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TESTING
CNAS L0681

CHPTL



TEST REPORT

No.: 2021046

Test object name: RIP Breaker bushing

Test object type: HCR-123/2000

Entrusted by: Dalian Hivolt Power System Co., Ltd.

Manufacture: Dalian Hivolt Power System Co., Ltd.

Kind of testing: type test

**CHINA NATIONAL TRANSFORMER QUALITY SUPERVISION AND
TESTING CENTER SHENYANG TRANSFORMER RESEARCH INSTITUTE
CO., LTD.**

China National transformer Quality Supervision Testing Center

Shenyang Transformer Research Institute

TEST REPORT

No:2021046

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Sample Name	RIP Breaker bushing	Manufacturing No.	21036077
Specification	HCR-123/2000	Company add	No.2804,75 Huili Street Ganjingzi district, China
Client	Dalian Hivolt Power System Co., Ltd.	Sampling method	-
Sample No.	018	Arrived date	1 st , June,2021
Sample quantity		Test date	2 nd , June,2021-20 st , June,2021
Manufacturer	Dalian Hivolt Power System Co., Ltd.	Main tech data	As per following report
Sort of test	Entrust test		
Test items	See page 2-4		
Manufacture date	May,2021		
Test standard	IEC 60137 Edition 6.0 Insulated bushings for alternating voltages above 1 000 V		
Test conclusion	The tested items, method and result are in compliance with the requirement of standard GB/T 4109-2008 (IEC 60137), all tested items are qualified.		
Remark	Sampling base, unit and data should be listed if test is sampling inspection.		

Approved by: L. Shicheneg

Checked by: Du Jiansong

Compiled by: Shi Yuxia

Statement : 1. Testing report is invalid without test special seal.

2. Testing report is invalid without compiler, checker and approver's signature.

3. Please inform CTQC in time after received the testing report if you have some disagreement to the testing report..

4. Testing or witnessing only apply to sample.

5. Copying testing certificate or testing report is forbidden without written permission from CTQC(except for copying all the testing report).

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Test items and conclusion

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No.	Test items	Specified value	Measurement value	Test result	Page
		Standard (technical service contract)			
1	Visual and Dimensional Inspection (Routine test)	No defect will effect operation of bushings. Specified creepage ratio distance: $\geq 31\text{mm/kV}$ Total creepage distance: $\geq 3906\text{mm}$ Clear insulation length of oil side: $\geq 1080\text{mm}$	No defect $\geq 34\text{mm/kV}$ $\geq 4332\text{mm}$ $\geq 1080\text{mm}$	Qualified	4
2	Measurement on dielectric dissipation factor and capacitance (Routine test)	$1.05U_m/\sqrt{3}(76\text{kV}) \leq 0.5\%$; Voltage from $1.05U_m/\sqrt{3}(76\text{kV})$ rise to $U_m(126\text{kV})$: $\Delta \tan \delta \leq 0.1\%$ Capacitance	$=0.351\%$ $\leq 0.1\%$ 336.3 pF	Qualified	4
3	Power frequency dry voltage withstand test (Routine test)	Dry withstand voltage; 230kV, last for 60s	230kV, last for 60s	Qualified	4
4	Measurement on partial discharge (Routine test)	$1.5U_m/\sqrt{3}(109\text{kV}) : \leq 10\text{ pC}$ $1.05U_m/\sqrt{3}(76\text{kV}) : \leq 5\text{ pC}$	4 pC 2pC	Qualified	4
5	Test tap insulation test (Routine test)	Power frequency dry voltage withstand test: 2kV, last for 60s. Dielectric dissipation $\tan\delta: \leq 5\%$ Capacitance to earth $< 10000\text{ pF}$	2kV, last for 60s $\tan\delta=1.21\%$ 400.9pF	Qualified	5
6	Sealing test on flange (Routine test)	Applied load: $0.15\pm 0.01\text{MPa}$ (Gage pressure) last for 15 min without leakage	0.15MPa No leakage(15min)	Qualified	5
7	Lighting impulse dry voltage withstand test (Type test)	Dry withstand voltage(kV): Full wave: ± 550 , 15 times each	+545.02~+554.25, 15times -549.47~553.71, 15 times	Qualified	5
8	Power frequency wet withstand voltage test(type test)	Wet withstand voltage(kV):230 Last for:60s,frequency:50Hz	230 Last for 60s,50Hz	Qualified	11

