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TEST REPORT

CEPRI-EET02-2023-0061 (E)

Client: Xi 'an Tiangong Electric Co.,Ltd

Object: Metal Oxide Varistor

Type: $\Phi 70\text{mm} \times 22\text{mm}$

Test Category: Characteristics test

**POWER INDUSTRY QUALITY INSPECTION AND TEST
CENTER FOR ELECTRIC EQUIPMENT**



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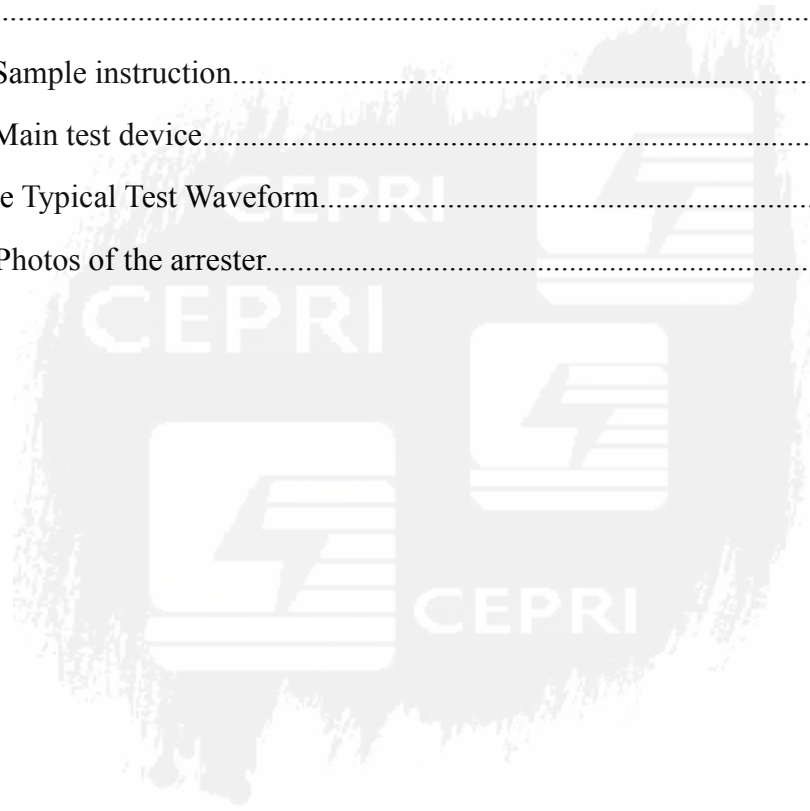
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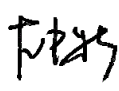
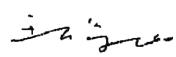
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Catalogue

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| Test Report | Power Industry Quality Inspection and Test Center for Electric Equipment 检测报告 专用章 | | CEPRI-EETC02-2023-0061(E) Total 12 Page 2 |
| Client | Xi 'an Tiangong Electric Co.,Ltd | Manufacturer | Xi 'an Tiangong Electric Co.,Ltd |
| Object | Metal Oxide Varistor | Type | Φ 70mm×22mm |
| Sampling procedure | By the client delivery | Serial No. | 19 resistors (301~319) |
| Test Category | Characteristics test | Date | 2023.02.13~2023.03.31 |
| Requirements | 1. GB/T 11032-2020 Metal-oxide surge arresters without gaps for a.c. systems 2. IEC 60099-4 Edition 3.0 (2014-06) Metal-oxide surge arresters without gaps for a.c. systems | | |
| Conclusion | The metal oxide Varistor(Φ 70mm×22mm)has passed the type test specified in GB/T 11032-2020 and IEC 60099-4 Edition 3.0 (2014-06). | | |
| Note | Note :See appendix A for sample instruction. | | |
| Tested by: 梁菊霞  陈立  | | | |
| Checked by: 王陆璐  Verified by: 左中秋  | | | |
| Approved by: 王保山  Date of issue: 2023-04-12 | | | |



