# IEC Type Test Report

## Report Number: EU1164-HR-00.7
## Polymer Distribution
## 5 kA Class Arresters

This report records the results of type tests made on PDV-65™ arresters in accordance with IEC Standard 60099-4, 2004-05 “Surge arresters - Part 4: Metal-oxide surge arresters without gaps for a.c. systems”, except as noted.

Type tests performed on 5 kA Class arresters demonstrate full compliance with the relevant clauses of the referenced standard and apply to all Hubbell 5 kA Class 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
Principal Engineer

Fayaz Khatri
Design Engineering Supervisor

Date: 02/27/2017

**SEPARATE REPORTS PROVIDE DETAILS OF EACH TEST, ACCORDING TO THE FOLLOWING TABLE:**

| Report No. | Description | Clause | Issue date |
|---|---|---|---|
| EU1164-HR-01.6 | Insulation Withstand Tests on the Arrester Housing | 8.2 | 8/27/12 |
| EU1164-HR-02.4 | Residual Voltage Tests | 8.3 | 6/30/16 |
| EU1164-HR-03.4 | Long Duration Current Impulse Withstand Tests | 8.4 | 6/30/16 |
| EU1164-HR-04.4 | Accelerated Aging Procedure | 8.5.2 | 6/30/16 |
| EU1164-HR-05.4 | Heat Dissipation Behaviour of Test Samples | 8.5.3 | 6/30/16 |
| EU1164-HR-06.4 | High Current Impulse Operating Duty Tests | 8.5.4 | 2/27/17 |
| EU1164-HR-07.3 | Tests on Arrester Disconnectors | 8.6 | 8/27/12 |
| EU1164-HR-08.3 | Power Frequency Voltage versus Time Characteristics | Annex D | 8/27/12 |
| EU1164-HR-09.2 | Short Circuit | Annex N | 8/27/12 |
| EU1164-HR-10.3 | Bending Moment | 10.8.11 | 6/30/16 |
| EU1164-HR-11.2 | Salt Fog- Series A-1000 Hours | 10.8.14 | 8/27/12 |

# IEC Type Test Report

Report Number:  EU1164-HR-01.6
Polymer Distribution
5 kA Class Arresters

Insulation Withstand Tests On
The Arrester Housing
IEC Clause 8.2

This report records the results of this type test made on PDV-65™ arresters in accordance with IEC Standard 60099-4, 2004-05 "Surge arresters - Part 4: Metal-oxide surge arresters without gaps for a.c. systems."

To the best of our knowledge and within the usual limits of testing practice, tests performed on these arresters demonstrate compliance with the relevant clauses of the referenced standard.

Dennis W. Lenk
Principal Engineer

Fayaz Khatri
Design Engineering Supervisor

Date: 08/27/2012

# IEC Type Test Report

## INSULATION WITHSTAND TESTS ON THE ARRESTER HOUSING

## IEC CLAUSE 8.2

Table 1 summarizes polymer housing minimum leakage and strike distances for each arrester rating, and 60 Hz and impulse withstand requirements for each housing size. In all cases, the actual withstand values of each arrester housing exceed the minimum values specified in the Standard.

**TABLE 1. INSULATION WITHSTAND TEST RESULTS**

| Ur Rated kVrms | Uc COV kVrms | IEC 5 kA Class Cat # | Arr Ht mm | Min Leak mm | Min Strike mm | Recommended Clearances | | Wt. kg | IEC Reqd Imp (kVc) | Actual Imp WS Arr Only kVc | 500 amp SS IR kVc | IEC reqd wet WS kVc | Actual 10 sec wet WS Arr Only kVc |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Ph-Ph (mm) | Ph-Gnd (mm) | | | | | | |
| 3 | 2.55 | 214003 | 140 | 390 | 155 | 127 | 76 | 1.6 | 13.7 | 125 | 8.5 | 9 | 34 |
| 6 | 5.1 | 214005 | 140 | 390 | 155 | 137 | 86 | 1.6 | 27.5 | 125 | 17.1 | 18 | 34 |
| 9 | 7.65 | 214008 | 140 | 390 | 155 | 152 | 102 | 1.6 | 39 | 125 | 24.4 | 26 | 34 |
| 10 | 8.4 | 214009 | 140 | 390 | 155 | 157 | 107 | 1.6 | 41 | 125 | 25.6 | 27 | 34 |
| 12 | 10.2 | 214010 | 140 | 390 | 155 | 191 | 140 | 1.7 | 50.5 | 125 | 31.3 | 33 | 34 |
| 15 | 12.7 | 214013 | 216 | 645 | 245 | 216 | 165 | 2.5 | 63.7 | 180 | 39.9 | 42 | 50 |
| 18 | 15.3 | 214015 | 216 | 645 | 245 | 241 | 191 | 2.5 | 74.1 | 180 | 46.4 | 49 | 50 |
| 21 | 17 | 214017 | 216 | 645 | 245 | 254 | 203 | 2.6 | 80.6 | 180 | 60.5 | 64 | 50 |
| 24 | 19.5 | 214020 | 277 | 780 | 285 | 305 | 254 | 3 | 101 | 210 | 62.7 | 66 | 65 |
| 27 | 22 | 214022 | 354 | 1035 | 360 | 330 | 279 | 4 | 114 | 230 | 71.2 | 75 | 82 |
| 30 | 24.4 | 214024 | 354 | 1035 | 360 | 356 | 305 | 4.1 | 122 | 230 | 76.1 | 81 | 82 |
| 36 | 29 | 214029 | 430 | 1290 | 450 | 419 | 368 | 4.8 | 145 | 250 | 90.4 | 96 | 100 |

# IEC Type Test Report

Report Number:  EU1164-HR-02.5

Polymer Distribution

5 kA Class Arresters

Residual Voltage Test

This report records the results of this type test made on Type PDV65 5 kA Class arresters in accordance with IEC Standard 60099-4, ED.3.0, 2014-06 “Surge arresters - Part 4: Metal-oxide surge arresters without gaps for a.c. systems.”

Dennis W. Lenk
Principal Engineer

Fayaz Khatri
Design Engineering Supervisor

Date: 06/07/2018

# Residual Voltage Tests
# IEC Clause 8.3

**Sample Preparation**

Residual voltage tests were performed on three 32mm x 42.8 mm MOV discs.

**Test Procedure**

The following tests were performed on each sample. Each sample was allowed to cool to ambient temperature between discharges.

1. Steep Current Impulse Residual Voltage Test: 1/2 μs, 5 kA;
2. Lightning Impulse Residual Voltage Test: 8/20μs, 1.5, 3, 5, 10, 20, 40 kA;
3. Switching Impulse Residual Voltage Test: 30-100/60-200 μs and 500 A.

**Test Results**

Each of the three test samples was subjected to a 5 kA, 1/2 μs steep current impulse with and without an aluminum disc with the same geometry of the MOV disc. The difference in the residual voltages is the inductive drop across the MOV disc. Figures 1a and 1b show the oscillograms of the measured FOW residual voltage discharges of Sample 1 without and with an aluminum spacer, respectively.

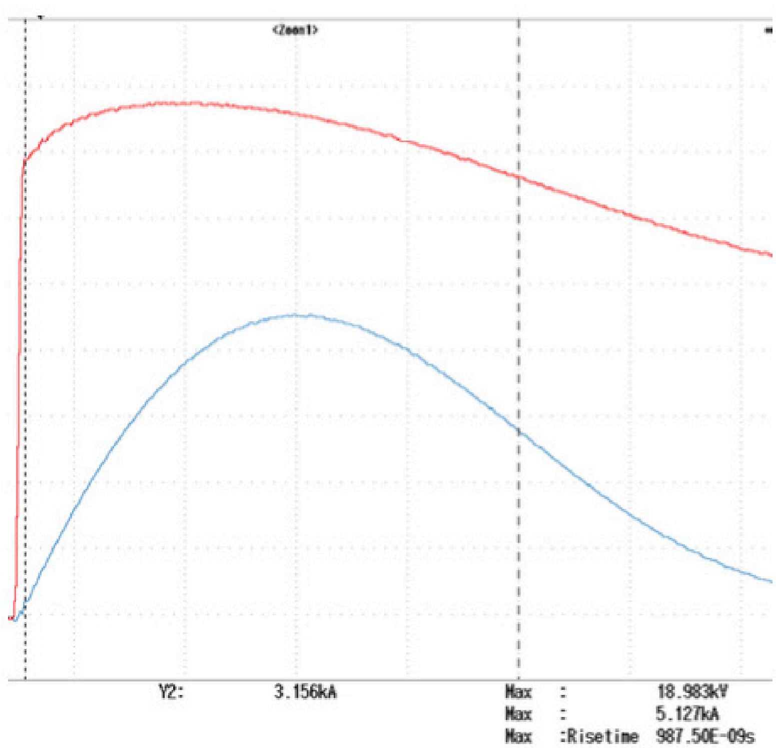



Figure 1a: Sample 1, 5.127 kA, 18.983 kV w/o Aluminum spacer.

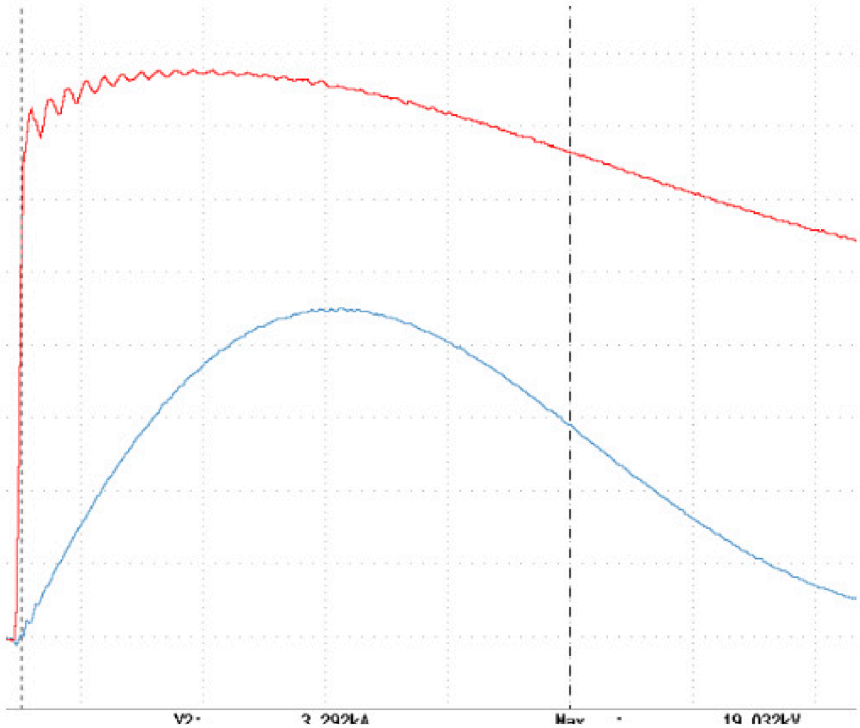


Figure 1b: Sample 1, 5.105 kA, 19.032 kV with Aluminum spacer.

Each sample was then subjected to 1.5, 3, 5, 10, 20 and 40 kA lightning surge impulses. Figures 2 thru 7 show the oscillogram for each of the referenced 8/20 discharge current levels on Sample 1.