China National transformer Quality Supervision Testing Center

Shenyang Transformer Research Institute

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Test items and conclusion

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No.	Test items	Specified value	Measurement value	Test result	Page
		Standard (technical service contract)			
9	Temperature rise test (Type test)	Under rated current 2000A: (1)Tinning stud in oil contact: Max temperature rise 75K,Max temperature 105°C (2) Tinning stud connected to block of conductor: Max temperature rise 75K,Max temperature 105°C	68.7K,99.3°C 10.4K, 41.0°C	Qualified	11
10	Cantilever load test (Type test)	4000N loading perpendicular to bushing axis, applied to midpoint of block, last for 60s	4000N,60s	Qualified	13
11	Short-time thermal current (Type test)	when $I_{th} = 50kA$, the finally calculated temperature $\leq 180^{\circ}C$	=131.3°C	Qualified	14
12	Measurement on dielectric dissipation factor and capacitance (Routine test after type test)	$1.05U_m/\sqrt{3}(76kV) \leq 0.5\%$; Voltage from $1.05U_m/\sqrt{3}(76kV)$ rise to $U_m(126kV)$: $\Delta \tan \delta \leq 0.1\%$	=0.348% $\leq 0.1\%$ 338.5 pF	Qualified	14
13	Power frequency dry voltage withstand test (Routine test after type test)	Dry withstand voltage: 230kV,last for 60s	230kV,last for 60s	Qualified	15
14	Measurement on partial discharge (Routine test after type test)	$1.5U_m/\sqrt{3}(109kV): \leq 10 pC$ $1.05U_m/\sqrt{3}(76kV): \leq 5 pC$	4 pC 2 pC	Qualified	15
15	Test tap insulation test (Routine test after type test)	Power frequency dry voltage withstand test: 2kV,last for 60s. Dielectric dissipation $\tan \delta: \leq 5\%$ Capacitance to earth $< 10000 pF$	2kV,last for 60s $\tan \delta = 1.21\%$ 400.9pF	Qualified	15
16	Sealing test on flange (Routine test after type test)	Applied load: $0.15 \pm 0.01 MPa$ (Gage pressure) last for 15 min without leakage	0.15MPa No leakage(15min)	Qualified	15

1 Sample specification

Product name: RIP Breaker bushing

Product No.: HCR-123/2000

Maximum voltage (U_m): 123kV

Rated current: 2000 A

Rated frequency: 50Hz

Insulation level: 550/230kV

Manufacturer: Dalian Hivolt Power System Co., Ltd.

Manufacture date: May, 2021

2 Test items and conclusion**2.1 Visual and Dimensional Inspection (Routine test)**

The tested bushing is without defect on the surface that will affect the normal operation, total creepage distance 4332mm, clear insulation length in oil is 1080mm, creepage ratio distance is 31mm/kV, other size of assembling part and relative connection part are in compliance with the drawing requirement.

2.2 Measurement on dielectric dissipation factor and capacitance (Routine test)

Barometric pressure:100.5kPa Relative humidity:28.0% Ambient temperature:33.0°C

Applied voltage		Test result	
Times	Voltage(kV)	Dielectric dissipation factor(%)	Capacitance (pF)
-	10	0.350	336.3
$1.05U_m/\sqrt{3}$	76	0.351	336.3
$U_1 = U_m$	126	0.351	336.3

2.3 Power frequency dry voltage withstand test (Routine test)

Barometric pressure:100.6kPa Relative humidity:50.0% Ambient temperature:33.0°C

U(kV)	Duration time	Frequency	Result
230	60s	50Hz	Pass

2.4 Measurement on partial discharge (Routine test)

Applied voltage		Partial discharge(pC)
Times	Voltage (kV)	
$U_2 = 1.5U_m/\sqrt{3}$	109	4
$1.05U_m/\sqrt{3}$	76	2
Partial discharge background noise:2pC		

2.5 Test tap insulation test (Routine test)

2.5.1 Power frequency withstand voltage test of test tap

Barometric pressure:100.5kPa Relative humidity:28.0% Ambient temperature:33.0°C

U(kV)	Duration time	Frequency	Result
3	60s	50Hz	Pass

2.5.2 Test tap grounding dielectric dissipation factor and capacitance measurement

Barometric pressure:100.5kPa Relative humidity:28.0% Ambient temperature:33.0°C

Applied voltage(kV)	Measurement value	
	Measurement of dielectric dissipation factor (%)	Capacitance(pF)
2	60s	50Hz

2.6 Sealing test on flange (Routine test)

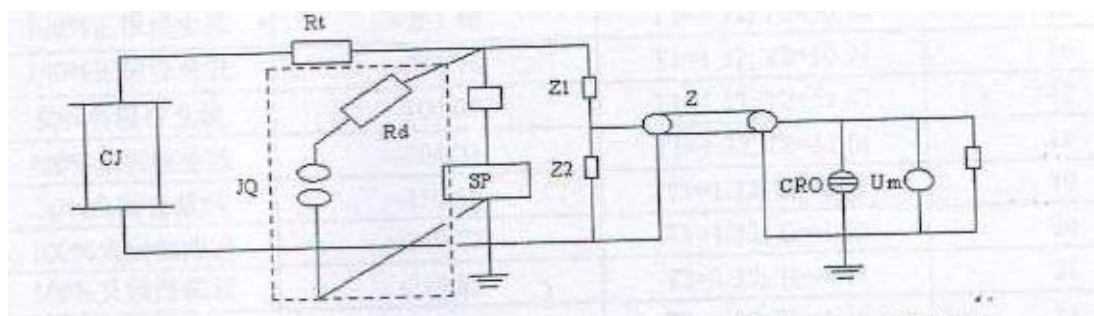
To apply 0.15MPa (Gage pressure) nitrogen pressure to mounted oil tank, last for 15 min, no leakage from sealing surface, experiment passed

2.7 Lighting impulse dry voltage withstand test (Type test)

2.7.1 Test condition

Barometric pressure:100.6kPa Relative humidity:50.0% Ambient temperature:31.0°C

2.7.2 Schematic diagram



CJ: Impulse voltage generator JQ: Chopping gap SP: Sample Rt: Wave regulation resistance

Rd: damping resistance Z1,Z2:voltage divider resistance Z:High frequency transmission cables r:matched resistance

CRO:HV digital memory oscillograph Um: Peak voltmeter

Figure 1 Lighting impulse experiment wiring diagram

2.7.3 Test items and applied voltage

Rated withstand voltage(kV)
Full wave
±550

2.7.4 Test procedure

1 time positive full wave lighting impulse at lower voltage, 15 times positive full wave lighting impulse at rated voltage.

