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实验室名称: 苏州电器科学研究院股份有限公司
国家电器产品质量检验检测中心

Lab Name: Suzhou Electrical Apparatus Science Research Institute Co., Ltd.
China National Center for Quality Inspection and Test of Electrical Apparatus Products

No 23M1279-S

型式试验报告 Type Test Report

委托单位: 江苏新特变科技股份有限公司

Client: JIANGSU XIN TEBIAN SCIENCE & TECHNOLOGY CO., LTD.

产品名称: 有载调压整流变压器

Name of Product: On-load tap changing rectifier transformer

产品型号: ZHSFT-12000/35

Product Type: ZHSFT-12000/35

检验类别: 型式试验

Test Category: Type test

本实验室对出具的检验（试验）结果负责，未经实验室书面同意，不得部分地复制本报告。

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Test Report

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Client	JIANGSU XIN TEBIAN SCIENCE & TECHNOLOGY CO.,LTD.	Test category	Type test
Manufacturer	JIANGSU XIN TEBIAN SCIENCE & TECHNOLOGY CO.,LTD.	Date of sample receiving	Nov.10,2023
Name of sample	On-load tap changing rectifier transformer	Type of sample	ZHSFT-12000/35
Address of manufacturer	No.833.Tangshi west street,Yangshe town ,Zhangjiagang city.	Original number or date of production	2112005.2
Date of test	From Nov.23,2023 To Jan.26,2024	Number of sample	1 set
Test items	Routine test Type test Short-circuit withstand test	Test standards	GB/T 1094.1—2013 GB/T 1094.2—2013 GB/T 1094.3—2017 GB/T 1094.5—2008 GB/T 1094.10—2022 GB/T 18494.1—2014 IEC 60076-1:2011 IEC 60076-2:2011 IEC 60076-3:2013+AMD1:2018 IEC 60076-5:2006 IEC 60076-10:2016 IEC 61378-1:2011 Commission requirements
Test conclusion	The test results of routine test,type test and short-circuit withstand test of the on-load tap changing rectifier transformer (type: ZHSFT-12000/35) are in accordance with test standards and commission requirements. The sample has passed the above tests. Signing and issuing date: 2024.02.05 Note: the conclusion is valid only for the inspected and tested sample.		
Remarks	/		

Compiled by:

刘峰

Proofread by:

周超

Checked by:

袁小勇

Approved by:

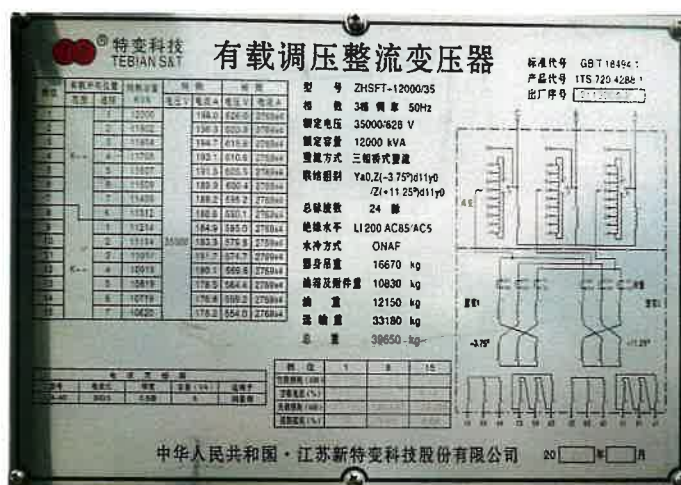
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1. Sample parameters Rated power: 12000kVA Rated voltage: 35/4×0.626kV Rated current: 198.0/4×2769A Rated frequency: 50Hz Number of phases: 3 Tapping ranges: / Connection symbol: Ya0,Zd11y0 Cooling method: ONAF Class of insulation and heat-resistant: A <table> <tr> <td>Insulation level: HV</td><td>Um/LI/LIC/AC</td><td>40.5/200/220/85kV</td></tr> <tr> <td>LV</td><td>Um/AC</td><td>≤1.1/5kV</td></tr> </table> 2. Test standards GB/T 1094.1—2013 <i>Power transformers—Part 1: General</i> GB/T 1094.2—2013 <i>Power transformers—Part 2: Temperature rise for liquid-immersed transformers</i> GB/T 1094.3—2017 <i>Power transformers—Part 3: Insulation levels, dielectric tests and external clearances in air</i> GB/T 1094.5—2008 <i>Power transformers—Part 5: Ability to withstand short circuit</i> GB/T 1094.10—2022 <i>Power transformers—Part 10: Determination of sound levels</i> GB/T 18494.1—2014 <i>Converter transformers—Part 1: Transformers for industrial applications</i> IEC 60076-1:2011 <i>Power transformers – Part 1: General</i> IEC 60076-2:2011 <i>Power transformers – Part 2: Temperature rise for liquid – immersed transformers</i> IEC 60076-3:2013+AMD1:2018 <i>Power transformers – Part 3: Insulation levels, dielectric tests and external clearances in air</i> IEC 60076-5:2006 <i>Power transformers – Part 5: Ability to withstand short circuit</i> IEC 60076-10:2016 <i>Power transformers – Part 10: Determination of sound levels</i> IEC 61378-1:2011 <i>Converter transformers—Part 1: Transformers for industrial applications</i> Commission requirements 3. Sample description The on-load tap changing rectifier transformer is for outdoor use, and the structure of the coil is rotundate concentric type coil .External photos of the sample have been attached.			Insulation level: HV	Um/LI/LIC/AC	40.5/200/220/85kV	LV	Um/AC	≤1.1/5kV
Insulation level: HV	Um/LI/LIC/AC	40.5/200/220/85kV						
LV	Um/AC	≤1.1/5kV						

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Photos of the sample



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Summary of test results					
No	Test items	Specified value	Measured value		Concl- usion
		Standards (commission requirements)	Before short-circuit test	After short-circuit test	
1	Measurement of d.c. insulation resistance between each winding to earth and between windings (routine test)	Providing value of insulation resistance(GΩ) Providing absorption ratio: (R ₆₀ /R ₁₅)	See 4.1	See 4.18.4.1	/
2	Check of core and frame insulation for liquid-immersed transformers with core or frame insulation (routine test)	Providing dielectric dissipation factor tanδ	See 4.2	See 4.18.4.2	/
3	Determination of capacitances windings-to-earth and between windings (routine test)	Providing value of capacitance	See 4.3	See 4.18.4.3	/
4	Measurement of voltage ratio and check of phase displacement (routine test)	Voltage ratio tolerance of principal tapping: obtaining the lower of the following values between ±0.5% of declared ratio and ±1/10 of the actual percentage impedance Connection symbol: Ya0,Zd11y0	See 4.4	See 4.18.4.4	PASS
5	Measurement of winding resistance* (routine test)	Maximum resistance unbalance rate Line resistance: ≤1%	See 4.5	See 4.18.4.5	PASS
6	Check of the ratio and polarity of built-in current transformers (routine test)	Providing measured value of ratio and polarity relation	See 4.6	See 4.18.4.6	/
7	Insulation test of auxiliary wiring (routine test)	secondary windings of current transformers: 2.5kV 60s On-load tap-changer: 2.0 kV 60s	2.5kV 60s 2kV 60s	2.5kV 60s 2kV 60s	PASS
8	Insulation test of auxiliary wiring (routine test)	HV:85kV 60s LV 1:5kV 60s LV 2:5kV 60s LV 3:5kV 60s LV 4:5kV 60s	85kV 60s 5kV 60s 5kV 60s 5kV 60s 5kV 60s	85kV 60s 5kV 60s 5kV 60s 5kV 60s 5kV 60s	PASS
9	Induced voltage withstand test (routine test)	Applied voltage(kV):2Ur Induced voltage(kV):70 Duration(s):120(f _r /f) Frequency (Hz):>50	1.252 70.0 30 200	1.252 70.0 30 200	PASS
*: According to client's clarification, LV resistance unbalance rate exceeding the specified value is caused by lead structure.					

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No	Test items	Specified value		Measured value		Concl- usion	
		Standards (commission requirements)		Before short-circuit test	After short-circuit test		
10	Measurement of no-load loss and current (routine test)	I ₀ (%):	measured	0.75	0.76	/	
		P ₀ (kW):	measured	16.2965	16.4480		
11	Measurement of no-load loss and current at 90% and 110% of rated voltage (type test)	I ₀ (%):	measured	90% 110%		/	
				0.43 1.56			
		P ₀ (kW):	measured	11.9373 24.4995			
12	Measurement of short-circuit impedance and load loss (routine test)	HV-LV1,	t:75℃			/	
		LV2,	Z(%):	measured	7.18		7.18
		LV3,	P _k (kW):	measured	129.3658		122.3286
		LV4	P _Σ (kW):	measured	145.6623		138.7766
		Bundle impedance Z _F (%): measured		5.693	5.045		
		Bundle factor k: measured		0.79	0.70		
13	Tests on on-load tap-changers (routine test)	According to clause 11.7 of GB/T1094.1-2013		Meet the requirements	Meet the requirements	PASS	
14	Insulating liquid test (routine, type test)	Breakdown voltage(kV): ≥40		53.5	50.9	PASS	
		tan δ (90℃): ≤1.0%		0.43%	0.49%		
		Providing gas chromatograph analysis:					
		Hydrogen: <30μL /L Acetylene: 0 Total hydrocarbon: <20μL /L		See 4.14			

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No	Test items	Specified value	Measured value	Concl- usion	
		Standards (commission requirements)			
15	Leak testing with pressure for liquid-immersed transformers (routine test)	Body: Applied pressure (kPa): 30 Duration (h): 24 No oil leakage or damage	30.0 24 No oil leakage or damage	PASS	
		On-load tap-changer tank: Applied pressure (kPa): 30 Duration (h): 24 No oil leakage or damage	30.0 24 No oil leakage or damage	PASS	
16	Temperature-rise test (type test)	Top oil temperature-rise limit (K):60 Winding temperature-rise limit (K):65	Top oil temperature-rise: 35.6 HV winding temperature-rise: 51.4 LV1 winding temperature-rise: 50.9 LV2 winding temperature-rise: 51.6 LV3 winding temperature-rise: 49.7 LV4 winding temperature-rise: 43.0	PASS	
17	Determination of sound levels (type test)	Sound pressure level $\overline{L}_{pA}$ dB(A): Sound power level L_{WA} dB(A): ≤78	55 74	PASS	
18	Short-circuit withstand test (special test)	Test times of each phase: 3 times Duration (s): 0.25±10% The test oscillogram shall be normal. The reactance variation in phase before and after the test is not more than 2%. The outside and out-of-tank inspection does not reveal any obvious defects. Routine retests shall be passed after short-circuit test.	3 times 0.256~0.256 Without abnormality The maximum reactance variation in phase is 0.23%. Without obvious defects. Routine retests are passed.	PASS	
19	Lightning impulse test (type test)	Full wave (kV):200 ±3% Chopped wave (kV):220 ±3%	197.84~201.32 218.78~222.94	PASS	
20	measurement of the power taken by the fan motors (type test)	Providing measured value	See 4.20	/	
Remarks:a1b1c1 side is LV1,a2b2c2 side is LV2,a3b3c3 side is LV3 and a4b4c4 side is LV4. Blank below					

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4. Test items and results			
4.1 Measurement of d.c. insulation resistance between each winding to earth and between windings (routine test)			
Test date: Nov. 23, 2023 Relative humidity: 27%; Oil temperature: 19.8℃			
Measured part	R ₁₅ (GΩ)	R ₆₀ (GΩ)	Absorption ratio (R ₆₀ /R ₁₅)
HV-LV1,LV2,LV3,LV4 and earth	24.7	35.4	1.43
LV1-HV,LV2,LV3,LV4 and earth	10.2	15.7	1.54
LV2- HV,LV1,LV3,LV4 and earth	17.9	24.2	1.35
LV3- HV,LV1,LV2,LV4 and earth	13.5	19.2	1.42
LV4- HV,LV1, LV2,LV3 and earth	13.0	18.8	1.45
HV and LV1,LV2,LV3,LV4- earth	51.1	68.7	1.34
4.2 Measurement of dissipation factor (tanδ) of the insulation system capacitances (routine test)			
Test date: Nov. 23, 2023			
Measured part	Dielectric dissipation factor tanδ(%)	Dielectric dissipation factor tanδ corrected to 20℃(%)	Capacitance(pF)
HV-LV1,LV2,LV3,LV4 and earth	0.48	0.48	4826
LV1-HV,LV2,LV3,LV4 and earth	0.35	0.35	9305
LV2- HV,LV1,LV3,LV4 and earth	0.33	0.33	8845
LV3- HV,LV1,LV2,LV4 and earth	0.36	0.36	9673
LV4- HV,LV1, LV2,LV3 and earth	0.39	0.39	8716
HV and LV1,LV2,LV3,LV4- earth	0.34	0.34	15628
4.3 Determination of capacitances windings-to-earth and between windings (routine test)			
Test date: Jan. 04, 2024			
See 4.2.			

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4.5 Measurement of voltage ratio and check of phase displacement (routine test) Test date: Nov. 23, 2023

HV winding		LV1 winding		Transformer ratio by calculation	Measured voltage ratio tolerance (%)			Connection symbol
Tapping position	Voltage (kV)	Tapping position	Voltage (kV)		AB/a1b1	BC/b1c1	CA/c1a1	
1	35.000	/	0.6260	55.911	0.06	0.21	0.09	Yd11
2			0.6209	56.370	0.08	0.19	0.13	
3			0.6158	56.837	0.10	0.21	0.13	
4			0.6106	57.321	0.08	0.22	0.13	
5			0.6055	57.803	0.08	0.25	0.14	
6			0.6004	58.294	0.08	0.24	0.18	
7			0.5952	58.804	0.10	0.25	0.15	
8			0.5901	59.312	0.14	0.24	0.15	
9			0.5850	59.829	0.15	0.25	0.18	
10			0.5798	60.366	0.15	0.26	0.17	
11			0.5747	60.901	0.15	0.28	0.19	
12			0.5696	61.447	0.16	0.30	0.19	
13			0.5644	62.013	0.18	0.28	0.20	
14			0.5592	62.589	0.16	0.29	0.20	
15			0.5540	63.177	0.15	0.27	0.21	

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HV winding		LV2 winding		Transformer ratio by calculation	Measured voltage ratio tolerance (%)			Connection symbol
Tapping position	Voltage (kV)	Tapping position	Voltage (kV)		AB/a2b2	BC/b2c2	CA/c2a2	
1	35.000	/	0.6260	55.911	-0.21	-0.10	-0.15	Yy0
2			0.6209	56.370	-0.20	-0.10	-0.13	
3			0.6158	56.837	-0.18	-0.09	-0.12	
4			0.6106	57.321	-0.20	-0.08	-0.18	
5			0.6055	57.803	-0.17	-0.08	-0.11	
6			0.6004	58.294	-0.16	-0.06	-0.10	
7			0.5952	58.804	-0.16	-0.07	-0.10	
8			0.5901	59.312	-0.15	-0.05	-0.09	
9			0.5850	59.829	-0.14	-0.04	-0.07	
10			0.5798	60.366	-0.15	-0.03	-0.08	
11			0.5747	60.901	-0.12	-0.03	-0.07	
12			0.5696	61.447	-0.11	-0.00	-0.05	
13			0.5644	62.013	-0.11	-0.01	-0.05	
14			0.5592	62.589	-0.11	-0.02	-0.06	
15			0.5540	63.177	-0.12	-0.02	-0.06	

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HV winding		LV3 winding		Transformer ratio by calculation	Measured voltage ratio tolerance (%)			Connection symbol
Tapping position	Voltage (kV)	Tapping position	Voltage (kV)		AB/a3b3	BC/b3c3	CA/c3a3	
1	35.000	/	0.6260	55.911	0.05	0.14	0.10	Yd11
2			0.6209	56.370	0.07	0.15	0.09	
3			0.6158	56.837	0.08	0.17	0.09	
4			0.6106	57.321	0.07	0.17	0.10	
5			0.6055	57.803	0.08	0.17	0.12	
6			0.6004	58.294	0.10	0.19	0.13	
7			0.5952	58.804	0.08	0.19	0.14	
8			0.5901	59.312	0.11	0.20	0.14	
9			0.5850	59.829	0.13	0.22	0.15	
10			0.5798	60.366	0.10	0.22	0.16	
11			0.5747	60.901	0.15	0.22	0.16	
12			0.5696	61.447	0.17	0.23	0.18	
13			0.5644	62.013	0.15	0.23	0.17	
14			0.5592	62.589	0.15	0.22	0.18	
15			0.5540	63.177	0.15	0.23	0.17	

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HV winding		LV4 winding		Transformer ratio by calculation	Measured voltage ratio tolerance (%)			Connection symbol
Tapping position	Voltage (kV)	Tapping position	Voltage (kV)		AB/a4b4	BC/b4c4	CA/c4a4	
1	35.000	/	0.6260	55.911	-0.20	-0.18	-0.17	Yy0
2			0.6209	56.370	-0.20	-0.16	-0.16	
3			0.6158	56.837	-0.18	-0.15	-0.14	
4			0.6106	57.321	-0.18	-0.16	-0.14	
5			0.6055	57.803	-0.18	-0.14	-0.13	
6			0.6004	58.294	-0.16	-0.13	-0.11	
7			0.5952	58.804	-0.16	-0.13	-0.12	
8			0.5901	59.312	-0.15	-0.12	-0.10	
9			0.5850	59.829	-0.13	-0.10	-0.09	
10			0.5798	60.366	-0.14	-0.11	-0.10	
11			0.5747	60.901	-0.13	-0.09	-0.08	
12			0.5696	61.447	-0.12	-0.07	-0.07	
13			0.5644	62.013	-0.12	-0.08	-0.07	
14			0.5592	62.589	-0.12	-0.08	-0.07	
15			0.5540	63.177	-0.13	-0.08	-0.08	