Test Results

| No. | Item | Requirements | Results | Evaluation | |
|-----|---|--|--|--|-----------|
| 1 | Residual voltage test | Lightning impulse | $\leq 12.35 \pm 0.5 kV_p$ | 12.41kV _p ~12.43kV _p | Data only |
| | | Switching impulse | Data only | See the text for details | |
| | | Steep current impulse | Data only | See the text for details | |
| 2 | High current impulse withstand test | 4/10 μ s、 100 kA 、 2times | 99.6kA~100.0kA | Pass | |
| 3 | Repetitive charge transfer rating withstand test | $Q_{rs} = 1.6C$ by 2ms rectangular current for 20 times. | 1.761 C ~1.887C | Pass | |
| 4 | Test to verify long term stability under continuous operating voltage | Charge ability 85%, 115 $^{\circ}$ C, 1000h. | $P_{max} \leq 1.3P_{min}$ $P_{all.max} \leq 1.1P_{start}$ | Pass | |

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Content:

1 Residual voltage test

1.1 Lightning impulse residual voltage test

| Samples | | | | 301 | 302 | 303 |
|----------|--------------------|-----------------|-----------------|----------------------|-------|-------|
| Resistor | U_{5mAAC} | Measured value | kV | 5.74 | 5.73 | 5.77 |
| | | Specified value | kV _p | ≥ 5.33 | | |
| | 8/20 μ s, 5kA | | kV _p | 11.86 | 11.84 | 11.89 |
| | 8/20 μ s, 10kA | | kV _p | 12.41 | 12.41 | 12.43 |
| | 8/20 μ s, 20kA | | kV _p | 13.48 | 13.42 | 13.58 |
| | Specified value | | kV _p | $\leq 12.35 \pm 0.5$ | | |

Note 1: Shunt 0.025 V/A, divider $K_d=206.8$

Note 2: According to the determined residual pressure, draw the residual voltage and current curve, in the curve corresponding to the nominal discharge current read residual voltage, defined as the lightning protection lightning protection level.

1.2 Switching impulse residual voltage test

| Samples | | | | 301 | 302 | 303 |
|----------|---------------------------|----|-----------------|-------|-------|-------|
| Resistor | U_{5mAAC} | kV | 5.74 | 5.73 | 5.77 | |
| | Residual voltage at 500A | | kV _p | 9.93 | 9.89 | 9.84 |
| | Residual voltage at 1000A | | kV _p | 10.38 | 10.30 | 10.27 |
| | Residual voltage at 2000A | | kV _p | 10.84 | 10.78 | 10.75 |

Note: Shunt 0.025 V/A, divider $K_d=206.8$

1.3 Steep current impulse residual voltage test

| Samples | | | | 301 | 302 | 303 |
|----------|--------------------|----|-----------------|-------|-------|-------|
| Resistor | U_{5mAAC} | kV | 5.74 | 5.73 | 5.77 | |
| | 8/20 μ s, 10kA | | kV _p | 13.63 | 13.59 | 13.63 |

Note1: Shunt 0.0267 V/A, divider $K_d=59.8$.

Note 2: If U_{res2}/U_{res1} is less than 2%, there is no need to correct Inductive effect.

Fulfilled the requirements. Test waveform is shown in figure C.1 ~ figure C.3.