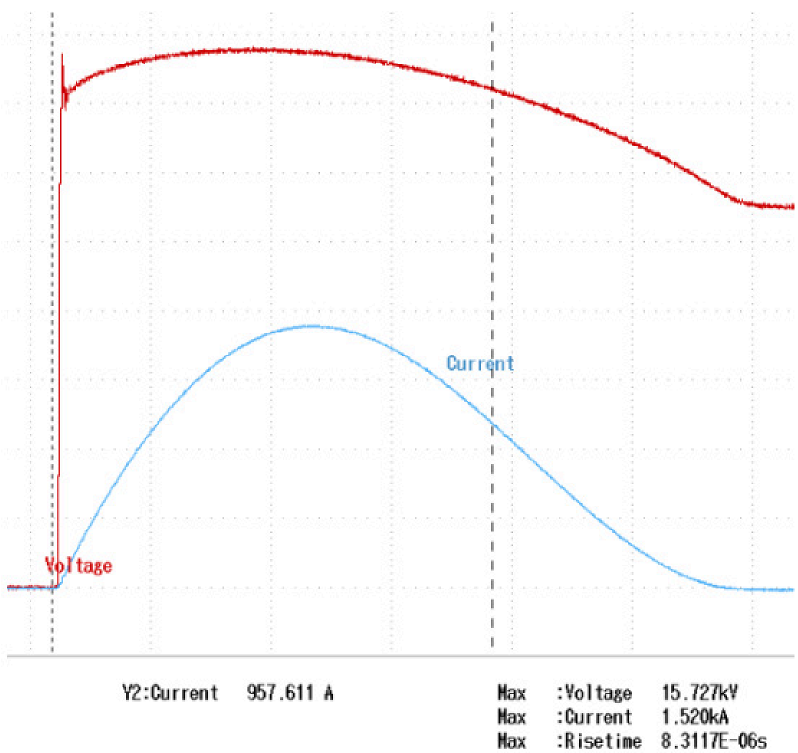



Figure 2: Sample 1, 1.520 kA, 15.727 kV

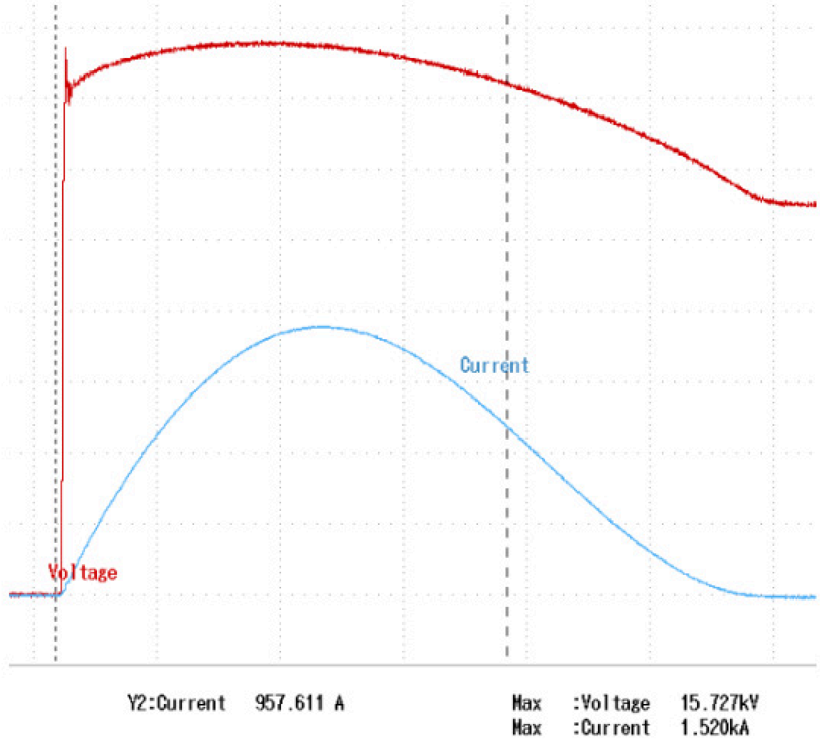



Figure 3: Sample 1 , 3.206 kA, 17.018 kV.

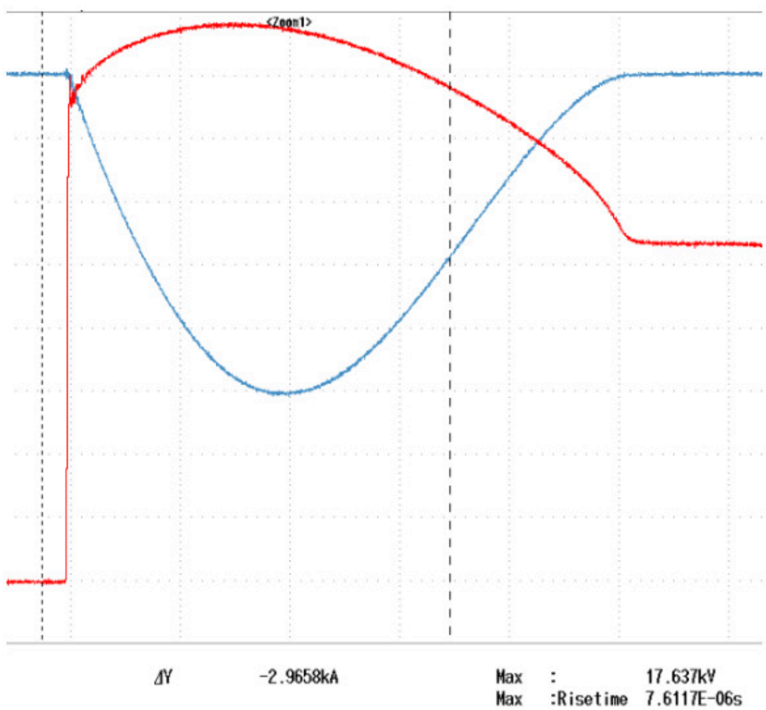



Figure 4: Sample 1 , 5.110 kA, 17.637 kV

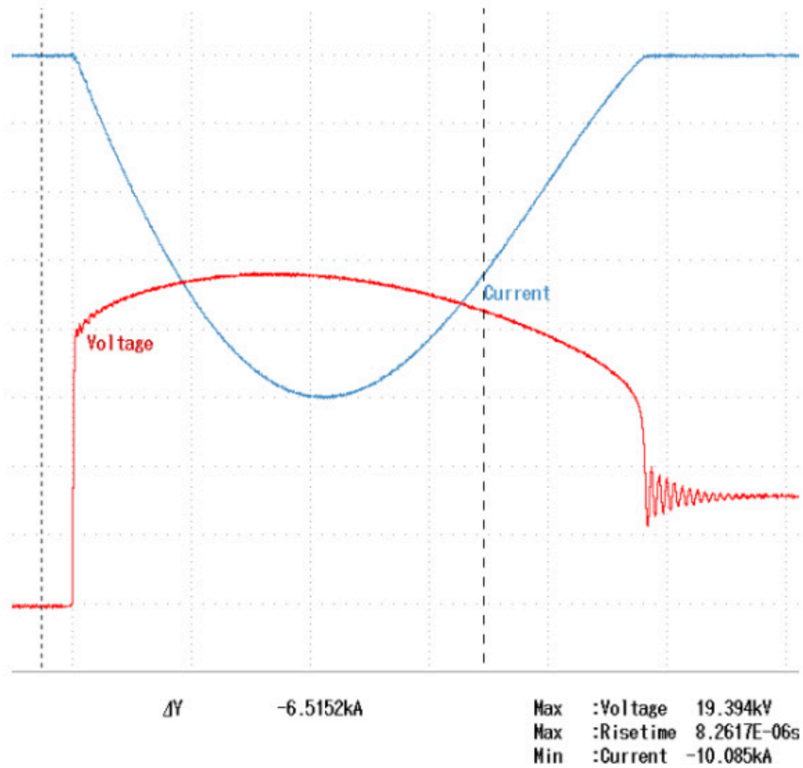



Figure 5: Sample 1 , 10.085 kA, 19.394 kV

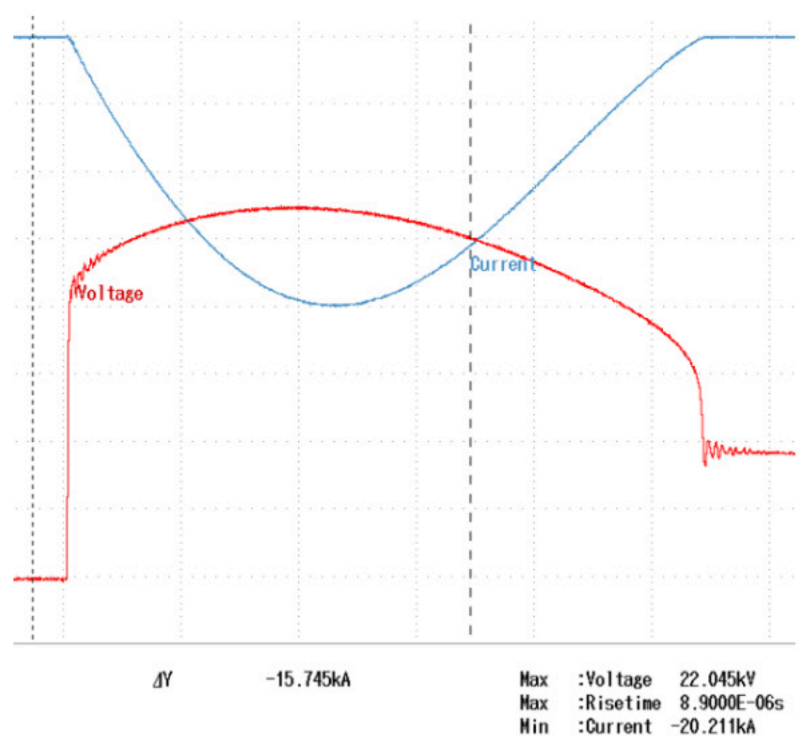



Figure 6: Sample 1 , 20.211 kA, 22.045 kV

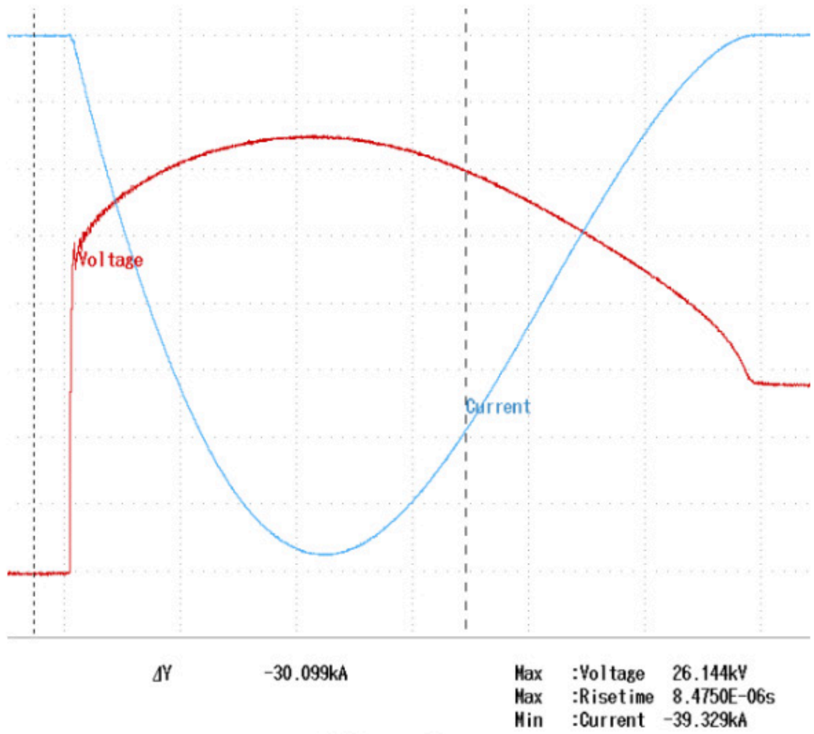



Figure 7: Sample 1 , 39.329 kA, 26.144kV

Each sample was then subjected to 500 A switching surge impulse. Figure 8 shows the oscillogram of the switching surge discharge of Sample 2.

