HUBBELL® POWER SYSTEMS, INC.

IEC Type Test Report
Report No. AT-A1019834
Type PDV 100 Polymer Arrester
10,000 A Line Discharge Class 1

This report records the results of this type test made on 10 kA Class 1 arresters rated 3 thru 48 kV in accordance with IEC Standard 60099-4 Ed. 1.1 (1998-08), "Surge arresters - Part 4: Metal-oxide surge arresters without gaps for a.c. systems."

Type tests performed on 10 kA Class 1 arresters demonstrate full compliance with the relevant clauses of the referenced standard and apply to all Hubbell 10 kA Class 1 arresters of this design manufactured and assembled at the following ISO 9001:2008 certified Hubbell locations:

Hubbell Power Systems
1850 Richland Avenue, East
Aiken, South Carolina
29801

Hubbell Electric (Wuhu) Company, Ltd.
Exports Processing Zone, No 68
North Jiuhua Road, Wuhu City
Anhui Province, PR China

The above locations manufacture, assemble, and test utilizing manufacturing, quality, and calibration procedures developed from Hubbell Engineering Department Specifications. Engineering Department Specifications are controlled by Arrester Business Unit design engineering in the USA.

Dennis W. Lenk

D. W. Lenk
Principal Engineer
Date: 12/13/2012

Separate reports provide details of each test, according to the following table:

Report No.	Description	Clause	Issue date
AT-A1/014253	Insulation Withstand Test	5.1 and 7.2	12/12/2012
AT-A1/013767	Residual Voltage Test	5.3 and 7.3	12/12/2012
AT-A1/013769	Long Duration Current Impulse Withstand Test	5.8 and 7.4	12/12/2012
AT-A1/013770 AT-A1/013772	Operating Duty Test -Accelerated Aging Test	5.9 and 7.5 7.5.2	12/12/2012
AT-A1/013771	Power Frequency Voltage Versus Time	5.10	12/12/2012
GPS-A1/019204	Pressure Relief Test	5.11	12/12/2012
AT-A1/015254	Partial Discharge Test	5.4	12/12/2012
MP-A1/015443	Disconnector Operation Test	7.6.3	12/12/2012

CESI

REPORT

APPROVED B2038735

Client Hubbell Power Systems (The Ohio Brass Company)
Wadsworth, OH (USA)

Subject Application criteria to extend the results of type testing according to IEC 60099-4 Ed. 1.1 (1998-08) to the complete series of surge arresters type PDV-100

Order B2037318

Notes Revision 1

N. of pages 11 **N. of pages annexed** -

Issue date December 12, 2012

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Reference documents not annexed:

Test Certificate of Complete Type Test - CESI AT-A1019834

REVISIONS HISTORY

Revision number	Date	Protocol	List of modifications and/or modified paragraphs
0	2008/04/28	A8012463	First Issue
1	2012/12/14	B2038735	Revision of calculated maximum residual voltage for all specified currents and wave shapes listed in table 3 according to the new values declared by the Manufacturer as specified in table 1

1 FOREWARD

The present report is to be considered as reference document to the CESI Test Certificate of Complete Type Test reference A1019834hat is relevant to test type certification according to IEC 60099-4 (1998) of metal-oxide surge arresters having the following characteristics:

Manufacturer:	Hubbell Power Systems (The Ohio Brass Company)
Type:	PDV-100
Rated voltage:	3 kV_{rms} to 48 kV_{rms}
Continuous operating voltage:	2.55 kV_{rms} to 39.0 kV_{rms}
Nominal discharge current:	10 kA_{pk}
Line discharge class:	1
Pressure relief rated current	20 kA_{rms}
Reference current:	5 mA_{pk}
Housing material:	ESP™ (Silicone Alloy)
Housing profile	A and B (1)

Note (1) Housing profile of type A and B differs for shed diameter and inclination angle. The wall thickness is the same.

Aim of this report is to clarify the conditions for which the tests performed on specific samples shall be regarded as demonstrating compliance with the requirements of the reference Standard for all the surge arresters of the series.

