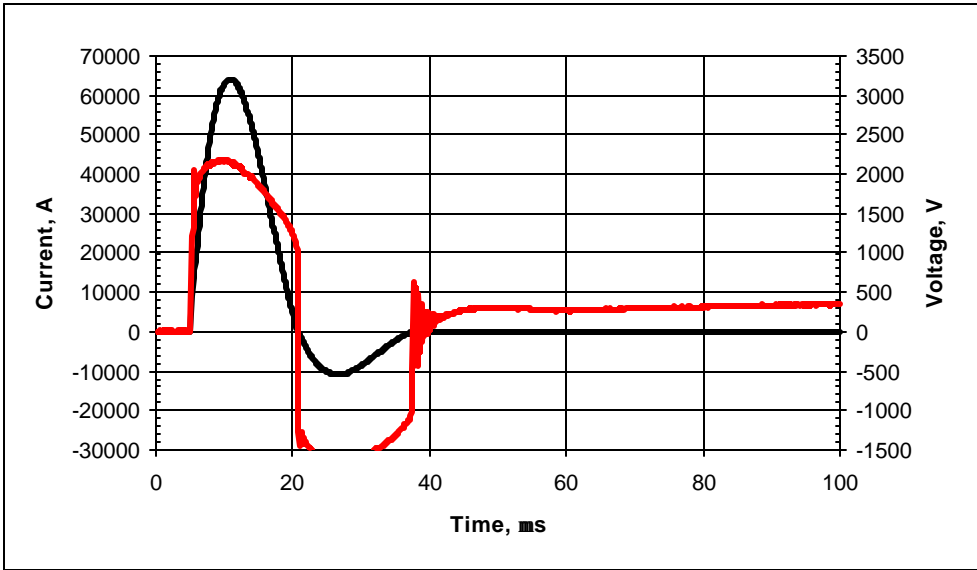


Figure 7: Voltage and current oscillograms ($I = 65 \text{ kA}$).

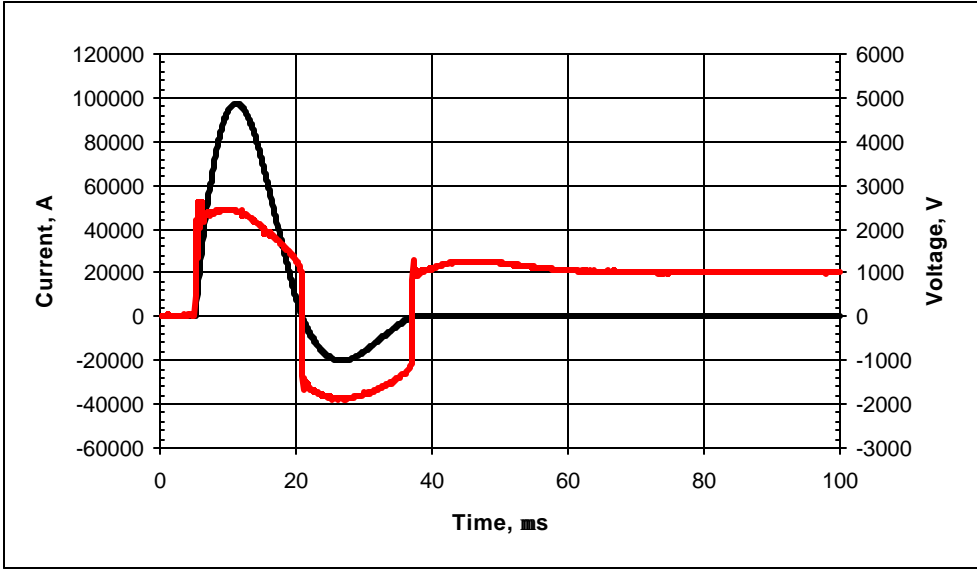


Figure 8: Voltage and current oscillograms ($I = 100 \text{ kA}$).

Figure 9 shows the voltage/ current characteristics under DC, 8/20 μ s and 4/10 μ s impulse.

