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检测  
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CNAS L0223

**XIHARI**

No. 237039G-M

# 检 验 报 告

## TEST REPORT

试品型号: S20-800/35-NX2  
TYPE  
试品名称: 电力变压器  
DESIGNATION Power Transformer  
委托单位: 平顶山天晟电气有限公司  
APPLICANT TSTY Electric Co.,Ltd  
制造单位: 平顶山天晟电气有限公司  
MANUFACTURER TSTY Electric Co.,Ltd  
检验类别: 型式试验  
CLASSIFICATION TYPE TEST

西安高压电器研究院股份有限公司

XI'AN HIGH VOLTAGE APPARATUS RESEARCH INSTITUTE CO.,LTD.



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This test report applies only to the test object. The responsibility for conformity of any apparatus having the same designations with that tested rests with the manufacturer.

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1) 型式试验报告: 报告包含了一个或多个型式试验系列, 试验依据公认的标准实施并验证了制造商给出的额定值。Type Test Report: a report contains records of one or more series of type tests carried out strictly in accordance with a recognized standard, and the relevant ratings assigned by the manufacturer are verified;

2) 性能试验报告: 报告包含了一项或多项试验, 试验依照相关的标准实施, 仅验证试品所做试验项目的性能。Performance Test Report: a report contains records of one or more tests carried out according to a related standards, only the performance conducted to the tests are verified.

3) 研究性试验报告: 报告包含了一项或多项试验, 试验依照客户要求或参照相关标准实施。



Researching Test Report: a report contains records of one or more tests carried out based on a recognized standard, or according to the client's instruction.

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In case the verdict standards adopted for the tests are not in the scope of accreditation, the test results provided are only for reference, not having the proven effect on society.

9 检验报告封面到结论页页面右下角无查询二维码无效。The entire report shall be considered invalid if there is no QR code in the bottom-right corner from the cover page to the "Conclusions" page.

10 本报告是对编号 237039G 报告的更改,自本报告签发之日起替代原报告,编号为 237039G 的报告同期作废。

This report is a modification of the report numbered 237039G, instead of the initial report from the date of issuance, the report numbered 237039G is invalid at the same time.

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**试品基本信息**  
**Description of the test object**

型号名称: S20-800/35-NX2&电力变压器  
 Type and Designation: S20-800/35-NX2&Power transformer  
 委托单位: 平顶山天晟电气有限公司  
 Applicant: TSTY Electric Co.,Ltd  
 地址: 河南省郸县城东产业集聚区  
 Address: Industry cluster district,Jiaxian,Pingdingshan City,Henan Province,China  
 电话 Tel: 0375-7215006 传真 Fax: 0375-7215006  
 制造单位: 平顶山天晟电气有限公司  
 Manufacturer: TSTY Electric Co.,Ltd  
 地址: 河南省郸县城东产业集聚区  
 Address: Industry cluster district,Jiaxian,Pingdingshan City,Henan Province,China  
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制造单位规定的试品主要技术数据 Main technical data assigned by the manufacturer:

额定容量 Rated power kVA	800	✓
额定电压 Rated voltage kV	35/0.4	✓
额定电流 Rated current A	13.19/1154.7	✓
额定频率 Rated frequency Hz	50	✓
联结组标号 Vector group	Dyn11	✓
分接范围 Tapping range	± 2×2.5%	✓
相数 Number of phasees	3	✓
冷却方式 Type of cooling	ONAN	✓
绝缘水平 Insulation level	HV LI/LIC/AC 200/220/85kV LV AC 5kV	✓
出厂日期及编号 Manufacture date and serial number	2023-08、2308079	

注 1: 以上信息和数据由委托单位/制造单位提供, 本实验室不对其准确性负责。

Note1: The above information and data are provided by Applicant/Manufacturer and the laboratory is not responsible for its accuracy.

注 2: “✓” 表示该额定值在本检验报告中已得到验证。

Note2: “✓” This rating has been proved by the tests in this report.



## 检验结论 Conclusions

型号名称: S20-800/35-NX2&电力变压器  
 Type and Designation: S20-800/35-NX2&Power transformer  
 委托单位: 平顶山天晟电气有限公司  
 Applicant: TSTY Electric Co.,Ltd  
 地址: 河南省郸县城东产业集聚区  
 Address: Industry cluster district,Jiaxian,Pingdingshan City,Henan Province,China  
 电话 Tel: 0375-7215006 传真 Fax: 0375-7215006  
 制造单位: 平顶山天晟电气有限公司  
 Manufacturer: TSTY Electric Co.,Ltd  
 地址: 河南省郸县城东产业集聚区  
 Address: Industry cluster district,Jiaxian,Pingdingshan City,Henan Province,China  
 电话 Tel: 0375-7215006 传真 Fax: 0375-7215006

依据标准 Standards for Test Performance: IEC 60076-1:2011、IEC 60076-2:2011、IEC 60076-3:2013、IEC 60076-5:2006、IEC 60076-10:2016、GB/T 1094.1—2013、GB/T 1094.2—2013、GB/T 1094.3—2017、GB/T 1094.5—2008、GB/T 6451—2015、JB/T 10088—2016、JB /T 3837—2016

实施的项目 Test have been performed:

