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TEST REPORT

CEPRI-EETC02-2022-0040 (E)

Client: ANHUI CHARDON ELECTRIC LTD.

Object: Separated Connectors 51kV/134kV Coupling

(Rear)T-Body Surge Arrester

Type: 51-RDTA134/51-FDTA134

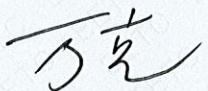
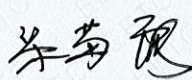
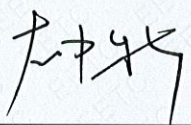
Test Category: Type Test



POWER INDUSTRY QUALITY INSPECTION AND TEST
CENTER FOR ELECTRIC EQUIPMENT

Catalogue

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Client	ANHUI CHARDON ELECTRIC LTD.	Manufacturer	ANHUI CHARDON ELECTRIC LTD.
Object	Separated Connectors 51kV/134kV Coupling(Rear)T-Body Surge Arrester	Type	51-RDTA134/51-FDTA134 (Φ42mm×23mm)
Sampling procedure	By the client delivery	Serial No.	1arresters (001) 10 thermally prorated sections (201~210) 13 resistors (301~313) 1 housings(401) 4 dielectrically prorated section(101~104)
Test Category	Type Test	Date	2021.12.31~2022.02.28
Requirements	GB/T 11032-2020 Metal-oxide surge arresters without gaps for a.c. systems		
Conclusion	The separated connectors 51kV/134kV coupling(Rear)T-Body surge arrester type 51-RDTA134/51-FDTA134 have successfully passed the type test specified in GB/T 11032-2020.		
Note	Note :See appendix A for sample instruction.		
Tested by: 万克  梁菊霞 			
Checked by: 王陆璐  Verified by: 左中秋 			
Approved by: 王保山  Date of issue: 2022.03.31			

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Test Results					
No.	Item	Requirements		Results	Evaluation
1	D.C. reference voltage test	$73.0\text{kV} \leq U_{1\text{mADC}} \leq 76.0\text{kV}$		74.9kV	Pass
2	Leakage current test at 0.75 times D.C. reference voltage	$I_L(0.75U_{1\text{mADC}}) \leq 50\mu\text{A}$		7μA	Pass
3	Continuous current test	Resistive current $I_R \leq 200\mu\text{A}$ Total current $I_X \leq 1000\mu\text{A}$		$I_R = 74\mu\text{A}$ $I_X = 318\mu\text{A}$	Pass
4	Power-frequency reference voltage test	Power-frequency reference voltage of the arrester $\geq 51.0\text{kV}_p / \sqrt{2}$		$54.7\text{kV}_p / \sqrt{2}$	Pass
5	Internal partial discharge test	$1.05U_c, PD \leq 10\text{ pC}$		PD=2.3 pC	Pass
6	Insulation withstand tests on the arrester housing	Power-frequency voltage: Dry $\geq 95\text{kV}$, for 1min. Lightning impulse voltage : 185kV_p , the positive and negative 15 times respectively.		Power-frequency voltage dry: $95.3\text{kV}_{\text{rms}}$, 1min. Lightning impulse voltage: $185.8\text{kV}_p \sim 186.9\text{kV}_p$ the positive and negative 15 times respectively.	Pass
7	Residual voltage test	Lightning impulse	$\leq 134.0\text{kV}_p$	122.8kV_p	Pass
		Switching impulse	$\leq 114.0\text{kV}_p$	99.5kV_p	
		Steep current	$\leq 154.0\text{kV}_p$	130.6kV_p	
8	Repetitive charge transfer withstand test	10 samples should withstand 20 times 8/20μs lightning impulse current and the charge value should not less than 0.4C.		0.440C ~0.454C	Pass
9	Test to verify long term stability under continuous operating voltage	The accelerated ageing test of resistors should be carried out according to the specified procedure.		$P_{\text{max}} \leq 1.3P_{\text{min}}$, $P_{\text{all,max}} \leq 1.1P_{\text{start}}$; the samples fulfilled the requirements.	Pass
10	Heat dissipation behavior verification test	The test section should have a temperature higher than the complete arrester for all instants during the cooling period.		Fulfilled the requirements. See fig 2.	Pass

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11	Operating duty test	Rated thermal charge injection $Q_{th} \geq 0.7$ C. The residual voltage should not have changed by more than 5%.	$Q_{th} \geq 0.723C$ The residual voltage changed ratio is from +1.56%~+2.01%	Pass	
12	Power-frequency voltage-versus-time characteristics	Supply the Power frequency voltage-versus-time characteristics for the range of voltage from $1.20U_r^*$ to $1.00U_r^*$, the range of time from 0.1s to 1200s for with prior duty, $1.20U_r^*$ to $1.00U_r^*$, the range of time from 1.1s to 1200s for without prior duty.	With prior duty test $1.20U_r^*$ 0.1s $1.15 U_r^*$ 1.1s $1.10 U_r^*$ 10.1s $1.00 U_r^*$ 1200s	Pass	
			Without prior duty test $1.20U_r^*$ 1.1s $1.00U_r^*$ 1200s		
13	Test to verify the dielectric withstand of the internal components of an	1 time 65kA-4/10μs	65.6kA, no puncture, flashover, cracking or other significant damage.	Pass	
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Content:						
1~2D.C. reference voltage test and leakage current at 0.75 times D.C. reference voltage test						
Environment temperature: 7.0℃ humidity: 73%						
Samples	D.C. reference voltage U_{1mADC} kV		0.75 times D.C. reference voltage kV		Leakage current μA	
	Measured value	Specified value	Measured value	Specified value	Measured value	Specified value
001	74.9	$73.0 \leq U_{1mADC} \leq 76.0$	56.2	$0.75U_{1mADC} \pm 1\%$	7	≤ 50
Note: The standard only provides the D.C. reference voltage lower limit. The upper limit declared by the manufacturer is used to determine the proportion of the arrester protection level.						
Fulfilled the requirements.						
3 Power-frequency reference voltage test						
Sample	$U_{1mAAC}, kV_p / \sqrt{2}$					
	Measured value		Specified value			
001	54.7		≥ 51.0			
Fulfilled the requirements.						
4 Continuous current test						
Sample	Resistive current $I_R \mu A_p$		Full current $I_X \mu A_{rms}$			
	Measured value	Specified value	Measured value		Specified value	
001	74	≤ 200	318		≤ 1000	
NOTE: The continuous current of the arrester under the continuous operating voltage declared by manufacturer.						
Fulfilled the requirements.						
5 Internal partial discharge test						
Samples	U_r	U_r duration time	$1.05U_c$	$1.05U_c$ duration time	Partial discharge	
	kV_{rms}	s	kV_{rms}	s	pC	
001	51.0	10	42.8	60	2.3	
Specified value	51.0	2~10	42.8	60	≤ 10	
Fulfilled the requirements.						