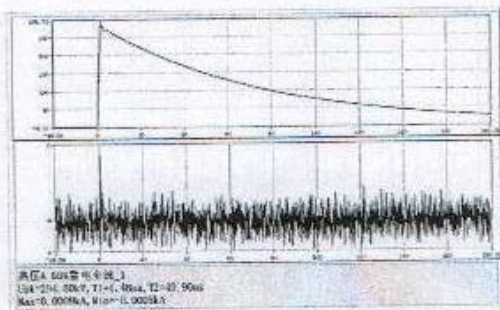
1 time negative full wave lighting impulse at lower voltage, 15 times negative full wave lighting impulse at rated voltage.

2.7.5 Experiment voltage and waveform

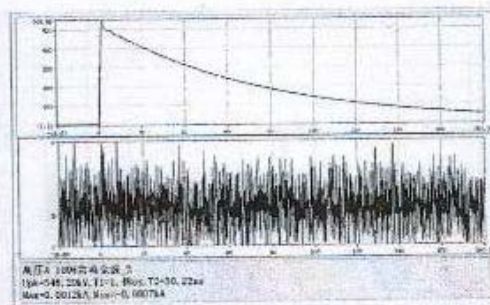
Experiment type	Experiment voltage(kV)	Experiment waveform (μ s)	Diagram No.
50% positive full wave	+294.60	T1=1.48,T2=49.90	1
100% positive full wave	+548.20	T1=1.48,T2=50.22	2
100% positive full wave	+553.92	T1=1.49,T2=50.26	3
100% positive full wave	+551.72	T1=1.49,T2=50.22	4
100% positive full wave	+554.09	T1=1.48,T2=50.22	5
100% positive full wave	+550.09	T1=1.48,T2=50.30	6
100% positive full wave	+552.77	T1=1.48,T2=50.30	7
100% positive full wave	+552.28	T1=1.48,T2=50.26	8
100% positive full wave	+545.05	T1=1.48,T2=50.26	9
100% positive full wave	+547.26	T1=1.48,T2=50.26	10
100% positive full wave	+545.12	T1=1.48,T2=50.17	11
100% positive full wave	+546.73	T1=1.48,T2=50.28	12
100% positive full wave	+552.74	T1=1.48,T2=50.31	13
100% positive full wave	+545.71	T1=1.48,T2=50.33	14
100% positive full wave	+554.25	T1=1.48,T2=50.30	15
100% positive full wave	+548.22	T1=1.48,T2=50.34	16
50% negative full wave	-272.37	T1=1.48,T2=50.03	17
100% negative full wave	-552.12	T1=1.48,T2=50.38	18
100% negative full wave	-553.07	T1=1.48,T2=50.39	19
100% negative full wave	-553.12	T1=1.48,T2=50.39	20
100% negative full wave	-552.37	T1=1.48,T2=50.50	21
100% negative full wave	-549.47	T1=1.48,T2=50.41	22
100% negative full wave	-553.24	T1=1.48,T2=50.44	23
100% negative full wave	-551.84	T1=1.48,T2=50.43	24
100% negative full wave	-551.69	T1=1.48,T2=50.53	25
100% negative full wave	-551.87	T1=1.48,T2=50.51	26
100% negative full wave	-552.00	T1=1.48,T2=50.47	27
100% negative full wave	-553.71	T1=1.48,T2=50.46	28
100% negative full wave	-549.65	T1=1.48,T2=50.47	29
100% negative full wave	-552.04	T1=1.48,T2=50.44	30
100% negative full wave	-551.68	T1=1.48,T2=50.43	31
100% negative full wave	-552.04	T1=1.48T2=50.44	32

试验波形:

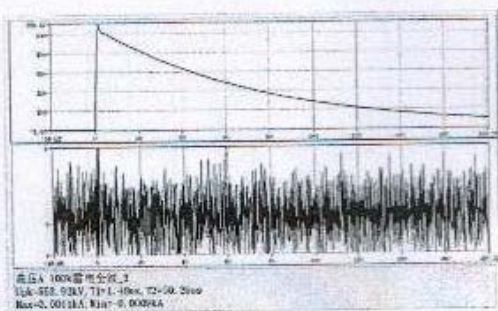
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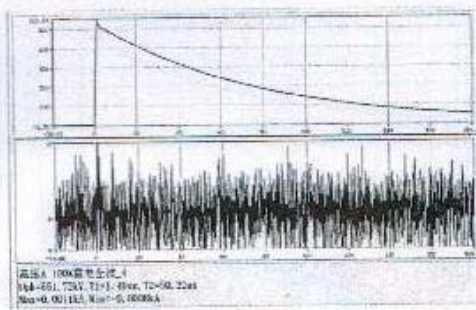
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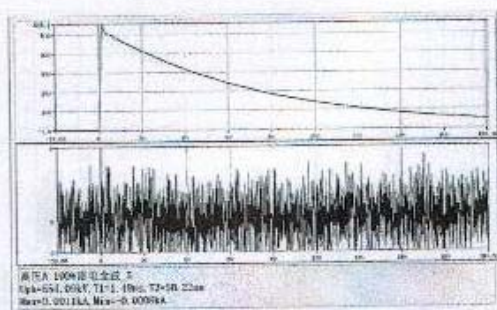
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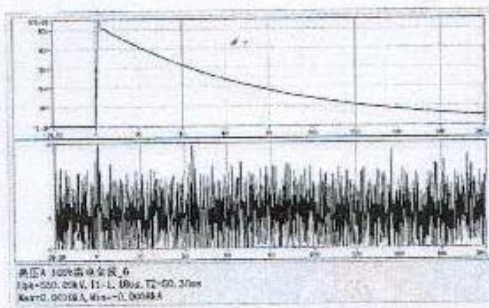
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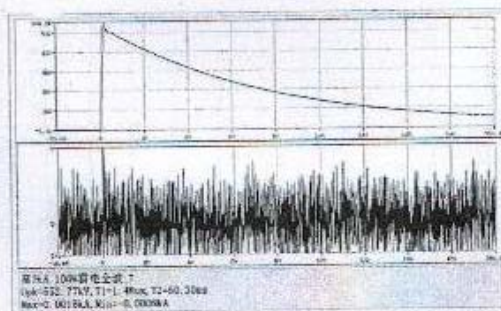
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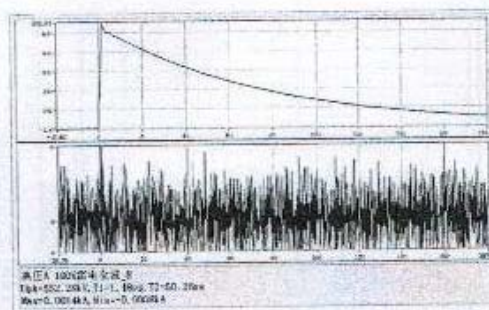
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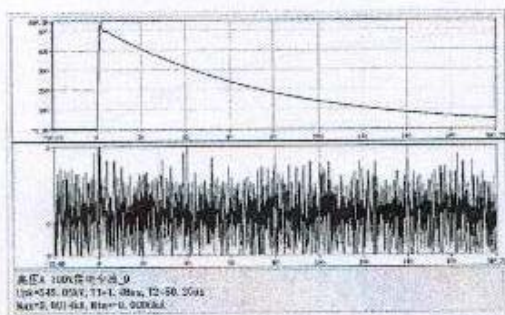


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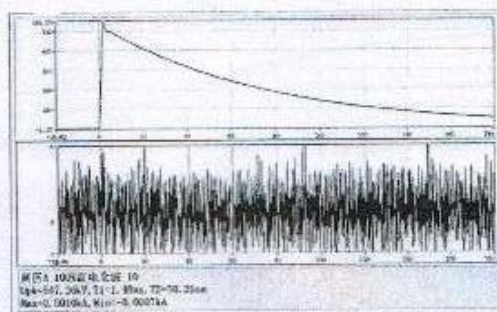


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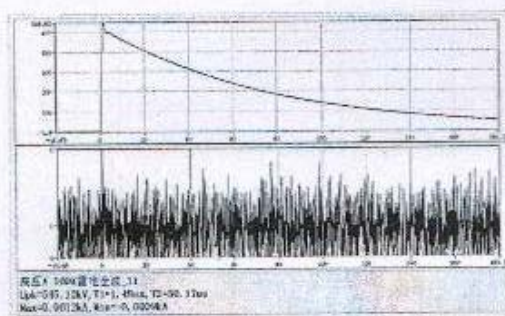
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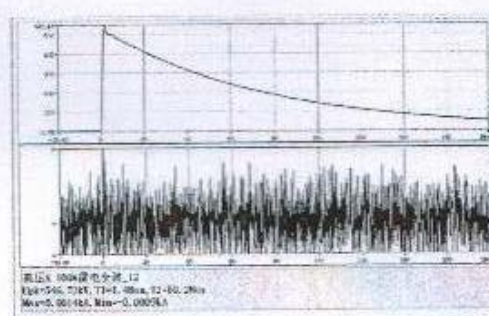
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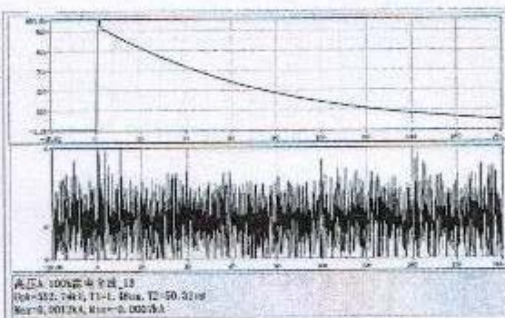
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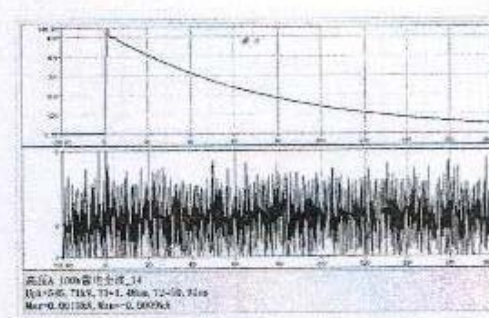
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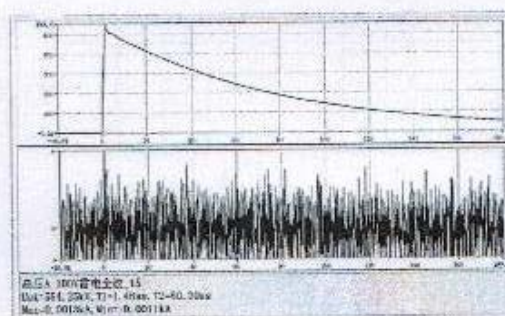
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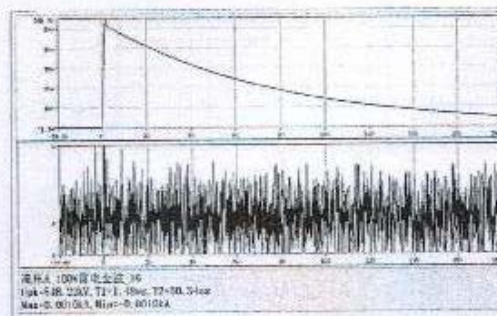
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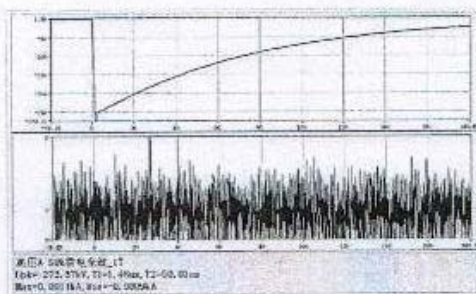