序号 NO.	项目 Items	规定值 Specified values	测量值 Measured values		判定标准 Standards for Verdict	项目 结论 Result
		标准 (委托要求) Standards(Technical contract)	短路前 Before S.C.T	短路后 After S.C.T		
1	绝缘油试验 Insulation oil test	击穿电压 Breakdown voltage: $\geq 40kV$ 介损 (90℃) $\tan \delta$ at 90℃: $\leq 1\%$	66.0kV  0.139%	64.5kV  0.151%	GB/T 7595—2017	符合 Satisfied
2	绕组对地及绕组间直流绝缘电阻测量 Measurement of d.c. insulation resistance between winding to earth	HV/LV+E: $\geq 1000M\Omega$ LV/HV+E: $\geq 500M\Omega$ HV+LV/E: $\geq 500M\Omega$	t=32.8℃ HV/LV+E: 48.5GΩ LV/HV+E: 28.6GΩ HV+LV/E: 26.2GΩ	t=28.9℃ HV/LV+E: 50.3GΩ LV/HV+E: 34.2GΩ HV+LV/E: 27.1GΩ	JB/T 501—2021 3.9	符合 Satisfied
3	绕组电阻测量 Measurement of winding resistance	最大电阻不平衡率 Max unbalance ratio among the three phase's resistance: 线 Line $\leq 2\%$ 相 Phase $\leq 4\%$	高压 HV: 0.17% 低压 LV (线 Line): 0.80% (相 Phase): 1.16%	高压 HV: 0.17% 低压 LV (线 Line): 0.78% (相 Phase): 1.22%	GB/T 1094.1—2013 11.2	符合 Satisfied



4	电压比测量和联结组标号检定 Measurement of voltage ratio and check of phase displacement	电压比允差不超过±0.5% Voltage ratio tolerances is No more than ±0.5% 连接组标号: Dyn11 Connection symbol	-0.01%~+0.10% Dyn11	-0.01%~+0.09% Dyn11	IEC 60076-1:2011 11.3 GB/T 1094.1—2013 11.3	符合 Satisfied
5	空载损耗和空载电流测量 Measurement of no-load loss and current	$I_0$ : (0.65%) +30% $P_0$ : ≤0.784kW	0.151% 0.724kW	0.151% 0.726kW	GB/T 6451—2015 JB/T 3837—2016 1TS.710.TH.8 00.1.	符合 Satisfied
6	在90%和110%额定电压下的空载损耗和空载电流测量 Measurement of no-load loss and current at 90% and 110% of rated voltage	$I_0$ : 提供实测值 Give measured value $P_0$ : 提供实测值 Give measured value	90%Ur 0.584kW 0.141%	110%Ur 0.884kW 0.158%	/	/
7	短路阻抗和负载损耗测量 Measurement of short-circuit impedance and load loss	$Z_{k75^\circ C}$ : (6.5%)±10% $P_{k75^\circ C}$ : ≤9.40kW $P_{总}$ : ≤10.184kW	6.35% 6.627kW 7.351kW	6.37% 6.629kW 7.355kW	GB/T 6451—2015 JB/T 3837—2016 1TS.710.TH.8 00.1.	符合 Satisfied
8	感应耐压试验 (IVW) Induced voltage withstand test	施加电压 supply voltage $2U_r$ 200Hz 30s	低压侧 LV 800V 200Hz 30s	低压侧 LV 800V 200Hz 30s	IEC 60076-3:2013 11 GB/T 1094.3—2017 11	符合 Satisfied
9	外施耐压试验 (AV) Applied voltage test	高压绕组HV winding: 85kV 1min 低压绕组LV winding: 5kV 1min	85.0kV 1min 5.0kV 1min	85.0kV 1min 5.0kV 1min	IEC 60076-3:2013 10 GB/T 1094.3—2017 10	符合 Satisfied






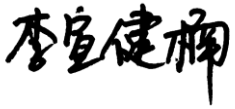

10	压力密封试验 Pressure integrity test	20kPa 12h 无渗漏油和损伤 No leakage and damage	20kPa 12h 无渗漏油和损伤 No leakage and damage	GB/T 6451—2015 4.3.4 ITS.710.TH.80 0.1.	符合 Satisfied
11	声级测定 Determination of sound levels	声功率级 Sound power $L_{WAUN} \leq 60(\text{dB})A$	声压级 Sound pressure level $\overline{L}_{PA}$ : 28.8(dB)A 声功率级 Sound power $L_{WAUN}$ : 43.4(dB)A	IEC 60076-10:2016 JB/T 10088— 2016	符合 Satisfied
12	温升试验 Temperature-rise test	顶层油温升 Top oil temperature rise: $\leq 60$ (K) 绕组平均温升 Average temperature-rise of windings: $\leq 65$ (K) 绕组热点温升 Hot spots temperature-rise of windings: $\leq 78$ (K) 油箱及结构件表面热点温升 Hot-spot temp. rise of oil tank and structure component: $\leq 75$ (K)	顶层油温升 Top oil temperature rise: 37.4K 绕组平均温升 Average temperature-rise of windings 高压 HV: 45.5K 低压 LV: 42.0K 绕组热点温升 Hot spots temperature-rise of windings: 高压 HV: 60.6K 低压 LV: 56.8K 油箱及结构件表面热点温升 Hot-spot temp. rise of oil tank and structure component: 41.5K	IEC 60076-2:2011 GB/T 1094.2—2013	符合 Satisfied
13	短时过负载能力试验 Short time overload capacity test	压力保护装置不动作 The pressure protection device does not operate  无渗漏现象 No leakage  油箱波纹及片式散热器的变形量在规定范围内。The deformation of the oil tank ripple and the chip radiator is within the specified range.  油箱外壳及套管的温升 The temperature rise of the tank shell and tube $\leq 85K$	不动作 Not operate  无渗漏现象 No leakage  油箱波纹及片式散热器的变形量见试验数据页 The deformation of the oil tank ripple and the chip radiator, see test data page  油箱外壳温升 The temperature rise of the tank shell: 49.3K 套管温升 The temperature rise of the tube: 70.8K	JB/T 501—2021 3.27 ITS.710.TH.80 0.1.	符合 Satisfied