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6 Insulation withstand tests on the arrester housing

6.1 Power frequency voltage withstand test

t=8.0℃ RH=65% Atmospheric pressure:101.9kPa

Samples	Specified value	Applied voltage	Duration	Test result
	kV _{rms}	kV _{rms}	s	
401	95.0(dry)	95.3	60	No flashover

Fulfilled the requirements.

6.2 Lightning impulse voltage withstand test

t=8.0℃ RH=65% Atmospheric pressure:101.9kPa

Samples	Specified value		Applied voltage	Withstand times	Test result
	kV		kV _p		
401	(+)	185	185.8~186.7	15	No breakdown, no flashover
	(-)	185	186.1~186.9	15	No breakdown, no flashover

Fulfilled the requirements.

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7 Residual voltage test

7.1 Lightning impulse current residual voltage test

Samples			301	302	303
Residual voltage of the sections	U_{1mAAC}	kV	5.43	5.42	5.42
	8/20 μ s, 2.5kA	kV _p	8.42	8.40	8.39
	8/20 μ s, 5kA	kV _p	8.77	8.75	8.73
	8/20 μ s, 10kA	kV _p	9.60	9.57	9.56
Residual voltage of the arresters	Ratio, n	-	14.0		
	8/20 μ s, 2.5kA	kV _p	117.9	117.8	117.7
	8/20 μ s, 5kA	kV _p	122.8	122.7	122.4
	8/20 μ s, 10kA	kV _p	134.4	134.2	134.1
	Lightning impulse protection level	kV _p	122.8		
	Specified value	kV _p	≤ 134.0		

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.

7.2 Switching impulse residual voltage test

Samples			301	302	303
Resistor	Residual voltage at 250A	kV _p	7.11	7.08	7.07
Complete arrester	Test value	kV _p	99.5	99.3	99.1
	Switching impulse protection level	kV _p	99.5		
	Specified value	kV _p	≤ 114.0		

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

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7.3 Steep impulse current residual voltage test

Samples			301	302	303
Residual voltage of the sections	5kA U_{res1}	kV _p	9.57	9.54	9.54
Residual voltage of metal block	5kA U_{res2}	kV _p	0.26		
Residual voltage after correction	$U_{res1}-U_{res2}$	kV _p	9.31	9.28	9.28
Complete arrester	Ratio, n	-	14.00	14.02	14.02
	Residual voltage for the arrester	kV _p	130.3	130.1	130.1
	inductive voltage drop	kV _p	0.3kV/m×0.229m×5=0.34kV		
	After correction	kV _p	130.6	130.5	130.5
	Steep current impulse protection level	kV _p	130.6		
	Specified value	kV _p	≤154.0		

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

Note 2: U_{res2}/U_{res1} is larger than 2%, need to correct Inductive effect.

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

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8 Repetitive charge transfer withstand

Samples: 10 resistors (304~313)

Requirements of standards: The samples should withstand more than 0.4C by 8/20us current impulse for 20 times, and after test, have no breakdown or flashover or breakage, the change of residual voltage within $\pm 5\%$, the change of reference voltage within $\pm 5\%$, also should withstand capability to one 8/20us current impulse of at least 0.5 kA/cm² peak current density or 2 times I_n , whichever is lower.

Test data: Fulfilled the requirements, the test waveforms were shown in appendix C fig C.4.

Samples		304	305	306	307	308	309	310	311	312	313
Before test	U_{1mAAC} , kV	3.95	3.92	3.93	3.89	4.00	3.90	3.94	3.91	3.92	3.93
	8/20 μ s U_{10kAp} , kV	8.98	8.77	8.85	8.71	9.01	8.81	8.93	8.82	8.85	8.85
Q_{rs} , C		Q_{rs} (Claimed repetitive charge transfer rating) $\times 1.1 = 0.44$									
1 st	Q_{rs} , C	0.444	0.440	0.447	0.446	0.441	0.454	0.452	0.449	0.443	0.447
2 nd	Q_{rs} , C	0.446	0.442	0.448	0.453	0.441	0.442	0.454	0.451	0.452	0.450
3 rd	Q_{rs} , C	0.443	0.447	0.449	0.448	0.447	0.444	0.442	0.445	0.446	0.452
4 th	Q_{rs} , C	0.451	0.442	0.446	0.441	0.442	0.449	0.452	0.442	0.445	0.447
5 th	Q_{rs} , C	0.447	0.449	0.447	0.445	0.440	0.447	0.453	0.446	0.444	0.443
6 th	Q_{rs} , C	0.451	0.447	0.446	0.444	0.451	0.445	0.453	0.450	0.443	0.453
7 th	Q_{rs} , C	0.443	0.452	0.448	0.444	0.440	0.446	0.444	0.442	0.447	0.440
8 th	Q_{rs} , C	0.448	0.449	0.443	0.441	0.453	0.442	0.450	0.444	0.447	0.442
9 th	Q_{rs} , C	0.452	0.445	0.451	0.450	0.453	0.449	0.444	0.449	0.448	0.452
10 th	Q_{rs} , C	0.450	0.443	0.442	0.442	0.447	0.452	0.449	0.447	0.446	0.444
11 th	Q_{rs} , C	0.449	0.444	0.449	0.449	0.450	0.445	0.441	0.452	0.446	0.454
12 th	Q_{rs} , C	0.452	0.451	0.444	0.452	0.453	0.449	0.447	0.449	0.448	0.453
13 th	Q_{rs} , C	0.442	0.447	0.450	0.451	0.454	0.452	0.447	0.445	0.444	0.442
14 th	Q_{rs} , C	0.446	0.451	0.453	0.442	0.446	0.440	0.452	0.447	0.448	0.453
15 th	Q_{rs} , C	0.443	0.442	0.449	0.442	0.448	0.452	0.443	0.451	0.443	0.446
16 th	Q_{rs} , C	0.441	0.447	0.454	0.454	0.448	0.440	0.447	0.445	0.452	0.442
17 th	Q_{rs} , C	0.446	0.447	0.453	0.448	0.452	0.442	0.450	0.450	0.447	0.446
18 th	Q_{rs} , C	0.451	0.442	0.453	0.448	0.447	0.447	0.442	0.444	0.450	0.449
19 th	Q_{rs} , C	0.454	0.441	0.446	0.445	0.448	0.454	0.449	0.449	0.446	0.450
20 th	Q_{rs} , C	0.451	0.454	0.445	0.447	0.451	0.445	0.449	0.448	0.441	0.443