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4.5 Measurement of winding resistance (routine test)					Test date: Nov. 23, 2023 Oil temperature:19.8℃
Winding	Tapping position	Measured resistance (Ω)			Resistance unbalance rate (%)
		A~B a1~b1 a2~b2 a3~b3 a4~b4	B~C b1~c1 b2~c2 b3~c3 b4~c4	C~A c1~a1 c2~a2 c3~a3 c4~a4	
HV	1	0.7210	0.7200	0.7217	0.24
	2	0.7154	0.7140	0.7157	0.24
	3	0.7098	0.7085	0.7101	0.23
	4	0.7042	0.7030	0.7044	0.20
	5	0.6986	0.6974	0.6989	0.21
	6	0.6930	0.6917	0.6931	0.20
	7	0.6870	0.6859	0.6873	0.20
	8	0.6782	0.6772	0.6786	0.21
	9	0.6867	0.6855	0.6868	0.19
	10	0.6925	0.6914	0.6927	0.19
	11	0.6984	0.6972	0.6984	0.17
	12	0.7039	0.7030	0.7042	0.17
	13	0.7090	0.7089	0.7100	0.16
	14	0.7142	0.7147	0.7157	0.21
	15	0.7219	0.7206	0.7213	0.18
LV	/	1.1032×10 ⁻³	1.1186×10 ⁻³	1.1045×10 ⁻³	1.39
		1.1105×10 ⁻³	1.0975×10 ⁻³	1.1089×10 ⁻³	1.18
		1.1100×10 ⁻³	1.1222×10 ⁻³	1.0978×10 ⁻³	2.20
		1.0992×10 ⁻³	1.0902×10 ⁻³	1.1136×10 ⁻³	2.13

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4.6 Check of the ratio and polarity of built-in current transformers(routine test) Test date: Jan. 04, 2024				
Tested windings	Connecting terminal	Ratio	Polarity	
A	1S1-1S1	61.56	-	
	1S1-1S2	61.73	-	
B	2S1-2S2	58.83	-	
	2S1-2S2	61.46	-	
C	3S1-3S2	59.79	-	
	3S1-3S2	61.23	-	
4.7 Insulation test of auxiliary wiring (routine test) Test date: Jan. 04, 2024 Relative humidity: 28%; Ambient temperature: 13.5℃; Air pressure: 102.7kPa				
Parts of applied voltage		Test voltage (kV)	Test duration (s)	Result
Wiring for secondary windings of current transformers	A	2.5	60	PASS
	B	2.5	60	
	C	2.5	60	
Wring for auxiliary power and control circuits	On-load tap-changer	2	60	

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4.8 Applied voltage test (routine test)					Test date: Nov. 23, 2023	
Relative humidity:27%;Ambient temperature: 20.4℃; Oil temperature:18.5℃;Air pressure: 102.8kPa						
Parts of applied voltage			Test voltage (kV)	Test duration (s)	Result	
HV-LV1,LV2,LV3,LV4 and earth			85	60	PASS	
LV1-HV,LV2,LV3,LV4 and earth			5	60		
LV2- HV,LV1,LV3,LV4 and earth			5	60		
LV3- HV,LV1,LV2,LV4 and earth			5	60		
LV4- HV,LV1, LV2,LV3 and earth			5	60		
4.9 Induced voltage withstand test (routine test)					Test date: Nov. 23, 2023	
Relative humidity:27%;Ambient temperature: 20.4℃; Oil temperature:18.5℃;Air pressure: 102.8kPa						
Tapping position	Applied voltage (kV)	Induced voltage (kV)	Induced multiple	Frequency (Hz)	Test duration (s)	Result
	LV	HV				
1	1.252	70.0	2	200	30	PASS
4.10 Measurement of no-load loss and current (routine test)					Test date: Nov. 24, 2023	
Voltage multiple	Applied voltage (kV)		No-load current		No-load loss (kW)	
	Average value	r.m.s. value	(A)	(%)	Measured value	Corrected value
90%Ur	0.5636	0.5642	47.95	0.43	11.950	11.9373
100%Ur	0.6258	0.6267	83.04	0.75	16.320	16.2965
110%Ur	0.6900	0.6917	173.0	1.56	24.560	24.4995
Remarks: at 100%Ur, the difference between r.m.s. voltage and average voltage is within 3%.						
4.11 Measurement of no-load loss and current at 90% and 110% of rated voltage (type test) See 4.10.						

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4.12 Measurement of short-circuit impedance and load loss (routine test)							Test date: Nov. 24, 2023 Oil temperature: 18.5℃		
Winding	Tapping position	Applied current I		Measured voltage (kV)	Measured load loss (kW)	Short-circuit impedance (for each phase)		Load loss (kW)	Total loss (kW)
		(A)	I/I _r (%)			HV impedance (Ω)	(%)	Corrected value	Corrected value
						t=75℃ I=I _r	t=75℃ I=I _r	t=75℃ I=I _r	t=75℃ I=I _r
HV LV1, LV2, LV3, LV4	1	105.90	53.50	1.340	32.130	7.33	7.18	129.3658	145.6623
	8	99.91	53.54	1.406	28.693	8.14	7.52	117.8579	134.0544
	15	94.37	53.87	1.528	32.629	9.37	8.12	125.8292	142.1257
HV LV1	1	29.41	59.43	0.8106	8.151	15.97	15.64	/	/
	8	31.02	66.50	0.9560	9.552	17.86	16.49	/	/
	15	26.63	60.80	0.9384	8.568	20.31	17.61	/	/
HV LV2	1	31.13	62.91	0.8824	9.467	16.42	16.08	/	/
	8	26.86	57.58	0.8441	8.029	18.19	16.80	/	/
	15	27.38	62.52	0.9931	9.417	20.99	18.20	/	/
HV LV3	1	30.94	62.52	0.8082	8.237	15.14	14.83	/	/
	8	29.84	63.97	0.8712	9.804	16.96	15.66	/	/
	15	26.73	61.04	0.8932	7.838	19.37	16.79	/	/
HV LV4	1	32.58	65.83	0.8780	9.069	15.62	15.30	/	/
	8	29.04	62.24	0.8773	7.646	17.51	16.17	/	/
	15	27.33	62.39	0.9415	8.183	19.97	17.31	/	/
Bundle short-circuit impedance									
Winding	Tapping position	Applied current I (A)	Measured voltage (V)	Bundle impedance (%)		Bundle factor k			
				t=75℃ I=I _r		t=75℃ I=I _r			
LV1 LV2,LV3,LV4	/	173.83	0.4954	5.69		0.79			

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4.13 Tests on on-load tap-changers (routine test)

Operation tests:

- a. with the transformer de-energized, eight complete cycles of operation (a cycle of operation goes from one end of the tapping range to the other, and back again);
- b. with the transformer de-energized, and with the auxiliary voltage reduced to 85 % of its rated value, one complete cycle of operation;
- c. with the transformer energized at rated voltage and frequency at no load, one complete cycle of operation;
- d. with one winding short-circuited and, as far as practicable, rated current in the tapped winding, 10 cycles of tap-change operations across the range of two steps on each side from where a coarse or reversing changeover selector operates, or otherwise from the middle tapping (the tapchanger will pass 20 times through the changeover position).

Test result: PASS

Test date: Jan. 04, 2024

4.14 Insulating liquid test (routine test, type test)

Test date: Nov. 23, 2023
Relative humidity:31%;Ambient temperature: 20.7℃

Dielectric dissipation factor (90℃)	Breakdown voltage (kV)
0.43%	53.5

Gas chromatograph analysis (before temperature-rise test)

Test date:Nov. 23, 2023
μL/L

H ₂	CO	CO ₂	CH ₄	C ₂ H ₆	C ₂ H ₄	C ₂ H ₂	Total hydrocarbon
0.00	4.38	255.41	1.10	0.00	0.00	0.00	1.10

Gas chromatograph analysis (after temperature-rise test)

Test date:Dec. 21, 2023
μL/L

H ₂	CO	CO ₂	CH ₄	C ₂ H ₆	C ₂ H ₄	C ₂ H ₂	Total hydrocarbon
0.39	6.99	305.42	1.29	0.00	0.00	0.00	1.29

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4.15 Leak testing with pressure for liquid-immersed transformers (routine test)
Test date: from Jan. 09, 2024 to Jan. 11, 2024

Test method	Parts of applied voltage	Applied pressure (kPa)	Duration (h)	Residual pressure (kPa)
Static pressure method	Body	30.0	24	No oil leakage or damage
	On-load tap-changer tank	30.0	24	No oil leakage or damage

Remarks: the tank of product is general structure.. No leakage or damage is found before tightness test.

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4.14 Temperature-rise test (type test)										Test date: from Dec.19,2023 to Dec.20,2023			
The method of temperature rise is the equivalent test in short-circuit connection. The tapping position is 1. Test duration is 7h of which the stabilization time is 3h.													
Measurement of top oil temperature-rise: it is required to apply 145.6623kW of total loss and 144.851kW is actually applied during testing.													
Measurement of winding temperature-rise: 198.0A current is required and 213.60A is actually applied during testing.													
Measured data													
Top oil temperature-rise and average oil temperature-rise			Measurement of average temperature-rise windings to oil								Ambient temperature (°C)		
Top oil temperature (°C)	Average oil temperature (°C)	Total loss injection/ specified total loss (%)	Current injection/ rated current (%)	Cold resistance (Ω)		Average oil temperature (°C)		Average winding temperature (°C)		Total loss	Measurement of cold resistance		
65.6	51.0	99.44	107.88	HV	0.7210	At the instant of shutdown	53.3	HV	88.2	30.1	19.8		
				LV1	1.1032×10^{-3}	At the end of cooling curve	52.0	LV1	87.6				
				LV2	1.1105×10^{-3}			LV2	88.4				
				LV3	1.1100×10^{-3}			LV3	86.2				
				LV4	1.0992×10^{-3}			LV4	78.6				
Calculations of temperature-rise													
Top oil temperature-rise (K)				35.6									
Winding temperature-rise (K)				HV		51.4							
				LV1		50.9							
				LV2		51.6							
				LV3		49.7							
				LV4		43.0							
Remarks: the calculated results of temperature-rise are the corrected values under specified total loss and rated current.													

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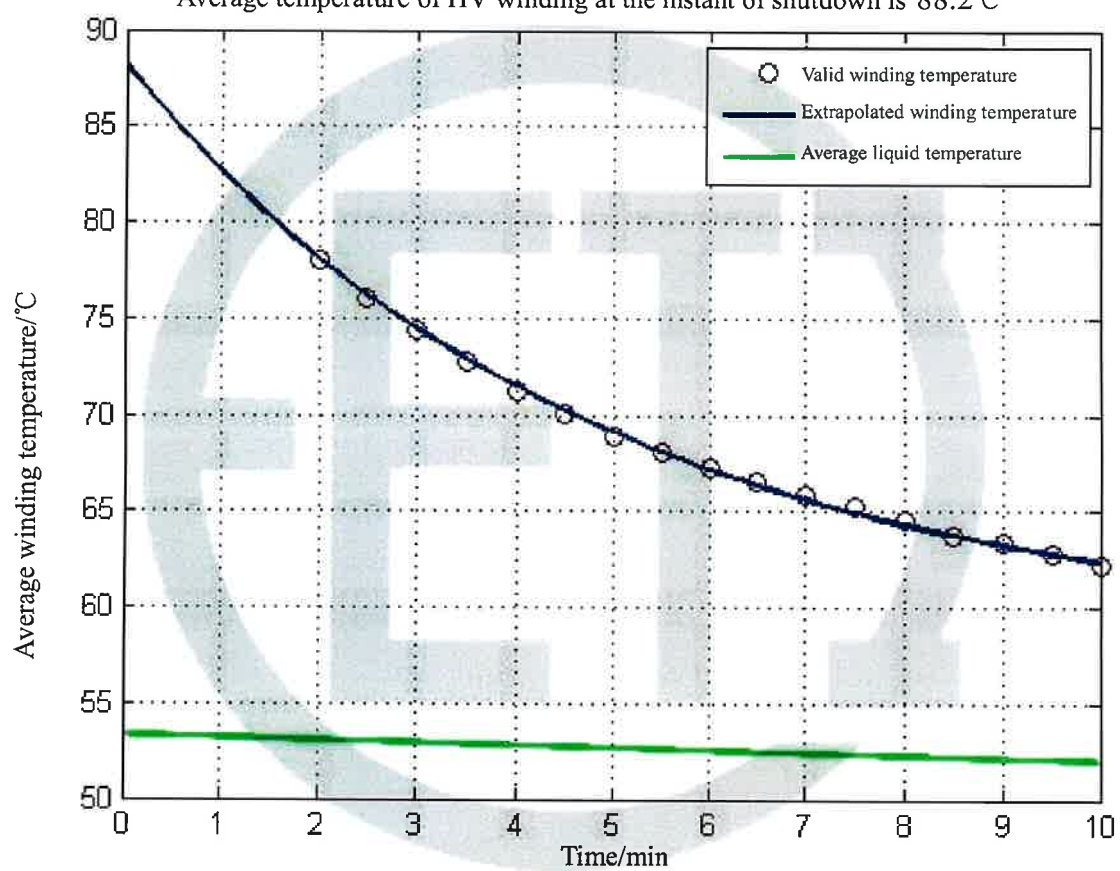
Winding temperature curve