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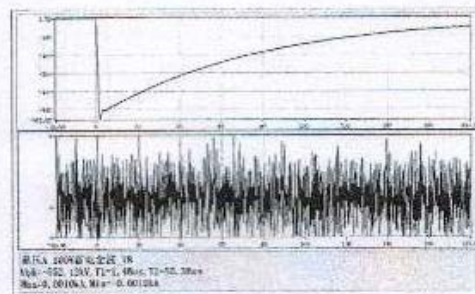


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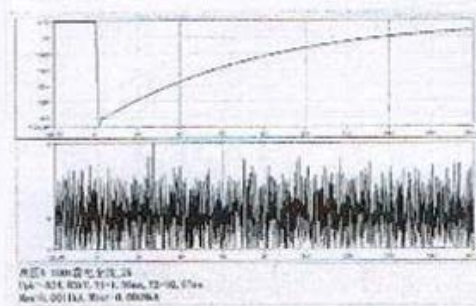
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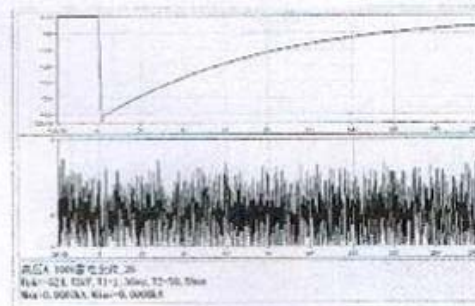
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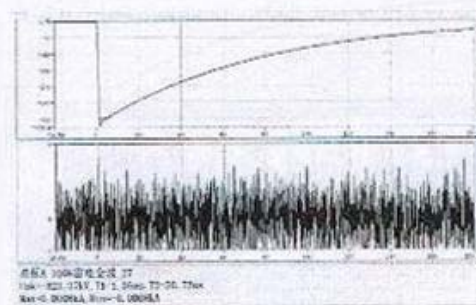
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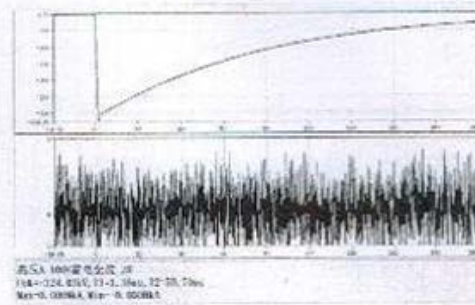
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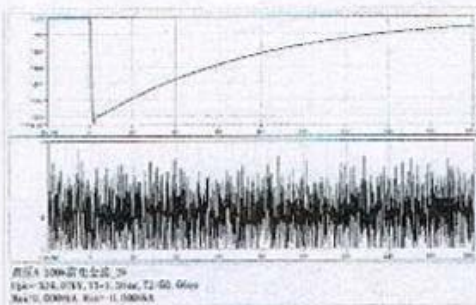
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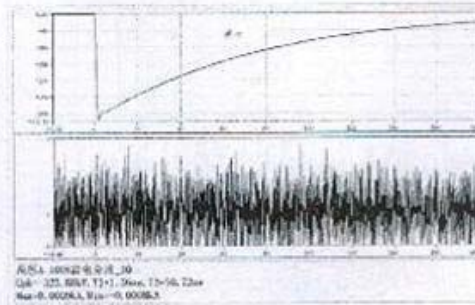
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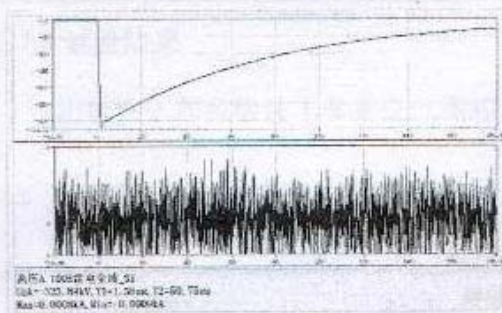