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2 High current impulse withstand test

Environment temperature: 17.0°C humidity: 53%

| Samples | | 304 | 305 | 306 | Specified value |
|----------------------------------|-------------------------------------|-------|-------|-------|---|
| U _{1mADC} (Positive +) | kV | 7.50 | 7.53 | 7.51 | / |
| U _{1mADC} (Negative -) | kV | 7.52 | 7.51 | 7.50 | / |
| 8/20μs U _{10kAp} before | kV _p | 12.35 | 12.38 | 12.37 | / |
| 1 st impulse | kA | 100.0 | 100.0 | 99.8 | 100kA, The interval should allow the samples to cool to ambient temperature |
| 2 nd impulse | | 99.6 | 100.0 | 99.8 | |
| U _{1mADC} (Positive +) | kV | 7.46 | 7.48 | 7.51 | / |
| Change rate (Positive +) | % | -0.53 | -0.66 | 0 | / |
| U _{1mADC} (Negative -) | kV | 7.38 | 7.40 | 7.42 | / |
| Change rate (Negative -) | % | -1.60 | -1.46 | -1.07 | / |
| Visual inspection | No puncture, flashover or cracking. | | | | No puncture, flashover or cracking. |

Note: Shunt 0.001V/A.

Fulfilled the requirements. Test waveform is shown in figure C.4.

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3 Repetitive charge transfer rating withstand test

Environment temperature: 17.0°C humidity:76%

| Samples | | 310 | 311 | 312 | 313 | 314 | 315 | 316 | 317 | 318 | 319 |
|---------------------|-------------------------------|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Before test | U _{5mAAC} , kV | 5.70 | 5.70 | 5.69 | 5.69 | 5.69 | 5.70 | 5.71 | 5.70 | 5.69 | 5.71 |
| | 8/20μsU _{10kA} , kV | 12.39 | 12.33 | 12.37 | 12.34 | 12.33 | 12.37 | 12.38 | 12.38 | 12.35 | 12.36 |
| Q _{rs} , C | | Q _{rs} (Claimed repetitive charge transfer rating) × 1.1=1.76 | | | | | | | | | |
| 1 st | Q _{rs} , C | 1.774 | 1.824 | 1.887 | 1.837 | 1.862 | 1.772 | 1.832 | 1.816 | 1.842 | 1.804 |
| 2 nd | Q _{rs} , C | 1.791 | 1.768 | 1.861 | 1.850 | 1.852 | 1.859 | 1.847 | 1.791 | 1.828 | 1.809 |
| 3 rd | Q _{rs} , C | 1.766 | 1.772 | 1.850 | 1.846 | 1.847 | 1.845 | 1.839 | 1.782 | 1.822 | 1.773 |
| 4 th | Q _{rs} , C | 1.807 | 1.761 | 1.855 | 1.834 | 1.829 | 1.832 | 1.786 | 1.786 | 1.814 | 1.804 |
| 5 th | Q _{rs} , C | 1.787 | 1.776 | 1.837 | 1.796 | 1.822 | 1.810 | 1.801 | 1.786 | 1.798 | 1.785 |
| 6 th | Q _{rs} , C | 1.781 | 1.767 | 1.841 | 1.773 | 1.805 | 1.798 | 1.816 | 1.783 | 1.780 | 1.767 |
| 7 th | Q _{rs} , C | 1.772 | 1.778 | 1.833 | 1.785 | 1.808 | 1.784 | 1.824 | 1.785 | 1.775 | 1.762 |
| 8 th | Q _{rs} , C | 1.787 | 1.772 | 1.792 | 1.776 | 1.789 | 1.768 | 1.812 | 1.774 | 1.764 | 1.782 |
| 9 th | Q _{rs} , C | 1.776 | 1.769 | 1.809 | 1.781 | 1.779 | 1.805 | 1.803 | 1.767 | 1.795 | 1.768 |
| 10 th | Q _{rs} , C | 1.796 | 1.778 | 1.764 | 1.791 | 1.781 | 1.773 | 1.775 | 1.769 | 1.780 | 1.785 |
| 11 th | Q _{rs} , C | 1.781 | 1.766 | 1.797 | 1.785 | 1.775 | 1.777 | 1.784 | 1.761 | 1.778 | 1.778 |
| 12 th | Q _{rs} , C | 1.775 | 1.782 | 1.784 | 1.782 | 1.782 | 1.765 | 1.769 | 1.779 | 1.772 | 1.769 |
| 13 th | Q _{rs} , C | 1.781 | 1.779 | 1.775 | 1.778 | 1.802 | 1.786 | 1.774 | 1.784 | 1.768 | 1.772 |
| 14 th | Q _{rs} , C | 1.775 | 1.786 | 1.768 | 1.783 | 1.770 | 1.801 | 1.780 | 1.765 | 1.768 | 1.767 |
| 15 th | Q _{rs} , C | 1.771 | 1.801 | 1.793 | 1.780 | 1.815 | 1.816 | 1.793 | 1.771 | 1.786 | 1.793 |
| 16 th | Q _{rs} , C | 1.776 | 1.816 | 1.787 | 1.784 | 1.798 | 1.824 | 1.786 | 1.762 | 1.769 | 1.768 |
| 17 th | Q _{rs} , C | 1.779 | 1.824 | 1.772 | 1.767 | 1.785 | 1.812 | 1.766 | 1.783 | 1.780 | 1.782 |
| 18 th | Q _{rs} , C | 1.784 | 1.812 | 1.780 | 1.781 | 1.782 | 1.803 | 1.780 | 1.768 | 1.770 | 1.791 |
| 19 th | Q _{rs} , C | 1.786 | 1.803 | 1.774 | 1.775 | 1.776 | 1.785 | 1.774 | 1.784 | 1.778 | 1.788 |
| 20 th | Q _{rs} , C | 1.779 | 1.777 | 1.779 | 1.772 | 1.787 | 1.779 | 1.780 | 1.782 | 1.781 | 1.784 |
| Test evaluation | U _{5mAAC} , kV | 5.79 | 5.83 | 5.82 | 5.79 | 5.78 | 5.80 | 5.79 | 5.81 | 5.83 | 5.82 |
| | Change rate, % | +1.58 | +2.28 | +2.28 | +1.76 | +1.58 | +1.75 | +1.40 | +1.92 | +2.46 | +1.93 |
| | 8/20μs U _{10kA} , kV | 12.50 | 12.55 | 12.52 | 12.44 | 12.45 | 12.50 | 12.52 | 12.55 | 12.46 | 12.54 |
| | Change rate, % | +0.89 | +1.78 | +1.21 | +0.81 | +0.97 | +1.05 | +1.13 | +1.37 | +0.89 | +1.46 |
| | One 8/20 current impulse, kA | 19.23kA (0.5kA/cm ² =0.5×3.14×(7/2) ² =19.23kA which is lower than 2 times I _n) | | | | | | | | | |
| | Visual inspection | All the samples have no puncture, flashover or cracking. | | | | | | | | | |