14	短路承受能力试验 Short circuit withstand test	3次/相 (Three times each phase) 持续时间 Duration: 0.50s ± 10% 试验波形无异常 Test waveshapes have no distortion. 试验前后测量相电抗差 Deviation of reactance before and after S.C.T. ≤ 7.5% 外观检查无明显变化 Appearance inspection shows no apparent defects. 短路后复试例行及雷电冲击试验合格 Successfully check items after S.C.T.	3次/相(Three times for each phase)  0.506~0.528s 无异常 No distortion.  最大相电抗差 Difference reactance values 2.50%  无明显变化 No apparent defects.  复试例行试验及雷电冲击试验合格 Successfully check items and lightning impulse test after S.C.T.	IEC 60076-5:2006  GB/T 1094.5—2008	符合 Satisfied
15	雷电冲击试验 Lightning impulse test	全波 Full lightning impulse: -200kV 截波 Chopped impulse: -220kV	全波 Full lightning impulse: -198.20kV~-201.90kV 截波 Chopped impulse: -216.22kV~-221.30kV	IEC 6007-3:2013 13 GB/T 1094.3—2017 13	符合 Satisfied

注 Note:

- 判定依据"ITS.710.TH.800.1. &S20-800/35-0.4 变压器技术条件"不在实验室授权/认可范围。  
 Verdict standard "ITS.710.TH.800.1. &S20-800/35-0.4 transformer technical conditions " was not authorized / accredited to XIHARI.
- 序号 14 的试验在分包实验室海检检测有限公司实施, 为有能力分包。(CNAS L10793 CMA 180008344069;地址: 山东省青岛市即墨区鳌山卫街道齐云山一路 118 号); No.20 test is performed in subcontracted laboratory: Marine Equipment Inspection & Testing Co., Ltd., within the authorized testing scope of XIHARI.( CNAS L10793 CMA 180008344069; Address: No. 118, Qiyunshan Yilu, Aoshanwei Street, Jimo, Qingdao, Shandong, China);

编写 Edited:  校核 Checked:  批准 Approved:   
 日期 Date: 2023-09-27 日期 Date: 2023-09-27 日期 Date: 2023-09-27



## 试品确认

### Identification of the test object

1、试品总体描述 General description of test object:

S20-800/35 油浸式电力变压器 Oil-immersed power transformer

2、制造单位保证试品符合的技术文件 The test object is guaranteed by the manufacturer to comply with the following technical documents:

1TS.710.TH.800.1. &S20-800/35-0.4 变压器技术条件

1TS.710.TH.800.1. &S20-800/35-0.4 transformer technical conditions

3、制造单位提供并由实验室确认的图纸 Drawings submitted by the manufacturer and identified by the laboratory:

1)、以下图纸编入本报告 The following drawings were attached in the report:

1TS.710.TH.800.1. &S20-800/35-0.4 变压器外形图

1TS.710.TH.800.1. &S20-800/35-0.4 transformer outline drawing

本实验室已确认制造单位提供的资料和图纸充分代表了试品的部件和零件，但不对这些资料和图纸细节的准确性负责。The laboratory is responsible for checking that the drawings and data schedules submitted adequately represent essential details of the equipment tested, but is not responsible for the accuracy of detailed drawings.

4、试品来源 Source of test object: 委托方送样 Provided by the applicant

5、样品确认日期 Date of identification of the test object: 2023-08-15

6、委托方代表 Tests witnessed by:

张亚宁 平顶山天晟电气有限公司

Zhang Yaning TSTY Electric Co.,Ltd

7、检验日期 Date of tests: 起 from 2023-08-17 止 to 2023-09-08

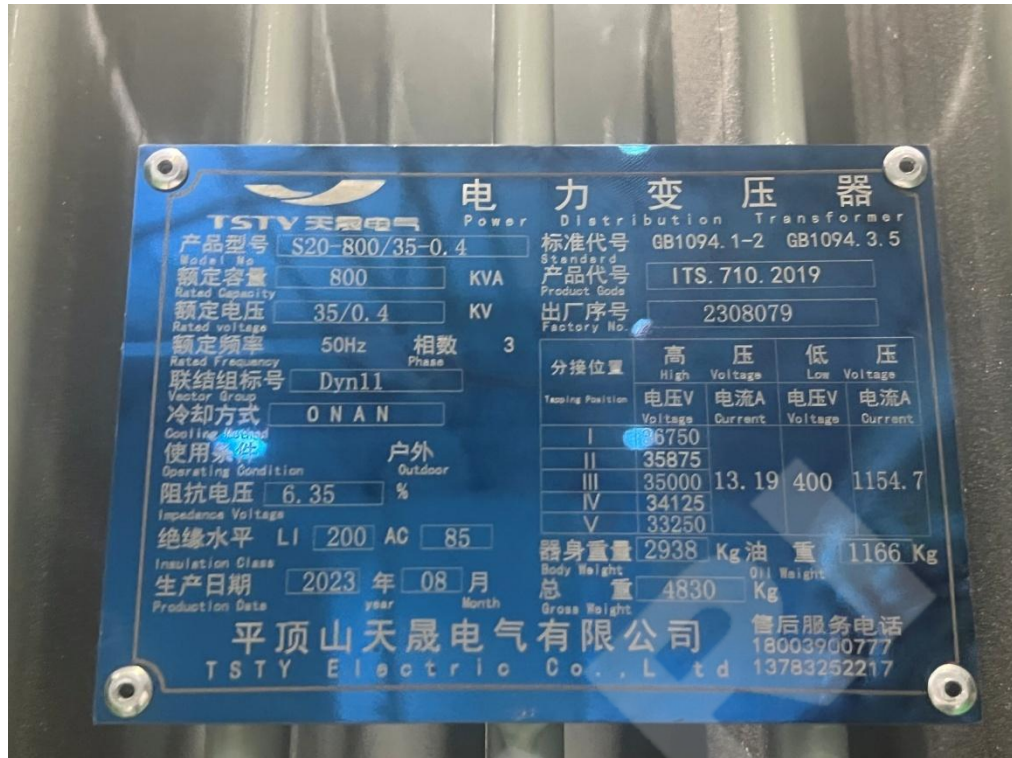
试品照片 Photographs:



TOZP237039G-M-01



TOZP237039G-M-02



TOZP237039G-M-03

## 报告中使用的符号和缩写

### Symbols and abbreviation used in test report

符号和缩写 Symbols and abbreviation	说明 Description
LI	雷电冲击 Lightning impulse
SI	操作冲击 Switching impulse
LIC	雷电冲击截波 Chopped lightning impulse
IG	冲击电压发生器 Impulse voltage generator
DCG	直流电压发生器 Direct current voltage generator
HV	高压 High voltage
LV	低压 Low voltage
PF	工频 Power-frequency
P-to-P & P-to-E	相间及对地 Phase to phase and phase to earth
SN	编号 Serial number
No.A	施加次数 Application number
T-OSC	典型示波图 Typical oscillogram
kV <sub>p</sub>	电压峰值 Voltage peak value
r.m.s.	有效值 Root mean square
U <sub>c</sub>	应施电压值 Expected voltage value
U <sub>t</sub>	实测电压值 Measured voltage
K <sub>ll</sub>	相间、相对地修正系数 Correction factor for P-to-P and/or P-to-E
K <sub>a</sub>	海拔修正系数 Altitude correction factor
U <sub>e</sub>	额定耐受电压值 Rated withstand voltage
U <sub>p</sub>	相电压 Phase voltage
R1	冷态线圈电阻 Resistance of winding at steady-state condition
R2	热态线圈电阻 Resistance of winding at instant shutdown
θ <sub>l</sub>	线圈冷态时环境温度 Ambient temperature of winding at steady-state condition
θ <sub>α</sub>	线圈热态时环境温度 Ambient temperature of winding at instant shutdown
Tr.	温升限值 Limit value of temperature rise

## 测量不确定度 Uncertainty of measurement

序号 Serial	测量系统 Measuring system	扩展不确定度 Expanded uncertainty
1	电压测量系统 Voltage measurement system	$U < 2\%$ ( $k=2$ )
2	大气压力 Atmospheric pressure testo622 环境记录仪 Environmental recorder	$U < 0.2\text{kPa}$ ( $k=2$ )
3	冲击电压波形时间测量系统 Impulse voltage waveform time measurement system	$U < 5\%$ ( $k=2$ )
4	温度 Temperature testo622 环境记录仪 Environmental recorder	$U < 1.0^\circ\text{C}$ ( $k=2$ )
5	绝对湿度 Absolute humidity testo622 环境记录仪 Environmental recorder	$U < 1\text{g/m}^3$ ( $k=2$ )
6	温升试验系统 Temperature rise test system	$< 2.0\text{K}$ ( $k=2$ )

## 试验总则

### General of test

- 1.试品样机编号 Serial No. of test object: 2308079;
- 2.试验依据标准 Applied standards: IEC 60076-1:2011、IEC 60076-2:2011、IEC 60076-3:2013、IEC 60076-5:2006、IEC 60076-10:2016、GB/T 1094.1—2013、GB/T 1094.2—2013、GB/T 1094.3—2017、GB/T 1094.5—2008、GB/T 6451—2015、JB /T 10088—2016、JB /T 3837—2016

3.试品是一个新的、干净的油浸式配电变压器。

Test object is a new, clean, oil -immersed distribution transformer.

4.A、B、C 为高压绕组端子，a、b、c 为低压绕组端子，o 为低压绕组中性点端子，F 为接地。

A、B、C are high voltage winding terminals, a、b、c are low voltage winding terminals ,o is low voltage winding neutral point terminal, F is ground.



## 绝缘油试验

### Insulation oil test

试验日期 Test date: 2023-08-17

试区大气条件 Atmospheric conditions: P=96.22kPa t=25.1℃ RH=50.0%

	测量值 Measured value	规定值 Specified value
击穿耐压 Breakdown voltage (kV/2.5mm)	66.0	≥ 40.0
介损 (90℃) Tanδ at 90℃ (%)	0.139	≤ 1.0

试验结果 Result: 通过 Passed.

## 绕组对地及绕组间直流绝缘电阻测量

### Measurement of d.c. insulation resistance between winding to earth

试验日期 Test date: 2023-08-17

试验数据 Test data:

油温 Oil temperature: 32.8℃; 相对湿度 Relative humidity: 59.3%;

试验电压 Test voltage: DC2500V

测量项目 Measured content	$R_{15}(G\Omega)$	$R_{60}(G\Omega)$	$R_{60}/R_{15}$
高压对低压及地 HV windings to LV and earth	38.2	48.5	1.27
低压对高压及地 LV windings to HV and earth	13.4	28.6	2.14
高压及低压对地 HV and LV windings to earth	17.2	26.2	1.52

试验结果 Result: 通过 Passed.