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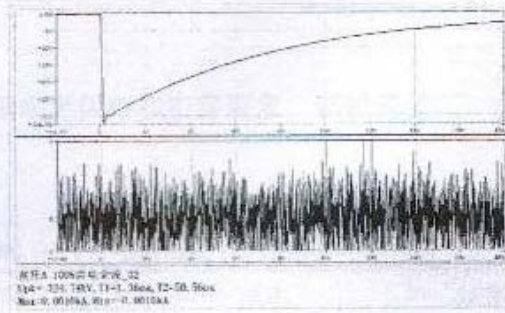


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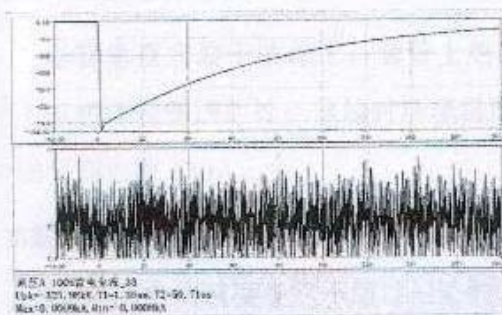
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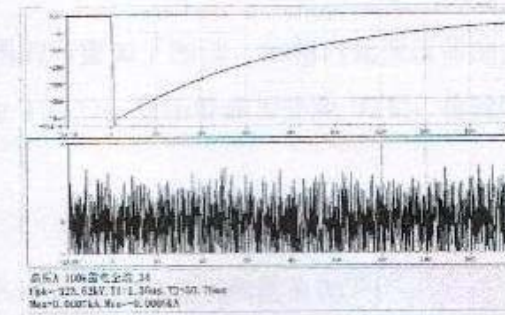
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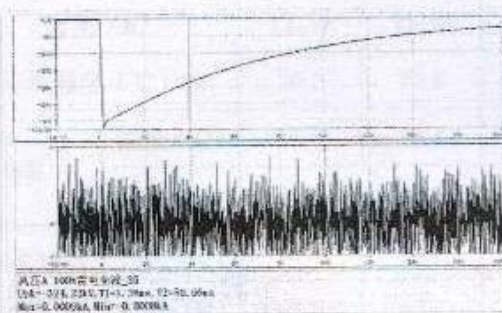
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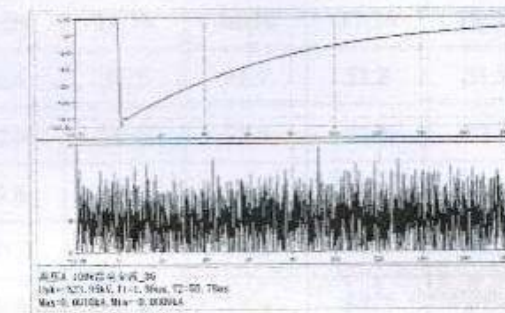
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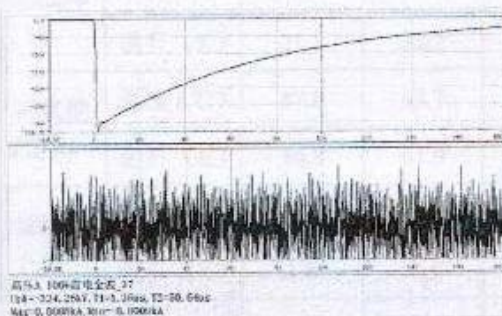
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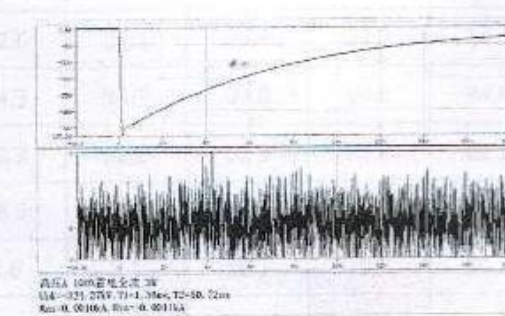
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№31 100%全波



№32 100%全波



2.7.6 Test result

No breakdown or flashover under the positive and negative experiment, experiment passed.

2.8 Power frequency wet voltage withstand test

Barometric pressure:100.6kPa Relative humidity:29.0% Ambient temperature:33.0°C

U(kV)	Duration time	Frequency	Result
230	60s	50Hz	pass

2.9 Temperature rise experiment (Type test)**2.9.1 Experiment method and requirement**

To mount the bushing vertically on the oil tank, the thermocouple was arranged as per figure 2. To fill the oil tank with transformer oil, let the oil level be near to the bushing flange. Ambient temperature was 31.5°C and transformer oil was heated to 92°C. To apply alternating current 2000A when inspection.

2.9.2 Experimental measurement result

When temperature changed within $\pm 1\text{K}$ in 1 hour, the measurement value of each point is as below