Note: Shunt 0.01V/A.

Fulfilled the requirements, the test waveforms were shown in fig C.5.



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| 4 Test to verify long term stability under continuous operating voltage | | | |
|---|-------|-------|-------|
| Samples | 307 | 308 | 309 |
| U _{1mADC} , kV | 7.52 | 7.51 | 7.51 |
| U _{ct} , kV _{rms} | 4.79 | 4.79 | 4.79 |
| Charge rate,% | 90.1 | 90.2 | 90.2 |
| U _{5mAAC} , before test | 5.70 | 5.73 | 5.72 |
| U _{5mAAC} ,after test | 5.88 | 5.86 | 6.02 |
| Change rate, % | +3.16 | +2.27 | +5.25 |
| Power losses P _{start} , 3h, W | 1.123 | 1.078 | 1.095 |
| Power losses P _{100h} , W | 1.124 | 1.085 | 1.092 |
| Power losses P _{200h} , W | 1.118 | 1.082 | 1.094 |
| Power losses P _{300h} , W | 1.114 | 1.079 | 1.088 |
| Power losses P _{400h} , W | 1.123 | 1.089 | 1.083 |
| Power losses P _{500h} , W | 1.111 | 1.077 | 1.092 |
| Power losses P _{600h} , W | 1.109 | 1.076 | 1.080 |
| Power losses P _{700h} , W | 1.133 | 1.099 | 1.079 |
| Power losses P _{800h} , W | 1.106 | 1.074 | 1.102 |
| Power losses P _{900h} , W | 1.103 | 1.071 | 1.076 |
| Power losses P _{end} , 1000+8h,W | 1.128 | 1.095 | 1.072 |
| P _{min} , W | 1.103 | 1.071 | 1.072 |
| Any increase of power losses from P _{min} during the remaining test period, P _{max} | 1.128 | 1.095 | 1.072 |
| P _{all.max} , W | 1.133 | 1.099 | 1.102 |
| P _{max} / 1.3P _{min} | 0.787 | 0.787 | 0.769 |
| P _{all.max} /1.1 P _{start} | 0.917 | 0.927 | 0.915 |
| Because P _{max} ≤ 1.3P _{min} , P _{all.max} ≤ 1.1P _{start} , the samples fulfilled the requirements. | | | |
| Note: The temperature of blocks:115±4°C. | | | |
| Fulfilled the requirements, the accelerated ageing curves were shown in fig 1. | | | |