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Test evaluation	One 8/20 current impulse, kA	6.92 kA $(0.5\text{kA}/\text{cm}^2=0.5\times 3.14\times (4.2/2)^2=6.92\text{kA}$ which is lower than 2 times I_n)									
		7.02	6.98	6.96	7.01	7.00	6.98	7.06	7.02	6.99	7.01
	U_{1mAAC} , kV	3.97	3.96	3.95	3.92	4.02	3.94	3.96	3.92	3.94	3.95
	Change rate, %	+0.51	+1.02	+0.51	+0.77	+0.50	+1.03	+0.51	+0.26	+0.51	+0.51
	8/20 μ s U_{10kAp} , kV	9.11	9.01	9.06	8.97	9.17	8.98	9.12	9.05	9.03	9.05
	Change rate, %	+1.45	+2.74	+2.37	+2.99	+1.78	+1.93	+2.13	+2.61	+2.03	+2.26
	Visual inspection	All the samples have no puncture, flashover or cracking.									
9 Test to verify long term stability under continuous operating voltage Samples: 3 dielectrically prorated sections(101~103) Requirements of standards: 3 resistors should pass the accelerated ageing test. Test data: Fulfilled the requirements, the accelerated ageing curves were shown in fig 1.											
Samples		101		102		103					
U_{1mADC} , kV		5.47		5.43		5.45					
U_c , kV _{rms}		3.29		3.29		3.29					
Power losses P_{start} , 3h, W		0.451		0.448		0.401					
Power losses P_{100h} , W		0.377		0.358		0.328					
Power losses P_{200h} , W		0.362		0.337		0.315					
Power losses P_{300h} , W		0.364		0.330		0.309					
Power losses P_{400h} , W		0.358		0.330		0.312					
Power losses P_{500h} , W		0.356		0.323		0.304					
Power losses P_{600h} , W		0.352		0.330		0.312					
Power losses P_{700h} , W		0.357		0.317		0.301					
Power losses P_{800h} , W		0.352		0.320		0.303					
Power losses P_{900h} , W		0.357		0.316		0.297					
Power losses P_{end} , 1000+8h,W		0.355		0.322		0.306					
P_{min} , W		0.352		0.316		0.297					
Any increase of power losses from P_{min} during the remaining test period, P_{max}		0.357		0.322		0.306					
$P_{all.max}$, W		0.451		0.448		0.401					
$P_{max} / 1.3P_{min}$		0.779		0.783		0.793					
$P_{all.max} / 1.1 P_{start}$		0.909		0.909		0.909					
Note: (1) Because $P_{max} \leq 1.3P_{min}$, $P_{all.max} \leq 1.1P_{start}$, the samples fulfilled the requirements. (2) The temperature of blocks:115±4 ℃.											

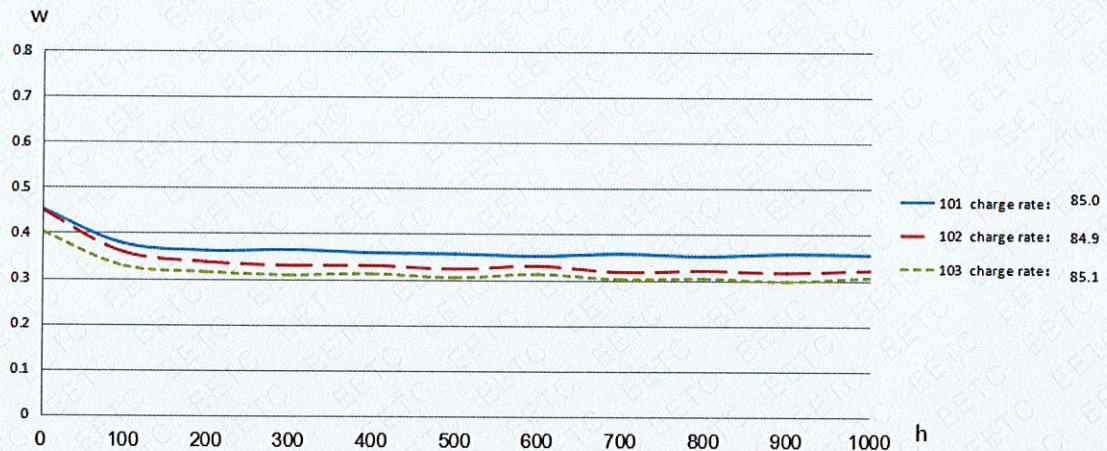


Fig 1 Accelerated ageing test curve

10 Heat dissipation behavior verification of test sample

Samples: 1 thermally prorated section (210) 1 arrester (001)

Requirements of standards: the MO resistors in the sample shall be heated to 140°C by the application of power-frequency voltage. When the temperature is reached, the voltage source shall be disconnected and the cooling time curve shall be determined. At any time, the measured cooling curve of section falls shall above the measured cooling curve of the arrester.

Test data: Fulfilled the requirements, the test waveform was shown in fig 2. The operating duty test preheated temperature should be 85°C.