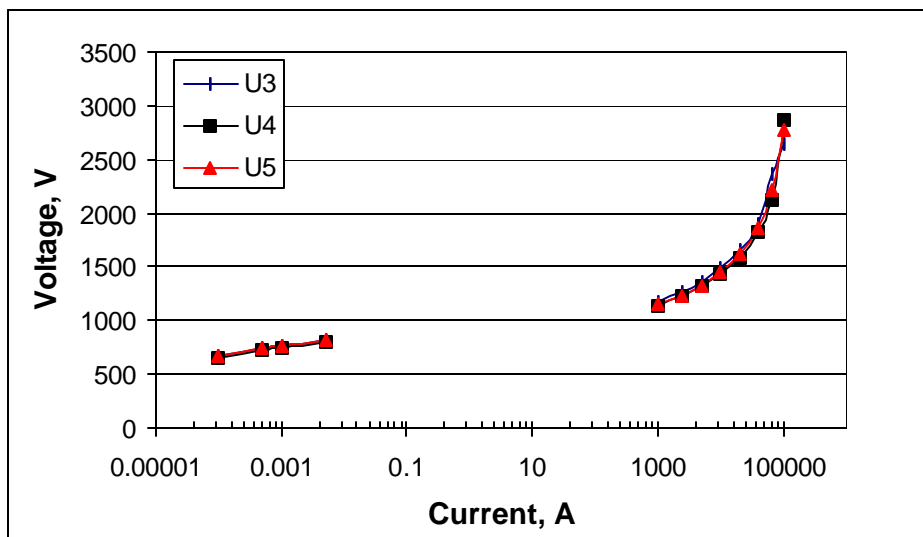


Figure 9: Voltage / current characteristics under DC, 8/20 μ s and 4/10 μ s impulse.

4.2 Test of protective level

The protective level was determined with 3 positive current impulses at 10 kA (8/20 μ s). The results are shown in Table 4.

Sample	Impulse #1	Impulse #2	Impulse #3
	Voltage, V		
U3	1482.1	1489.6	1491.2
U4	1437.7	1444.0	1443.4
U5	1461.9	1467.5	1473.0

Table 4: Residual voltage at 10 kA, 8/20 μ s.

5. TEST WITH INCREASED DISCHARGE CURRENT 40 kA, 8/20 ms

Each of the samples previously used in Test #4 above, was subjected to 3 lightning impulse currents with positive polarity at 4 times the nominal discharge current level (10 kA, 8/20 μ s).

Table 5 shows the residual voltage measured across the samples during this test.

Sample	Impulse #1	Impulse #2	Impulse #3
	Voltage, V		
U3	1911.8	1895.7	1912.6
U4	1838.3	1832.9	1840.8
U5	1879.4	1879.8	1892.8

Table 5: Residual voltage at 40 kA, 8/20 μ s.

6. MAXIMUM SURGE CURRENT RATING

Three new Everprotect 40-380 units were each subjected to a single impulse of peak value of 100 kA, 8/20 μ s. The maximum change in the residual voltage at under 6 kV/3 kA (1.2/50 μ s/ 8/20 μ s combination waveform) should not exceed $\pm 10\%$ (according to NEMA LS1 standard). The test was performed by an independent test lab (IITRI – R&B Laboratory – Report # 00_0565_4).

Table 6 shows a summary of the maximum surge current rating test results.

	Sample H027			Sample H030			Sample H034		
	Before (V)	After (V)	Change %	Before (V)	After (V)	Change %	Before (V)	After (V)	Change %
U_{res}	1254	1254	0.0	1254	1254	0.0	1254	1284	2.4

Table 6: Change of reference voltage and nominal residual voltage due to the high current impulse.

The maximum change of the residual voltage was 1.0% (permissible $\pm 10\%$).

Test results:

The samples passed the test. The maximum surge rating of Everprotect 40-380 is 100 kA.

7. OPERATING DUTY TEST

The test was made on three new Everprotect 40-380 units according to the procedure outlined in the IEC 99-4 standard. The initial measurements, conditioning and the measurements after the test were all made at ambient temperature.

Test procedure :

- Initial measurement of reference voltage (U_{ref}) at the reference current ($I_{ref} = 5 \text{ mA}$) and residual voltage (U_{res}) at the nominal current ($I = 10 \text{ kA}$, $8/20 \mu\text{s}$) were carried out.
- Conditioning with 20 lightning impulses of 10 kA , $8/20 \mu\text{s}$, 1 minute apart, with applied continuous operating voltage U_c (150 V).
- Application of a 100 kA , $4/10 \mu\text{s}$ lightning impulse.
- Heating of sample to $+65 \text{ }^\circ\text{C}$.
- With the sample temperature at $+60 \pm 3 \text{ }^\circ\text{C}$, application of a 100 kA , $4/10 \mu\text{s}$ lightning impulse followed within 100 ms by the continuous operating voltage U_c .
- Continuous registration of the Everprotect 40-380 temperature with the applied voltage (for 30 min.) to demonstrate thermal and electrical stability.
- Final measurement of reference voltage (U_{ref}) at the reference current ($I_{ref} = 5 \text{ mA}$) and residual voltage (U_{res}) at the nominal current ($I = 10 \text{ kA}$, $8/20 \mu\text{s}$) were carried out.

Figure 10 shows a schematic diagram of the test sequence.