Load current(A)		Applied current 2000A						
Time(h)		12:30	13:30	14:30	15:30	16:30	17:30	18:30
Ambient temperature($^{\circ}\text{C}$)		30.2	30.8	31.4	31.5	31.7	31.8	31.8
Oil temperature 1 #	Temperature($^{\circ}\text{C}$)	85.5	90.4	92.0	92.0	92.0	92.0	92.0
	Temperature rise(K)	55.3	59.6	60.6	60.5	60.3	60.2	60.2
Lower terminal block 2#	Temperature($^{\circ}\text{C}$)	91.7	98.6	101.2	99.9	99.6	99.5	99.2
	Temperature rise(K)	61.5	67.8	69.8	68.4	67.9	67.7	67.4
Lower equipotential shielding 3#	Temperature($^{\circ}\text{C}$)	52.0	53.0	54.0	56.7	56.5	56.0	56.3
	Temperature rise(K)	21.8	22.2	22.6	25.2	24.8	24.2	24.5
Lower Epoxy insulator 4#	Temperature($^{\circ}\text{C}$)	87.0	92.7	94.2	94.1	94.0	94.0	94.0
	Temperature rise(K)	56.8	61.9	62.8	62.6	62.3	62.2	62.2
Upper terminal block 5#	Temperature($^{\circ}\text{C}$)	32.0	35.2	36.0	37.0	42.0	42.0	42.0
	Temperature rise(K)	1.8	4.4	4.6	5.5	10.3	10.2	10.2
Upper cover 6#	Temperature($^{\circ}\text{C}$)	33.5	50.8	55.3	55.3	55.6	55.6	55.5
	Temperature rise(K)	3.3	20.0	23.9	23.8	23.9	23.8	23.7
Connection between upper metal part and epoxy housing 7#	Temperature($^{\circ}\text{C}$)	37.5	46.2	50.7	50.8	51.4	51.6	51.1
	Temperature rise(K)	7.3	15.4	19.3	19.3	19.7	19.8	19.3
Flange 8#	Temperature($^{\circ}\text{C}$)	35.2	43.3	47.3	48.1	48.2	48.5	48.2
	Temperature rise(K)	6.2	14.4	17.3	18.4	18.7	19.2	19.3

2.9.3 Embedded thermocouple diagram in temperature rise experiment

Note:

- 1-oil temperature
- 2-Lower terminal block
- 3-Lower equipotential shielding
- 4-Lower epoxy insulator
- 5-Upper terminal block
- 6-Upper cover
- 7-Connection between upper metal part and epoxy insulator
- 8-Flange
- 9-Ambient temperature

Distance between upper terminal block and measurement point in the air:1000mm

Distance between upper terminal block and measurement point in oil:1000mm

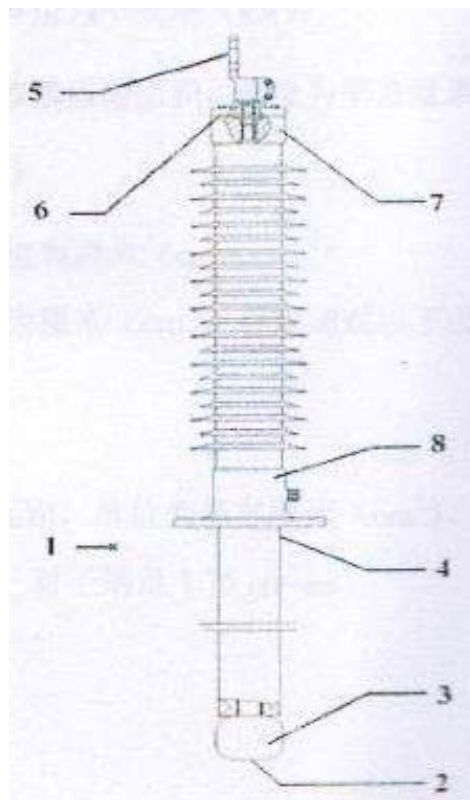


Figure 2 Embedded thermocouple diagram in temperature rise experiment

2.10 Cantilever load test (Type test)

After fixing the bushing as per operation status, to apply a 4000N loading vertically on the upper block, last for 60s.After checking, there is no damage or leakage of each seal surface, test qualified.

2.11 Short-time thermal current (Type test)

2.11.1 Method of calculation

To verify the bushing's withstand ability to 1th standard value by the following method.

$$\theta = \theta_0 + \alpha \cdot \frac{I_{th}^2}{S_t \cdot S_e} \cdot t_{th}$$

In the formula:

I_r Rated current, (A)

θ_f The final temperature, (°C)

θ_0 The temperature of conductor for continuous operation when loading I_r , (°C)

α For copper is $0.8(\text{K/s})/(\text{kA/cm}^2)^2$

t_{th} The specified rated duration time, (s)

I_{th} Above specified standard value, (kA)

S_e The equivalent cross sectional area(considering skin effect) (cm^2), can be calculated by following formula,

$$S_e = \pi \cdot d \cdot (De - d)$$

De Outer diameter of cross section, (cm)

d Current penetration depth, (cm), can be calculated by below formula,

$$d = \frac{1}{2 \cdot \pi} \cdot \sqrt{\frac{\rho \cdot 10^3}{f}}$$

S_t Be correspond to total cross section of I_r , (cm^2)

ρ_{20} Electrical resistivity of conductor under 20°C, for copper is $1.75 \mu\Omega\text{-cm}$

2.11.2 Calculation result

θ_0	α	ρ_{20}	De	f	I_r	t_{th}
°C	(K/s)/(kA/cm ²)	$\mu\Omega\text{-cm}$	cm	Hz	A	s
107.4-111.9	0.8	1.75	4.492	50	2000	2

d	ρ_{160}	S_t	S_e	I_{th}	θ
cm	$\mu\Omega\text{-cm}$	cm^2	cm^2	kA	°C
0.94	2.64	15.84	10.48	50	131..3

2.12 Measurement on dielectric dissipation factor and capacitance (Routine test after type test)

Barometric pressure:100.6kPa Relative humidity:35.0% Ambient temperature:32.0°C

Applied voltage		Test result	
Times	Voltage(kV)	Dielectric dissipation factor(%)	Capacitance (pF)
-	10	0.350	336.3
$1.05U_m/\sqrt{3}$	76	0.351	336.6
$U_1 = U_m$	126	0.351	336.6