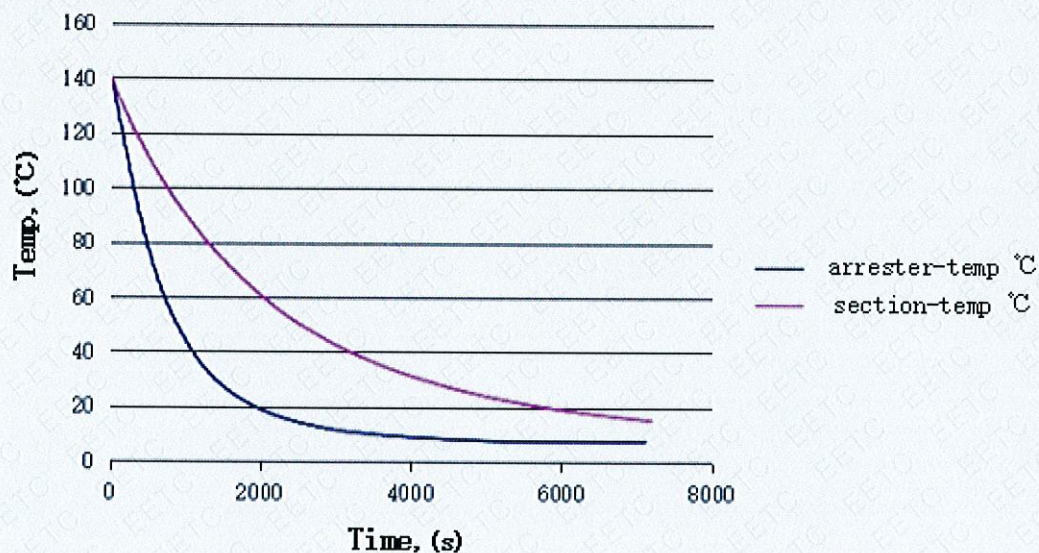


Fig 2 The cooling curve for the section and arrester

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11 Operating duty test					
Samples: 3 thermally prorated sections（201~203）					
Requirements of standards: 3 thermally prorated sections should pass the high current impulse operating duty test.					
Test data: Fulfilled the requirements, the test waveforms were shown in appendix C fig C.5~C.8.					
Samples			201	202	203
U _{ImADC} , kV			5.47	5.47	5.48
U _{sr} , kV _{rms}			3.82	3.82	3.83
U _{sc} , kV _{rms}			3.06	3.06	3.06
8/20μs, U _{5kAp} ,before, kV			8.97	8.96	8.97
Conditioning test	1 st high current impulse, kA _p		65.2	65.1	64.9
	2 nd high current impulse, kA _p		64.8	65.2	65.2
preheated samples			preheated samples to 85.0℃±3℃		
Rated thermal charge transfer ,Q _{th}	Lightning current impulse	1 st Q _{th} ,C	0.362	0.358	0.361
		2 nd Q _{th} ,C	0.367	0.365	0.369
	Q _{th} rating (2 times) , C		0.729	0.723	0.730
Applied voltage after the 2 nd impulse	Time	Req.	as short as possible (within 100ms)		
		Actual	88	89	86
	Applied voltage and duration	U _{sr} [*] , kV _{rms}	3.82	3.82	3.83
		Duration, s	10	10	10
		U _{sc} [*] , kV _{rms}	3.06	3.06	3.06
		Duration, min	30	30	30
Power loss, W	1 s		5.27	5.16	5.78
	5 min		3.52	3.55	3.76
	10 min		2.73	2.69	2.82
	15 min		2.04	2.10	2.35
	20 min		1.56	1.52	1.85
	25 min		1.17	1.09	1.26
	30 min		0.92	0.88	1.07
Samples cooled to			cooled to ambient 20℃±15℃		
8/20μs, U _{5kAp} ,after, kV			9.15	9.10	9.12
Variability of the residual voltage, %			+2.01	+1.56	+1.67
Visual inspection			No puncture, flashover, cracking or other significant damage		
Fulfilled the requirements.					

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12 Power-frequency voltage-versus-time test						
12.1 Power-frequency voltage-versus-time test data (with prior duty)						
Samples			204	205	206	207
U _{ImADC} , kV			5.48	5.48	5.49	5.49
U _{sr} , kV _{rms}			3.83	3.83	3.84	3.84
U _{sc} , kV _{rms}			3.06	3.06	3.07	3.07
8/20μs, U _{5kAp} ,before, kV			8.98	8.97	9.00	8.99
preheated samples			preheated samples to85℃±3℃			
2ms long-duration current impulse	1 st impulse	Q _{th} ,C	5.48	5.48	5.49	5.49
	2 nd impulse	Q _{th} ,C	3.83	3.83	3.84	3.84
	Q _{th} rating (2 times) , C		0.719	0.727	0.729	0.735
Applied voltage after the 3 rd impulse	Time	Req.	as short as possible (within 100ms)			
		Actual	86	86	88	86
	Applied voltage and duration	U [*] _{sr} , kV _{rms}	4.59	4.40	4.22	3.84
		TOV scale	1.20	1.15	1.10	1.00
		Duration, s	0.1	1.10	10.1	1200
		U [*] _{sc} , kV _{rms}	3.06	3.06	3.07	3.07
		Duration, min	30	30	30	30
Power loss, W	1 s		9.27	7.63	6.22	4.33
	5 min		6.78	5.72	4.57	3.15
	10 min		4.62	4.32	3.67	2.28
	15 min		3.72	3.44	3.02	1.48
	20 min		3.06	2.83	2.74	1.17
	25 min		2.49	2.69	2.51	1.02
	30 min		2.22	2.45	2.42	0.90
Samples cooled to			cooled to ambient 20℃±15℃			
8/20μs, U _{5kAp} ,after, kV			9.08	8.91	8.95	9.06
Variability of the residual voltage, %			+1.11	-0.67	-0.56	+0.78
Visual inspection			No puncture, flashover, cracking or other significant			

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12.2 Power-frequency voltage-versus-time test data (without prior duty):					
Samples			208	209	
U _{ImADC} , kV			5.49	5.49	
U _{sr} , kV _{rms}			3.84	3.84	
U _{sc} , kV _{rms}			3.07	3.07	
8/20μs, U _{5kAp} ,before, kV			8.99	9.01	
preheated samples			preheated samples to 85.0℃±3℃		
Applied voltage	Applied voltage and duration	U _{sr} [*] , kV _{rms}	4.60	3.84	
		TOV scale	1.20	1.00	
		Duration, s	1.1	1200	
		U _{sc} [*] , kV _{rms}	3.07	3.07	
		Duration, min	30	30	
Power loss, W	1 s		3.36	2.17	
	5 min		2.25	1.56	
	10 min		1.62	1.17	
	15 min		1.25	1.03	
	20 min		1.03	0.95	
	25 min		0.91	0.88	
	30 min		0.85	0.87	
Samples cooled to			cooled to ambient 20℃±15℃		
8/20μs, U _{5kAp} ,after, kV			9.03	9.02	
Variability of the residual voltage, %			+0.44	+0.11	
Visual inspection			No puncture, flashover, cracking or other significant damage		
Fulfilled the requirements, the test waveforms were shown in appendix C fig C.9.					

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13 Test to verify the dielectric withstand of the internal components of an arrester

Samples: 1 dielectrically prorated section (104)

Requirements of standards: preheat the sample to 60°C, consists of one application of a 65kA high-current impulse.

There should be no evidence of a dielectric breakdown. The test waveforms were shown in appendix C fig C.10.