2 CHARACTERISTICS OF THE SURGE ARRESTERS OF THE SERIES AS SPECIFIED BY THE MANUFACTURER

Designation [kV_{rms}]	Housing profile type A/B	Rated voltage [kv_{rms}]	Continuous operating Voltage [kV_{rms}]	Minimum reference voltage (1) [$kV_{pk}/\sqrt{2}$]	Maximum residual voltage (2) [kV_{pk}]	Surge arrester length [mm]	No. of mechanical units
PDV-100	A	3	2,55	3,23	10,1	140	one
PDV-100	A	6	5,10	6,46	19,1	140	one
PDV-100	A	9	7,65	9,69	27,0	140	one
PDV-100	A	10	8,40	10,64	30,0	140	one
PDV-100	A	12	10,2	12,92	34,3	140	one
	B	12	10,2	12,92	34,3	216	one
PDV-100	B	15	12,7	16,09	42,8	216	one
PDV-100	B	18	15,3	19,38	52,7	216	one
PDV-100	A	21	17,0	21,54	60,0	280	two
	B	21	17,0	21,54	60,0	216	one
PDV-100	A	24	19,5	25,84	68,5	280	two
	B	24	19,5	25,84	68,5	432	two
PDV-100	B	27	22,0	29,01	77,1	432	two
PDV-100	B	30	24,4	32,18	85,5	432	two
PDV-100	A	36	29,0	38,76	106,0	420	three
	B	36	29,0	38,76	106,0	432	two
PDV-100	B	39	31,5	40,92	120,0	432	two
PDV-100	B	45	36,5	48,27	128,4	648	three
PDV-100	A	48	39,0	51,68	138,3	560	four
	B	48	39,0	51,56	138,3	648	three

Table 1: Characteristics of the surge arresters of the series

Note (1):
Minimum reference voltage at reference current as specified and published by the Manufacturer and proved in the routine tests

Note (2):
Maximum residual voltage at nominal discharge current as specified and published by the Manufacturer and proved in the routine tests

3 TEST PERFORMED

In order to prove compliance of the surge arrester types PDV-100 to IEC 60099-4 (1998) the following tests have been performed:

Description of tests	No. Standard / Sub- clause
Insulation withstand test	IEC 60099-4 / 5.1 and 7.2
Residual voltage test	IEC 60099-4 / 5.3 and 7.3
Long duration current impulse withstand test	IEC 60099-4 / 5.8 and 7.4
Operating duty test	IEC 60099-4 / 5.9 and 7.5
- Accelerated ageing test	IEC 60099-4 / 7.5.2
Power frequency voltage versus time test	IEC 60099-4 / 5.10
Pressure relief test	IEC 60099-4 / 5.11
Partial discharge test	IEC 60099-4 / 5.4
Disconnector operation test	IEC 60099-4 / 7.6.3

4 EXTENSION OF THE VALIDITY OF THE TESTS CARRIED OUT ON SPECIFIC SAMPLES TO ALL THE ARRESTER OF THE PDV-100 PRODUCT

4.1 Insulation withstand test

Surge arresters with the two types of housing profile have been considered separately:

- Surge arresters with housing profile type A
The test has been performed on one sample of the longest surge arrester housing (type PDV-100 rated 48 kV), representing at the same time the surge arrester with the highest specific voltage stress per unit length within the series.
The test has been performed on the most critical surge arresters and therefore it shall be regarded as demonstrating compliance with the requirements of the reference Standard for all the surge arresters of the series with housing profile type A.

- Surge arresters with housing profile type B

The test has been performed on one sample of the longest surge arrester housing (type PDV-100 rated 48 kV). In addition the test has been performed on one housing of the surge arrester having the highest specific voltage stress per unit length (type PDV-100 rated 21 kV).
The test has been performed on the most critical surge arresters and therefore it shall be regarded as demonstrating compliance with the requirements of the reference Standard for all the surge arresters of the series with housing profile type B.

4.2 Residual voltage test

The test has been performed on three samples of surge arrester type PDV-100 rated 12 kV.
Purpose of the test is to obtain the maximum residual voltage for all specified currents and wave shapes, assuming as reference the maximum residual voltage at nominal discharge current specified by the manufacturer and proved in the routine tests.
Relevant data obtained by the test are given in table 2 below and and fig. 1 on page 8.
The maximum residual voltage for all specified currents and wave shapes calculated for all the surge arresters of the PDV-100 series are given in table 3 on page 7.

Current wave shape	Peak current [kA]	Maximum residual voltage [p.u.]
steep current impulse	10	1,067
lightning current impulse	5	0,920
	10	1,000
	20	1,113
switching current impulse	0,125	0,715
	0,500	0,760

Table 2: Maximum residual voltage for all specified currents and waveshapes in p.u. of the maximum residual voltage at nominal discharge current