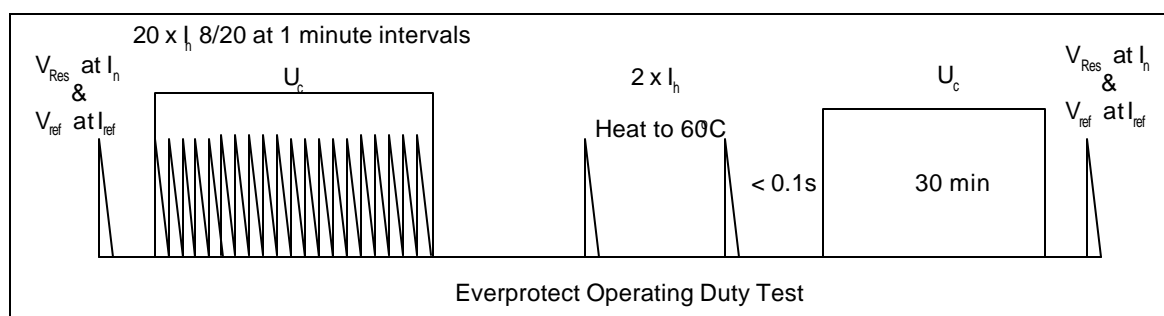


Figure 10: Schematic diagram of the operating duty test as performed on the Everprotect 40-380.

Table 7 shows a summary of the operating duty test results.

	Sample T28			Sample T29			Sample T30		
	Before (V)	After (V)	Change %	Before (V)	After (V)	Change %	Before (V)	After (V)	Change %
U_{ref}	863.3	844.6	-2.2	884.9	772.4	-12.7	878.7	861.2	-2.0
U_{res}	1533.2	1541.7	0.6	1528.8	1538.0	0.6	1457.0	1464.9	0.5

Table 7: Change of reference voltage and nominal residual voltage due to the operating duty test.

The thermal stability was reliably reached (Figure 11). The maximum change of the residual voltage is 0.6% (permissible $\pm 5\%$).

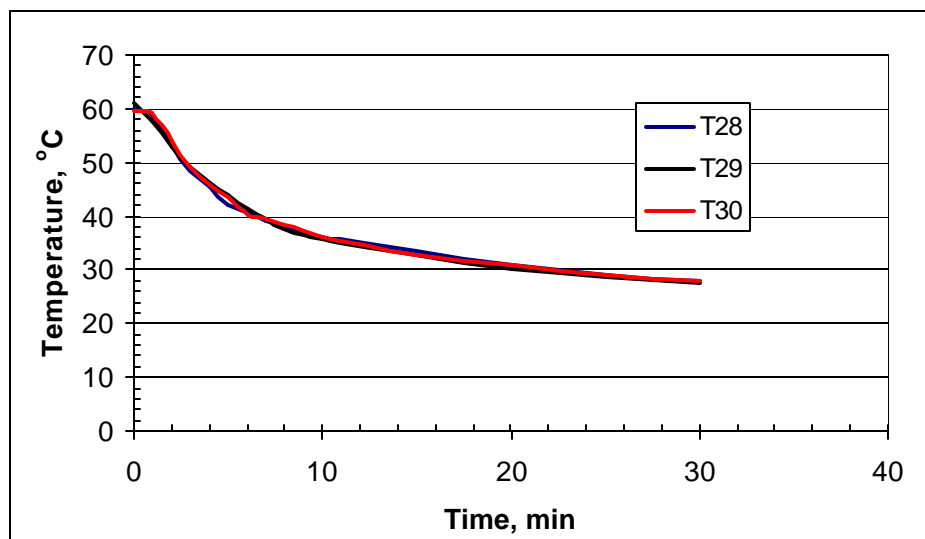


Figure 11: Variation of the Surge Protective Devices' temperature with time after the second 100 kA impulse.

There were no punctures, sparkovers or any other mechanical damages during the test.

Test results:

The samples passed the test.

8. LONG DURATION CURRENT IMPULSE TEST (ENERGY HANDLING TEST)

The test was made on three new units at ambient temperature according to the procedure outlined in the IEC 99-4 standard. Each sample was subjected to 20 rectangular current impulses 500A/2000 μ s, 60 seconds apart.

The reference voltage (U_{ref}) at $I_{ref} = 5$ mA, and the rated residual voltage at 10 kA, 8/20 μ s were measured in each case before and after the test.

Figure 12 shows a schematic diagram of the test sequence.