Sample			104
U _{1mAAC} , kV			3.87
8/20μs, U _{5kA} ,before, kV			8.72
preheated samples			preheated samples to 60°C±3°C
high-current impulse, kA			65.6
Samples cooled to			cooled to ambient 20°C±15°C
8/20μs, U _{10kA} ,after, kV			8.69
Variability of the residual voltage, %			-0.34
Visual inspection	The block can not remove from the section	8/20μs current impulse, 2 times	6.92 kA (0.5kA/cm ² =0.5×3.14×(4.2/2) ² =6.92kA which is lower than 2 times I _n)
		1 st impulse, kA _p	6.98
		2 nd impulse, kA _p	6.97
		Curve check	No puncture, flashover, cracking or other significant damage

(No content in this page below)

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Appendix A: Object Parameters

Rated voltage U_r : 51kV

Continuous operating voltage U_c : 40.8kV_{rms}

Nominal discharge current I_n : 5kA

Lightning impulse residual voltage: U_{res} : $\leq 134kV_p$

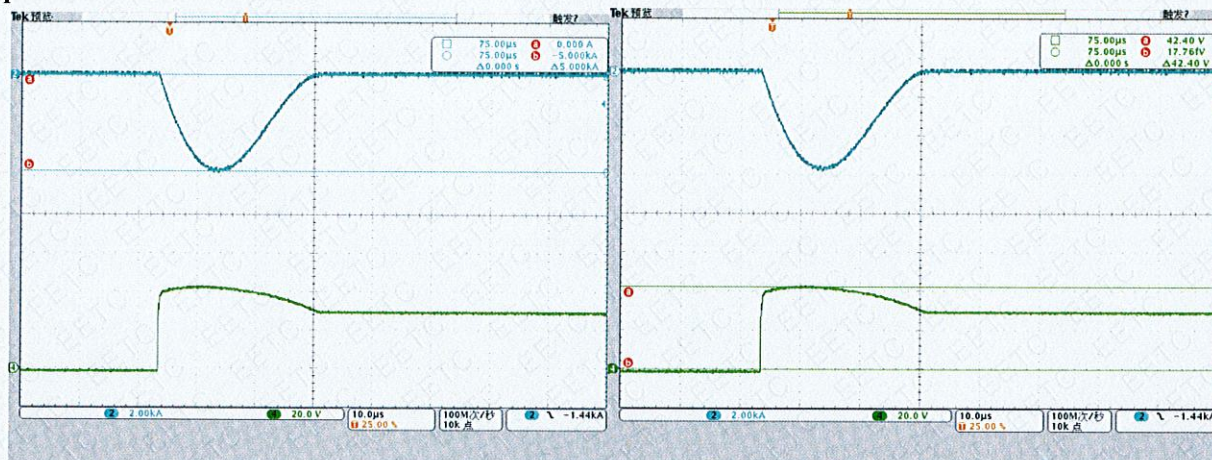
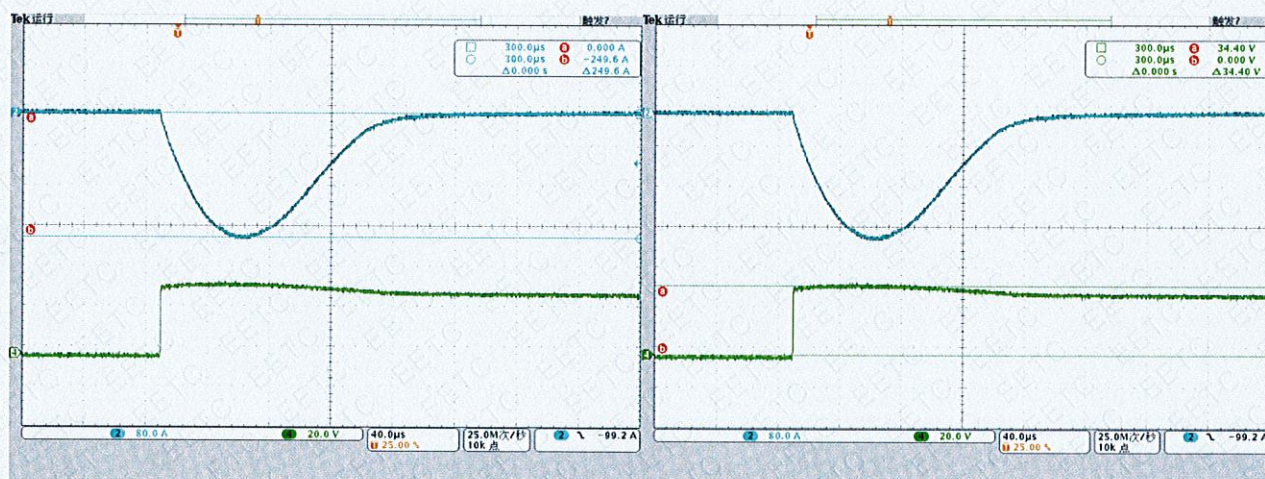
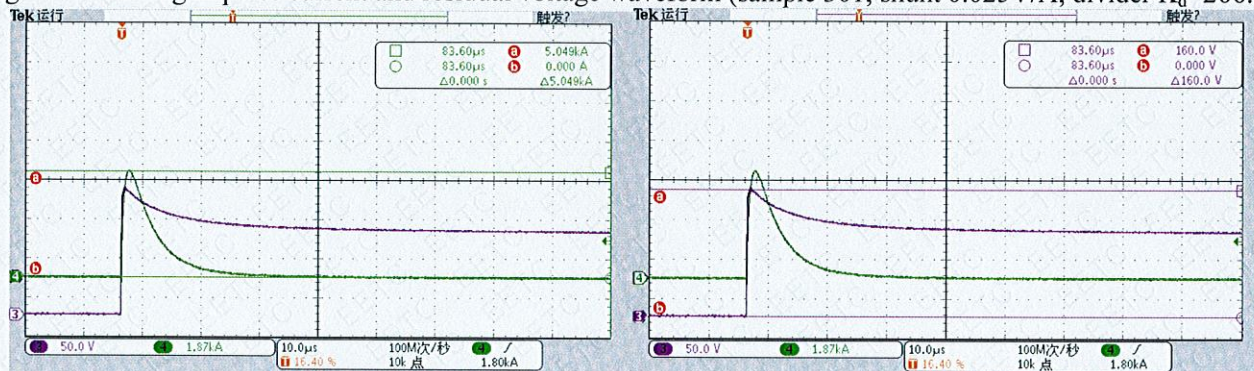
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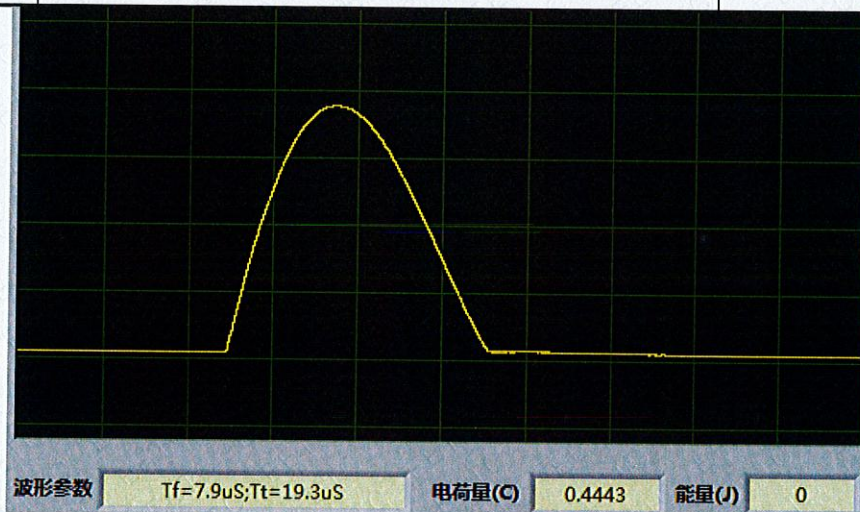
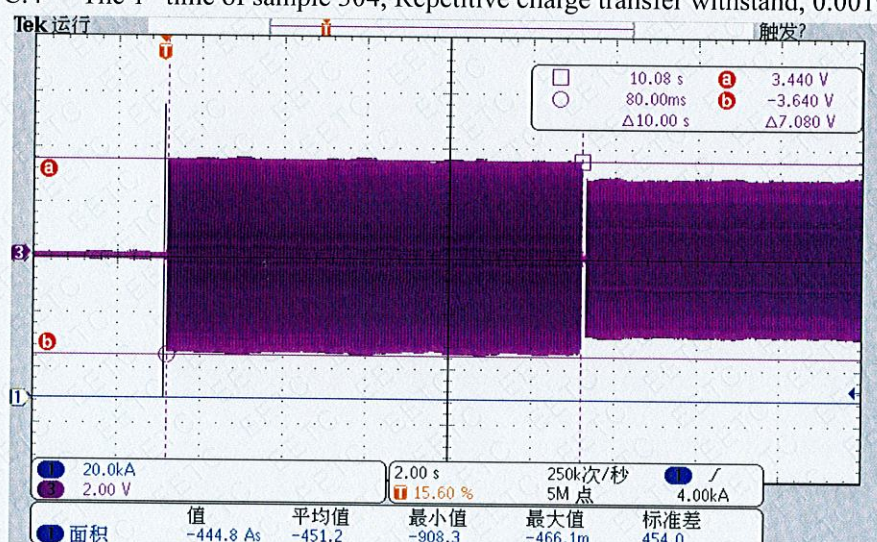
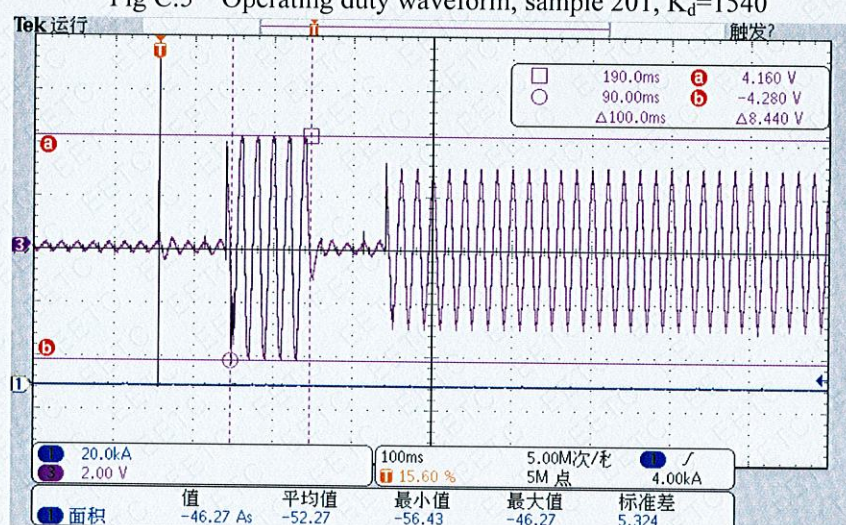
①1 arrester, number EETC02-21/11/30-0040-001, short for 001 in report; ②10 thermally prorated sections, number EETC02-21/11/30-0040-201~EETC02-21/11/30-0040-210 short for 201~210 in report; ③13 resistors, number EETC02-21/11/30-0040-301~EETC02-21/11/30-0040-313, short for 301~313 in report; ④1 housings, number EETC02-21/11/30-0040-401, short for 