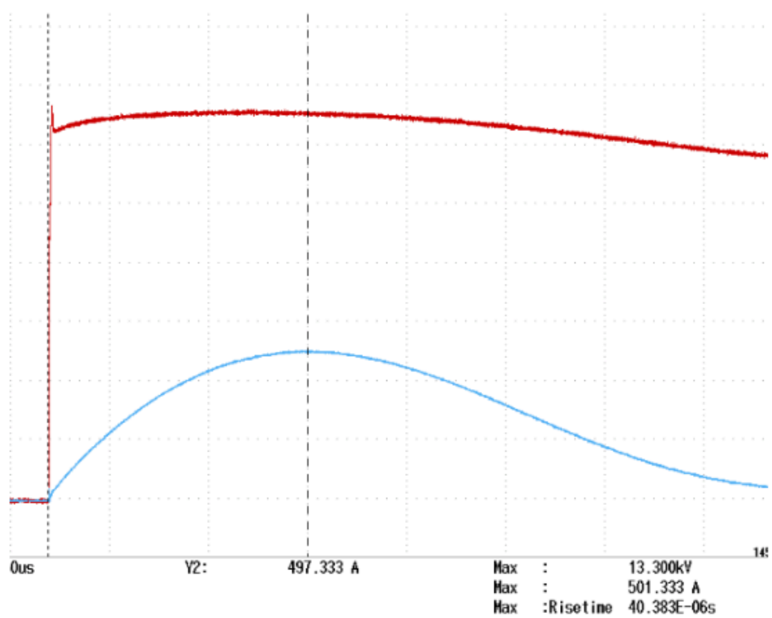



Figure 8: Sample 1, 501 A, 13.30 kV

Table 1 shows the 5 kA residual voltage of the steep front wave measured on the three test samples with and without the aluminum disc. Per section 8.3.2 of IEC 60099-4, Ed. 3.0, 2014 Standard, since measured spacer inductive drop is less than 2% of the MOV disc recorded FOW residual voltage, the inductive drop of the MOV disc can be disregarded.

**TABLE 1: MEASUREMENT OF INDUCTIVE EFFECT ON MOV DISCS**

| Sample No. | I (kA) | IR (KVpk) with Al disc | IR (KVpk) w/o Al disc | Al disc L(di/dt) effect (kV) | Recorded MOV disc FOW voltage drop (kV) |
|---|---|---|---|---|---|
| 1 | 5 | 19.032 | 18.983 | 0.049 | 18.934 |
| 2 | | 19.114 | 18.999 | 0.115 | 18.884 |
| 3 | | 18.983 | 18.95 | 0.033 | 18.917 |

Table 2 summarizes the design factors used to extrapolate the 1.5 through 40 kA 8/20 residual voltage, the 500 amp switching surge residual voltage, and MOV disc 0.5 microsecond FOW residual voltage. The highest factor for each wave shape is shown bolded and is multiplied by the 5 kA residual voltage of each rating to develop the family of residual voltage values. Table 3 summarizes the residual voltage values measured and claimed for each arrester rating.

**TABLE 2: RESIDUAL VOLTAGE TEST**

| Impulse Current (kA) | Wave Shape (μs) | Discharge Voltage (kVpk) | | | Discharge Voltage Ratio (IR/5 kA IR) | | |
|---|---|---|---|---|---|---|---|
| | | Sample 1 | Sample 2 | Sample 3 | Sample 1 | Sample 2 | Sample 3 |
| 0.5 | 45/99 | 13.3 | 13.3 | 13.099 | 0.754 | 0.752 | 0.745 |
| 1.5 | 8/20 | 15.727 | 15.7 | 15.619 | 0.892 | 0.888 | 0.888 |
| 3 | 8/20 | 17.018 | 16.964 | 16.91 | 0.965 | 0.960 | 0.962 |
| 5 | 8/20 | 17.637 | 17.678 | 17.584 | 1 | 1 | 1 |
| 10 | 8/20 | 19.394 | 19.394 | 19.507 | 1.100 | 1.097 | 1.109 |
| 20 | 8/20 | 22.045 | 22.072 | 21.938 | 1.250 | 1.249 | 1.248 |
| 40 | 8/20 | 26.144 | 26.385 | 26.412 | 1.482 | 1.493 | 1.502 |
| 10 | 1/2 (w/o inductive effect) | 18.934 | 18.884 | 18.917 | 1.074 | 1.068 | 1.076 |

## TABLE 3: SUMMARY OF ARRESTER DISCHARGE VOLTAGES

| Uc | Ur | IR Factors | 0.754 | 0.892 | 0.965 | 1 | 1.1 | 1.25 | 1.482 | 1.076 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Wave | 45/99 | 8/20 | 8/20 | 8/20 | 8/20 | 8/20 | 8/20 | Disc FOW | Unit Ht | 5 kA Induct Drop | Total FOW |
| | | I (kA) | 0.5 | 1.5 | 3 | 5 | 10 | 20 | 40 | 5 | m | kV | 5 |
| 2.55 | 3 | Measured IR | 7.5 | 8.9 | 9.6 | 9.97 | 11 | 12.5 | 14.8 | 10.7 | 0.14 | 0.7 | **11.4** |
| | | Catalog IR | 7.6 | 9.0 | 9.7 | 10.1 | 11.1 | 12.6 | 15.0 | 10.9 | 0.14 | 0.7 | **11.6** |
| 5.1 | 6 | Measured IR | 15 | 17.8 | 19.3 | 19.95 | 21.9 | 24.9 | 29.6 | 21.5 | 0.14 | 0.7 | **22.2** |
| | | Catalog IR | 15.2 | 17.9 | 19.4 | 20.1 | 22.1 | 25.1 | 29.8 | 21.6 | 0.14 | 0.7 | **22.3** |
| 7.65 | 9 | Measured IR | 21.5 | 25.4 | 27.5 | 28.5 | 31.4 | 35.6 | 42.2 | 30.7 | 0.14 | 0.7 | **31.4** |
| | | Catalog IR | 21.7 | 25.7 | 27.8 | 28.8 | 31.7 | 36.0 | 42.7 | 31.0 | 0.14 | 0.7 | **31.7** |
| 8.4 | 10 | Measured IR | 22.6 | 26.7 | 28.9 | 29.92 | 32.9 | 37.4 | 44.3 | 32.2 | 0.14 | 0.7 | **32.9** |
| | | Catalog IR | 22.8 | 26.9 | 29.1 | 30.2 | 33.2 | 37.8 | 44.8 | 32.5 | 0.14 | 0.7 | **33.2** |
| 10.2 | 12 | Measured IR | 27.6 | 32.6 | 35.3 | 36.57 | 40.2 | 45.7 | 54.2 | 39.3 | 0.14 | 0.7 | **40** |
| | | Catalog IR | 27.8 | 32.9 | 35.6 | 36.9 | 40.6 | 46.1 | 54.7 | 39.7 | 0.14 | 0.7 | **40.4** |
| 12.7 | 15 | Measured IR | 35.1 | 41.5 | 44.9 | 46.55 | 51.2 | 58.2 | 69 | 50.1 | 0.216 | 1.08 | **51.2** |
| | | Catalog IR | 35.4 | 41.9 | 45.4 | 47 | 51.7 | 58.8 | 69.7 | 50.6 | 0.216 | 1.08 | **51.7** |
| 15.3 | 18 | Measured IR | 40.8 | 48.3 | 52.3 | 54.15 | 59.6 | 67.7 | 80.3 | 58.3 | 0.216 | 1.08 | **59.3** |
| | | Catalog IR | 41.2 | 48.8 | 52.8 | 54.7 | 60.2 | 68.4 | 81.1 | 58.9 | 0.216 | 1.08 | **59.9** |
| 17 | 21 | Measured IR | 44.4 | 52.5 | 56.8 | 58.9 | 64.8 | 73.6 | 87.3 | 63.4 | 0.216 | 1.08 | **64.5** |
| | | Catalog IR | 44.9 | 53.1 | 57.4 | 59.5 | 65.5 | 74.4 | 88.2 | 64 | 0.216 | 1.08 | **65.1** |
| 19.5 | 24 | Measured IR | 55.1 | 65.2 | 70.6 | 73.12 | 80.4 | 91.4 | 108.4 | 78.7 | 0.277 | 1.385 | **80.1** |
| | | Catalog IR | 55.7 | 65.9 | 71.3 | 73.9 | 81.3 | 92.4 | 109.5 | 79.5 | 0.277 | 1.385 | **80.9** |
| 22 | 27 | Measured IR | 62.7 | 74.1 | 80.2 | 83.12 | 91.4 | 103.9 | 123.2 | 89.4 | 0.354 | 1.77 | **91.2** |
| | | Catalog IR | 63.3 | 74.9 | 81.1 | 84 | 92.4 | 105 | 124.5 | 90.4 | 0.354 | 1.77 | **92.2** |
| 24.4 | 30 | Measured IR | 67 | 79.2 | 85.7 | 88.82 | 97.7 | 111 | 131.6 | 95.6 | 0.354 | 1.77 | **97.3** |
| | | Catalog IR | 67.6 | 80 | 86.6 | 89.7 | 98.7 | 112.1 | 132.9 | 96.5 | 0.354 | 1.77 | **98.3** |
| 29 | 36 | Measured IR | 79.5 | 94.1 | 101.8 | 105.45 | 116 | 131.8 | 156.3 | 113.5 | 0.43 | 2.15 | **115.6** |
| | | Catalog IR | 80.3 | 95 | 102.8 | 106.5 | 117.2 | 133.1 | 157.8 | 114.6 | 0.43 | 2.15 | **116.7** |

### Test Summary

Table 1 summarizes the result of FOW discharge testing performed, per the standard, with and without an aluminum spacer. The MOV disc FOW residual voltage is combined with the inductive drop (associated with the arrester height) to develop each rated arrester’s Total FOW residual voltage.

Table 2 summarizes residual voltage measurements for the three test samples across the range of specified wave shapes and current values. The residual voltage of each MOV disc is measured as a routine test with a discharge current of 5 kA, 8/20 μs. The MOV discs of each arrester are accumulated within 5 kA residual voltage ranges as specified for each arrester rating. To verify the catalog maximum residual voltage levels, a discharge voltage ratio was established at each current level based on the 5 kA residual voltage of each test sample, as shown in Table 2. This ratio was multiplied by the maximum 5 kA residual voltage accumulation specified for each rating.

As summarized on Table 3, the residual voltage calculated (based on the prorated test sample data) was less than the maximum declared catalog levels for each rated arrester.

# IEC Type Test Report

Report Number:  EU1164-HR-03.4
Polymer Distribution
5 kA Class Arresters

Long Duration Current Impulse Withstand Tests
IEC Clause 8.4

This report records the results of this type test made on PDV-65™ arresters in accordance with IEC Standard 60099-4, 2004 "Surge arresters - Part 4: Metal-oxide surge arresters without gaps for a.c. systems."

To the best of our knowledge and within the usual limits of testing practice, tests performed on these arresters demonstrate compliance with the relevant clauses of the referenced standard.

Dennis W. Lenk
Principal Engineer

Fayaz Khatri
Design Engineering Supervisor

Date: 06/30/2016

# Long Duration Current Impulse Withstand Tests IEC Clause 8.4

**Sample Preparation**

Long duration current impulse withstand tests were performed on three test samples. Each test sample consisted of one 32-mm diameter x 43 mm long MOV disc.

**Test Parameters and Procedure**

Three samples were subjected to line discharge tests in accordance with 5 kA Discharge Class of Clause 8.4.3. Prior to the transmission line discharge tests, 5 kA, 8/20 μs discharge voltage of the test samples were measured.