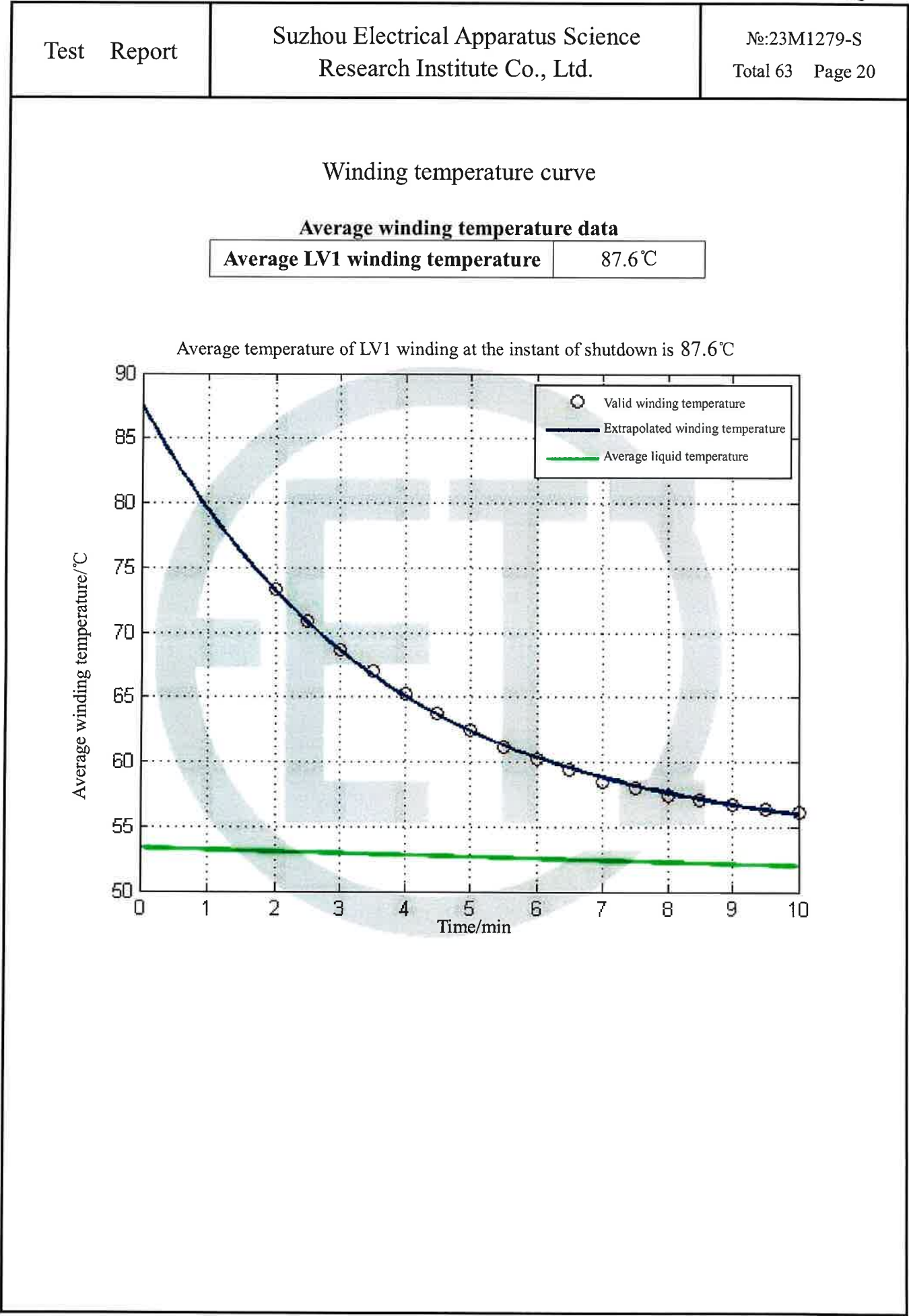
Average winding temperature data

Average HV winding temperature

88.2℃

Average temperature of HV winding at the instant of shutdown is 88.2℃





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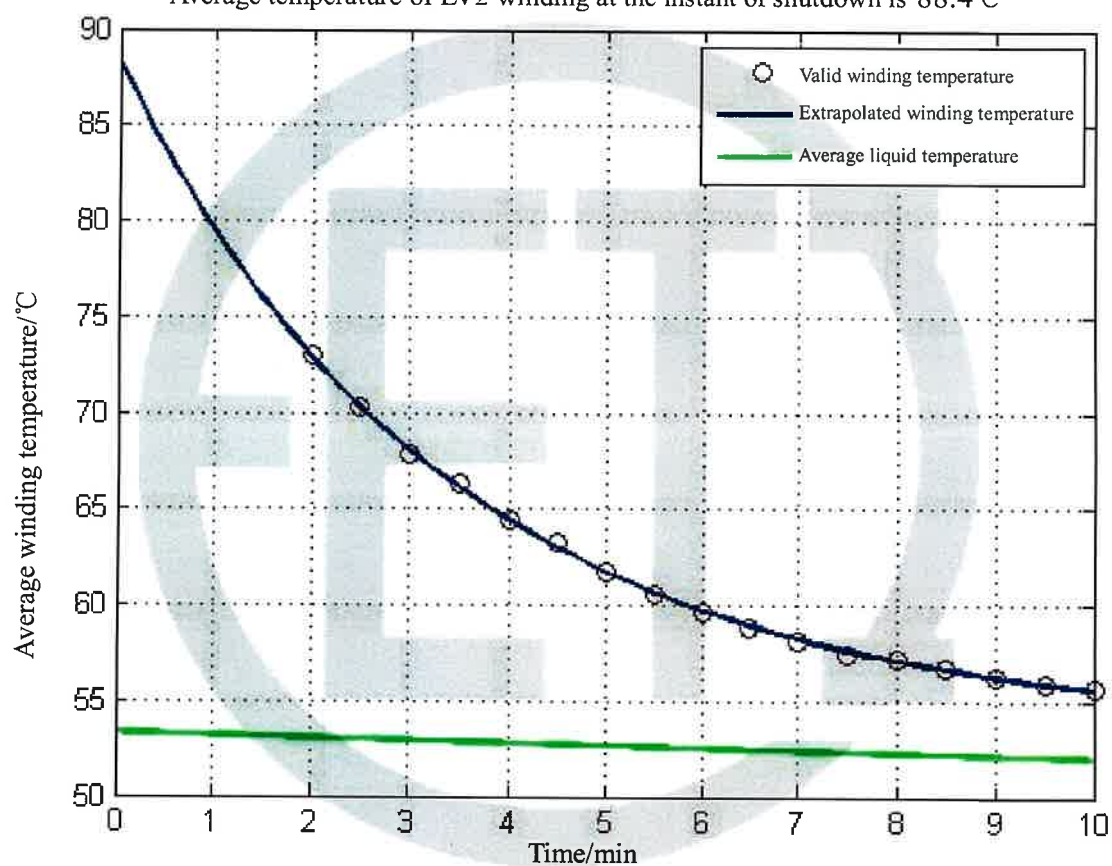
Suzhou Electrical Apparatus Science
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Winding temperature curve

Average winding temperature data

Average LV2 winding temperature	88.4℃
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Average temperature of LV2 winding at the instant of shutdown is 88.4℃



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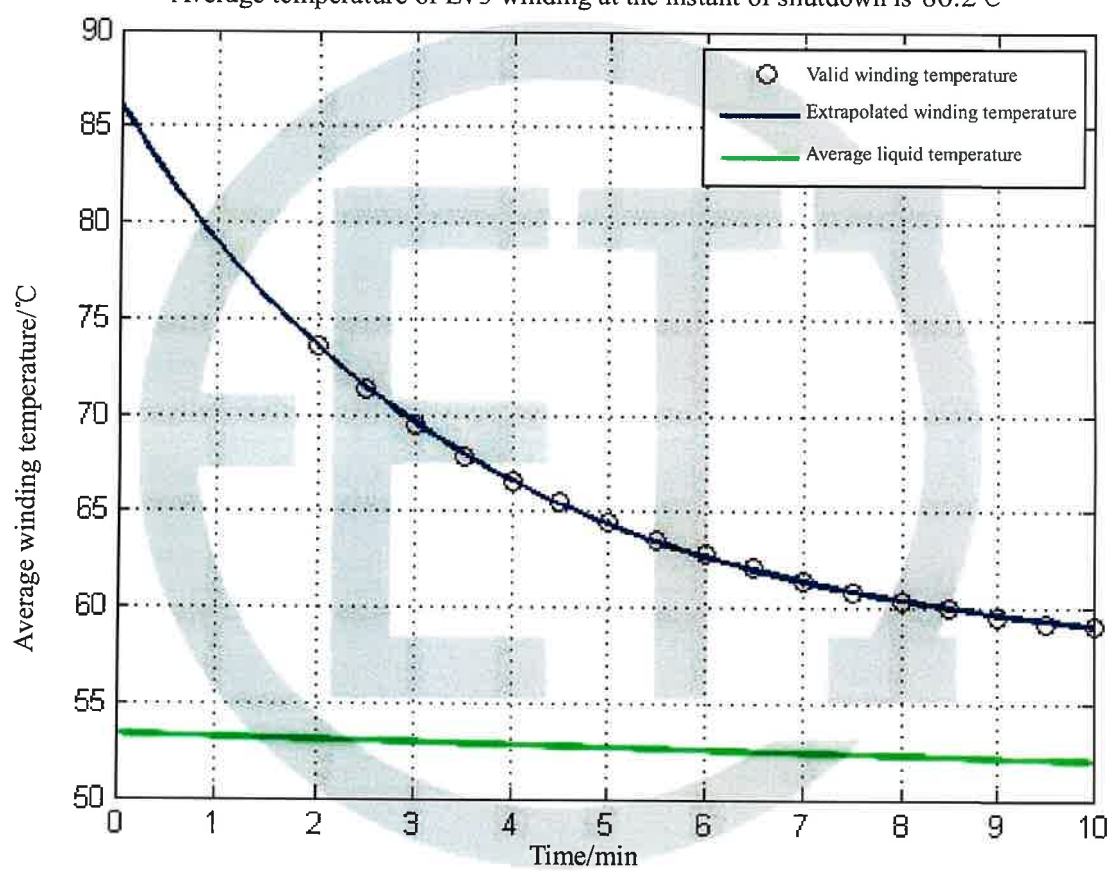
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Winding temperature curve

Average winding temperature data

Average LV3 winding temperature	86.2°C
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Average temperature of LV3 winding at the instant of shutdown is 86.2°C



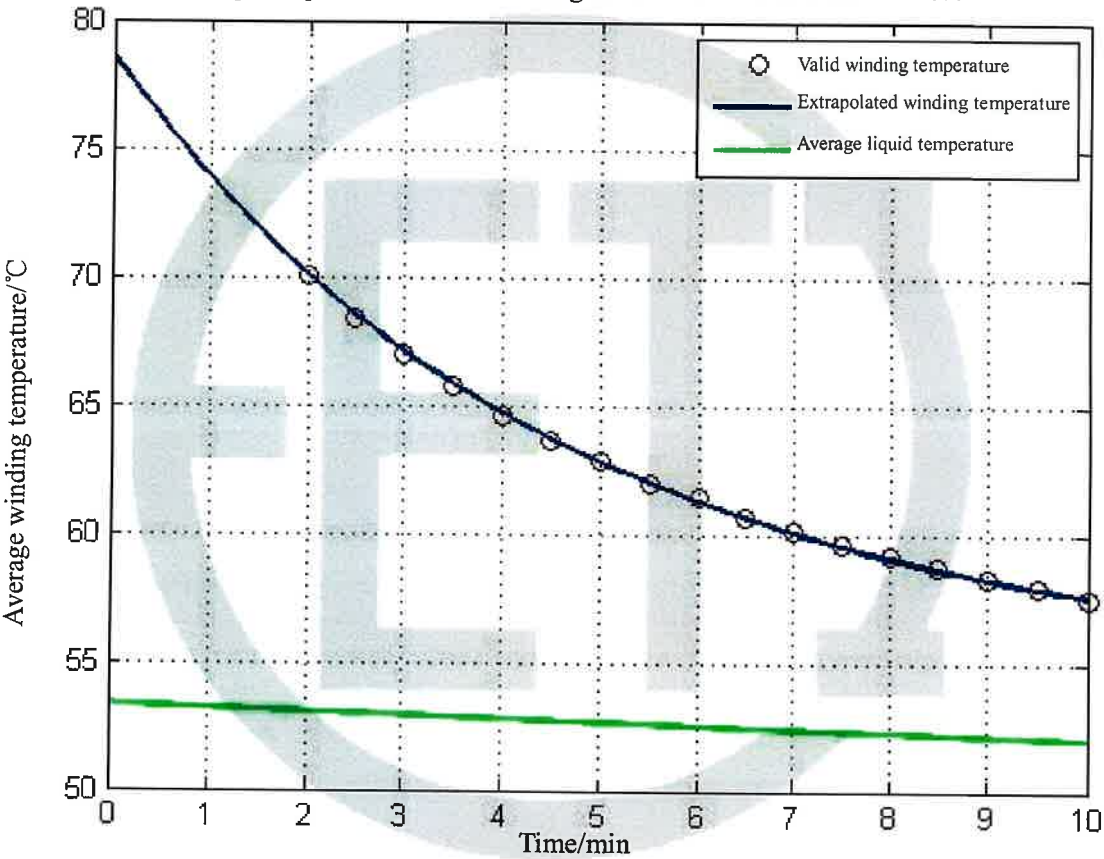
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Winding temperature curve

Average winding temperature data

Average LV4 winding temperature	78.6℃
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Average temperature of LV4 winding at the instant of shutdown is 78.6℃



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4.17 Determination of sound levels (type test)

Test date: Jan.09,2024

4.17.1 Rough estimation of the load current sound power level

Equation:

$$L_{WA,IN} \approx 39 + 18 \lg \frac{S_r}{S_p} = 58.42 \text{dB(A)}$$

where: S_r —the rated power is 12MVA;
 S_p —the reference power is 1MVA.

Because $L_{WA,IN}$ is less 19.58dB (A) than limit value 78dB (A) of assured sound power level, according to standard requirement, it does not need to measure load current sound power level.

4.17.2 Measurement of sound pressure level and calculation of sound power level

The transformer is excited at rated conditions. The prescribed contour shall be spaced 1.0m away from the principal radiating surface. Walk-around measurement is adopted in the test with 1/3 octave band. The height of the measured point is 1.12m.

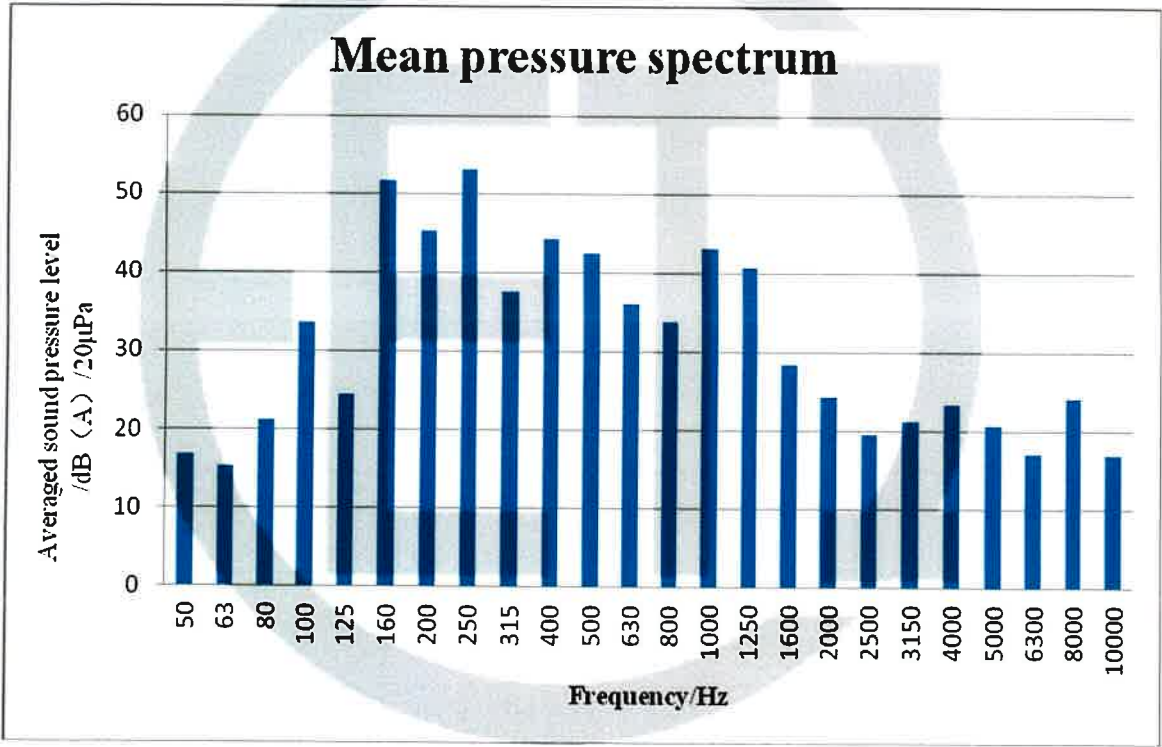
Test environment					
The total area of the surface of the test room S_v (m ²)	The average acoustic absorption coefficient α	The amount of acoustic absorption A (m ²)	Distance from the principal radiating surface (m)	The area of the measurement surface S (m ²)	Environmental correction K (dB)
3293.2	0.2	658.6	1.0	87.2	1.8

Measured value					(dB)
Status of cooling device	Average of background noise		Average noise value of transformer $\overline{L_{pA0}}$	A weighted sound pressure level $\overline{L_{pA}} = 10 \lg(10^{0.1\overline{L_{pA0}}} - 10^{0.1\overline{L_{bgA}}}) - K$	A weighted sound power level $L_{WA} = \overline{L_{pA}} + 10 \lg(S/S_0)$
	Before the test	After the test			
AF	32.7	33.0	56.8	55	74

Remarks: $\overline{L_{pA0}}$: the uncorrected average A-weighted sound pressure level; $\overline{L_{pA0}} = 10 \lg(\frac{1}{N} \sum_{i=1}^N 10^{0.1L_{pAi}})$
 $\overline{L_{bgA}}$: the lower of the two calculated average A weighted background noise pressure level.

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4.17.3 Values of frequency spectrum during the test			
Octave band (Hz)	Initial $\overline{L}_{bgA}$ (dB)	Final $\overline{L}_{bgA}$ (dB)	$\overline{L}_{pA0}$ (dB)
50	14.3	13.5	16.8
63	12.7	16.1	15.3
80	18.6	21.8	21.3
100	23.5	18.1	33.6
125	17.1	15.8	24.5
160	16.8	19.1	51.6
200	18.2	16.3	45.2
250	19.3	18.3	53.1
315	14.1	21.2	37.6
400	20.6	14.9	44.3
500	19.3	22.8	42.5
630	20.7	15.1	36.1
800	19.2	14.6	33.8
1000	23.1	18.2	43.1
1250	22.8	19.7	40.7
1600	18.3	23.3	28.4
2000	19.5	21.5	24.3
2500	20.1	14.2	19.6
3150	17.2	19.9	21.2
4000	14.9	21.2	23.3
5000	15.3	18.6	20.8
6300	14.1	22.3	17.1
8000	12.8	16.3	24.2
10000	12.1	14.2	16.9
Remarks: for the diagram of pressure spectrum see P ₂₆ .			

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4.18 Short-circuit withstand test (special test) Single-phase supply should be used, and test voltage shall be supplied between line terminal and the other two line terminals connected together. The test oscillogram shall be normal. For the test oscillogram, see P₃₀₋₃₈. The percentages of peak current and symmetrical current are the ratio of measured current to calculated current.								
4.18.1 Current calculation of short-circuit test (reference temperature 75℃)								
Tapping position		Symmetrical short-circuit current value of phase		Peak current value of phase (A)		Peak coefficient ($K\sqrt{2}$)		
1		2480		5707		2.301		
8		2255		5263		2.334		
15		1985		4594		2.315		
4.18.2 Current injection of short-circuit test								
Tapping position / phase category	Applied voltage terminal	Times	Measurement of current					Oscillogram No
			Symmetrical current value of phase		Peak current value of phase		Duration (s)	
			Measured value (A)	(%)	Measured value (A)	(%)		
1/A	A-BC	The first time	2396	96.60	5651	99.02	0.256	23M1279-S-T001
		The second time	2415	97.39	5704	99.95	0.256	23M1279-S-T002
		The third time	2384	96.13	5645	98.92	0.256	23M1279-S-T003
		Times	Measurement of reactance					
			Reactance values of phase (Ω)			Reactance variation of phase (%)		
			A	B	C	A	B	C
		Before tests	7.223	7.141	7.177	/	/	/
		The first time	7.233	7.152	7.190	0.14	0.15	0.18
		The second time	7.234	7.153	7.190	0.15	0.17	0.18
		The third time	7.236	7.154	7.190	0.18	0.18	0.18
The maximum reactance variation of phase is 0.18%.								