401 in report.; ⑤4 dielectrically prorated sections, number EETC02-21/11/30-0040-101~EETC02-21/11/30-0040-104, short for 101~104 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 μ s 100 kA, 20kV 4/10 μ s 150 kA, 20kV 30/80 μ s 50 kA, 20kV	$U_{rel}=0.015$ k=2 $U_{rel}=0.021$ k=2	National center for high voltage measurement	2023-06-23
2	impulse current generator	EETC02-0005	8/20 μ s 50 kA, 20kV 30/80 μ s 10 kA, 20kV	$U_{rel}=0.015$ k=2 $U_{rel}=0.018$ k=2	National center for high voltage measurement	2023-06-29
3	Steep current impulse generator	EETC02-0004	1/5 μ s 20kA , 20kV	$U_{rel}=0.015$ k=2 $U_{rel}=0.018$ k=2	National center for high voltage measurement	2023-06-29
4	800kV impulse voltage generator	EETC02-0007	0~800 kV	$U_{rel}=0.019$ k=2 $U_{rel}=0.016$ k=2	National center for high voltage measurement	2022-05-28
5	400kV DC high voltage generator	EETC02-0008	DC 0~400kV	$U_{rel}=0.012$ k=2	National center for high voltage measurement	2022-08-18
6	Operating duty test system-voltage	EETC02-0009	0~10kV	$U_{rel}=0.006$ k=2	Beijing Aerospace measurement and testing technology institute	2023-01-06
7	JFD-251 PD tester	EETC02-0043	/	$U_{rel}=0.015$ k=2	Beijing Aerospace measurement and testing technology institute	2023-01-04
8	DC reference voltage tester	EETC02-0048	DC 0~9 kV	$U_{rel}=0.008$ k=2	National center for high voltage measurement	2022-05-10
9	Temperature measuring system	EETC02-0053	0~150℃	$U_{rel}=0.2^{\circ}C$ k=2	Hubei province meteorological metrological verification station	2022-12-05