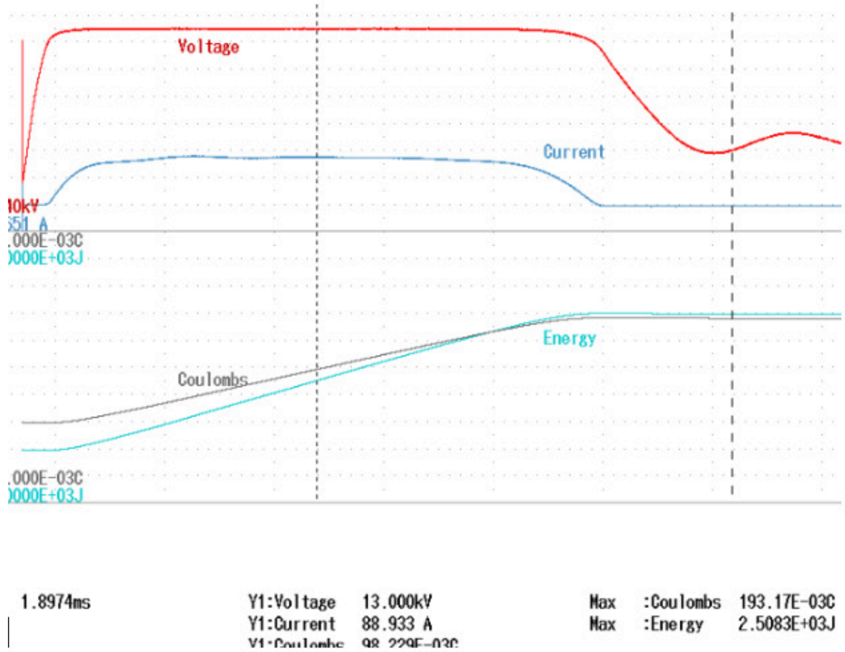
The transmission line discharge tests defined by IEC Standard 60099-4, 2004-05, consisted of subjecting each test sample with eighteen 80 ampere rectangular waveshape discharges, exceeding 1000 microsecond duration. The eighteen discharges were of six groups with three consecutive operations at a time interval of 50 to 60 seconds between the consecutive operations. The samples were allowed to cool to ambient temperature between groups of discharges.

**Test Results**

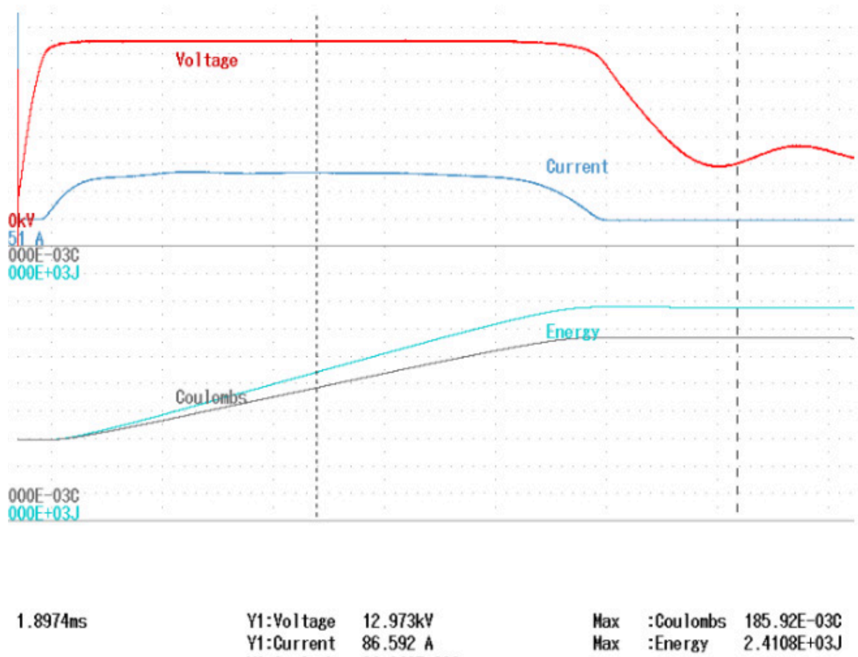
A summary of the 18 shot TLD test results is shown in Table 1.

| TABLE 1. TRANSMISSION LINE DISCHARGE TESTS | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | SAMPLE 1 | | | SAMPLE 2 | | | SAMPLE 3 | | |
| Shot # | I (A) | V (kV) | E (kJ) | I (A) | V (kV) | E (kJ) | I (A) | V (kV) | E (kJ) |
| 1 | 88.9 | 12.86 | 2.46 | 88.6 | 12.94 | 2.44 | 88.9 | 12.86 | 2.5 |
| 2 | 87.9 | 12.93 | 2.47 | 89.9 | 12.94 | 2.50 | 88.6 | 12.92 | 2.45 |
| 3 | 88.9 | 13.00 | 2.51 | 88.9 | 13.05 | 2.47 | 86.6 | 12.97 | 2.41 |
| 4 | 87.3 | 13.00 | 1.8 | 85.6 | 12.86 | 2.35 | 87.9 | 12.88 | 2.43 |
| 5 | 86.9 | 12.96 | 2.41 | 84.3 | 13.02 | 2.38 | 85.9 | 12.92 | 2.4 1 |
| 6 | 87.9 | 12.98 | 2.44 | 86.9 | 13.04 | 2.42 | 88.6 | 13.00 | 2.47 |
| 7 | 84.3 | 12.96 | 2.36 | 83.2 | 13.00 | 2.33 | 84.6 | 12.88 | 2.37 |
| 8 | 85.9 | 12.94 | 2.42 | 83.6 | 13.02 | 2.31 | 86.6 | 12.92 | 2.41 |
| 9 | 83.9 | 13.08 | 2.37 | 83.6 | 12.98 | 2.36 | 85.3 | 13.06 | 2.41 |
| 10 | 85.6 | 12.86 | 2.41 | 82.9 | 12.88 | 2.29 | 82.9 | 12.88 | 2.32 |
| 11 | 83.9 | 13.01 | 2.32 | 84.3 | 12.93 | 2.33 | 85.3 | 13.02 | 2.39 |
| 12 | 86.3 | 13.00 | 2.41 | 86.6 | 13.06 | 2.41 | 85.3 | 13.05 | 2.4 |
| 13 | 84.6 | 12.97 | 2.33 | 84.9 | 12.90 | 2.34 | 83.6 | 12.96 | 2.34 |
| 14 | 84.9 | 13.02 | 2.35 | 83.9 | 13.02 | 2.32 | 85.6 | 13.02 | 2.37 |
| 15 | 86.3 | 13.09 | 2.4 4 | 84.6 | 13.05 | 2.35 | 84.9 | 13.00 | 2.36 |
| 16 | 82.2 | 12.98 | 2.31 | 83.2 | 12.91 | 2.30 | 83.6 | 12.96 | 2.31 |
| 17 | 84.6 | 13.02 | 2.37 | 85.3 | 12.96 | 2.39 | 84.9 | 12.94 | 2.35 |
| 18 | 86.6 | 13.00 | 2.41 | 85.9 | 13.08 | 2.43 | 85.3 | 13.01 | 2.36 |

Figure 1 shows oscillograms of the third and eighteenth transmission line discharges of Sample 1.




Sample 1, Shot 3, Discharge Current = 88.9 A
Discharge Voltage = 13.0 kV, Energy Under V-I Curve = 2.51 kJ




Sample 1, Shot 18, Discharge Current = 86.6 A
Discharge Voltage = 13.0 kV, Energy Under V-I Curve = 2.41 kJ

Figure 1. Transmission line discharges of Sample 1.

Subsequent to the completion of the transmission line discharges, 5 kA, 8/20 μs discharge voltage of the three test samples was measured. Results of the residual voltage measurements are summarized in Table 2. The maximum change of residual voltage of the three samples is less than the permissible change of 5 % defined by IEC Standard 60099-4, 2004-05.

**TABLE 2**
**RESIDUAL VOLTAGE (5 KA, 8/20 μS) MEASUREMENTS**
**BEFORE AND AFTER TRANSMISSION LINE DISCHARGE DUTY**

| SAMPLE | RESIDUAL VOLTAGE (KV) | | CHANGE (%) |
|---|---|---|---|
| | Before | After | |
| 1 | 17.74 | 17.61 | -0.7 |
| 2 | 17.68 | 17.68 | 0 |
| 3 | 17.68 | 17.68 | 0 |

### Test Summary

The three test samples successfully passed the transmission line discharge tests per Section 8.4 of IEC Standard 60099-4, 2004-05. For all three samples, the change of 5 kA, 8/20 μs residual voltage measured before and after the transmission line discharges is less than 5%. Disassembly revealed no evidence of physical damage to the three test samples. Each of the three test samples has fulfilled the transmission line discharge requirements of IEC 5 kA Class arresters.

# IEC Type Test Report

## Report Number: EU1164-HR-04.4
## Polymer Distribution
## 5 kA Class Arresters

## Accelerated Ageing Procedure
## IEC Clause 8.5.2

This report records the results of this type test made on PDV-65™ arresters in accordance with IEC Standard 60099-4, 2004 "Surge arresters - Part 4: Metal-oxide surge arresters without gaps for a.c. systems."

To the best of our knowledge and within the usual limits of testing practice, tests performed on these arresters demonstrate compliance with the relevant clauses of the referenced standard.

Dennis W. Lenk
Dennis W. Lenk
Principal Engineer

Fayaz Khatri
Fayaz Khatri
Design Engineering Supervisor

Date: 06/30/2016

# Design Test Report
# PDV 65 IEC 5 kA Class Surge Arrester

**Title**
MOV Disc Accelerated aging procedure.

**Test Procedures**

Tests were performed to verify that the varistors remain stable and do not increase in power dissipation at MCOV during their expected lifetime.

**Test Samples**

Six arrester sections were prepared. Three sections consisted of the longest 32mm diameter disc and three consisted of the shortest 32mm diameter disc. Each section also consisted of a spring, end terminals, barrier film and fiberglass/epoxy wrap using standard module construction.

**Test Procedure**

Tests were performed per section 8.4 of the standard. Samples were placed inside a 115° C 3 2° C. oven and energized at Uct for 1,000 hours.

**Test Results**

Watts loss for each sample was measured at Uct two hours after energization and at the completion of the 1000 hour test duration. The table below summarizes test results. Watts loss was periodically monitored at Uct during the 1000 hour test duration to identify the minimum watts loss value recorded during the test.

**ACCELERATED AGING TEST DATA**

| Sample No. -length | WATTS LOSS AT 3 HR @UC PSTART (W) | Watts Loss minimum @Uc PMIN (w) | WATTS LOSS AT 1000 HR @UR PEND (W) | Required ratio | |
|---|---|---|---|---|---|
| | | | | <1.1 | <1.3 |
| | | | | Measured | |
| | | | | PEND / PMIN | |
| 1-32x21 | .64 | .33 | .34 | 1.03 | .51 |
| 2-32x21 | .63 | .34 | .34 | 1 | .52 |
| 3-32x21 | .65 | 40 | .42 | 1.05 | .65 |
| 4-32x42 | 1.15 | .85 | .85 | 1 | .74 |
| 5-32x42 | 1.05 | .81 | .81 | 1 | .77 |
| 6-32x42 | 1.05 | .84 | .84 | 1 | .80 |

**Conclusion**

Each test sample demonstrated continually decreasing watts loss at Uct. Since the PEND/PMIN ratio was less than 1.3 and the PEND/PSTART ratio was less than 1.1, the MOV discs successfully passed the Long Term Stability test.

# IEC Type Test Report

Report Number: EU1164-HR-05.4
Polymer Distribution
5 kA Class Arresters

Heat Dissipation Behaviour Of Test Samples
IEC Clause 8.5.3

This report records the results of this type test made on PDV-65™ arresters in accordance with IEC Standard 60099-4, 2004 "Surge arresters - Part 4: Metal-oxide surge arresters without gaps for a.c. systems."

To the best of our knowledge and within the usual limits of testing practice, testsperformed on these arresters demonstrate compliance with the relevant clauses of the referenced standard.