## 绕组电阻测量 Measurement of winding resistance

试验日期 Test date: 2023-08-17

试验数据 Test data:

油温 Oil temperature: 32.8℃;

测量绕组 Winding measured	分接位置 Tap position	测量电阻值 Resistance Measured value			最大不平衡率(%) Max unbalance ratio among the resistance	不平衡率 允许值(%) Allowed unbalance ratio
		$R_{AB}$	$R_{BC}$	$R_{CA}$		
高压 HV( $\Omega$ )	1	10.068	10.081	10.085	0.17	$\leq 2$
	2	9.803	9.815	9.819		
	3	9.529	9.541	9.545		
	4	9.264	9.276	9.275		
	5	8.993	9.005	9.003		
低压 LV (m $\Omega$ )	/	$R_{ab}$	$R_{bc}$	$R_{ca}$	0.80	$\leq 2$
		1.3823	1.3733	1.3844		
		$R_{ao}$	$R_{bo}$	$R_{co}$	1.16	$\leq 4$
		0.7301	0.7359	0.7386		

试验结果 Result: 通过 Passed.

**电压比测量和联结组标号检定**  
**Measurement of voltage ratio and check of phase displacement**

试验日期 Test date: 2023-08-17

试验数据 Test data:

测量绕组 Winding measured	分接位置 Tap position	实测电压比偏差(%) Measured ratio error			联结组标号 Connection symbol
		AB/ab	BC/bc	CA/ca	
高压对低压 HV/LV	1	+0.02	+0.08	+0.07	Dyn11
	2	+0.03	+0.09	+0.09	
	3	+0.01	+0.07	+0.07	
	4	-0.01	+0.08	+0.04	
	5	+0.00	+0.10	+0.06	

试验结果 Result: 通过 Passed。

**空载损耗和空载电流测量**  
**Measurement of no-load loss and current**

试验日期 Test date: 2023-08-17

试验布置 Test arrangement:

变压器以额定频率在低压侧三相励磁，高压绕组开路。

The three-phase AC voltage at the rated frequency shall be applied to the LV winding of transformer, the high windings shall be open.

试验数据 Test data:

励磁相电压(V) Excited phase voltage		励磁电流 (A) Exciting current	功率 (kW) Loss	空载损耗 (kW) No-load Loss	空载电流 No-load Current (%)	
平均值 Average value	有效值 r.m.s					
U/Ur	U'	U	I <sub>LV</sub>	P <sub>m</sub>	$P = P_m (1+d);$ $d = (U' - U)/U'$	I/I <sub>rated LV</sub>
1.0	230.9	231.3	1.738	0.725	0.724	0.151

试验结果 Test result: 通过 Passed.

## 在 90% 及 110% 额定电压下空载损耗和空载电流测量

### Measurement of no-load loss and current at 90% and 110% of rated voltage

试验日期 Test date: 2023-08-17

试验布置 Test arrangement:

变压器以额定频率在低压侧三相励磁，其它绕组开路。

The three-phase AC voltage at the rated frequency shall be applied to the LV winding of transformer, the high windings shall be open.

试验数据 Test data:

励磁相电压(V) Excited phase voltage		励磁电流 (A) Exciting current	功率 (kW) Loss	空载损耗 (kW) No-load Loss	No-load Current 空载电流 (%)
平均值 Average value	有效值 r.m.s				
U/U <sub>r</sub>	U'	U	I <sub>LV</sub>	P <sub>m</sub>	$P = P_m(1+d)$ $d = (U' - U)/U'$ I/I <sub>rated LV</sub>
0.9	207.8	208.2	1.626	0.585	0.584 0.141
1.1	254.0	254.4	1.822	0.885	0.884 0.158

试验结果 Test result: /

## 短路阻抗和负载损耗测量

### Measurement of short-circuit impedance and load loss

试验日期 Test date: 2023-08-17

试验布置 Test arrangement:

高压侧送电，低压侧短接。

The transformer's h.v. side is energized with rated frequency, l.v. side are short-circuit.

试验数据 Test data:

油温 Oil temperature: 32.5°C;

分接位置 Tap position	施加电流 Supply current (A)	测量电压 Measured voltage(V)	测量损耗 Measured loss(kW)	负载损耗 $P_{k75^{\circ}\text{C}}$ Load loss(kW)	短路阻抗 $Z_{k75^{\circ}\text{C}}$ Short-circuit impedance		总损耗 $P_{\text{总}}$ (kW)
					(%)	(Ω/相)	
1	8.650	1630	2.748	6.528	6.46	109.1	—
3	10.41	1749	3.662	6.627	6.35	97.23	7.351
5	10.19	1505	3.219	6.749	6.19	85.54	—

试验结果 Test result: 通过 Passed.

**感应耐压试验(IVW)**  
**Induced voltage withstand test**

试验日期: 2023-08-17

试验数据 Test data:

大气条件 Atmospheric conditions: P=96.67kPa t=31.3℃ RH: 59.3 %

分接位置 Tap position	加压部位 Supply winding	试验电压 2Ur Test voltage		持续时间 Duration (s)	频率 Frequency (Hz)
		低压 LV (kV)	高压 HV (kV)		
3	低压端 LV	0.800	70.0	30	200

试验结果 Result: 通过 Passed.