Rated voltage [kv_{rms}]	Housing profile type A/B		Max. residual voltage at steep current impulse [kV_{pk}]	Max residual voltage at switching impulse [kV_{rms}]		Max. residual voltage at lightning impulse [kV_{pk}]		
		Multi. factor	1,067	0,715	0,760	0,920	1,000	1,113
3	A		10,78	7,22	7,67	9,29	10,1	11,24
6	A		20,38	13,66	14,52	17,57	19,1	21,26
9	A		28,81	19,30	20,52	24,84	27,0	30,05
10	A		32,01	21,45	22,8	27,6	30,0	33,39
12	A/B		36,60	24,52	26,07	31,55	34,3	38,17
15	B		45,67	30,60	32,52	39,38	42,8	47,63
18	B		56,23	37,68	40,05	48,48	52,7	58,65
21	A		64,02	42,9	45,60	55,2	60,0	66,78
21	B		64,02	42,9	45,60	55,2	60,0	66,78
24	A/B		73,09	48,98	52,06	63,02	68,5	76,24
27	B		82,27	55,13	58,60	70,93	77,1	85,81
30	B		91,23	61,13	64,98	78,66	85,5	95,16
36	A		113,10	75,79	80,56	97,52	106	117,98
36	B		113,10	75,79	80,56	97,52	106	117,98
39	B		128,04	85,80	91,2	110,4	120,0	133,56
45	B		137,00	91,81	97,58	118,12	128,4	142,91
48	A		147,57	98,88	105,11	127,24	138,3	153,93
48	B		147,57	98,88	105,11	127,24	138,3	153,93

Table 3: Calculated maximum residual voltage for all specified currents and wave-shapes

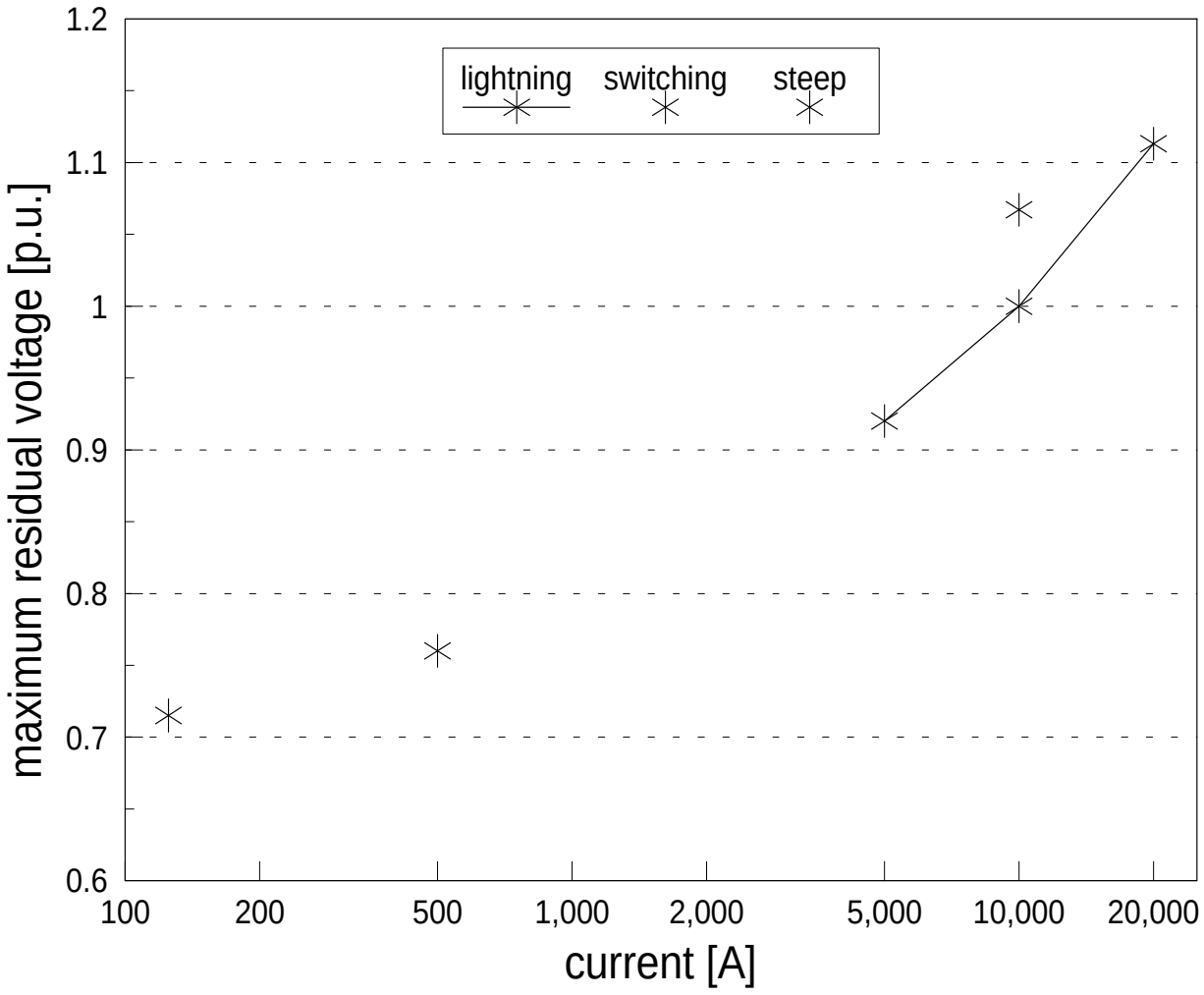

Fig 1: Maximum residual voltage for all specified currents and wave-shapes in p.u. of the maximum residual voltage at nominal discharge current

4.3 Long duration current impulse withstand test

The test has been performed on three samples of surge arrester type PDV-100 rated 12 kV fitted with bracket/disconnector.