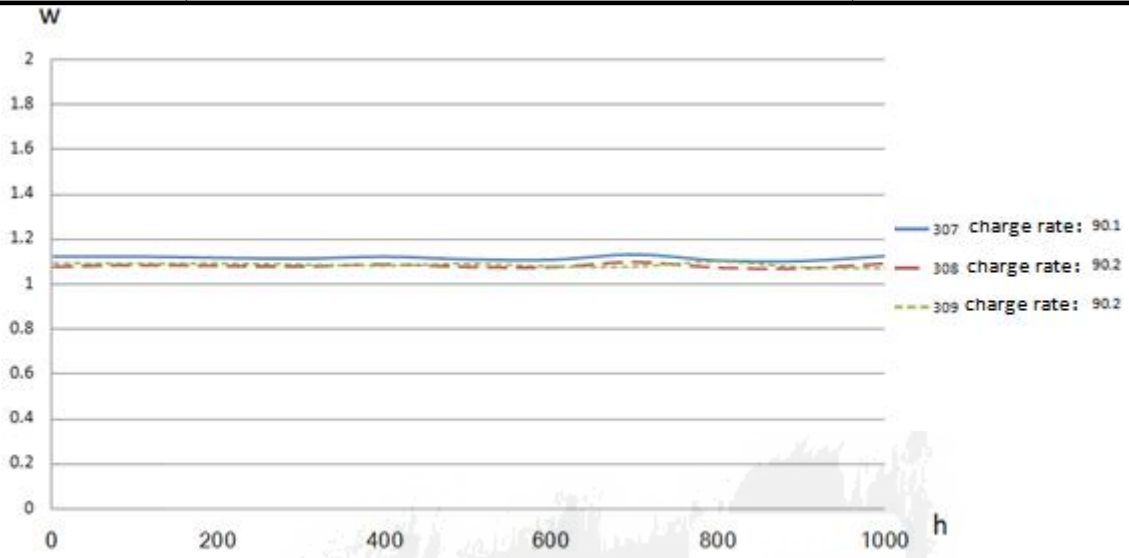


Fig 1 The Accelerated ageing curve of samples

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Appendix A: Sample instruction

Sample instruction:

- 1) 19 resistors, number EETC02-23/01/20-0061-301~ EETC02-23/01/20-0061-319, short for 301~319 in report.