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Tapping position / phase category	Applied voltage terminal	Times	Measurement of current						
			Symmetrical current value of phase		Peak current value of phase		Duration (s)	Oscillogram No	
			Measured value (A)	(%)	Measured value (A)	(%)			
8/B	B-CA	The first time	2162	95.86	5151	97.88	0.256	23M1279-S-T004	
		The second time	2158	95.71	5167	98.18	0.256	23M1279-S-T005	
		The third time	2202	97.65	5260	99.93	0.256	23M1279-S-T006	
		Times	Measurement of reactance						
			Reactance values of phase (Ω)			Reactance variation of phase (%)			
			A	B	C	A	B	C	
		Before tests	8.058	7.964	8.004	/	/	/	
		The first time	8.076	7.978	8.020	0.22	0.18	0.20	
		The second time	8.075	7.978	8.020	0.21	0.18	0.20	
		The third time	8.074	7.977	8.020	0.20	0.16	0.20	

The maximum reactance variation of phase is 0.22%.

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Tapping position / phase category	Applied voltage terminal	Times	Measurement of current					
			Symmetrical current value of phase		Peak current value of phase		Duration (s)	Oscillogram No
			Measured value (A)	(%)	Measured value (A)	(%)		
15/C	C-AB	The first time	1951	98.28	4612	100.39	0.256	23M1279-S-T007
		The second time	1917	96.60	4548	99.00	0.256	23M1279-S-T008
		The third time	1912	96.32	4542	98.87	0.256	23M1279-S-T009
		Times	Measurement of reactance					
			Reactance values of phase (Ω)			Reactance variation of phase (%)		
			A	B	C	A	B	C
		Before tests	9.231	9.131	9.172	/	/	/
		The first time	9.249	9.151	9.188	0.20	0.22	0.17
		The second time	9.251	9.149	9.188	0.22	0.20	0.17
		The third time	9.252	9.149	9.187	0.23	0.20	0.16

The maximum reactance variation of phase is 0.23%.

4.18.3 Outside and out-of-tank inspection

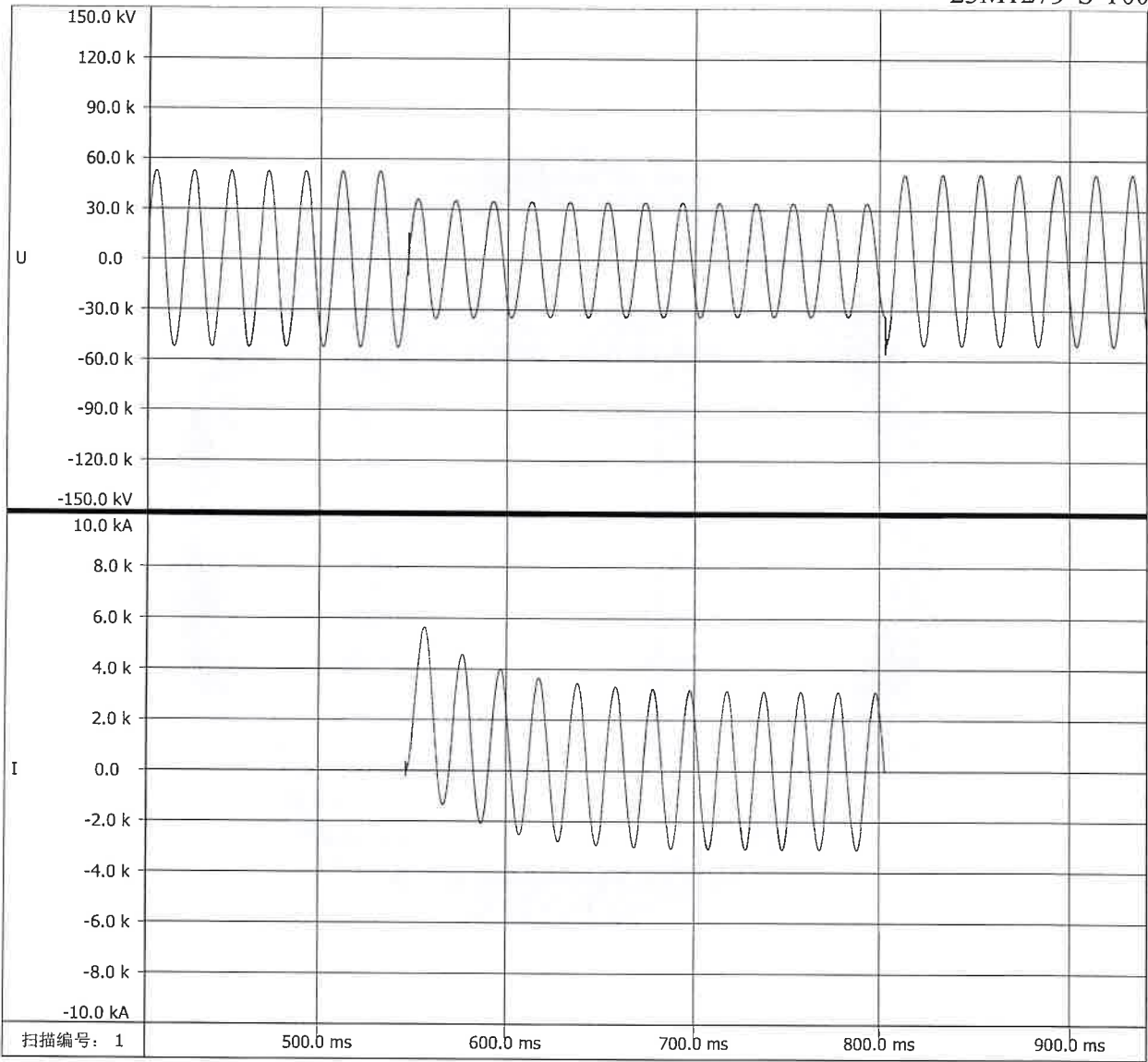
Test date: Jan.12,2024 and Jan.26,2024

The outside inspection indicates no anomalies. The out-of-tank inspection does not reveal any obvious distortion and displacement of coil, lead and supporting structures after the short-circuit test and no traces of discharge are found. For the pictures before and after the short-circuit test, see P₅₄₋₅₅.

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Oscillogram

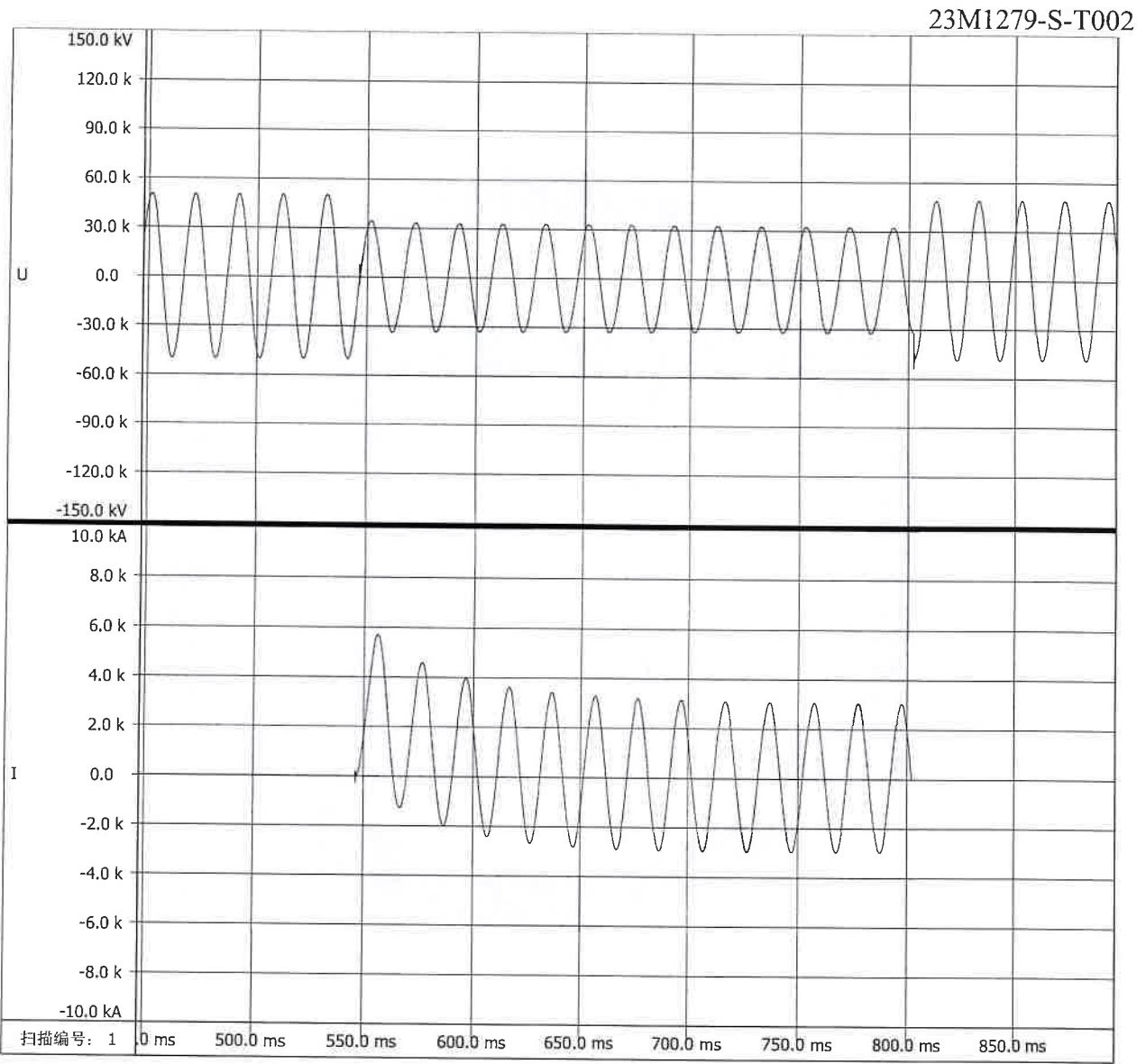
23M1279-S-T001



Tapping position / phase category	Applied voltage terminal	The first peak value of phase asymmetrical current (A)		The value of phase symmetrical short-circuit current (A)		Duration (s)
		Measured value (A)	measured value/ calculated value (%)	Measured value (A)	measured value/ calculated value (%)	
1/A	A-BC	5651	99.02	2396	96.60	0.256

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Oscillogram

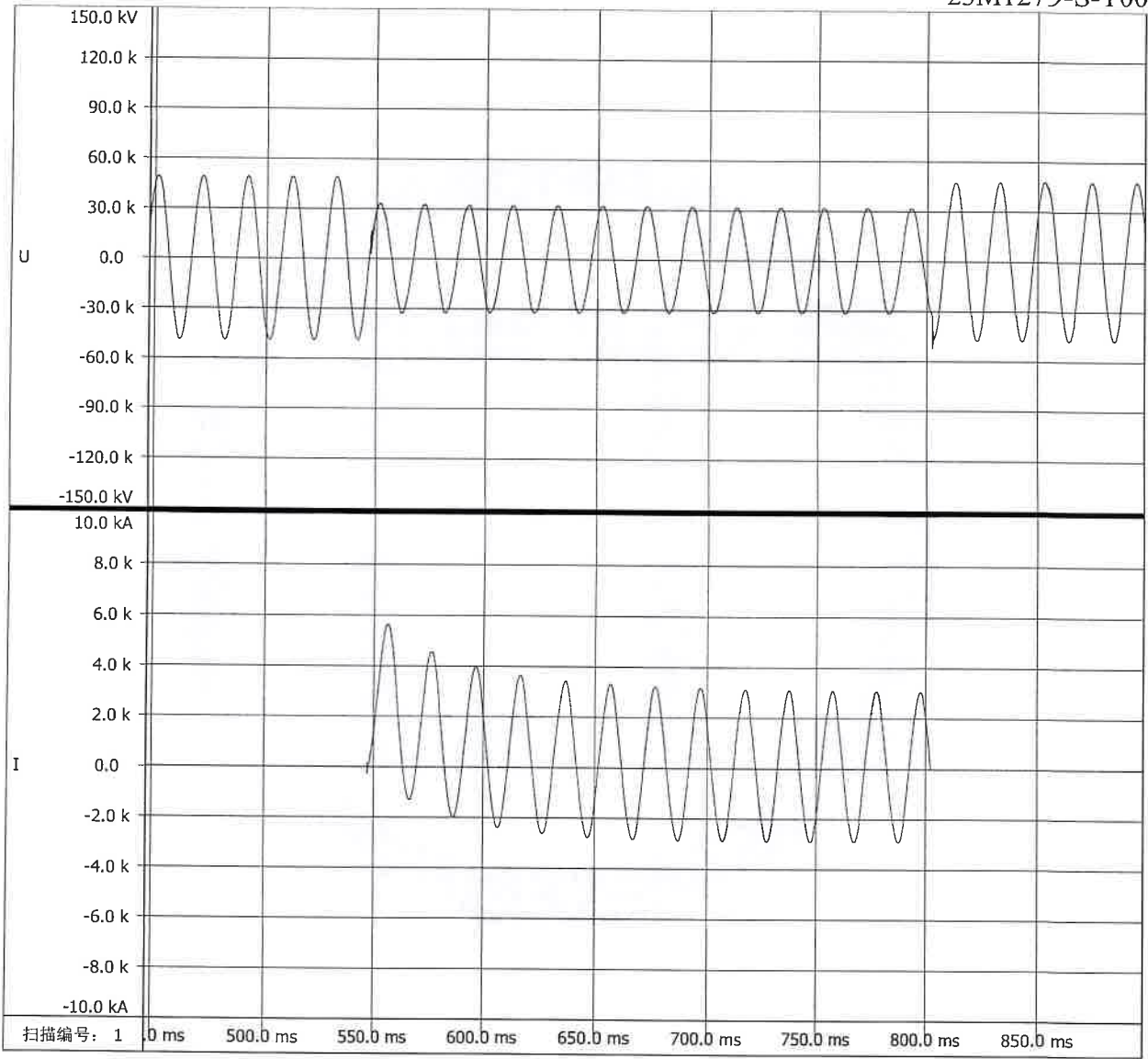


Tapping position / phase category	Applied voltage terminal	The first peak value of phase asymmetrical current (A)		The value of phase symmetrical short-circuit current (A)		Duration (s)
		Measured value (A)	measured value/ calculated value (%)	Measured value (A)	measured value/ calculated value (%)	
1/A	A-BC	5704	99.95	2415	97.39	0.256

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Oscillogram

23M1279-S-T003



Tapping position / phase category	Applied voltage terminal	The first peak value of phase asymmetrical current (A)		The value of phase symmetrical short-circuit current (A)		Duration (s)
		Measured value (A)	measured value/ calculated value (%)	Measured value (A)	measured value/ calculated value (%)	
1/A	A-BC	5645	98.92	2384	96.13	0.256

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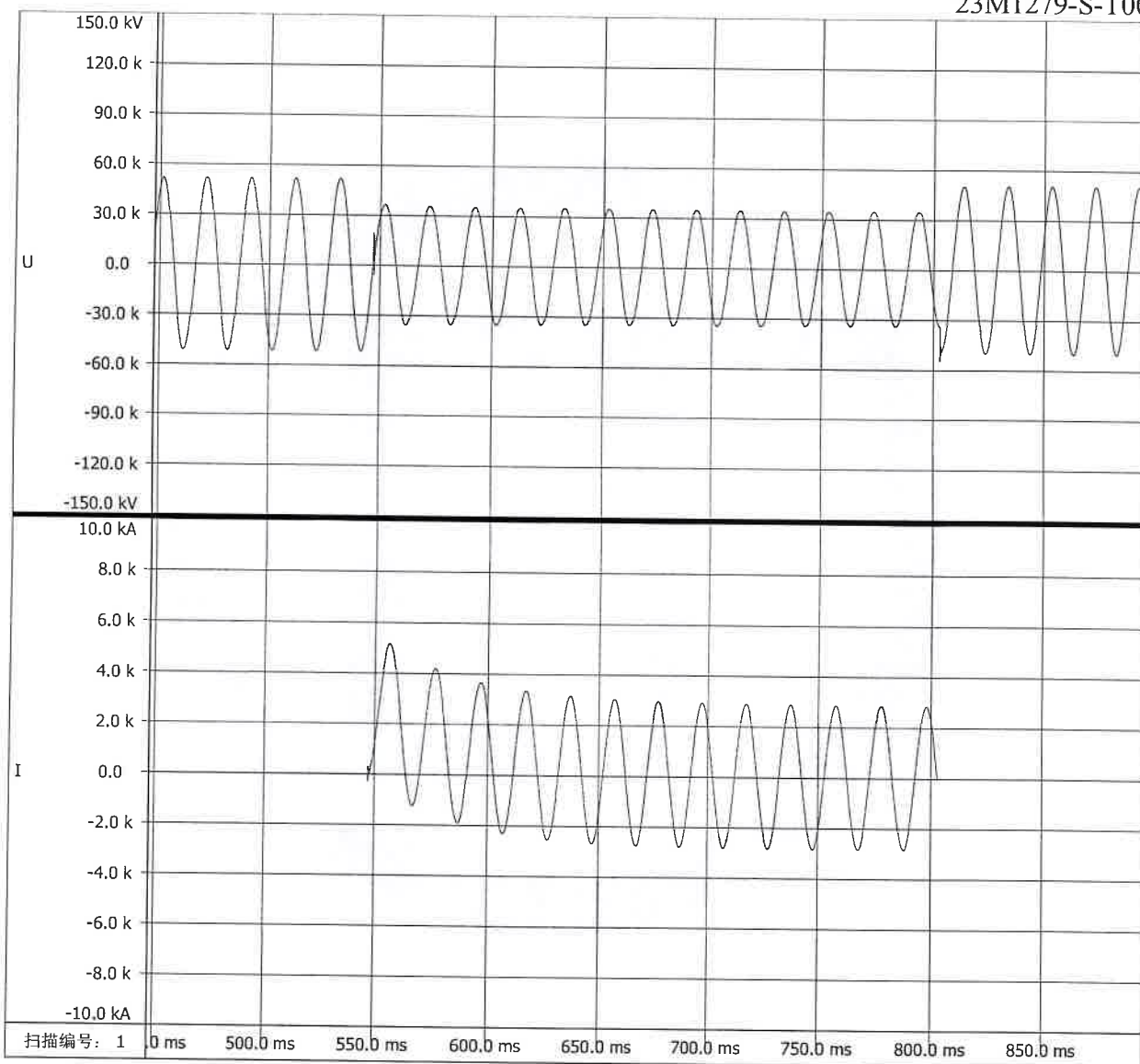
Suzhou Electrical Apparatus Science
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Oscillogram