Appendix C: Waveforms

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 Steep impulse current and residual voltage waveform (sample 301, shunt 0.0267V/A, divider $K_d=59.8$)

Fig C.4 The 1st time of sample 304, Repetitive charge transfer withstand, 0.00192V/AFig C.5 Operating duty waveform, sample 201, $K_d=1540$ Fig C.6 Power-frequency voltage-versus-time test waveform, sample 204, $K_d=1540$

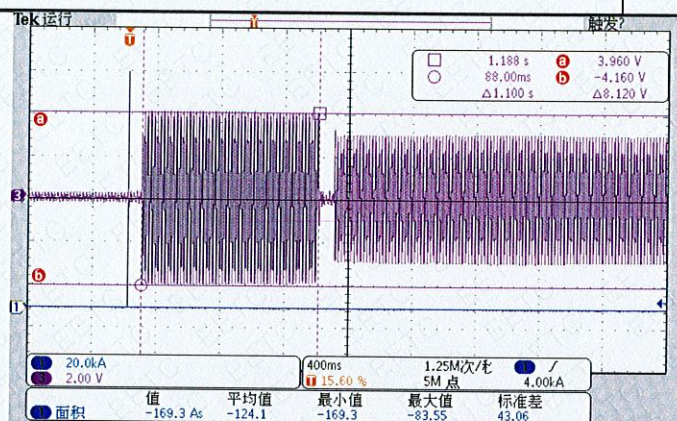
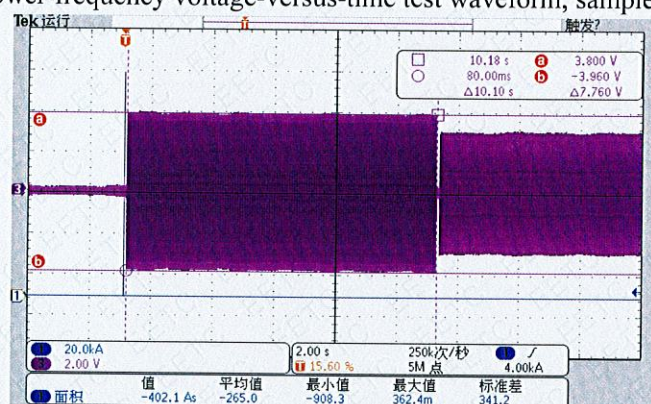
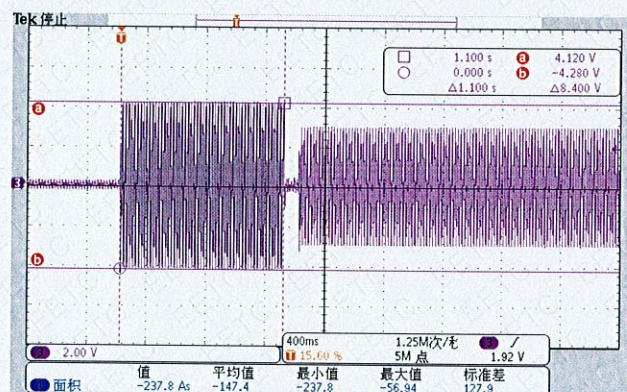
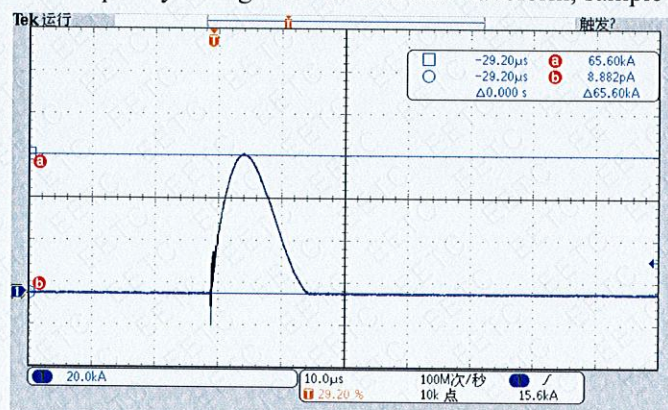
Fig C.7 Power-frequency voltage-versus-time test waveform, sample 205, $K_d=1540$ Fig C.8 Power-frequency voltage-versus-time test waveform, sample 206, $K_d=1540$ Fig C.9 Power-frequency voltage-versus-time test waveform, sample 208, $K_d=1540$ 

Fig C.10 Test to verify the dielectric withstand of the internal components of an arrester, sample 104