Dennis W. Lenk
Principal Engineer

Fayaz Khatri
Design Engineering Supervisor

Date: 06/30/2016

# IEC Type Test Report

# Heat Dissipation Behaviour Of Test Samples
# IEC CLAUSE 8.5.3

**Objective**

Tests were performed in accordance with Annex B of IEC Standard 60099-4, 2004. The purpose of this test was to verify that the thermal cooling curve of the arrester prorated sections, when internally heated, cools slower than that of full size arrester units.

**Test Samples**

A full size single module 21 kV rated arrester and a thermally prorated arrester section of 10 kV rating size were built. The 21 kV rated arrester was chosen as it has the highest percent MOV mass per unit arrester length, the lowest mass per unit MCOV, and the highest Vref per unit length at minimum design tolerance.

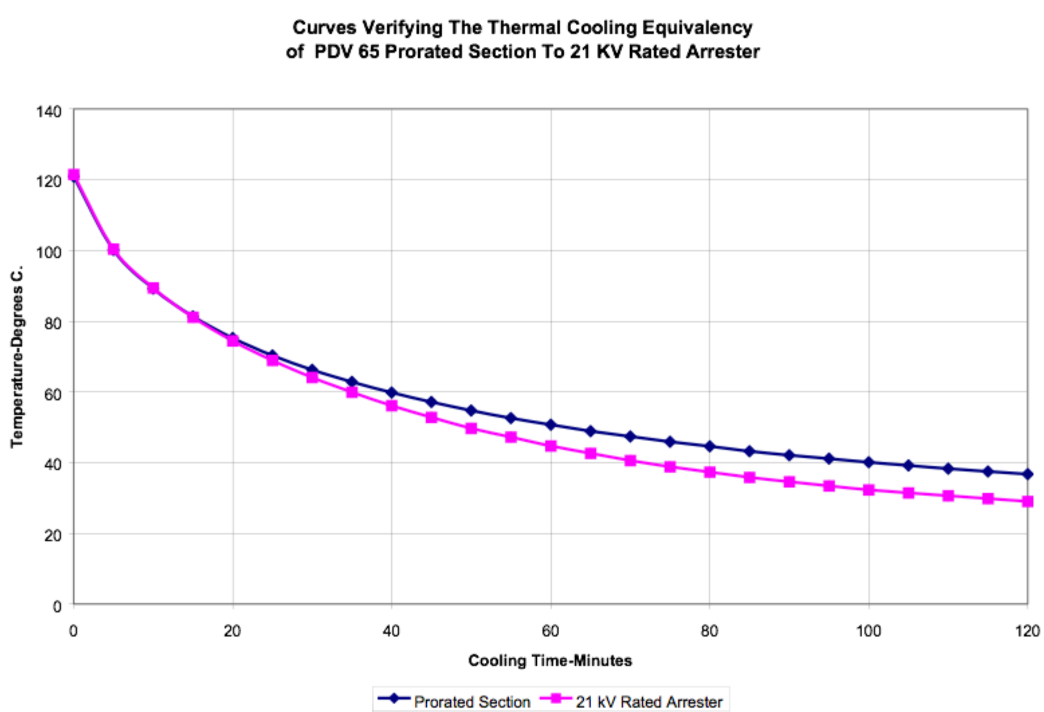
**Test Procedure**

The full size arrester and prorated arrester section were simultaneously heated to the target temperature using a 60 Hz source. The target temperature was 120 - 130° C with test lab ambient at 23 +/- 2° C.. The duration of applied voltage was 10 minutes. A single thermocouple was located in the middle of the 21 kV rated arrester and at the midpoint of the thermal test section. In both cases, thermocouples were located between two adjacent MOV discs.

**Conclusion**

Upon achieving the desired target temperature, the thermocouples were attached to a data logger and temperature was monitored continuously for 30 minutes. Figure 1 contains cooling curves verifying the 21 kV rated arrester cooling rate was always greater than the prorated thermal test section.

Figure 1



# IEC Type Test Report

Report Number: EU1164-HR-06.4
Polymer Distribution
5 kA Class Arresters

High Current Impulse Operating Duty Tests
IEC Clause 8.5.4

This report records the results of this type test made on PDV-65™ arresters in accordance with IEC Standard 60099-4, Ed. 2.2, 2009 “Surge arresters - Part 4: Metal-oxide surge arresters without gaps for a.c. systems.”

To the best of our knowledge and within the usual limits of testing practice, tests performed on these arresters demonstrate compliance with the relevant clauses of the referenced standard.

Dennis W. Lenk
Principal Engineer

Fayaz Khatri
Design Engineering Supervisor

Date: 02/27/2017

# IEC Type Test Report

# High Current Impulse Operating Duty Tests
# IEC CLAUSE 8.5.4

**Sample Preparation**
High current impulse operating duty tests were performed on three prorated test sections prepared based on the thermal equivalency test results. Each section consisted of three (3) 32 mm diameter MOV discs. The MOV discs for each sample were selected to represent the lowest acceptable reference voltage level.

**Test Procedure**

Prior to the conditioning series, reference voltage of each section was measured at 3-mA reference current and room temperature. Initial 5 kA, 8/20 µs residual voltage of each section was also measured.

Conditioning tests consisted of subjecting each prorated section to (20) 5 kA, 8/20 µs lightning current impulses, divided into four groups of five impulses. The interval between impulses was between 50 and 60 seconds and the interval between groups was between 25 and 30 minutes. Test sections were energized at 60 Hz voltage of 1.2 x Uc during each group testing. The impulses were timed to occur 60° before the crest of the 60 Hz voltage with the same polarity of the impulse. Tests were performed in still air at ambient temperature of 20° C.

During the operating duty test, each section was subjected to two (2) 65 kA, 4/10 µs current impulses. Between the two shots, each section was placed in an oven and heated overnight to 66 ± 3° C. Within 100 milliseconds of the last high current impulse, rated voltage (Ur) was applied to each section for 10 seconds immediately followed by Uc for a recovery test of 30 min. During the recovery period, power dissipation of each section was monitored.

After this test sequence, each section was allowed to cool to ambient temperature and then its 5 kA, 8/20 µs discharge voltage was measured.

### Test Results

Initial measurements and parameters of the prorated sections are shown in Table 1.

| TABLE 1. INITIAL MEASUREMENTS AND PARAMETERS OF PRORATED SECTIONS | | | |
|---|---|---|---|
| Test Parameters | Section 1 | Section 2 | Section 3 |
| Initial Residual Voltage (kV) @ 5 kA, 8/20 µs | 35.158 | 35.158 | 35.292 |
| Reference Current (mA) Iref | 3 | 3 | 3 |
| Reference Voltage (kV peak) Uref | 20.78 | 20.72 | 20.78 |
| Maximum COV (kV rms): Uc | 11.60 | 11.58 | 11.60 |
| Maximum Rating (kV rms): Ur | 13.58 | 13.56 | 13.58 |

A summary of results of the three sections for the 20-shot conditioning test is shown in Table 2. The sections were exposed to still air at ambient temperature of 20° C during the test.

| TABLE 2. 20-SHOT CONDITIONING TEST | | | |
|---|---|---|---|
| IMPULSE NUMBER | SECTION 1 I (kA) | SECTION 2 I (kA) | SECTION 3 I (kA) |
| 1 | 5.23 | 5.32 | 5.37 |
| 2 | 5.23 | 5.31 | 5.28 |
| 3 | 5.19 | 5.36 | 5.16 |
| 4 | 5.16 | 5.31 | 5.24 |
| 5 | 5.20 | 5.14 | 5.23 |
| Cool | | | |
| 6 | 5.23 | 5.20 | 5.14 |
| 7 | 5.12 | 5.44 | 5.12 |
| 8 | 5.10 | 5.26 | 5.07 |
| 9 | 5.07 | 5.03 | 5.10 |
| 10 | 5.08 | 5.03 | 5.10 |
| Cool | | | |
| 11 | 5.19 | 5.17 | 5.32 |
| 12 | 5.16 | 5.14 | 5.24 |
| 13 | 5.10 | 5.10 | 5.22 |
| 14 | 5.10 | 5.19 | 5.16 |
| 15 | 5.16 | 5.03 | 5.16 |
| Cool | | | |
| 16 | 5.15 | 5.22 | 5.17 |
| 17 | 5.10 | 5.19 | 5.21 |
| 18 | 5.00 | 5.11 | 5.16 |
| 19 | 5.18 | 5.17 | 5.14 |
| 20 | 5.08 | 5.14 | 5.17 |

Figures 4 thru 6 show oscillograms of the time delay from the high current shot until the application of Ur to each of the three sections. Table 4 summarizes the 10-second rated voltage test results on the three sections.