Appendix B: Main test device

| NO. | Device name | Device NO. | Measurement | Uncertainty /Accuracy | Calibration institution | Expiration date |
|-----|--|-------------|--|--|---|-----------------|
| 1 | impulse current generator | EETC02-0003 | 8/20 μs 40 kA 4/10 μs 130 kA | U _{rel} =0.015 k=2 | National center for high voltage measurement | 2023-06-23 |
| 2 | impulse current generator | EETC02-0005 | 8/20 μs 40 kA 30 kV 4/10 μs 2 kA 30 kV | U _{rel} =0.015 k=2 U _{rel} =0.018 k=2 | National center for high voltage measurement | 2023-06-29 |
| 3 | Steep current impulse generator | EETC02-0004 | 8/20 μs 40 kA 30 kV 30/80 μs 2 kA 30 kV | U _{rel} =0.015 k=2 U _{rel} =0.018 k=2 | National center for high voltage measurement | 2023-06-29 |
| 4 | DC reference voltage tester | EETC02-0049 | DC 0~9 kV | U _{rel} =0.008 k=2 | Hubei province meteorological metrological verification station | 2023-07-12 |
| 5 | Accelerated aging device for MO resistor | EETC02-0036 | 115℃ | U _{rel} =0.3℃k=2 | Hubei province meteorological metrological verification station | 2023-08-03 |
| | | | 0~10kV | U _{rel} =0.013 k=2 | National center for high voltage measurement | 2024-03-08 |

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Appendix C The typical test waveform

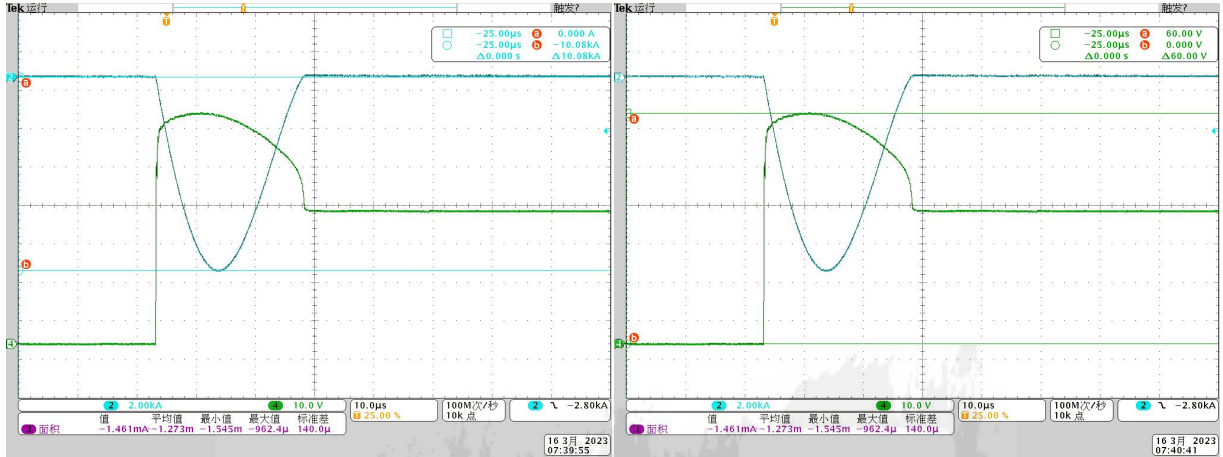


Fig C.1 Lightning impulse current and residual voltage waveform (sample 301, shunt 0.025V/A, divider $K_d=206.8$)