2.13 Power frequency dry voltage withstand test (Routine test after type test)

U(kV)	Duration time	Frequency	Result
230	60s	50Hz	Pass

2.14 Measurement of partial discharge (Routine test after type test)

Applied voltage		Partial discharge(pC)
Times	Voltage (kV)	
$U_2 = 1.5U_m/\sqrt{3}$	109	4
$1.05U_m/\sqrt{3}$	76	2
Partial discharge background noise:2pC		

2.15 Test tap insulation test (Routine test after type test)**2.15.1 Power frequency withstand voltage test of test tap**

Barometric pressure:100.6kPa Relative humidity:37.0% Ambient temperature:33.0°C

U(kV)	Duration time	Frequency	Result
2	60s	50Hz	Passed

2.15.2 Measurement on dielectric dissipation factor and capacitance of test tap

Barometric pressure:100.4kPa Relative humidity:38.0% Ambient temperature:33.0°C

Applied voltage (kV)	Measurement value	
	Dielectric dissipation factor(%)	Capacitance(pF)
2	1.27	400.9

2.16 Sealing test on flange (Routine test after type test)

To apply 0.15MPa (Gage pressure) nitrogen pressure to mounted oil tank, last for 15 min, no leakage from sealing surface, experiment passed.

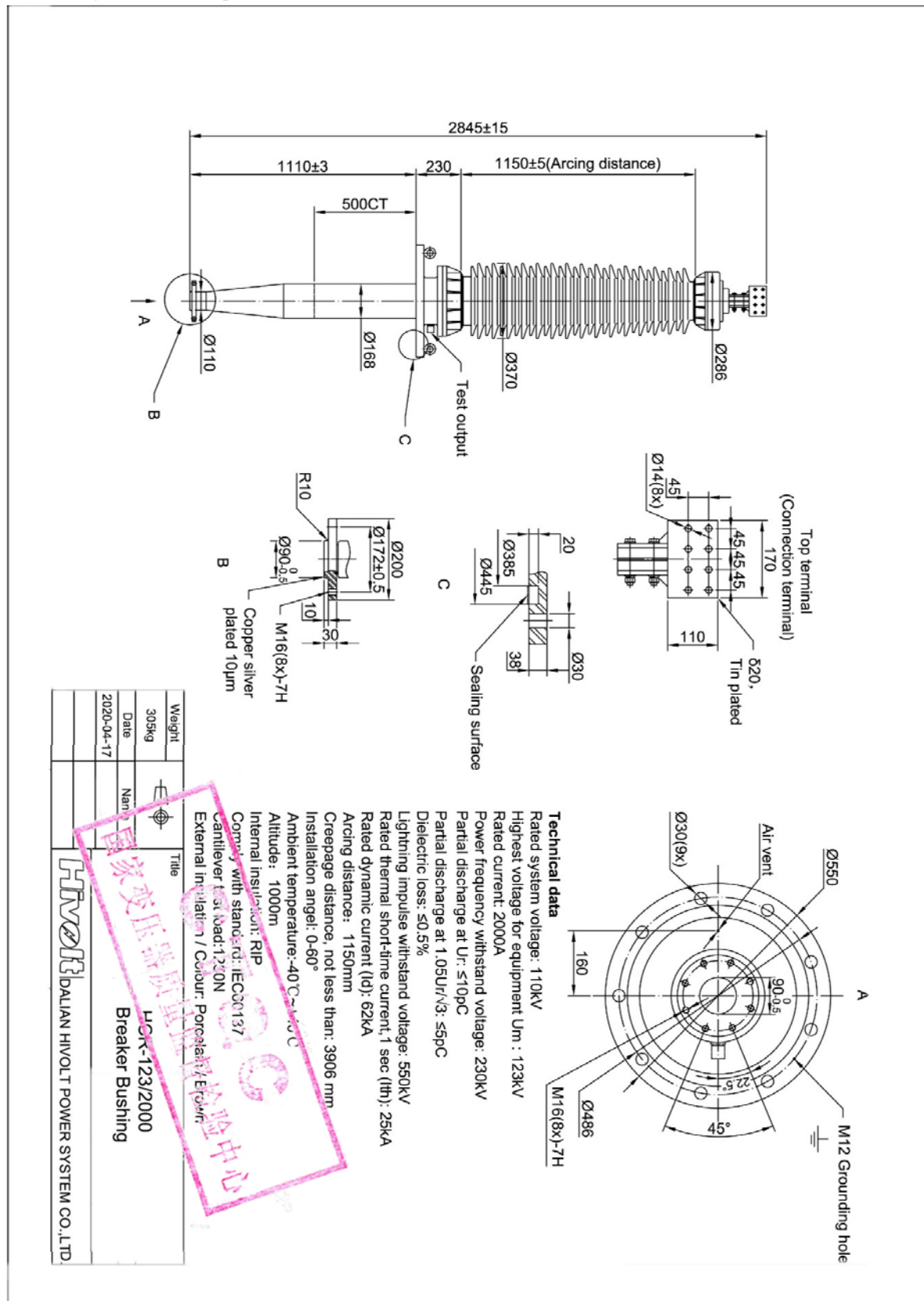


Photo of tested sample