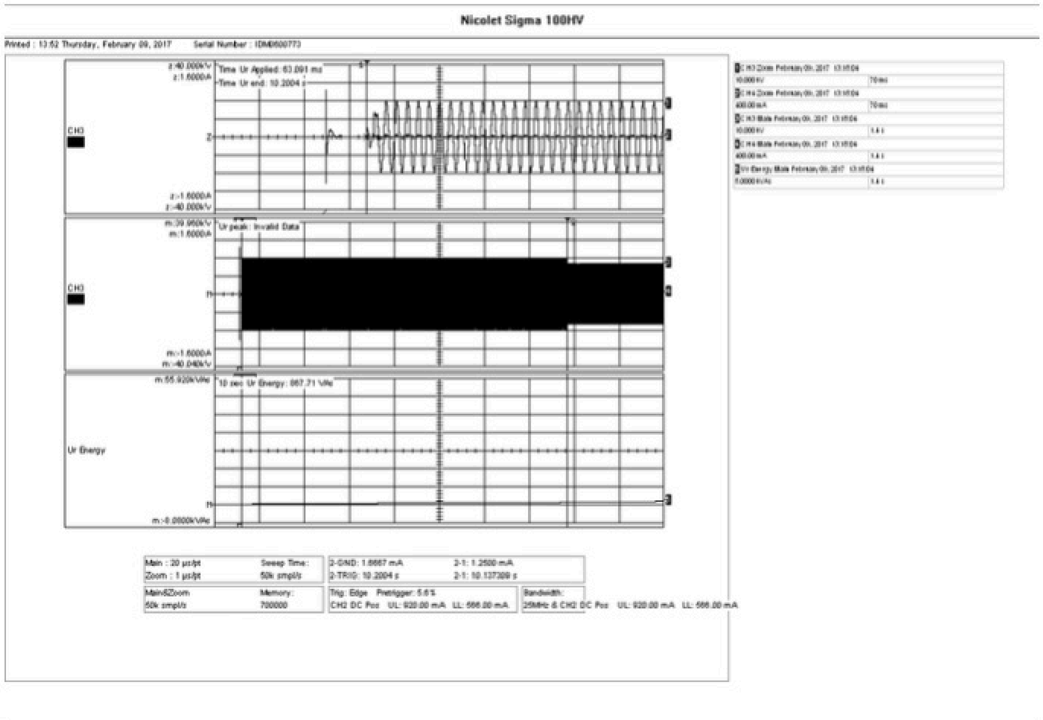



Figure 4
Section 1, 73 millisecond delay

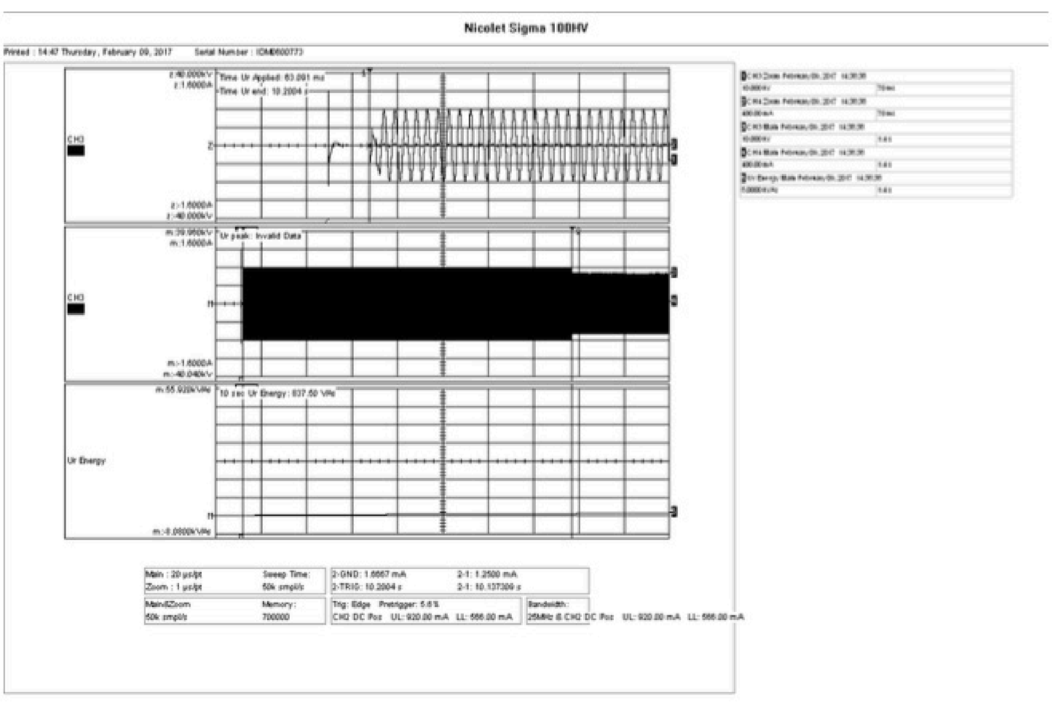



Figure 5
Section 2, 63 millisecond delay

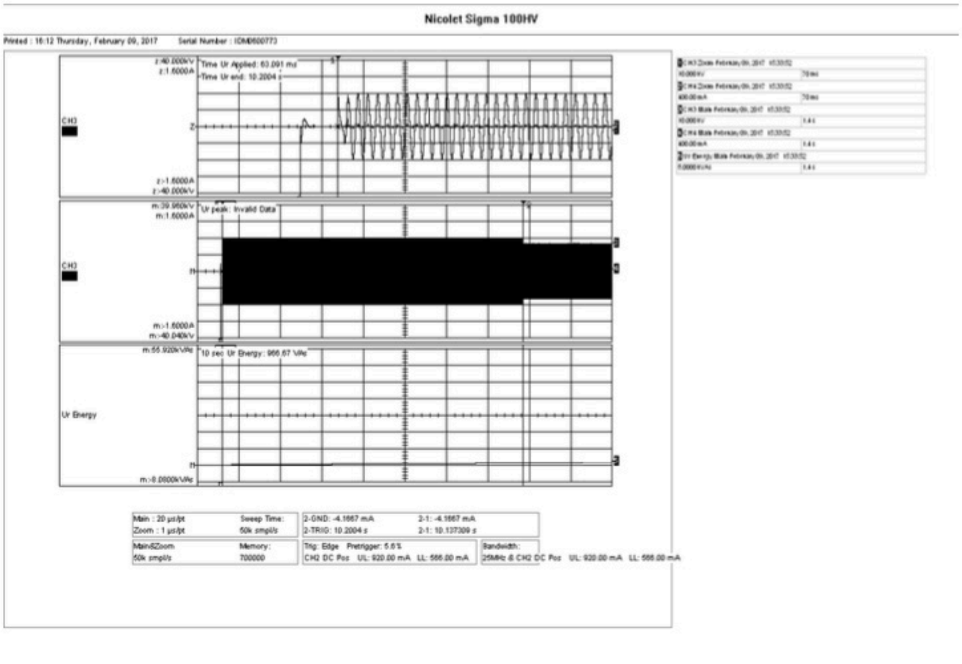



Figure 6
Section 3, 63 millisecond delay

| TABLE 4. 10-SECOND RATED VOLTAGE TEST | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SECTION 1 | | | SECTION 2 | | | Section 3 | | |
| Time (Second) | Rated Ur (kVc) | Current I (mA) | Time (Second) | Rated Ur (kVc) | Current I (mA) | Time (Second) | Rated Ur (kVc) | Current I (mA) |
| 0.06 | 19.39 | 47.1 | 0.06 | 19.53 | 43.3 | 0.06 | 19.49 | 48.8 |
| 1 | 19.40 | 28.8 | 1 | 19.49 | 29.2 | 1 | 19.46 | 31.7 |
| 2 | 19.42 | 25.4 | 2 | 19.52 | 25.0 | 2 | 19.51 | 27.9 |
| 4 | 19.42 | 20.8 | 4 | 19.53 | 21.3 | 4 | 19.51 | 23.3 |
| 6 | 19.37 | 17.9 | 6 | 19.56 | 19.2 | 6 | 19.49 | 20.4 |
| 8 | 19.37 | 16.7 | 8 | 19.51 | 17.1 | 8 | 19.50 | 18.8 |
| 10.2 | 19.42 | 15.0 | 10.2 | 19.52 | 16.3 | 10.2 | 19.47 | 17.5 |

Thermal stability defined by Section 8.5.6 of IEC Standard 60099-4, 2004, was verified during the recovery period by continuous monitoring of power dissipation of the test sections. Typical values of the measurements are shown in Table 5. The results indicated that all three sections demonstrated thermal stability.

**TABLE 4. 10-SECOND RATED VOLTAGE TEST**

| RECOVERY TIME (Min) | SECTION 1 WATTS LOSS (W) | SECTION 2 WATTS LOSS (W) | SECTION 3 WATTS LOSS (W) |
|---|---|---|---|
| 0 | 14.7 | 11.8 | 8.6 |
| 0.5 | 5.5 | 5.2 | 4.9 |
| 1 | 3.6 | 3.4 | 3.5 |
| 2 | 2.2 | 2.1 | 2.3 |
| 5 | 1.3 | 1.3 | 1.5 |
| 10 | 1.0 | 1.0 | 1.1 |
| 20 | 0.8 | 1.0 | 0.9 |
| 30 | 0.7 | 0.9 | 0.7 |

Results of the residual voltages measured are given in Table 6. The maximum change of the residual voltages of the three sections is less than the permissible value of 5 %.

**TABLE 6. SUMMARY OF RESIDUAL VOLTAGE MEASUREMENTS**

| SAMPLE | RESIDUAL VOLTAGE (KV) | | CHANGE (%) |
|---|---|---|---|
| | Before | After | |
| 1 | 35.158 | 35.692 | +1.5 |
| 2 | 35.158 | 35.491 | +0.9 |
| 3 | 35.292 | 35.491 | +0.6 |

### Test Summary

The three prorated sections successfully passed the operating duty test per Section 8.5 of IEC Standard 60099-4, Ed. 2.2, 2009. Disassembly revealed no evidence of puncture, flashover or cracking of the non-linear metal oxide resistors in any of the three sections. All three sections demonstrated thermal stability. The change of residual voltage measured before and after the test is less than 1.5%. The three test sections have successfully completed the 5 kA Class IEC operating duty test requirements.

# IEC Type Test Report

## Report Number: EU1164-HR-07.3
## Polymer Distribution
## 5 kA Class Arresters

## Tests On Arrester Disconnectors
## IEC CLAUSE 8.6

This report records the results of this type test made on PDV-65™ arresters in accordance with IEC Standard 60099-4, 2004 "Surge arresters - Part 4: Metal-oxide surge arresters without gaps for a.c. systems."

To the best of our knowledge and within the usual limits of testing practice, tests performed on these arresters demonstrate compliance with the relevant clauses of the referenced standard.

Dennis W. Lenk
Principal Engineer

Fayaz Khatri
Design Engineering Supervisor

Date: 08/27/2012

# IEC Type Test Report

# Tests On Arrester Disconnectors
# IEC CLAUSE 8.6

The ground lead disconnector is an integral part of the insulating base bracket. High current short duration and low current long duration duty tests and duty cycle tests were performed on thermally prorated test sections having the disconnector assembly connected in series. Disconnectors did not operate when subjected to these tests.

Disconnector detonation tests were performed on five (5) bracket/disconnector assemblies each at 20, 200, and 800 A rms. Figure 1 shows the rms value of the current and time duration to the first movement of the disconnector. This test was performed without the arrester. The ground lead arrester disconnectors tested met the requirements of this IEC Clause.

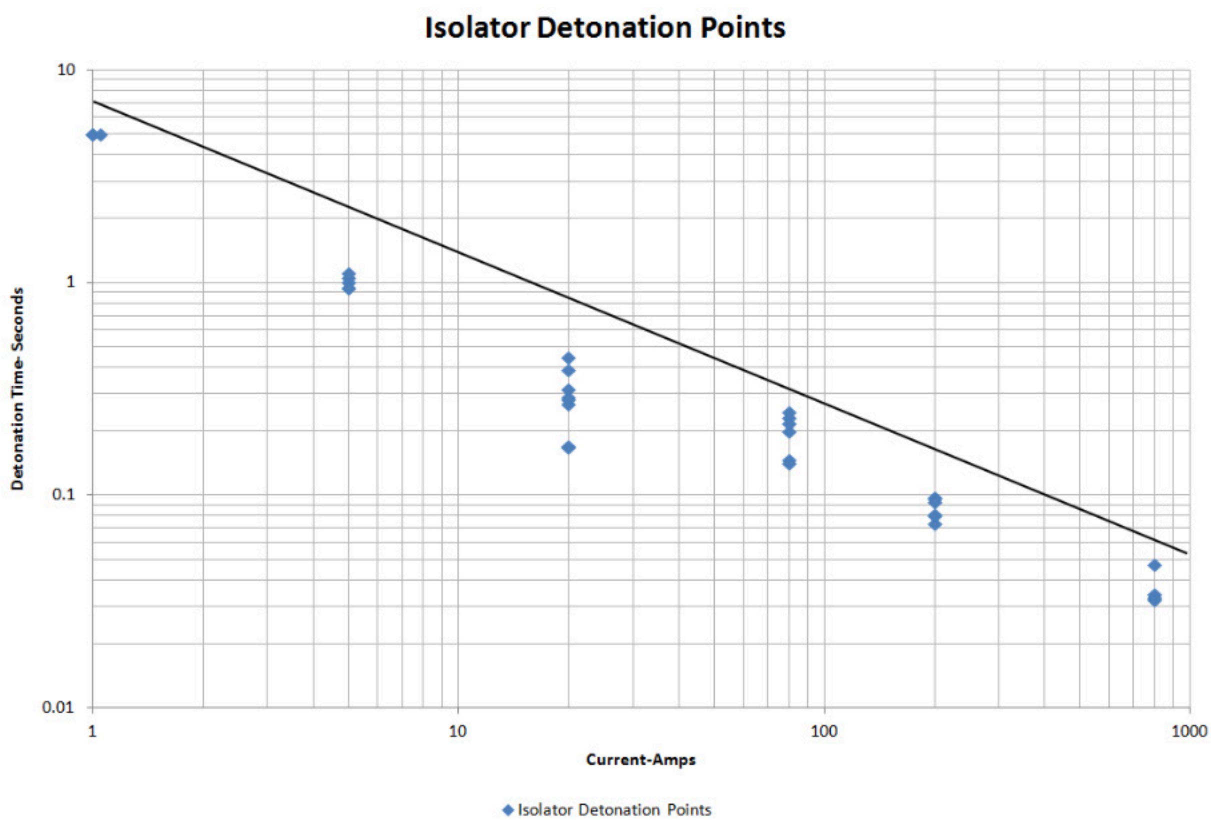



Figure 1. Time vs. current characteristics of disconnectors

# IEC Type Test Report

## Report Number: EU1164-HR-08.3
## Polymer Distribution
## 5 kA Class Arresters

### Power Frequency Voltage Versus Time Characteristics
### IEC ANNEX D

This report records the results of this type test made on PDV-65™ arresters in accordance with IEC Standard 60099-4, 2004 “Surge arresters - Part 4: Metal-oxide surge arresters without gaps for a.c. systems.”