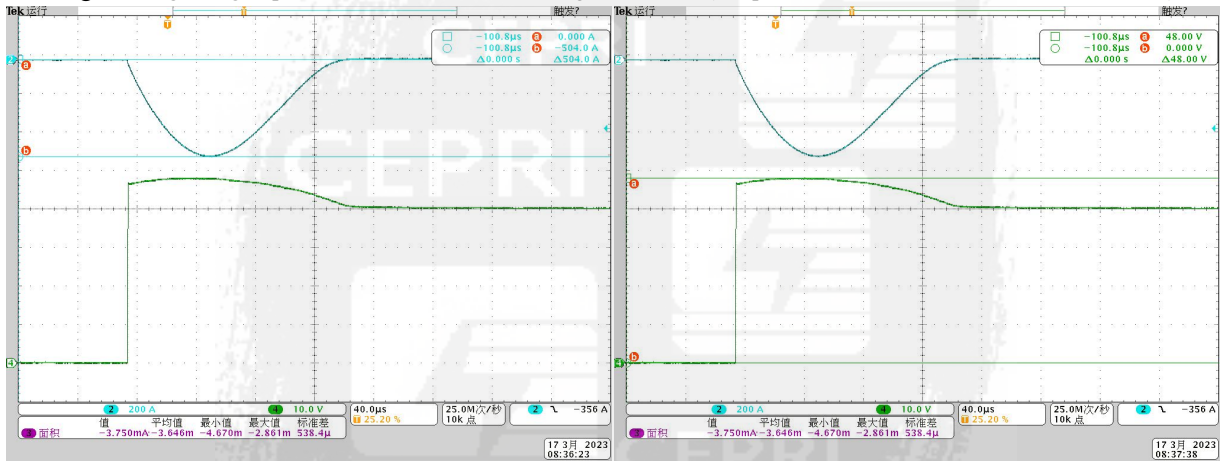


Fig C.2 Switching impulse current and residual voltage waveform (sample 301, shunt 0.025V/A, divider $K_d=206.8$)

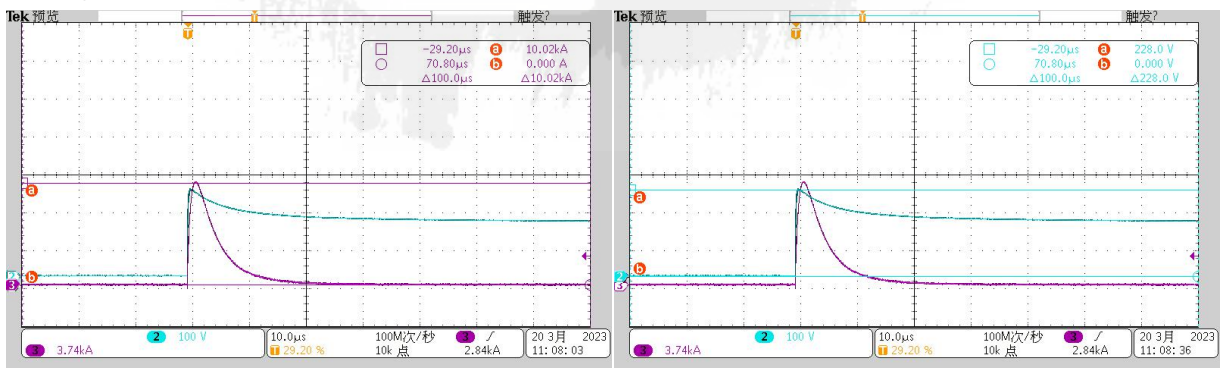


Fig C.3 Step impulse current and residual voltage waveform (sample 301, shunt 0.0267V/A, divider $K_d=59.8$)