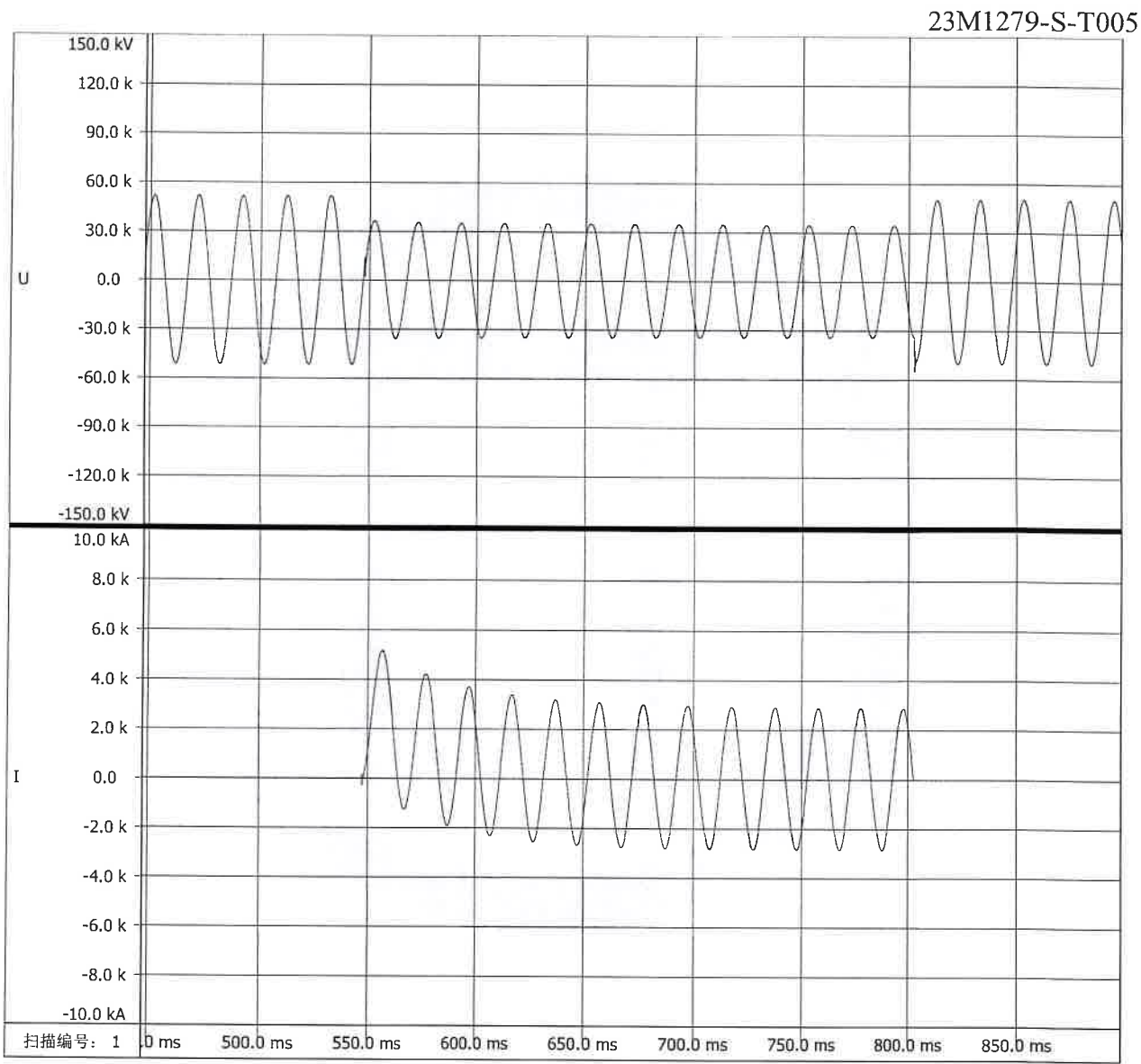
23M1279-S-T004



Tapping position / phase category	Applied voltage terminal	The first peak value of phase asymmetrical current (A)		The value of phase symmetrical short-circuit current (A)		Duration (s)
		Measured value (A)	measured value/ calculated value (%)	Measured value (A)	measured value/ calculated value (%)	
8/B	B-CA	5151	97.88	2162	95.86	0.256

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Oscillogram

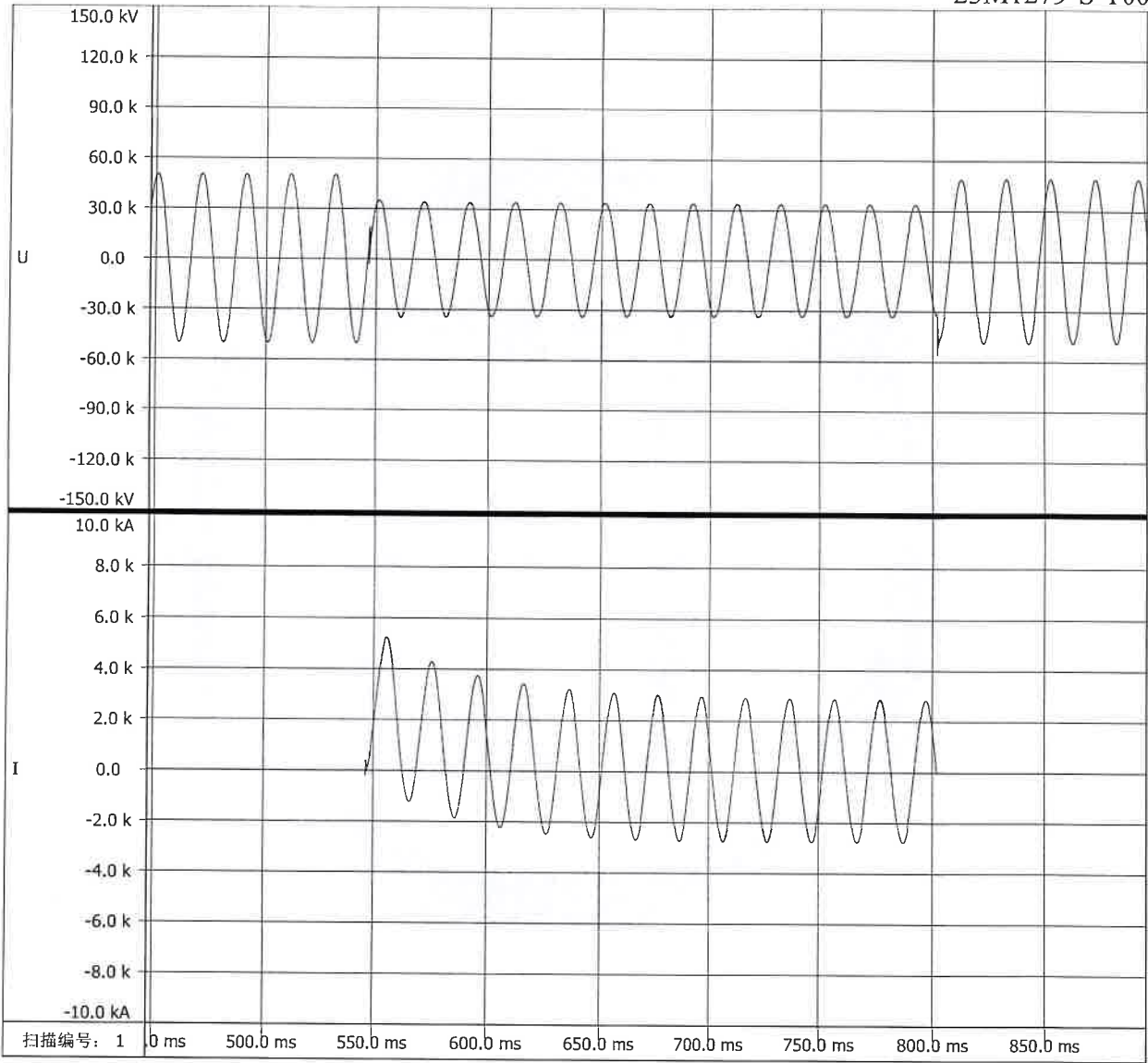


Tapping position / phase category	Applied voltage terminal	The first peak value of phase asymmetrical current (A)		The value of phase symmetrical short-circuit current (A)		Duration (s)
		Measured value (A)	measured value/ calculated value (%)	Measured value (A)	measured value/ calculated value (%)	
8/B	B-CA	5167	98.18	2158	95.71	0.256

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Oscillogram

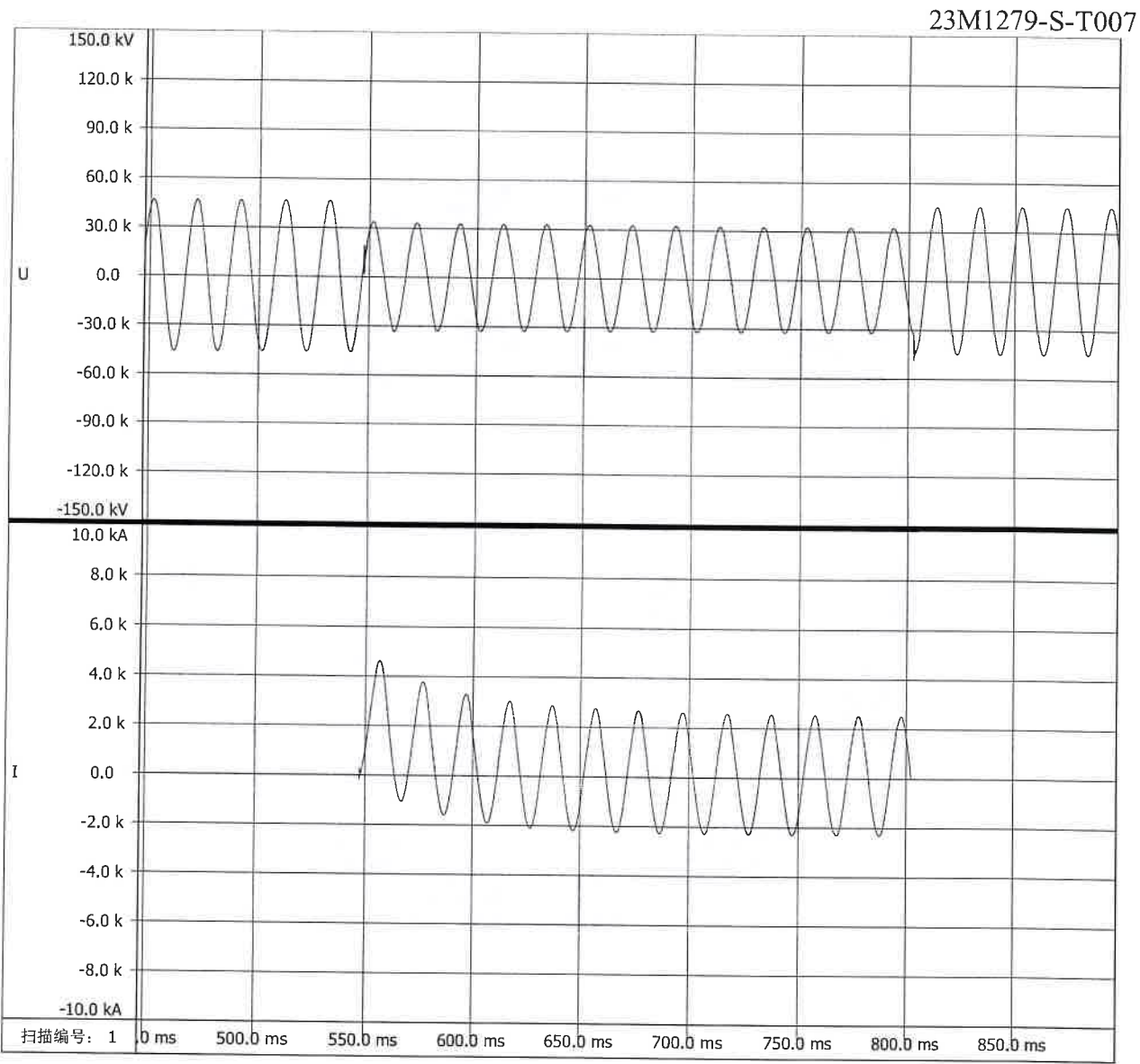
23M1279-S-T006



Tapping position / phase category	Applied voltage terminal	The first peak value of phase asymmetrical current (A)		The value of phase symmetrical short-circuit current (A)		Duration (s)
		Measured value (A)	measured value/ calculated value (%)	Measured value (A)	measured value/ calculated value (%)	
8/B	B-CA	5260	99.93	2202	97.65	0.256

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Oscillogram



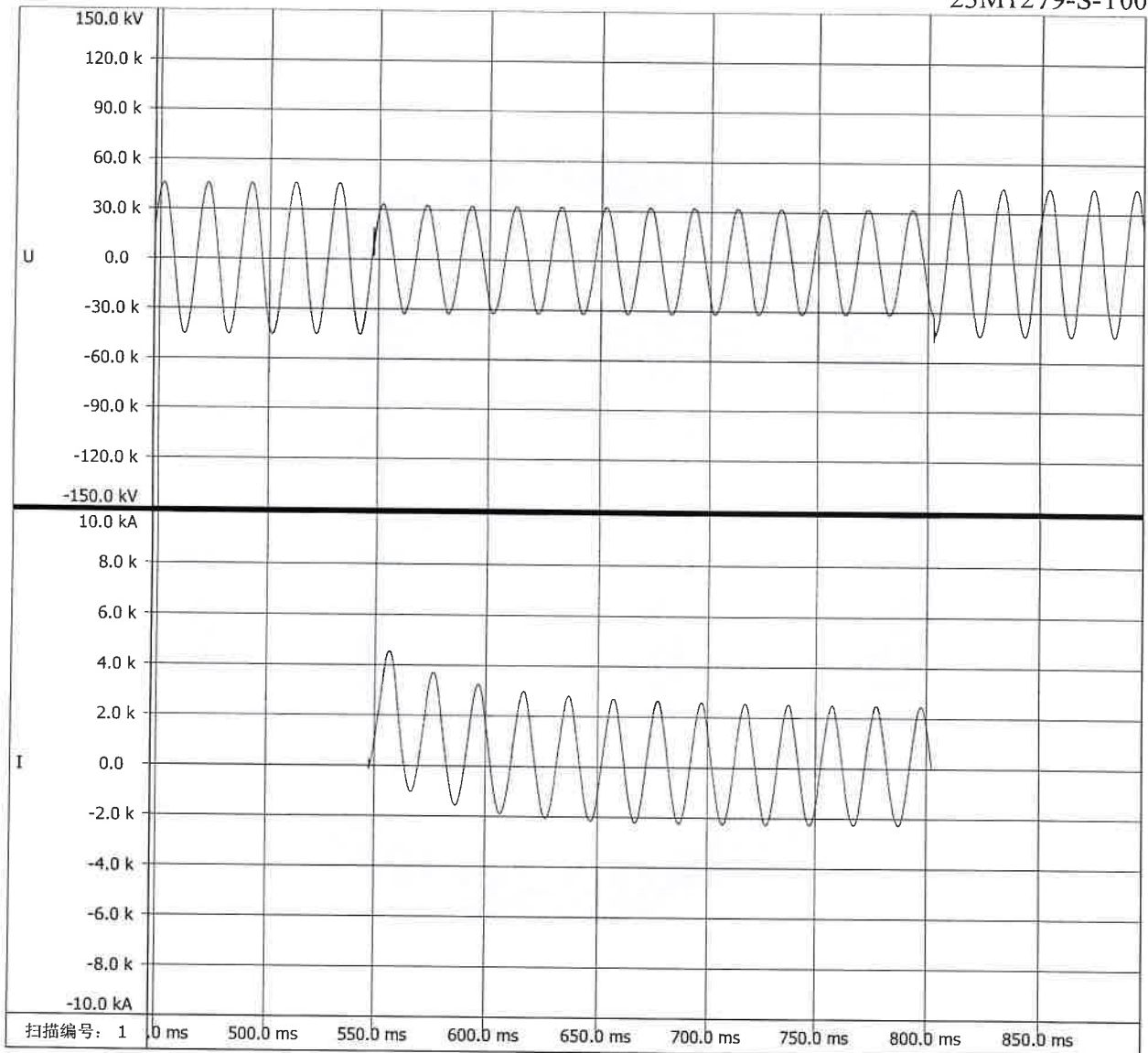
Tapping position / phase category	Applied voltage terminal	The first peak value of phase asymmetrical current (A)		The value of phase symmetrical short-circuit current (A)		Duration (s)
		Measured value (A)	measured value/ calculated value (%)	Measured value (A)	measured value/ calculated value (%)	
15/C	C-AB	4612	100.39	1951	98.28	0.256