To the best of our knowledge and within the usual limits of testing practice, tests performed on these arresters demonstrate compliance with the relevant clauses of the referenced standard.

Dennis W. Lenk

Dennis W. Lenk
Principal Engineer

Date: 08/27/2012

# IEC Type Test Report

# Power Frequency Voltage Versus Time Characteristics IEC ANNEX D

The claimed power frequency voltage capability for the PDV-65 design is summarized in Figure 1. The test procedure is listed below:

1. Preheat to 60 ± 3° C;
2. Apply two long duration discharge spaced 60 seconds apart;
3. Within 100 ms of the second discharge, apply the selected P. U. of voltage for a time greater than the abscissa value on Figure 1;
4. Apply the continuous operating voltage (Uc) for 30 minutes and monitor the power loss to confirm stability.

The PDV-65 arresters met the requirements of this clause.

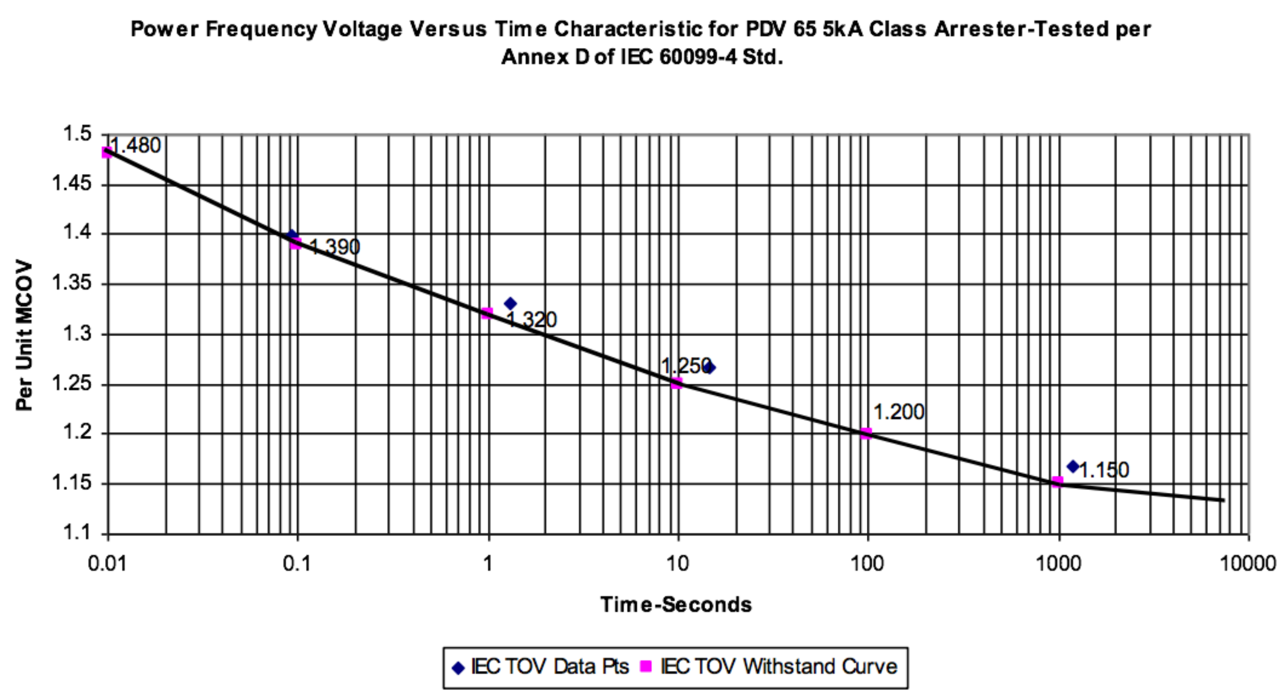



Figure 1. Power frequency voltage versus time characteristics

# IEC Type Test Report

## Report Number: EU1164-HR-09.2
## Polymer Distribution
## 5 kA Class Arresters

### Short Circuit Test

This report records the results of this type test made on 5 kA Class Type PDV 65 arresters rated 3 thru 36 kV in accordance with IEC Standard 60099-4, 2001, including Amendment “Surge arresters - Part 4: Metal-oxide surge arresters without gaps for a.c. systems.”

To the best of our knowledge and within the usual limits of testing practice, tests performed on these arresters demonstrate compliance with the relevant clauses of the referenced standard.

Dennis W. Lenk
Principal Engineer

Date: 08/27/2012

# PDV 65 Distribution Class Surge Arrester

## Short-circuit test for polymer housed distribution arresters

**Objective**

Short circuit tests were performed on the Type PDV 65 polymer-housed Distribution Class arrester per IEC Standard 60099-5. Tests were performed per Table 14 of the referenced standard.

**TEST SAMPLE**

Fault current tests were performed on the longest mechanical section used to assemble the 12.7 thru 17 kV MCOV arresters, as required in Section 8.15.1 of the standard. As required in Section 8.15.1.1, two test samples for the high current test were assembled with a fuse wire oriented axially between the mov disc stack and the fiberglass-epoxy wrap. These samples were subjected to the full offset current test. In addition, six samples represented standard production arresters. These samples were failed using the specified 2-source failure mode procedure.

**TEST RESULTS**

Table 1 summarizes the results these tests which validated the claimed maximum 15 kArms symmetrical, 12 cycle fault current withstand capability of this design, with an applied ratio of 1.55 between total asymmetrical to symmetrical rms currents. This corresponds to a 2.6 ratio, in the first half loop of fault current, between the crest asymmetrical to rms symmetrical current, i.e., full offset. In addition to testing at the claimed maximum capability, tests were also performed, using the 2-source procedure, at half the claimed capability and at 600 amps as specified in Table 14 of the standard.

All tests were performed at full voltage. Therefore, the prospective fault current, as measured during the bolted fault test on the generator, is the claimable fault current capability of the design.

## TABLE 1

| Sample # | Failure Mode | Minimum Test Duration-seconds | Condition of Module/Polymer Housing After Test |
|---|---|---|---|
| **Calibration Test** | **15.0 kA Symmetrical RMS** | **40.0 kAc 1st Half Loop** | |
| 1 | Fuse Wire | .2 | Module Intact/Hsg Torn but in Place |
| 2 | Fuse Wire | .2 | Module Intact/Hsg Torn but in Place |
| 3 | 2-Source | .2 | Module Intact/Hsg Torn but in Place |
| 4 | 2-Source | .2 | Module Intact/Hsg Torn but in Place |
| 5 | 1.3 | 1.3 | 1.5 |
| 10 | 1.0 | 1.0 | 1.1 |
| 20 | 0.8 | 1.0 | 0.9 |
| 30 | 0.7 | 0.9 | 0.7 |
| **Calibration Test** | **7.59 kA Symmetrical RMS** | **No Asymmetrical Requirement** | |
| **Sample #** | **Failure Mode** | **Minimum Test Duration-seconds** | **Condition of Module/Polymer Housing After Test** |
| 5 | 2-Source | .2 | Module Intact/Hsg Torn but in Place |
| 6 | 2-Source | .2 | Module Intact/Hsg Torn but in Place |
| **Calibration Test** | **600 Amp Symmetrical RMS** | **No Asymmetrical Requirement** | |
| **Sample #** | **Failure Mode** | **Minimum Test Duration-seconds** | **Condition of Module/Polymer Housing After Test** |
| 7 | 2-Source | 1.0 | Module Intact/Hsg Torn but in Place |
| 8 | 2-Source | 1.0 | Module Intact/Hsg Torn but in Place |

### Conclusion

All eight test arresters, assembled with the longest mechanical unit, met the test evaluation criteria as specified in IEC Standard 60099-5. In all tests, the arrester module remained intact on the insulating support bracket after the completion of each test. The flexible polymer housing wall section split, as intended, on all samples to allow venting of internal arcing gases to the outside of the arrester. In all cases, flames associated with the fault current test extinguished immediately after completion of the test, well within the allowed 2 minute duration. These tests have demonstrated the capability of the PDV 65 arrester design to discharge a maximum claimable 15 kArms symmetrical fault current using the test procedure defined in IEC Standard 60099-5.

# IEC Type Test Report

## Report Number: EU1164-HR-10.3
## Type PDV65
## IEC 5 kA Distribution Class Arrester

### Bending Moment Test

This report records the results of this type test made on the Type PDV65 IEC 5 kA Class Distribution arrester design rated 3 thru 42 kV in accordance with IEC Standard 60099-4, Ed. 3.0, 2014-06 “Surge arresters - Part 4: Metal-oxide surge arresters without gaps for a.c. systems.”

To the best of our knowledge and within the usual limits of testing practice, tests performed on these arresters demonstrate compliance with the relevant clauses of the referenced standard.

Dennis W. Lenk
Principal Engineer

Fayaz Khatri
Design Engineering Supervisor

Date: 06/30/2016

# Type PDV65 5 kA Class Distribution Arrester Bending Moment Clause 10.8.11

**Introduction**

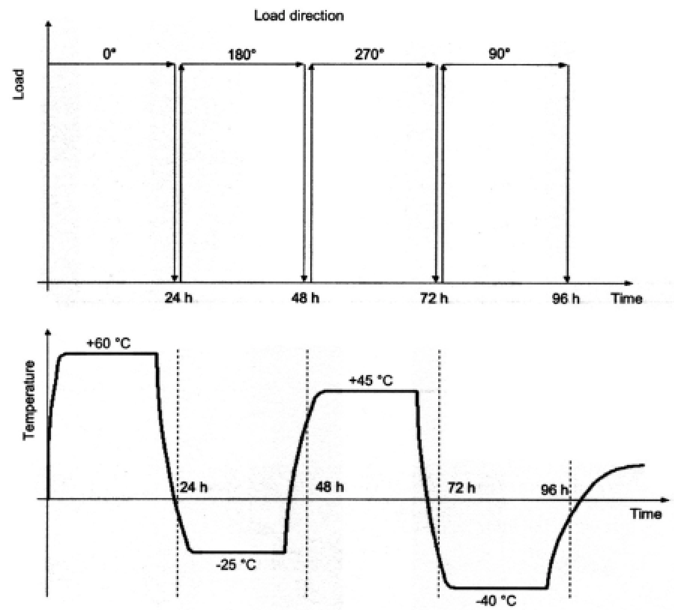
The bending moment test has two test procedure requirements as shown in Figure G.5 of the IEC 60099-4 Ed. 3.0 2014-06 Standard:

- Specified Long Term Loading (SLL)
- Specified Short Term Loading (SSL)

**SLL Test Procedure**

The test was performed per section 10.8.11.3.1 of IEC 60099-4 Ed.3.0 2014-06 Standard. The test arrester was subjected to PD, watts loss, and discharge voltage tests prior to the bending moment and boiling water immersion test. The mechanical portion of the test consisted of first applying a 20 ft-lb torque to the arrester end terminals for 30 second duration. One of the test arresters was then placed inside a thermal cycling oven and mechanically loaded to its 300 in-lb continuous cantilever rating. The load application and test temperature is shown on Figure 1.

Figure 1.




After completion of the mechanically loading portion of the test procedure, the water immersion portion of the bending moment test was performed per section 10.8.11.3.2 and consists of placing the mechanically stressed arrester into an 80 degree C. salt water bath for 168 hours, after which the same is cooled to room temperature and electrical tests are repeated.

**SLL Test Procedure**

Per the Figure G.5, Section 10.8.11.3 b), Step 1.1 defines the specified short-term load (SSL) bending moment test. Each of these two test units was securely mounted to the horizontal base of the test equipment and lateral (horizontal) loading was applied to the free end of the unit, in a direction perpendicular to the axis of the unit, at a rate necessary to reach the bending moment corresponding to the specified short-term load (SSL) in approximately 50 s. The load was then maintained at this level for about 90 s. Deflection was measured prior to release of the load. After release of load, the test sample was inspected to verify that no mechanical damage had occurred, and the load-deflection curve was examined to verify that there was no discontinuity which might indicate mechanical damage. The unloaded residual deflection was measured on each sample.