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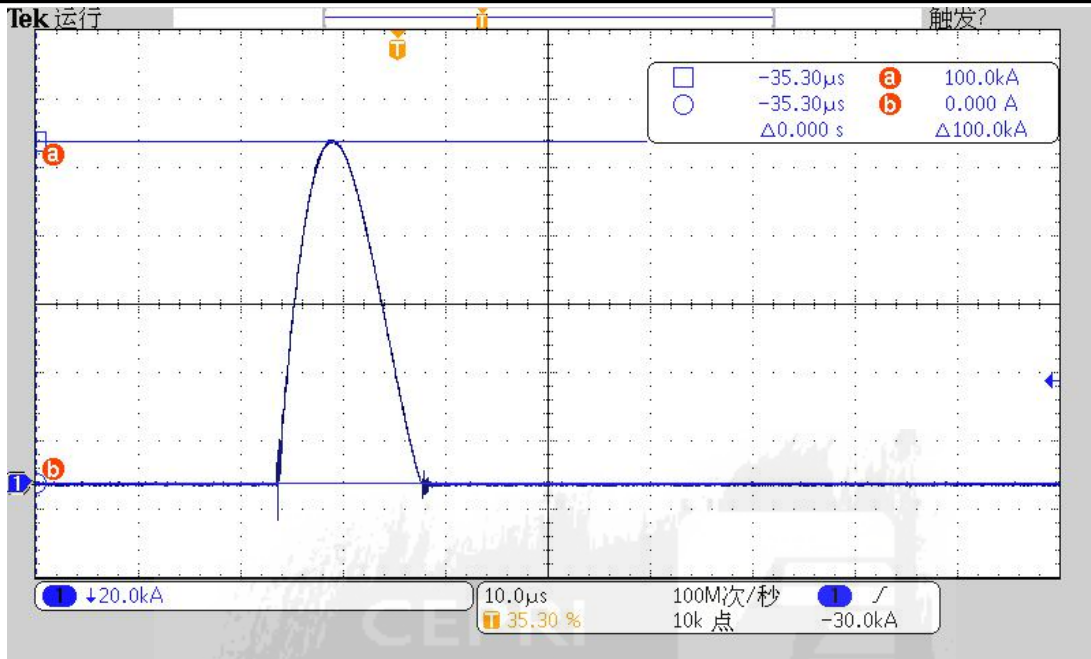


Fig C.4 Waveform of 304 conditioning test (first impulse)

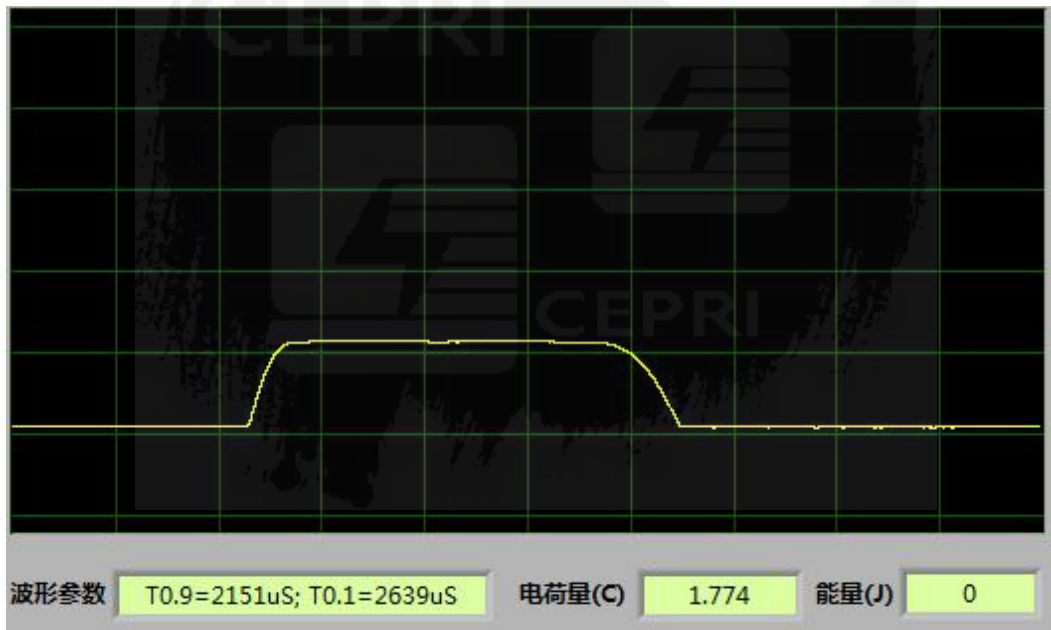


Fig C.5 The 1st time of sample 310, Repetitive charge transfer withstand, 0.01V/A

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Appendix D: Photos of the arrester



Fig D1: Outside view of MO resistor ($\Phi 70\text{mm} \times 22\text{mm}$)



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