**外施耐压试验(AV)**  
**Applied voltage test**

试验日期: 2023-08-17

试验数据 Test data:

大气条件 Atmospheric conditions: P=96.67kPa t=31.3℃ RH: 59.3 %

试验部位 Test position	加压部位 Applied voltage position	接地部位 Earthed terminal	应施电压 U <sub>c</sub> (kV)	实测电压 U <sub>t</sub> (kV)	持续时间 Duration (s)
高压绕组 HV	ABC	abcoF	85.0	85.0	60
低压绕组 LV	abco	ABCF	5.0	5.0	60

试验结果 Result: 通过 Passed.

## 声级测定 Determination of sound levels

试验日期 Test date: 2023-08-17

大气条件 Atmospheric conditions: P=96.67kPa t=31.3℃ RH=59.3%

试验采用声压法 Test used sound pressure measurement methods.

负载电流声功率级估算:  $L_{WA.IN} \approx 39 + 18 \lg \frac{S_r}{S_p} = 37.3 \text{dB(A)}$ ,  $L_{WA.IN}$  比声功率级的标准要求值低

22.7dB(A), 则只需要进行空载声功率级测量, 不需进行负载电流声功率级测量。

the load current sound power level estimation:  $L_{WA.IN} \approx 39 + 18 \lg \frac{S_r}{S_p} = 37.3 \text{dB(A)}$ , The  $L_{WA.IN}$  is 22.7 dB

below the sound power level estimated at no-load excitation, the contribution of load current will be negligible and therefore need not be tested.

空载状态下的声级测定 Measurement of sound level under no-load condition:

试验时低压绕组励磁电压: 0.4 kV, 电源频率: 50Hz, 分接位置: 3, 轮廓线周长  $l_m$ : 11.68m, 试品高度 h: 1.46m, 轮廓线距基准发射面: 1m。

During test, the field voltage of the Low-voltage winding: 0.4kV, power source frequency: 50Hz, tapping position: 3, the length of the prescribed contour: 11.68m, the hight of the test object: 1.46m, the length between the prescribed contour and the principal radiating surface: 1m.

测点分布见声级试验测点示意图。试验环境条件如表 1 所示:

Distribution of measuring points shows in schematic graph of measuring points for sound measurement test. Test condition see Table 1 as follows:

表 table 1 试验环境条件 Measured environmental condetion

平均吸声系数 $\alpha$ Mean sound absorption coefficient	试验室总表面积 $S_v$ Area of the test room (m <sup>2</sup> )	吸声量 A Sound absorption(m <sup>2</sup> )	测量表面面积 S Area of effective surface(m <sup>2</sup> )	环境修正值 K Environmental correction factor(dB)
0.5	278.2	139.1	28.73	2.62

测量及计算结果如表 2 所示 Test result of measured and calculated value are shown in the table 2:

表 table 2 测量及计算结果 Test result of measured and calculated

测量位置 Measuring position	背景噪声 Background noise [dB(A)]		变压器噪声值 $\bar{L}_{PAO}$ Noise measurement of the test object [dB(A)]
	试验前 Before test	试验后 After test	
1	20.9	20.9	29.8
2	20.6	21.5	30.7
3	21	20.2	29.2
4	21.1	19.7	29.2
5	21	20.1	31.9
6	20.9	21.7	34.8

测量位置 Measuring position	背景噪声 Background noise [dB(A)]		变压器噪声值 $\overline{L}_{PA0}$ Noise measurement of the test object [dB(A)]
	试验前 Before test	试验后 After test	
7	20.8	21.3	33.3
8	21.1	20.3	32.9
9	20.4	21.3	33.8
10	20.8	20.9	33.2
11	21.1	20.5	32.2
12	20.9	21.8	32.9
噪声平均值 Average value of noise[dB(A)]	20.9	20.8	31.8
A 计权声压级 $\overline{L}_{PA}$ The total spatially averaged A-weighted sound pressure level [dB(A)]	28.8		
A 计权声功率级 $L_{WA}$ The total A-weighted sound power level [dB(A)]	43.4		
声功率级规定值 The required sound power level [dB(A)]	60		

试验结果 Result: 通过 Passed.

## 温升试验 Temperature rise test

试验日期 Test date: 2023-08-18

1. 试验布置 Test arrangement:

1.1. 试验方法 Test method: 短路法 Short-circuit method。高压侧送电，低压侧短接； Apply the voltage at the High-voltage side, and the Low-voltage side is short-circuited;

1.2. 分接位置 Tap position: 3;

1.3. 应施加总损耗: 7.351kW，实际施加总损耗: 7.351kW，直到油温升达到稳定，试验持续时间为 10h。测定顶层油温升和油平均温升；

Apply the test current for producing the total loss (Actual value: 7.351kW, required value: 7.351kW), until steady-state oil temperature rises are established, and the test lasts 10h in total. Measure the top oil temperature rise and the average oil temperature rise;

1.4. 降至额定电流 13.19A，实际施加电流: 13.19A。施加电流 1 小时后，迅速切断电源和打开短路接线，测量高压绕组、低压绕组的电阻。

Reduce the test current to the rated current (Actual value: 13.19A, required value: 13.19A). After maintaining the current for 1h, switch off the power supply and open the short-circuit connector rapidly, measure the resistances of the HV and LV windings.