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Oscillogram

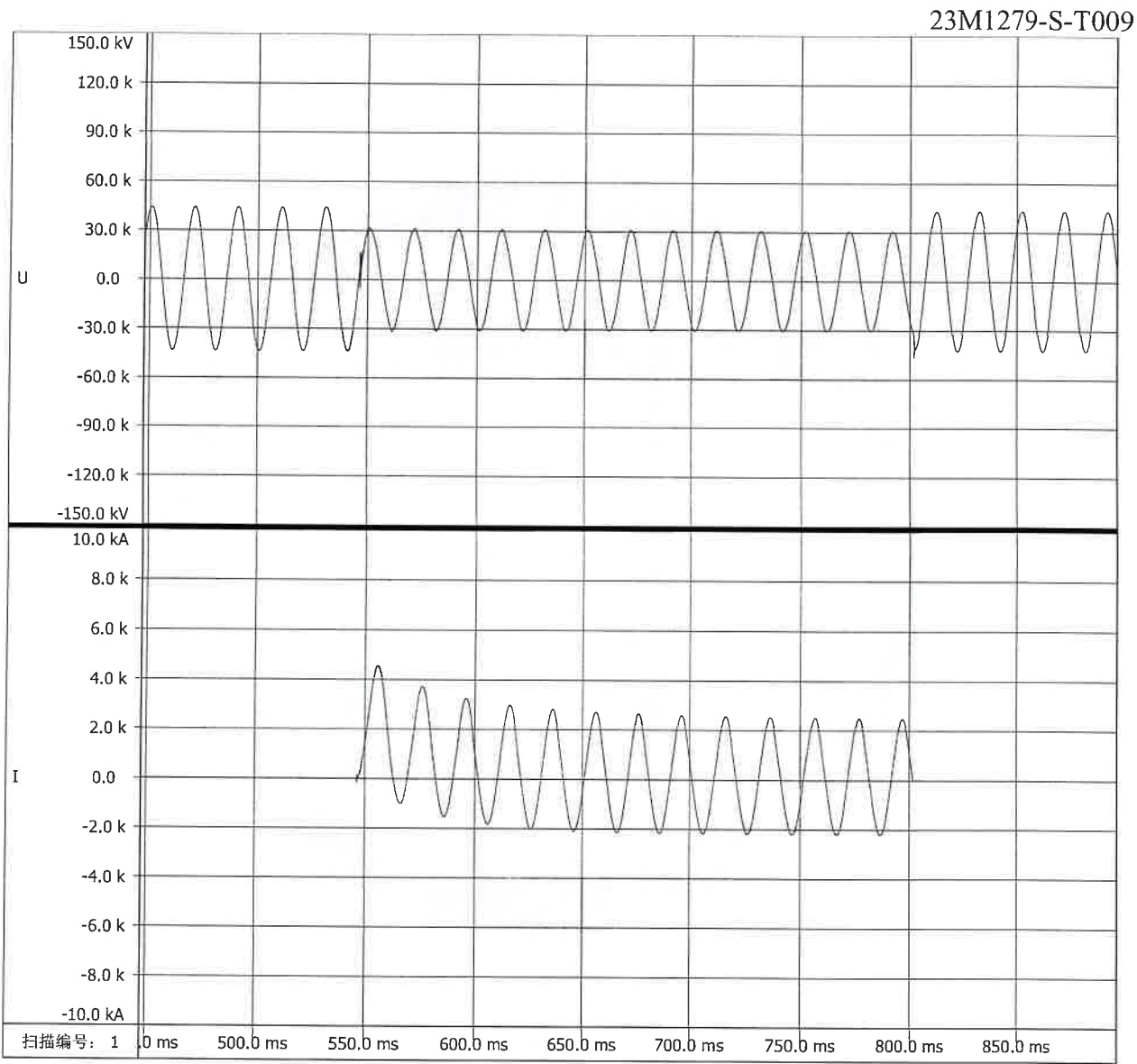
23M1279-S-T008



Tapping position / phase category	Applied voltage terminal	The first peak value of phase asymmetrical current (A)		The value of phase symmetrical short-circuit current (A)		Duration (s)
		Measured value (A)	measured value/ calculated value (%)	Measured value (A)	measured value/ calculated value (%)	
15/C	C-AB	4548	99.00	1917	96.60	0.256

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Oscillogram



Tapping position / phase category	Applied voltage terminal	The first peak value of phase asymmetrical current (A)		The value of phase symmetrical short-circuit current (A)		Duration (s)
		Measured value (A)	measured value/ calculated value (%)	Measured value (A)	measured value/ calculated value (%)	
15/C	C-AB	4542	98.87	1912	96.32	0.256

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4.18.4 Routine retests			
4.18.4.1 Measurement of d.c. insulation resistance between each winding to earth and between windings (routine test)			
Test date: Jan. 19, 2024 Relative humidity: 50%; Oil temperature: 13.9°C			
Measured part	R ₁₅ (GΩ)	R ₆₀ (GΩ)	Absorption ratio (R ₆₀ /R ₁₅)
HV-LV1,LV2,LV3,LV4 and earth	21.8	29.9	1.37
LV1-HV,LV2,LV3,LV4 and earth	11.6	17.5	1.51
LV2- HV,LV1,LV3,LV4 and earth	15.4	21.2	1.38
LV3- HV,LV1,LV2,LV4 and earth	12.7	17.8	1.40
LV4- HV,LV1, LV2,LV3 and earth	16.3	23.5	1.44
HV and LV1,LV2,LV3,LV4- earth	42.2	58.6	1.39
4.18.4.2 Measurement of dissipation factor (tanδ) of the insulation system capacitances (routine test)			
Test date: Jan. 19, 2024 Relative humidity: 50%; Oil temperature: 13.9°C			
Measured part	Dielectric dissipation factor tanδ(%)	Dielectric dissipation factor tanδ corrected to 20°C(%)	Capacitance(p F)
HV-LV1,LV2,LV3,LV4 and earth	0.45	0.47	4759
LV1-HV,LV2,LV3,LV4 and earth	0.35	0.36	9364
LV2- HV,LV1,LV3,LV4 and earth	0.31	0.32	8903
LV3- HV,LV1,LV2,LV4 and earth	0.37	0.38	9527
LV4- HV,LV1, LV2,LV3 and earth	0.36	0.37	8639
HV and LV1,LV2,LV3,LV4- earth	0.32	0.33	15816
4.18.4.3 Determination of capacitances windings-to-earth and between windings (routine test)			
Test date: Jan. 19, 2024 See 4.18.4.2.			

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4.18.4.4 Measurement of voltage ratio and check of phase displacement (routine test) Test date: Jan. 19, 2024

HV winding		LV1 winding		Transformer ratio by calculation	Measured voltage ratio tolerance (%)			Connection symbol
Tapping position	Voltage (kV)	Tapping position	Voltage (kV)		AB/a1b1	BC/b1c1	CA/c1a1	
1	35.000	/	0.6260	55.911	0.05	0.20	0.09	Yd11
2			0.6209	56.370	0.07	0.18	0.14	
3			0.6158	56.837	0.09	0.20	0.13	
4			0.6106	57.321	0.07	0.20	0.12	
5			0.6055	57.803	0.07	0.23	0.11	
6			0.6004	58.294	0.08	0.24	0.17	
7			0.5952	58.804	0.10	0.23	0.14	
8			0.5901	59.312	0.13	0.23	0.14	
9			0.5850	59.829	0.13	0.24	0.17	
10			0.5798	60.366	0.12	0.25	0.15	
11			0.5747	60.901	0.12	0.26	0.17	
12			0.5696	61.447	0.14	0.30	0.17	
13			0.5644	62.013	0.15	0.24	0.21	
14			0.5592	62.589	0.13	0.27	0.15	
15			0.5540	63.177	0.12	0.26	0.19	

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HV winding		LV2 winding		Transformer ratio by calculation	Measured voltage ratio tolerance (%)			Connection symbol
Tapping position	Voltage (kV)	Tapping position	Voltage (kV)		AB/a2b2	BC/b2c2	CA/c2a2	
1	35.000	/	0.6260	55.911	-0.21	-0.12	-0.16	Yy0
2			0.6209	56.370	-0.21	-0.10	-0.15	
3			0.6158	56.837	-0.19	-0.10	-0.13	
4			0.6106	57.321	-0.17	-0.09	-0.14	
5			0.6055	57.803	-0.18	-0.09	-0.12	
6			0.6004	58.294	-0.13	-0.07	-0.10	
7			0.5952	58.804	-0.17	-0.07	-0.12	
8			0.5901	59.312	-0.16	-0.04	-0.10	
9			0.5850	59.829	-0.13	-0.03	-0.09	
10			0.5798	60.366	-0.14	-0.02	-0.10	
11			0.5747	60.901	-0.13	-0.01	-0.08	
12			0.5696	61.447	-0.12	0.01	-0.04	
13			0.5644	62.013	-0.12	0.00	-0.07	
14			0.5592	62.589	-0.12	-0.03	-0.08	
15			0.5540	63.177	-0.13	-0.05	-0.09	

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HV winding		LV3 winding		Transformer ratio by calculation	Measured voltage ratio tolerance (%)			Connection symbol
Tapping position	Voltage (kV)	Tapping position	Voltage (kV)		AB/a3b3	BC/b3c3	CA/c3a3	
1	35.000	/	0.6260	55.911	0.04	0.13	0.08	Yd11
2			0.6209	56.370	0.06	0.14	0.08	
3			0.6158	56.837	0.07	0.17	0.05	
4			0.6106	57.321	0.07	0.16	0.11	
5			0.6055	57.803	0.07	0.16	0.12	
6			0.6004	58.294	0.10	0.17	0.15	
7			0.5952	58.804	0.09	0.17	0.15	
8			0.5901	59.312	0.12	0.18	0.12	
9			0.5850	59.829	0.15	0.19	0.16	
10			0.5798	60.366	0.12	0.20	0.18	
11			0.5747	60.901	0.16	0.20	0.19	
12			0.5696	61.447	0.19	0.21	0.19	
13			0.5644	62.013	0.19	0.20	0.20	
14			0.5592	62.589	0.17	0.19	0.18	
15			0.5540	63.177	0.16	0.22	0.16	

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HV winding		LV4 winding		Transformer ratio by calculation	Measured voltage ratio tolerance (%)			Connection symbol
Tapping position	Voltage (kV)	Tapping position	Voltage (kV)		AB/a4b4	BC/b4c4	CA/c4a4	
1	35.000	/	0.6260	55.911	-0.21	-0.20	-0.18	Yy0
2			0.6209	56.370	-0.21	-0.19	-0.17	
3			0.6158	56.837	-0.19	-0.17	-0.15	
4			0.6106	57.321	-0.20	-0.18	-0.16	
5			0.6055	57.803	-0.19	-0.16	-0.15	
6			0.6004	58.294	-0.17	-0.14	-0.11	
7			0.5952	58.804	-0.18	-0.17	-0.13	
8			0.5901	59.312	-0.17	-0.16	-0.12	
9			0.5850	59.829	-0.16	-0.13	-0.12	
10			0.5798	60.366	-0.16	-0.12	-0.11	
11			0.5747	60.901	-0.14	-0.13	-0.10	
12			0.5696	61.447	-0.13	-0.10	-0.09	
13			0.5644	62.013	-0.14	-0.10	-0.08	
14			0.5592	62.589	-0.14	-0.10	-0.08	
15			0.5540	63.177	-0.14	-0.11	-0.09	

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4.18.4.5 Measurement of winding resistance (routine test)

Test date: Jan. 19, 2024
Oil temperature:13.9℃

Winding	Tapping position	Measured resistance (Ω)			Resistance unbalance rate (%)
		A~B a1~b1 a2~b2 a3~b3 a4~b4	B~C b1~c1 b2~c2 b3~c3 b4~c4	C~A c1~a1 c2~a2 c3~a3 c4~a4	
HV	1	0.6969	0.6959	0.6968	0.14
	2	0.6914	0.6905	0.6913	0.13
	3	0.6860	0.6851	0.6859	0.13
	4	0.6806	0.6797	0.6805	0.13
	5	0.6752	0.6742	0.6751	0.15
	6	0.6697	0.6687	0.6696	0.15
	7	0.6640	0.6630	0.6639	0.15
	8	0.6552	0.6546	0.6554	0.12
	9	0.6637	0.6626	0.6635	0.17
	10	0.6692	0.6682	0.6691	0.15
	11	0.6748	0.6738	0.6748	0.15
	12	0.6805	0.6795	0.6804	0.15
	13	0.6860	0.6851	0.6861	0.15
	14	0.6916	0.6906	0.6916	0.14
	15	0.6969	0.6960	0.6970	0.14
LV	/	1.0633×10 ⁻³	1.0719×10 ⁻³	1.0641×10 ⁻³	0.81
		1.0690×10 ⁻³	1.0464×10 ⁻³	1.0721×10 ⁻³	2.42
		1.0687×10 ⁻³	1.0765×10 ⁻³	1.0570×10 ⁻³	1.83
		1.0593×10 ⁻³	1.0472×10 ⁻³	1.0744×10 ⁻³	2.57

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4.18.4.6 Check of the ratio and polarity of built-in current transformers(routine test) Test date: Jan. 19, 2024				
Tested windings	Connecting terminal	Ratio	Polarity	
A	1S1-1S1	60.86	-	
	1S1-1S2	61.23	-	
B	2S1-2S2	58.97	-	
	2S1-2S2	61.04	-	
C	3S1-3S2	59.85	-	
	3S1-3S2	61.10	-	
4.18.4.7 Insulation test of auxiliary wiring (routine test) Test date: Jan. 19, 2024 Relative humidity: 40%; Ambient temperature: 14.8℃; Air pressure: 101.8kPa				
Parts of applied voltage		Test voltage (kV)	Test duration (s)	Result
Wiring for secondary windings of current transformers	A	2.5	60	PASS
	B	2.5	60	
	C	2.5	60	
Wring for auxiliary power and control circuits	On-load tap-changer	2	60	

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4.18.4.8 Applied voltage test (routine test) Test date: Jan. 20, 2024 Relative humidity:26%;Ambient temperature: 20.3℃; Oil temperature:19.6℃;Air pressure: 102.4kPa						
Parts of applied voltage		Test voltage (kV)	Test duration (s)	Result		
HV-LV1,LV2,LV3,LV4 and earth		85	60	PASS		
LV1-HV,LV2,LV3,LV4 and earth		5	60			
LV2- HV,LV1,LV3,LV4 and earth		5	60			
LV3- HV,LV1,LV2,LV4 and earth		5	60			
LV4- HV,LV1, LV2,LV3 and earth		5	60			
4.18.4.9 Induced voltage withstand test (routine test) Test date: Jan. 20, 2024 Relative humidity:26%;Ambient temperature: 20.3℃; Oil temperature:19.6℃;Air pressure: 102.4kPa						
Tapping position	Applied voltage (kV)	Induced voltage (kV)	Induced multiple	Frequency (Hz)	Test duration (s)	Result
	LV	HV				
1	1.252	70.0	2	200	30	PASS
4.18.4.10 Measurement of no-load loss and current (routine test) Test date: Jan. 19, 2024						
Applied voltage (kV)		No-load current		No-load loss (kW)		
Average value	r.m.s. value	(A)	(%)	Measured value	Corrected value	
0.6263	0.6282	83.90	0.76	16.498	16.4480	
Remarks: the difference between r.m.s. voltage and average voltage is within 3%.						