**Water Immersion Test Procedure**

Subsequent to the SSL and SLL tests, the three test samples were immersed in a 80°C. bath of de-ionized water with 1 kg/m$^3$ of NaCl for 168 hours after which the samples were electrically evaluated.

**Test Results**

Per Clause 10.8.11.2 of IEC 60099-4 Ed. 3.0, 2012 Standard, preliminary electrical tests were performed on the three PDV65 arresters

Per step 2.1 of Clause 10.8.9.3.a), test samples # 5 and 6 were rigidly base mounted in a cantilever fixture and loaded within 30 to 90 seconds to the arresters claimed specified 800 in-lb short-term load (SSL) and maintained at this moment load for 60 to 90 seconds, after which the applied load was slowly removed. Figure 2 shows the test sample's top end deflection as plotted against time for test sample #5. The maximum recorded top end deflection under load was 0.37 inches while the recorded residual deflection was 0.04".

Figure 2

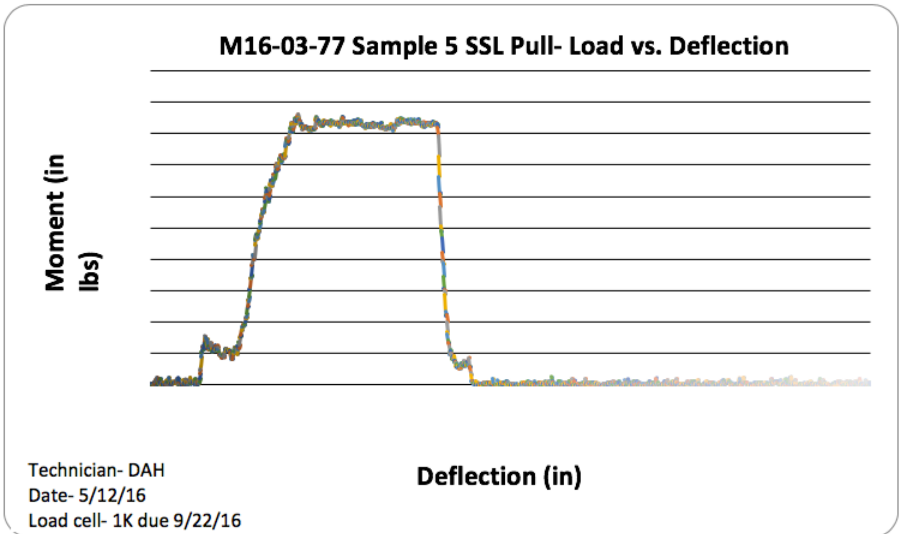
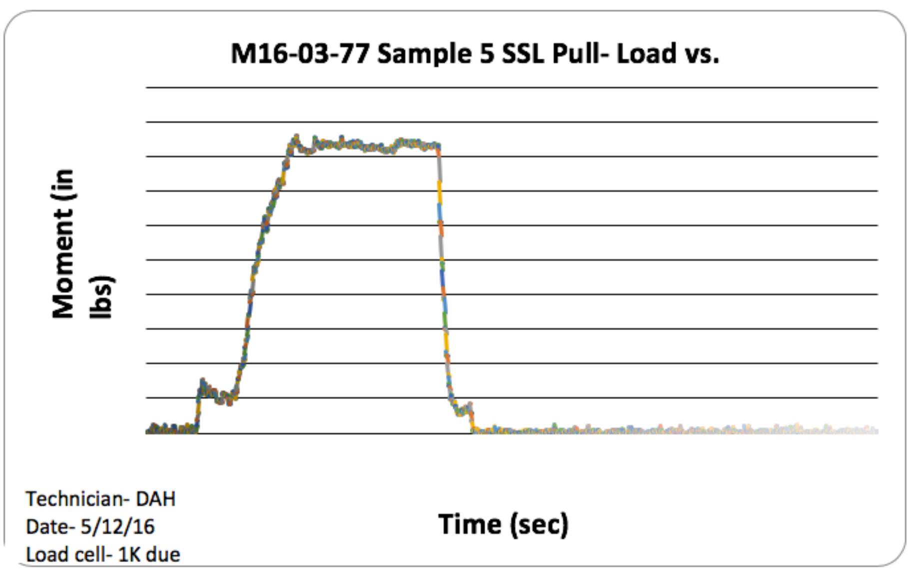


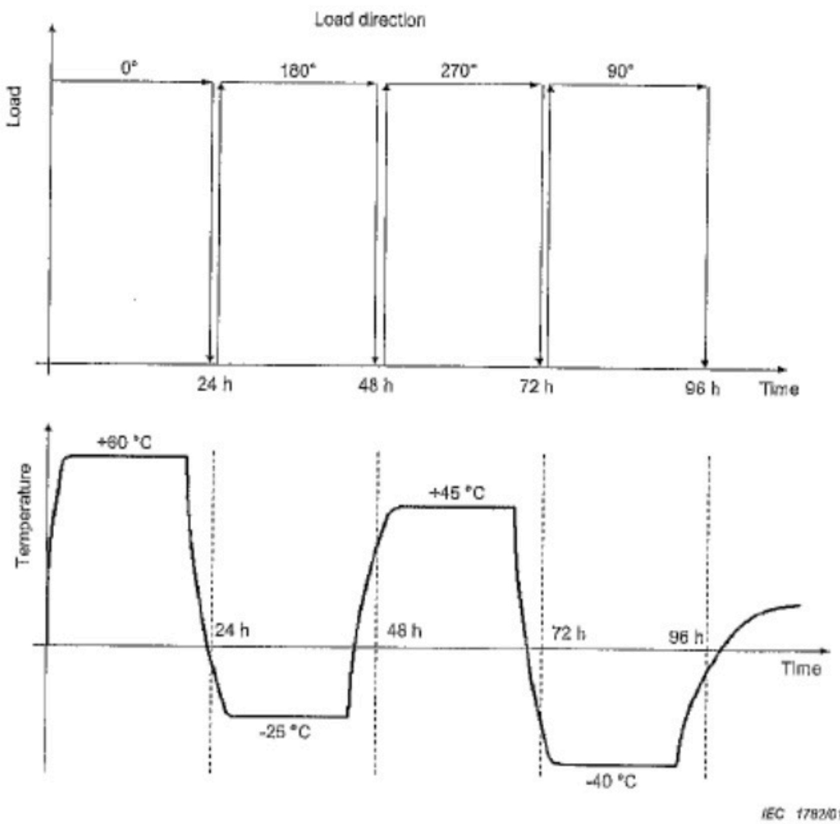

Figure 3 shows moment applied to the top end of sample #5 during the SSL loading cycle

Figure 3



Per step 2.2 of Clause 10.8.11.3.a), test sample #4 was subjected to thermo-mechanical preconditioning as specified in Clause 10.8.11.3.1.2. During this test, the test sample is placed inside a thermal cycling oven which loads the top end of the sample to its claimed 400 in-lb SLL. Figure 4 shows the sample's load and temperature cycle.

Figure 4




At the completion of the specified mechanical loading, samples 4, 5, and 6 were placed into 80°C. NaCl water for 168 hours, as specified in Clause 10.8.11.3.2. After 168 hours exposure, the water bath temperature was reduced to 50°C. After stabilizing in 50°C water bath, the test samples were dried off and 60 Hz electrical tests were repeated per Clause 10.8.11.4. Table 2 summarizes the results of electrical tests performed on the test samples prior to and after the 42 hour boiling water test.

**TABLE 2**

| Test Parameter | Sample #4 | Sample #5 | Sample #6 |
|---|---|---|---|
| Initial watts Loss at Uc | .335 | .323 | .328 |
| Final Watts Loss at Uc | .362 | .343 | .349 |
| Watts Loss % Increase | +8.1% | +6.2% | +6.4% |
| Final PD at 1.05*Uc-pC | 0 | 0 | 0 |

As specified in Clause 10.8.11.4, to further confirm the electrical integrity, each test sample was subjected to the following test before and after the boiling water test. Results are shown in Table 3.

| TABLE 3 | | | | |
|---|---|---|---|---|
| **Final Test Steps** | **Test Description** | **Test Sample #4** | **Test Sample #5** | **Test Sample #6** |
| Before | 3 ma Uref kVc | 22.04 | 22.09 | 22.12 |
| Before | 8/20 5 kA IR-kVc | 52.53 | 52.67 | 52.74 |
| After | 8/20 5 kA IR-kVc | 52.70 | 52.77 | 52.70 |
| After | 3 ma Uref kVc | 21.98 | 22.03 | 22.07 |

Finally, each sample was subjected to two additional 5 kA IR surges spaced 1 minute apart. Close examination of oscillograms showed the traces to be smooth and less than 1% apart, confirming the integrity of each test sample.

**Conclusion**

Three Type PDV65 arresters were subjected to bending moment tests as defined in Clause 10.8.9 of IEC 60099-4 Ed 3.0 2014 Standard. Specified short-term load (SSL) testing was successfully completed at 800 in-lb, while specified long-term load (SLL) testing was successfully completed at 400 in-lb. 60 HZ electrical tests, performed on each arrester prior to and after the mechanical and moisture ingress tests, confirmed arrester PD levels below the allowed 10 pC and watts loss was below the allowed 20% change. 5 kA residual voltage tests also confirmed the electrical integrity of the three test arresters.
In summary, the three PDV65 IEC 5 kA Class Distribution arresters successfully passed the bending moment test at the designated SLL and SSL levels.

# IEC Type Test Report

## Report Number: EU1164-HR-10.3
## Base Mounted Polymer Arrester
## 5 kA Line Discharge Class

### 1000 Hour Salt Fog Test
### SERIES A

This report records the results of this type test made on IEC 5 kA Class arresters rated 3 thru 72 kV in accordance with IEC Standard 60099-4, 2005 “Surge arresters - Part 4: Metal-oxide surge arresters without gaps for a.c. systems.”

To the best of our knowledge and within the usual limits of testing practice, tests performed on these arresters demonstrate compliance with the relevant clauses of the referenced standard.


Dennis W. Lenk
Dennis W. Lenk
Principal Engineer

Fayaz Khatri
Fayaz Khatri
Design Engineering Supervisor


Date: 08/27/2012

# IEC Type Test Report
# 1000 Hour Salt Fog Test

# IEC CLAUSE 10.8.14.2.1

## Introduction

Tests were performed in accordance with clause 10.8.14.2.1 of IEC Standard 60099-4, 2005. The purpose of this test was to verify the electrical integrity of the arrester polymer housing after being subjected to 1000 hours in a salt fog environment.

## Sample Preparation

One 24.4 kV MCOV IEC 5 kA Class arrester was assembled for this test.

## Test Procedure

The 1000 hour weathering test was performed per clause 10.8.14.2.2 of IEC 60099-4. Salt fog salinity was 10 kg per cubic meter.

## Test Results

The test arrester successfully withstood the 1000 hour salt fog exposure test with no evidence of surface tracking, erosion, or puncturing. The following table summarizes the results of electrical tests performed on the arrester before and after the salt fog exposure.

| Sample No. | Initial PD @ 1.05 times Uc (pC) | Final PD @ 1.05 times Uc (pC) | Initial 3 ma reference voltage kVc | Final 3 ma reference voltage kVc |
|---|---|---|---|---|
| 1 | <1 | <1 | 34.98 | 35.89 |

## Test Conclusions

Reference voltage changed less than 3% as a result of salt fog exposure. No tracking, shed puncture or significant erosions were evidenced by visual inspection carried out at the end of the test. The IEC 5 kA Class arrester design successfully passed the 1000 hour salt fog test, as defined in IEC 60099-4 standard.

For details of test report, reference CESI AT-A3/033718 test report.