2. 试验数据 Test data:

— —	顶层油温度 Top oil temperature(°C)	底部油温度 Bottom oil temperature(°C)	环境温度 Ambient air temperature(°C)
总损耗下最后 1 小时平均值 The average value of the last 1h in the total loss injection(°C)	69.0	43.2	31.7
总损耗下结束时 At the end of the total loss injection(°C)	68.8	44.2	31.7
电源断开时 At the instant of power-off(°C)	68.8	44.2	31.7
电阻测量结束时 At the end of resistance measurement(°C)	67.6	43.9	31.7
电源断开瞬间的高压绕组平均温度 The average temperature of HV windings at the instant of power-off(°C)	77.52		
电源断开瞬间的低压绕组平均温度 The average temperature of LV windings at the instant of power-off (°C)	74.00		

电源切断后绕组电阻随时间的变化情况:

The change of the winding resistances with time after switching off the power supply:

冷态电阻 Cold resistance	绕组温度 Temperature of windings (°C)	高压绕组电阻 Resistance of HV winding $R_{BC}(\Omega)$	低压绕组电阻 Resistance of LV winding $R_{bc}(m\Omega)$
		32.8	9.541

热态 电阻 Hot resistance	时间 Time	1'	2'	3'	4'	5'	6'	7'	8'	9'	10'
	$R_{BC}(\Omega)$	11.109	11.084	11.061	11.040	11.019	10.999	10.981	10.964	10.947	10.931
	$R_{bc}(m\Omega)$	1.578	1.572	1.567	1.562	1.558	1.554	1.551	1.548	1.545	1.542
	时间 Time	11'	12'	13'	14'	15'	16'	17'	18'	19'	20'
	$R_{BC}(\Omega)$	10.915	10.900	10.886	10.872	10.859	10.846	10.834	10.822	10.811	10.801
	$R_{bc}(m\Omega)$	1.540	1.538	1.536	1.534	1.532	1.531	1.529	1.528	1.527	1.525

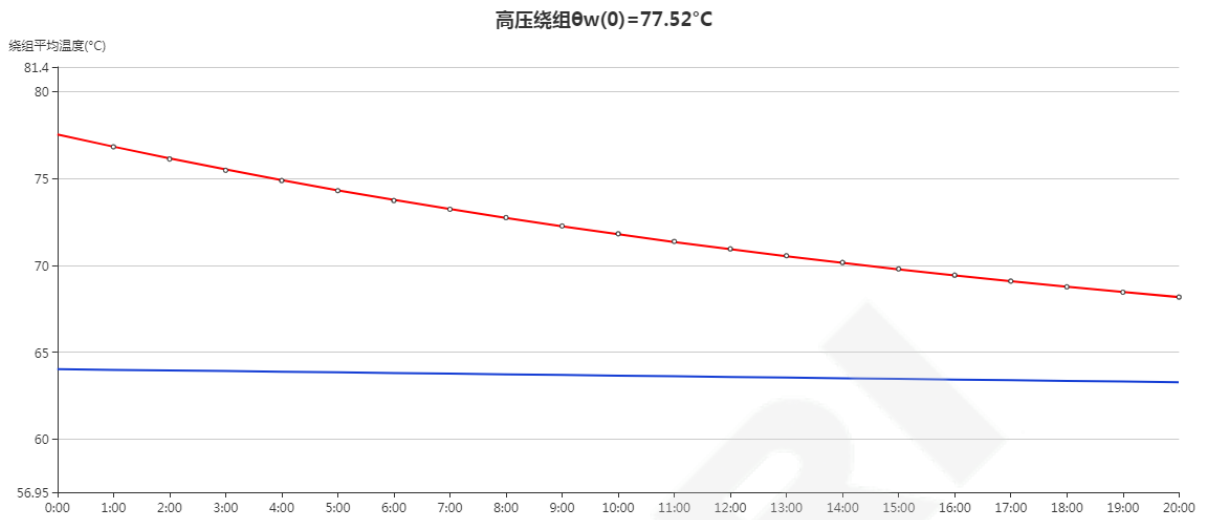
### 3. 温升计算结果 Temperature rise calculation results:

顶层油温升 Temperature-rise of top oil(K)	37.4
油平均温升(K) Average temperature rise of oil(K)	24.4
高压绕组平均温升 Average temperature-rise of HV winding(K)	45.5
低压绕组平均温升 Average temperature-rise of LV winding (K)	42.0
高压绕组热点温升 Hot-spot winding temp. rise of HV winding(K)	60.6
低压绕组热点温升 Hot-spot winding temp. rise of LV winding (K)	56.8
油箱及结构件表面热点温升 Hot-spot temp. rise of oil tank and structure component(K)	41.5

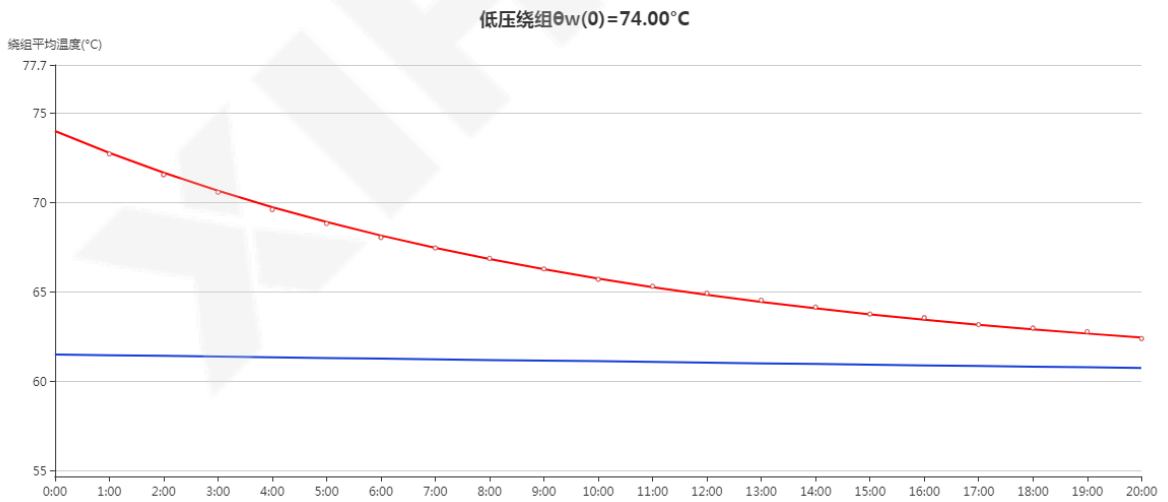
试验结果 Test result: 通过 passed.