Appendix D: Visual and dimensional check

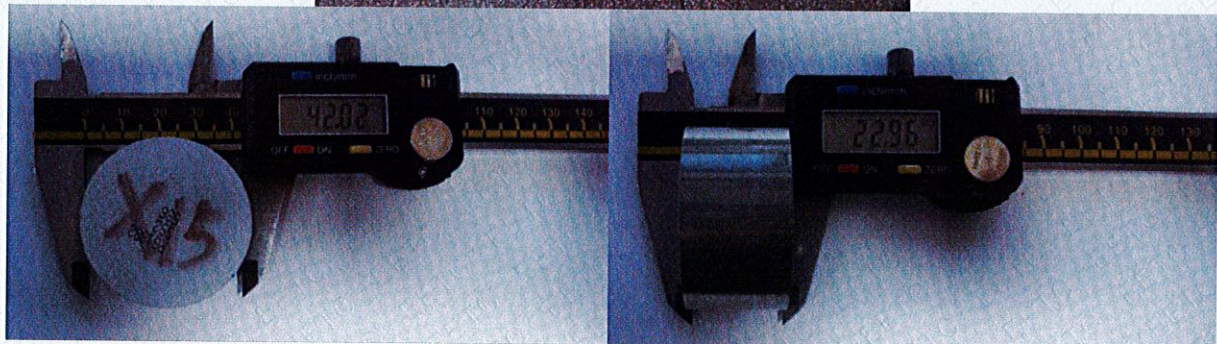
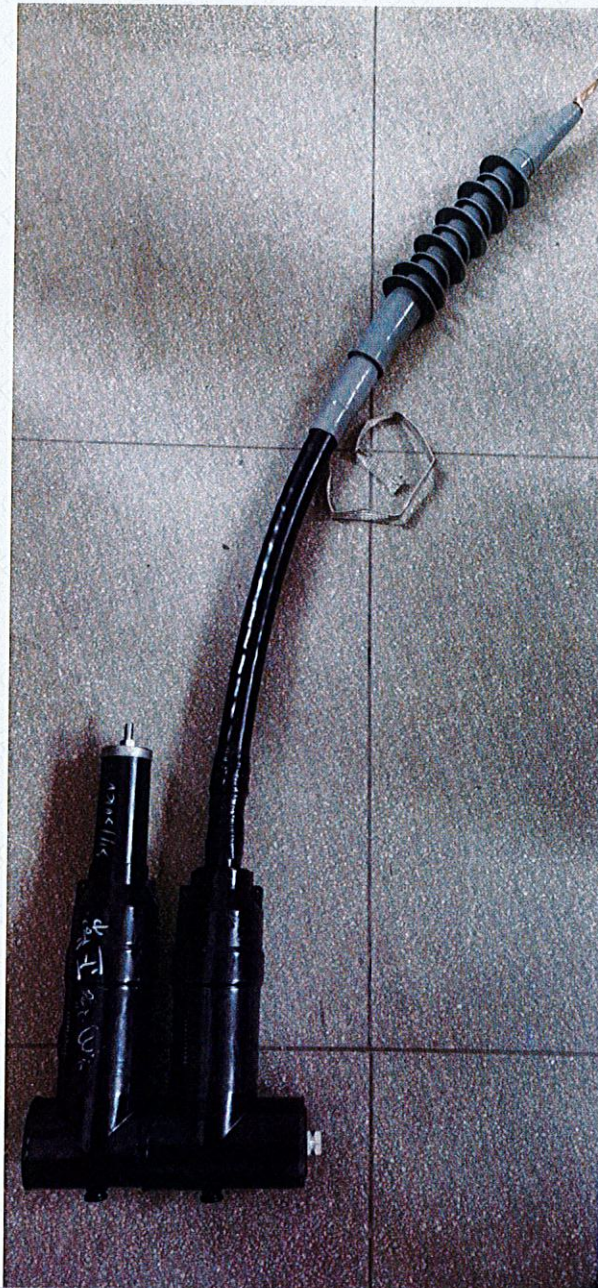


Fig D1: 51-RDTA134/51-FDTA134 type arrester and resistors

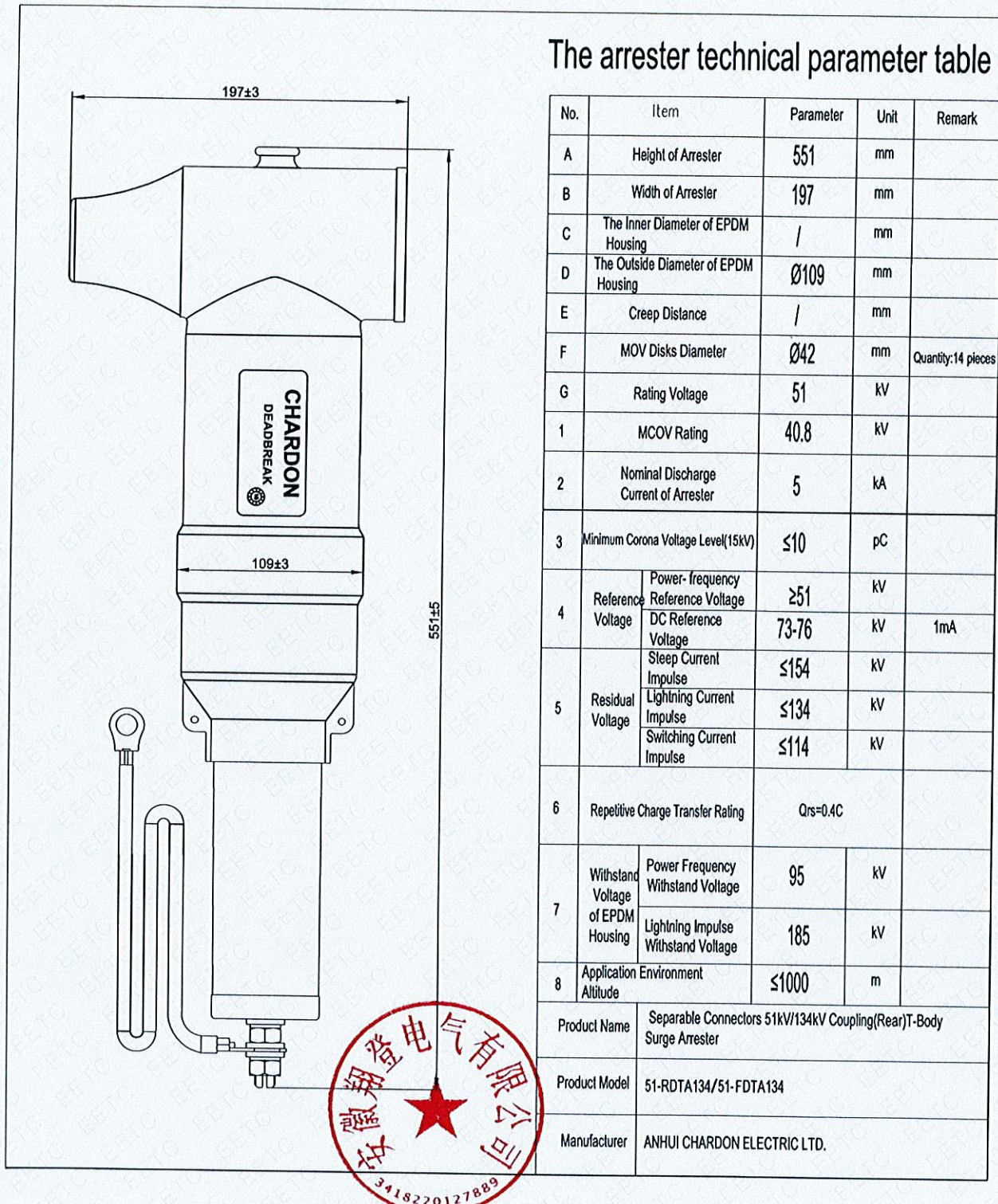


Fig D2 : Dimensional drawing of 51-RDTA134/51-FDTA134