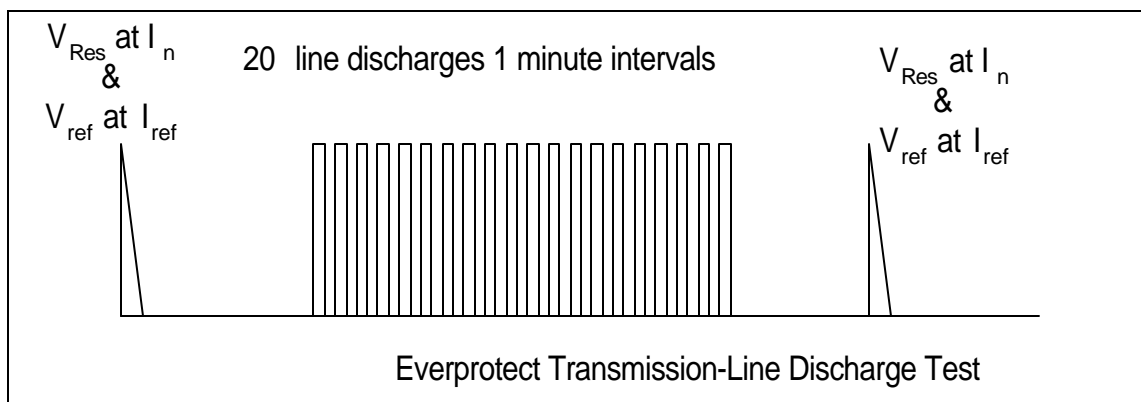


Figure 12: Schematic diagram of the long duration current impulse test as performed on the Everprotect 40-380. Each line discharge is a 500 A/2000 μ s impulse.

Table 8 shows a summary of the test results.

		R90	R92	R95
Reference voltage	Before (V)	867.9	864.7	882.8
	After (V)	866.8	868.8	895.0
	Change (%)	-0.1	0.5	1.4
Residual voltage	Before (V)	1495.5	1486.0	1543.8
	After (V)	1488.0	1474.8	1537.1
	Change (%)	-0.5	-0.8	-0.4
Rectangular impulse current (A/ μ s) number of impulses		500/2000 20		
Rect. Impulse #1	I (A)	474	499	500
	V (V)	1100	1106	1132
Rect. Impulse #20	I (A)	498	502	496
	V (V)	1122	1128	1152
Energy per pulse (J)		>1240	>1300	>1330

Table 8: Summary of the long duration current impulse test results.

There were no sparkovers, punctures or other mechanical damages during the test.

The reference voltage and the nominal residual voltage changed by a maximum of 1.4% (permissible $\pm 5\%$).

Test results:

The samples passed the test.

9. ACCELERATED AGING TEST

The test was carried out on 3 fully assembled Everprotect 40-380 units according to the procedure outlined in the IEC 99-4 standard.

- Test temperature : 115 °C
- Medium : Air
- Test duration : 1000 hours
- Test voltage : 480 V r.m.s.

The power loss in each of the three samples is monitored continuously during the test. The power loss/time characteristics shows a continuous negative slope after reaching a maximum about 2hours into the test (Figure 13).

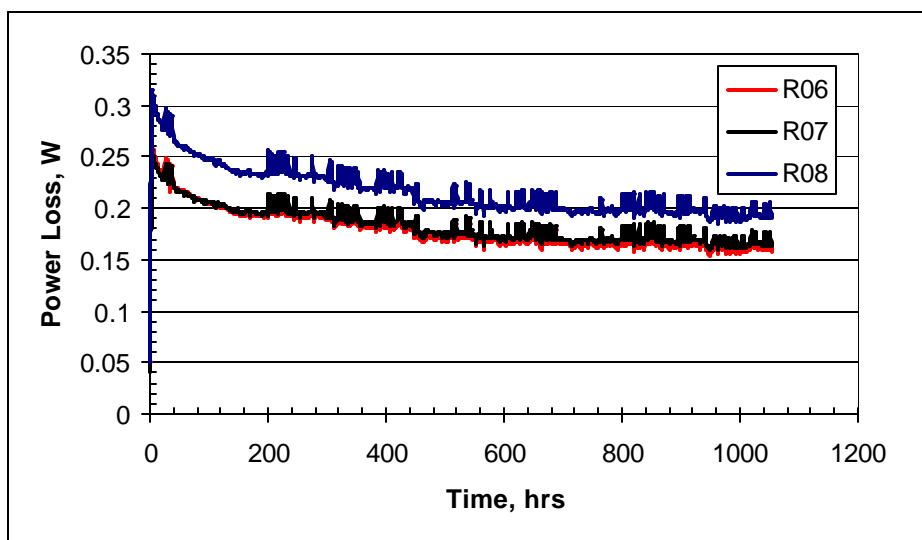


Figure 13: Power loss/time characteristics during the accelerated aging procedure.