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4.18.4.11 Measurement of short-circuit impedance and load loss (routine test)								Test date: Jan. 19, 2024 Oil temperature: 13.9℃	
Winding	Tapping position	Applied current I		Measured voltage (kV)	Measured load loss (kW)	Short-circuit impedance (for each phase)		Load loss (kW)	Total loss (kW)
		(A)	I/Ir (%)			HV impedance (Ω)	(%)	Corrected value	Corrected value
						t=75℃ I=Ir	t=75℃ I=Ir	t=75℃ I=Ir	t=75℃ I=Ir
HV LV1, LV2, LV3, LV4	1	105.79	53.44	1.339	29.365	7.33	7.18	122.3286	138.7766
	8	100.71	53.97	1.422	28.776	8.18	7.55	116.1275	132.5755
	15	101.07	57.69	1.636	34.296	9.37	8.12	118.5913	135.0393
HV LV1	1	30.88	62.40	0.8458	7.796	15.86	15.56	/	/
	8	31.73	68.01	0.9752	9.131	17.81	16.45	/	/
	15	28.75	66.65	1.008	8.602	20.31	17.61	/	/
HV LV2	1	32.80	66.29	0.9242	8.938	16.33	16.00	/	/
	8	28.73	61.59	0.9070	7.634	18.29	16.89	/	/
	15	29.05	66.33	1.047	8.962	20.88	18.10	/	/
HV LV3	1	30.99	62.63	0.8080	7.532	15.12	14.81	/	/
	8	31.53	67.59	0.9216	8.668	16.95	15.65	/	/
	15	30.15	68.84	1.007	9.116	19.37	16.79	/	/
HV LV4	1	33.26	67.22	0.8949	9.001	15.60	15.28	/	/
	8	30.24	64.83	0.9123	8.268	17.49	16.15	/	/
	15	27.34	62.42	0.9397	7.757	19.92	17.27	/	/
Bundle short-circuit impedance									
Winding	Tapping position	Applied current I (A)	Measured voltage (V)	Bundle impedance (%)		Bundle factor k			
				t=75℃ I=Ir		t=75℃ I=Ir			
LV1 LV2,LV3,LV4	/	167.98	0.4790	5.04		0.70			

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4.18.4.12 Tests on on-load tap-changers (routine test) Test date: Jan. 19, 2024 Operation tests: a. with the transformer de-energized, eight complete cycles of operation (a cycle of operation goes from one end of the tapping range to the other, and back again); b. with the transformer de-energized, and with the auxiliary voltage reduced to 85 % of its rated value, one complete cycle of operation; c. with the transformer energized at rated voltage and frequency at no load, one complete cycle of operation; d. with one winding short-circuited and, as far as practicable, rated current in the tapped winding, 10 cycles of tap-change operations across the range of two steps on each side from where a coarse or reversing changeover selector operates, or otherwise from the middle tapping (the tapchanger will pass 20 times through the changeover position). Test result: PASS						
4.18.4.13 Insulating liquid test (routine test) Test date: Jan. 19, 2024 Relative humidity:35%;Ambient temperature: 19.8℃ <table><tr><td>Dielectric dissipation factor (90℃)</td><td>Breakdown voltage (kV)</td></tr><tr><td>0.49%</td><td>50.9</td></tr></table>			Dielectric dissipation factor (90℃)	Breakdown voltage (kV)	0.49%	50.9
Dielectric dissipation factor (90℃)	Breakdown voltage (kV)					
0.49%	50.9					

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4.19 Lightning impulse test (type test, special test)

Test date: Jan. 20, 2024

Atmospheric conditions of test:
Relative humidity:64%;Ambient temperature: 12.4℃; Oil temperature:12.2℃;Air pressure: 102.3kPa.

Test items and voltage

Withstand terminals	Rated withstand voltage (kV)		Tapping position
	Lightning full wave	Lightning chopped wave	
A,B,C	200	220	1,8,15

Test sequence:

Line terminal

- One negative reduced level full wave impulse;
- One negative full level full wave impulse;
- One negative reduced level chopped wave impulse;
- Two negative full level chopped wave impulses;
- Two negative full level full wave impulses.

Test records:

T1: front time; T2: time to half-value; Tc: time to chopping; Upk: peak voltage.
For waveform diagram, see P₅₀₋₅₂.

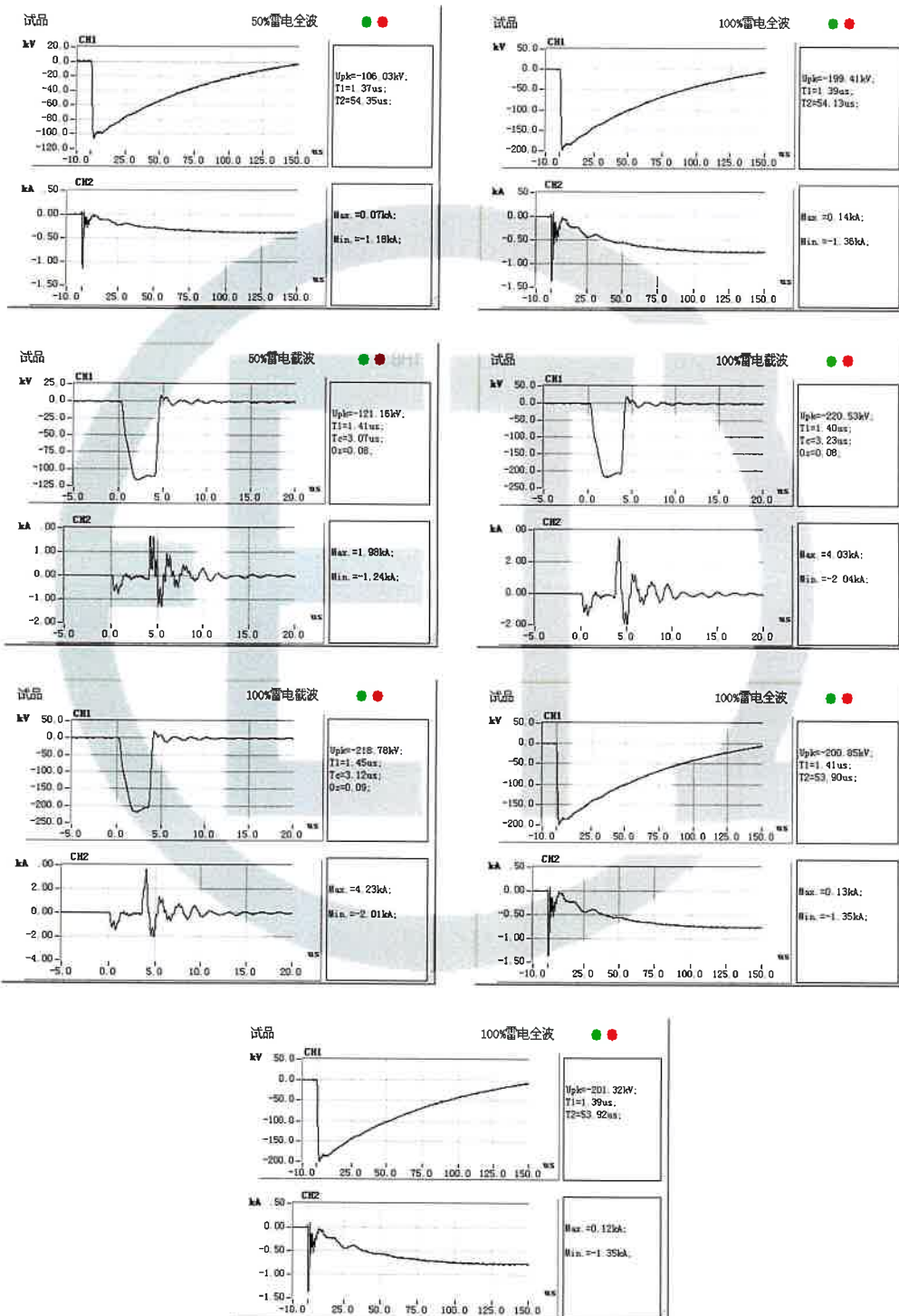
Voltage ranges of oscillograms are as below:

Withstand terminal	Full wave (kV)	Chopped wave (kV)
A,B,C	197.84~201.32	218.78~222.94

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Tested terminal: A Test polarity: negative Channel 1: voltage wave Channel 2: current wave



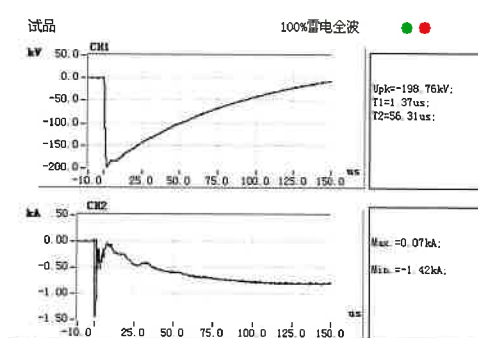
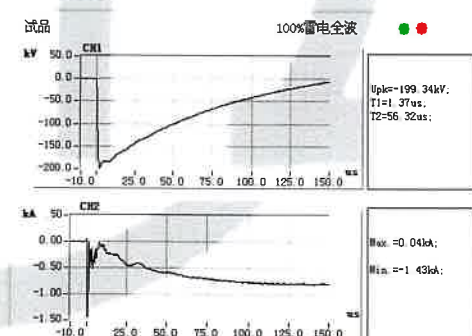
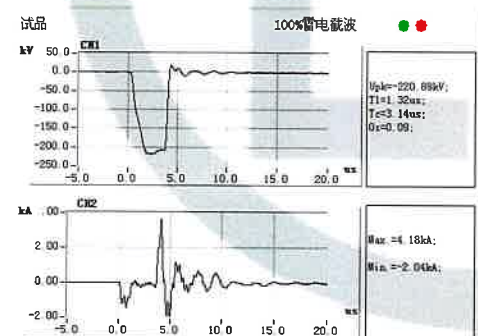
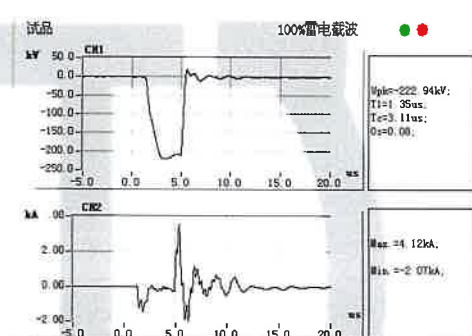
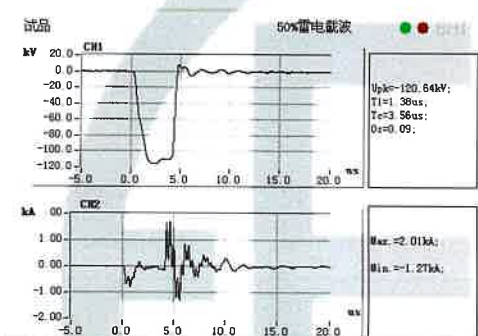
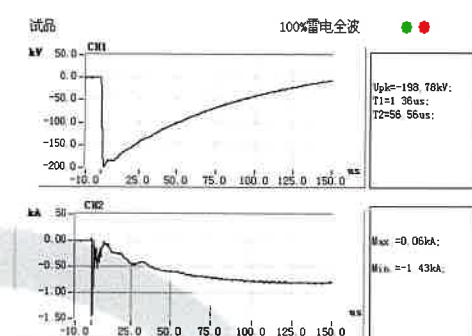
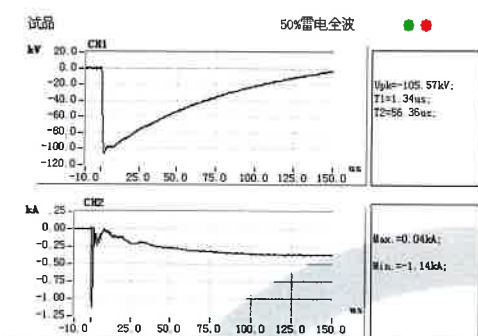
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Tested terminal: B Test polarity: negative Channel 1: voltage wave Channel 2: current wave



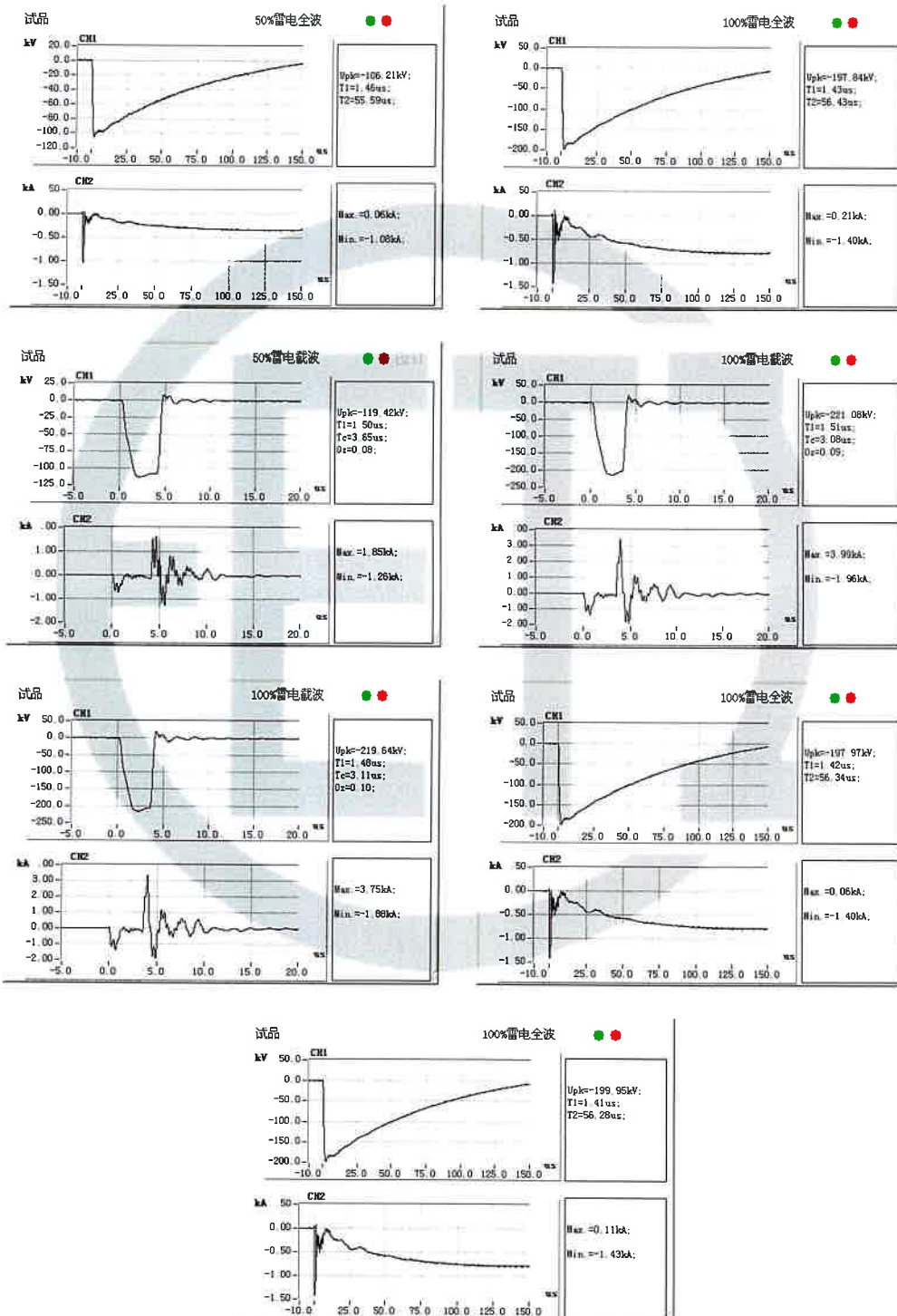
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Tested terminal: C Test polarity: negative Channel 1: voltage wave Channel 2: current wave



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4.20 Measurement of the power taken by the fan and liquid pump motors (type test) Test date: Jan. 19, 2024

No	Voltage (V)	Current (A)	Measured power (W)
2301-2112130101-01	380.4	2.0	913
2301-2112130101-02	382.2	2.0	929
2301-2112130101-04	380.7	2.0	910

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HV side before short-circuit test:



LV side before short-circuit test:



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HV side after short-circuit test:



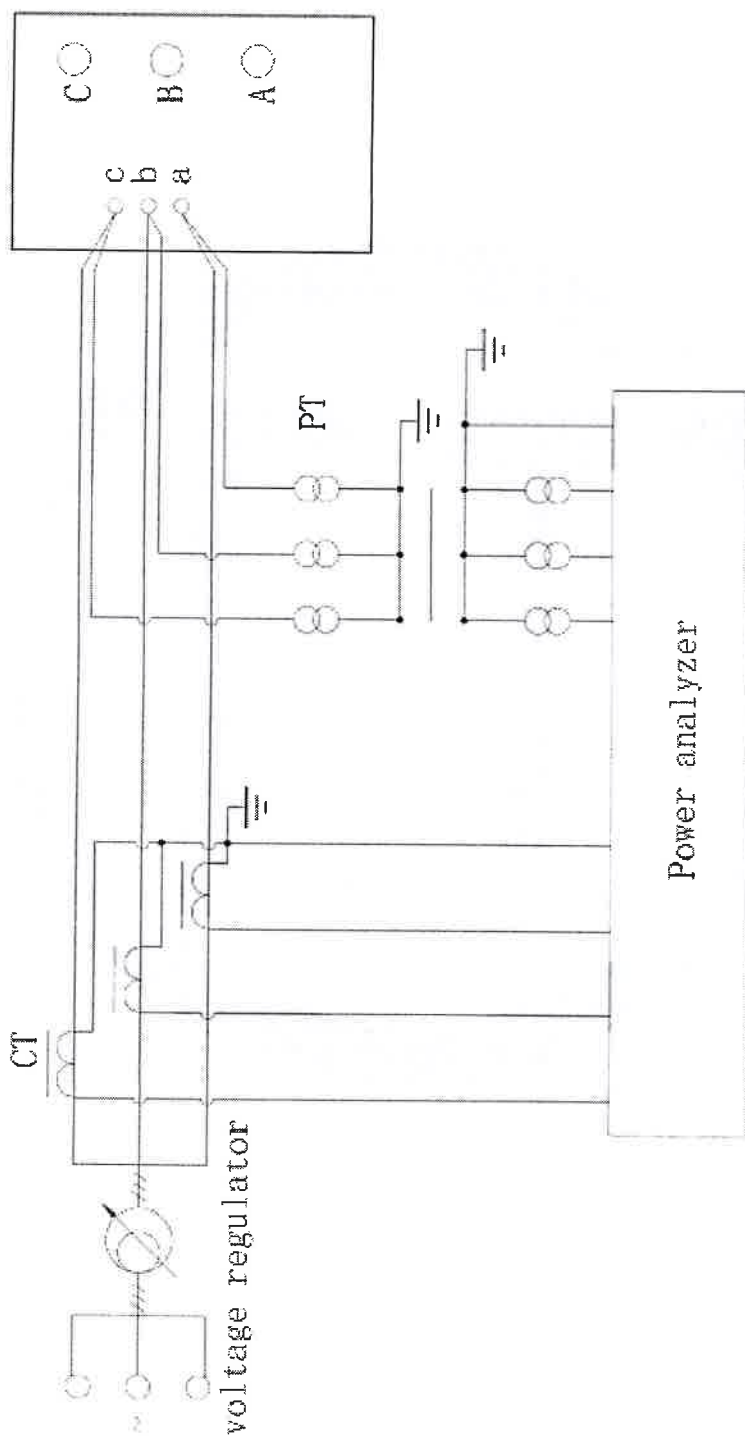
LV side after short-circuit test:



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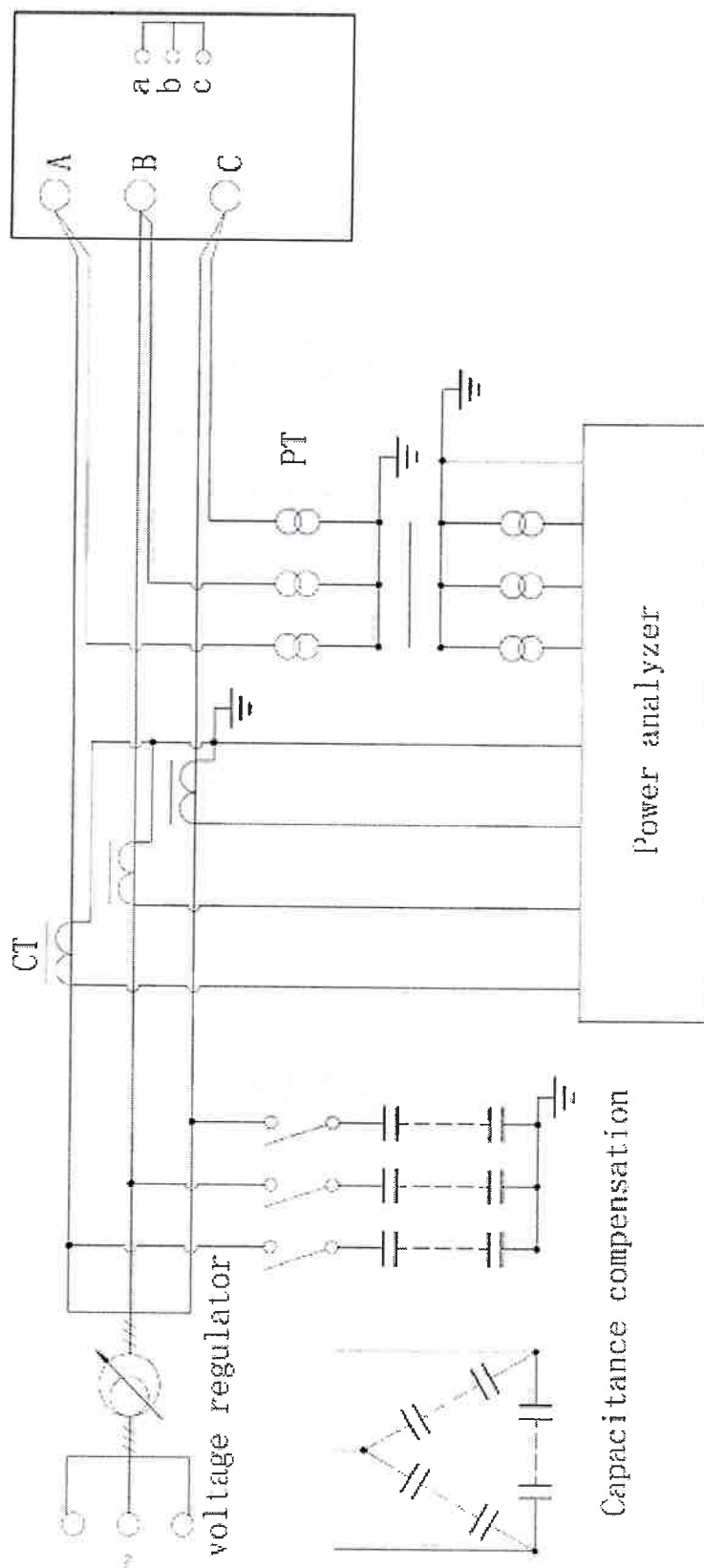
CT-current transformer PT-voltage transformer
Schematic diagram of measurement of no-load loss and current

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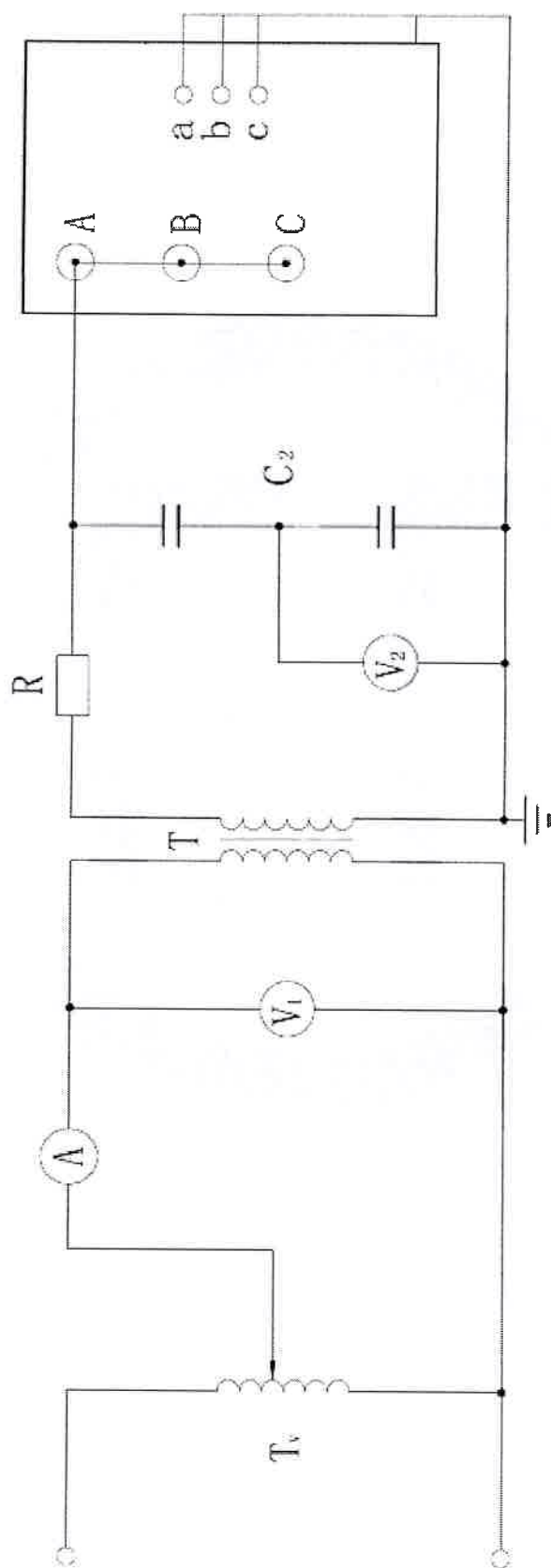
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Schematic diagram of measurement of short-circuit impedance and load loss

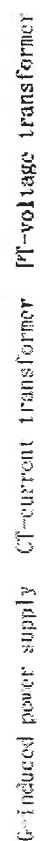
CT-current transformer PT-voltage transformer

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T - power supply T - testing transformer A - ammeter V₁ - voltmeter V₂ - peak value voltmeter
 R - resistance C₂ - capacitive divider

Schematic diagram of applied voltage test



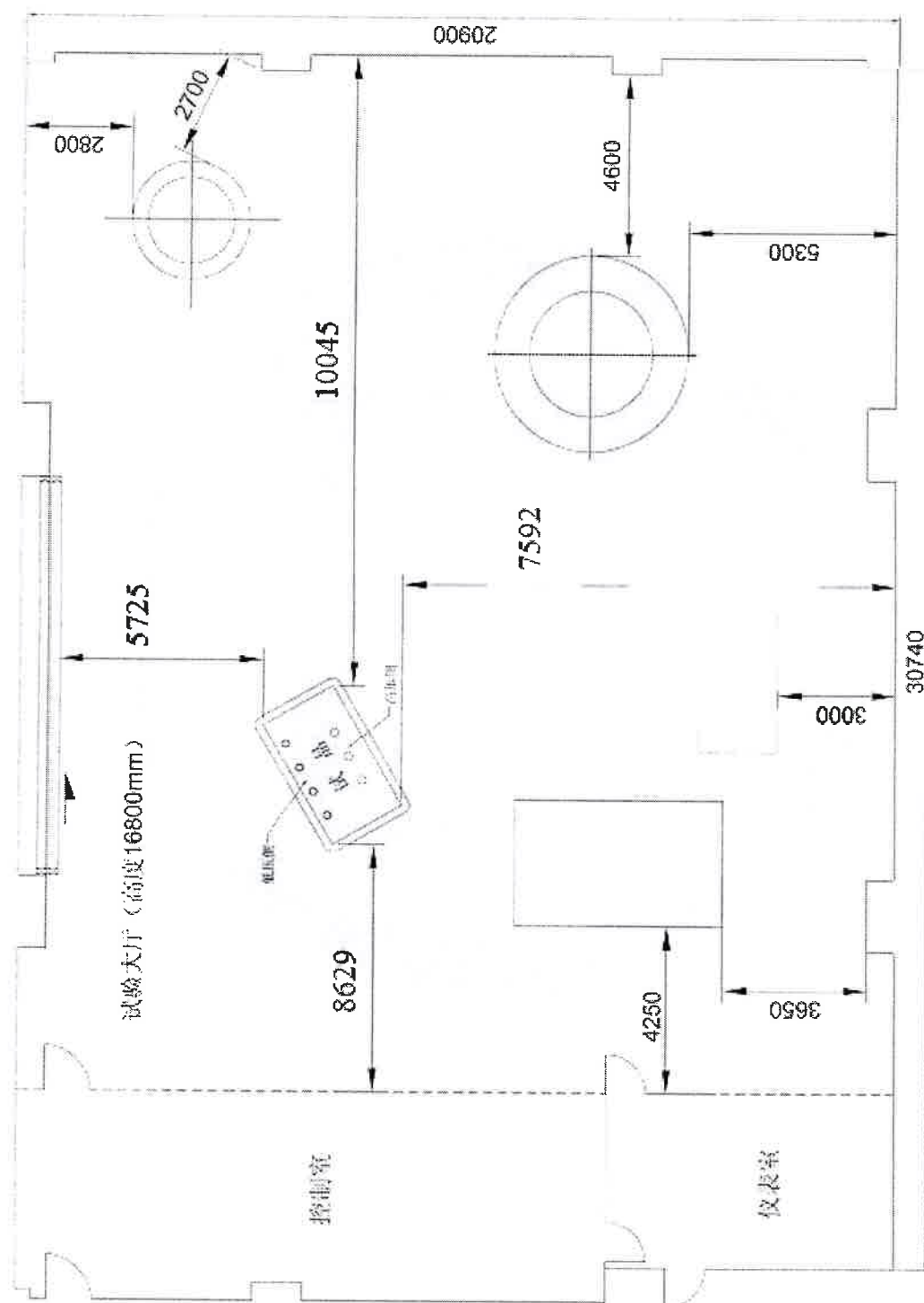
Schematic diagram of induced voltage withstand test

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Sound levels arrangement diagram

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Instruments used in the tests					
No	Test items	Name & type of instrument	Number & validity		Accuracy class
1	Measurement of d.c. insulation resistance between each winding to earth and between windings	Digital mega-ohm meter F1550C	ER17-008 2024-02-14		200k~5/10/20/50/100GΩ class 5, others class 20
2	Measurement of dissipation factor (tanδ) of the insulation system capacitances	Movable insulation diagnostic and analysis system MIDAS2880	ER19-002 2024-02-09		Capacitance: ±0.3%rdg±0.3pF Inductance: ±0.5%rdg±0.5mH
3	Determination of capacitances windings-to-earth and between windings				
4	Measurement of winding resistance	DC resistance tester JYR(50C)	ER16-056 2024-08-14		0.2%±0.2 μ Ω
5	Measurement of voltage ratio and check of phase displacement	Transformer ratio tester JYT(A)	RI15-045 2024-05-25		AC10V:≤150±0.1% 150~500±0.3%; AC160V: <2000±0.1% 2000~10000±0.3%; Automatic DC power supply<1000±0.1% 1000~5000±0.3%
6	Check of the ratio and polarity of built-in current transformers				
7	Insulation test of auxiliary wiring	AC/DC power-frequency withstand voltage tester PFT6-5	745-083 2024-09-22		/
8	Insulation test of auxiliary wiring	Assemblies equipment of power-frequency pollution YDT-1200/300	745-052 2024-08-04		/
9	Induced voltage withstand test	Transformer loss test system TMS580	749-1137 2024-04-26		100V~100kV precision 0.12% 1A~2000A precision 0.15%
10	Measurement of short-circuit impedance and load loss	Transformer loss test system TMS580	749-1137 2024-04-26		100V~100kV precision 0.12% 1A~2000A precision 0.15%
11	Measurement of no-load loss and current				
12	Measurement of no-load loss and current at 90% and 110% of rated voltage				
13	Tests on on-load tap-changers	Transformer loss test system TMS580	749-1137 2024-04-26		100V~100kV precision 0.12% 1A~2000A precision 0.15%
14	Insulating liquid test	Automatic dielectric strength tester NRRNY-1004	ER18-007 2024-10-17		±2%
		High precision full-automatic capacitance, inductance and dielectric loss measuring bridge 2840-Combi	ER18-003 2024-06-19		±0.2%rdg±0.01pF; ±0.5%rdg±1×10 ⁻⁵
		Gas chromatogram analyzer 7890B	749-1732 2024-10-20		/

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Instruments used in the tests					
No	Test items	Name & type of instrument	Number & validity		Accuracy class
15	Leak testing with pressure for liquid-immersed transformers	Pressure gauge Y-100	FP81-428 2024-07-03		Class 1.6
16	Temperature-rise test	Transformer loss test system TMS580	749-1137 2024-04-26		100V~100kV precision 0.12% 1A~2000A precision 0.15%
		Data acquisition/switch unit 34970A	TT11-159 2024-08-08		DC V±0.01%, A±0.11% AC V±5.25%, A±1.5% T±1℃ Ω±0.81%
		Thermocouple type T	TT33-031/032/033/034/035/036 2024-08-08		/
		DC resistance tester JYR(50C)	ER16-025 2024-03-03		0.2%±0.2μΩ
		DC resistance tester JYR(50C)	ER16-056 2024-08-14		0.2%±0.2μΩ
		DC resistance tester JYR(50C)	ER16-101 2024-10-18		0.2%±0.1μΩ
		DC resistance tester JYR(50C)	ER16-102 2024-10-18		0.2%±0.1μΩ
		Electronic stopwatch PC396	HT15-010 2024-02-17		/
17	Determination of sound levels	Transformer loss test system TMS580	749-1137 2024-04-26		100V~100kV precision 0.12% 1A~2000A precision 0.15%
		Sound level calibrator 2270	SP01-013 2024-05-25		Class 1
		Multi-function sound level 4231	SP01-020 2024-05-25		Class 1
		Steel tapeline 5m	LS05-032 2024-03-13		/

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Instruments used in the tests				
No	Test items	Name & type of instrument	Number & validity	Accuracy class
18	Short-circuit withstand test	Data collector 1-GEN16T-2	EI56-019 2024-11-13	Class 1.5
		LCR automatic tester UC2860XD	ER16-091 2024-06-05	±0.05%
		Voltage transformer JDZX8-35R2	EH105-001 2024-02-10	Class 0.5
		Voltage transformer JDZX8-35R2	EH105-002 2024-02-10	Class 0.5
		Voltage transformer JDZX8-35R2	EH105-006 2024-02-10	Class 0.5
		Current transformer AGU-40.5	EH166-001 2024-07-11	0.2TPY
		Current transformer AGU-40.5	EH166-002 2024-07-11	0.2TPY
		Current transformer AGU-40.5	EH166-003 2024-07-11	0.2TPY
19	Lightning impulse test	Assemblies testing equipment of impulse voltage generator CJDY-1050kV/59kJ	750-009 2024-07-04	/
20	measurement of the power taken by the fan motors	Harmonic analyzer CA8335	EP21-003 2024-03-13	/
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1. The report is invalid without special seal for testing and page combining seal on the report;
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The test report is in total 63 pages including 23 figures and 3 photos

Typist Liu Lian

Proofreader Zhou Chao

Binder Liu Lian

Address: No.5 Qianzhu Rd., Yuexi, Wuzhong District, Suzhou

Tel: (0512)66556600(switchboards) 68252753 68081201

Fax: (0512)68081686

Post code: 215104

<http://www.eeti.cn>

E-mail: eservice@eeti.cn