The corrected rated voltage U_r' of the samples has been calculated as:

$U_r' = K_r * U_{ref} = 0.975 * U_{ref}$

Where:

U_{ref}	is the reference voltage measured on the sample
K_r	is the highest ratio $U_r/U_{ref\ min}$ of all the surge arresters of the series

The test has been performed in the most severe conditions. Therefore it shall be regarded as demonstrating compliance with the requirements of the reference Standard for all the surge arresters of the series.

4.4 Operating duty test

The test has been performed on three samples of surge arresters type PDV-100 rated 12 kV fitted with bracket/disconnector. The samples have been suitably modified with additional thermal insulation in order to satisfy the thermal equivalency for all the surge arrester of the series type PDV-100 (for both housing profile types A and B).

The corrected rated voltage U_r' and the corrected continuous operating voltage U_c' of the samples have been calculated as:

$U_r' = K_r * U_{ref} = 0.975 * U_{ref}$

$U_c' = K_c * U_{ref} = 0.789 * U_{ref}$

Where:

U_{ref}	is the reference voltage measured on the sample
K_r	is the highest ratio $U_r/U_{ref\ min}$ of all the surge arresters of the series
K_c	is the highest ratio $U_c/U_{ref\ min}$ of all the surge arresters of the series

The test has been performed in the most severe conditions. Therefore it shall be regarded as demonstrating compliance with the requirements of the reference Standard for all the surge arresters of the series.

4.4.1 Accelerated ageing test

The test has been performed on three sample of resistor blocks surrounded by the same material as in the actual surge arrester.

The test voltage U_{ct} has been calculated as:

$U_{ct} = K_c*(1 + 0.15*L) * U_{ref} = Ka * U_{ref}$

Where:

U_{ref}	is the reference voltage measured on the sample
K_c	is the ratio $U_c/U_{ref\ min}$
(1+0.15*L)	is the correction factor related to voltage unbalance
L	is the surge arrester length in meter

The factor K_a has been calculated for all the surge arresters of the series. The highest value found was 0.830. The test has been conducted at a test voltage equal U_{ct} = 0.830*U_{ref}

The test has been performed in the most severe conditions. Therefore the test covers all the surge arresters of the series.

4.5 Pressure relief test

The test has been performed on two samples of the longest mechanical units (type PDV-100 rated 21 kV - housing type B) with shorting wire suitably placed along the resistor stack. The test has been performed on the most critical samples and therefore it shall be regarded as demonstrating compliance with the requirements of the reference Standard for all the surge arresters of the series. Thus tests confirmed 20 kA_{rms} symmetrical short circuit withstand capability of PDV-100 product series.

4.6 Power frequency voltage versus time test

Purpose of the test is to verify the temporary-overvoltage withstand (TOV) curve submitted by the manufacturer. The curve submitted by the manufacturer has been numbered by CESI as A1/018528 and annexed to the relevant test report. The temporary overvoltage withstand level is expressed in per unit of the continuous operating voltage.
The test has been performed on three samples of surge arresters type PDV-100 rated 12 kV. The samples have been suitably modified with additional thermal insulation in order to satisfy thermal equivalency with all the surge arrester of the series PDV-100 (for both housing profile type A and B).

The corrected continuous operating voltage U_c' of the samples have been calculated as:

$U_c' = K_c * U_{ref} = 0.789 * U_{ref}$

where:

U_{ref}	is the reference voltage measured on the sample
K_c	is the highest ratio $U_c/U_{ref\ min}$ of all the surge arresters of the series

The test has been performed in the most severe conditions. Therefore the temporary overvoltage curve submitted by the manufacturer has been verified for all the surge arresters of the series.

4.7 Partial discharge test

The test has been performed on one sample of the longest surge arrester (type PDV-100 rated 48 kV - housing profile type B) and one sample of the surge arrester having the highest voltage specific stress per unit length (type PDV-100 rated 21 kV - housing profile type B). The measured partial discharge level was less than 1 pC for both samples.
The test has been performed on the most critical samples and therefore it shall be regarded as demonstrating compliance with the requirements of the reference Standard for all the surge arresters of the series.

4.8 Disconnector operation test

The test has been performed on fifteen disconnectors.
The prospective test voltage applied for the test was less than the lowest rated voltage of all the arresters of the series. The test has been performed in the most severe conditions and therefore it shall be regarded as demonstrating compliance with the requirements of the reference Standard for