注 Note: 企业提供热点系数 The hotspot coefficient provided by enterprise: 1.1.

4. 绕组温度曲线 Temperature curves of the windings:



高压绕组温度曲线 Temperature curve of the HV windings



低压绕组温度曲线 Temperature curve of the LV windings

5. 油箱及结构件表面温升热成像图 Infrared thermal imaging of oil tank and structure component:



## 短时过负载能力试验 Short time overload capacity test

试验日期 Test date: 2023-08-18

1. 试验布置 Test arrangement:

在温升试验后进行, 试验时施加 1.5 倍额定电流 19.8A, 试验时间 2h。

After the temperature rise test, 1.5 times the rated current 19.8A is applied during the test, 2h.

2. 试验数据 Test data:

压力保护装置不动作 The pressure protection device does not operate	是 yes
无渗漏现象 No leakage	是 yes
油箱波纹及片式散热器的变形量在规定范围内 The deformation of the oil tank ripple and the chip radiator is within the specified range.	见表 1 See Table1
油箱外壳及套管的温升不大于 85K The temperature rise of the tank shell and tube is not greater than 85K.	见表 2 See Table2

表 1 变形量的测量

Table1 Measurement of deformation

测量项目 Test program	测量点 Measured point			
	散热器 Radiator			
	高压侧 HV	低压侧 LV	左侧面 left side	右侧面 right side
变形量 Deformation (mm)	0.32	0.28	0.25	0.26

注 Note:

1. 该产品为波纹式油箱。The product is a corrugated oil tank.

2. 测试点中描述的左侧面和右侧面是从高压侧看的。The left and right sides described in the test point are viewed from the high pressure side.

3. 高压侧和低压侧的左、右测试点在高度方向取散热片 1/2 高度, 水平方向位置分别取中间位置。The left and right test points on the HV and LV are 1/2 height of the heat sink in the height direction, and the middle position in the horizontal direction is taken respectively.

表 2 油箱外壳及套管的温升测量

Table2 Temperature rise measurement of tank and tube

部位 Part	油箱外壳 (K) tank casing									套管 (K) Bushing					
	油箱顶 Tank cap			油箱壁 Tank sidewall											
	A-a	B-b	C-c	A	B	C	a	b	c	A	B	C	a	b	c
实测值 Measured value	44.2	46.5	45.2	44.7	47.7	46.6	49.1	49.3	48.5	33.8	34.6	34.1	67.5	70.8	66.3

试验结果 Test result: 通过 Passed.



## 压力密封试验

### Pressure integrity test

试验日期 Test date: 2023-08-19

试验数据 Test data:

试验方法 Test method	施加压力 supply (kPa)	持续时间 Duration (h)
加入干燥压缩空气 Add dry compressed air	20	12

无泄漏, 无损伤 No leakage, no damage

试验结果 Test result: 通过 Passed.

## 短路承受能力试验

### Short circuit withstand test

试验日期 Test date: 2023-09-01

试验前状态 Condition before test:

未检修。No maintenance;

试验回路 A、B、C 相与试品高压侧绕组 A、B、C 相对应，试品变压器低压侧绕组 a、b、c 三相短接。Phase A,B,C of test circuit corresponding to phase A,B,C of test object's high-voltage winding terminals, three-phase-short-circuit on low-voltage winding terminals.

试验按照 3 分接, 1 分接, 5 分接顺序进行试验。Test performed as in sequence of 3 tapping, 1 tapping, 5 tapping.

示波图号 Oscillogram number:

230431-001 ~ 230431-009;

试验前照片 Photos before test:



ZP237039G-M-01



ZP237039G-M-02



ZP237039G-M-03



ZP237039G-M-04



ZP237039G-M-05

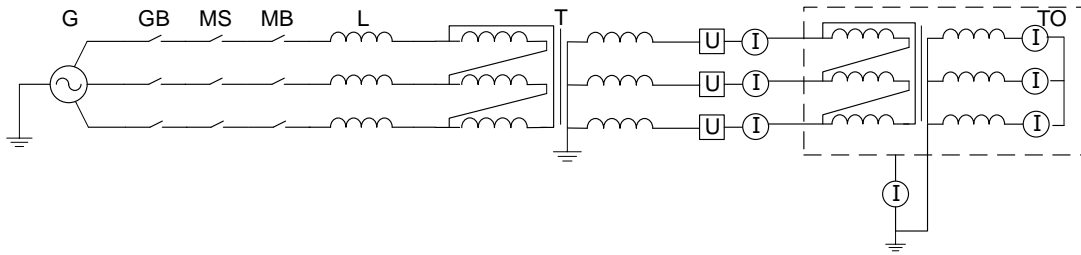


ZP237039G-M-06



ZP237039G-M-07

试验回路 Test circuit:



G : 短路发电机(Generator)

L : 调节电抗 (Reactor)

TO : 试品 (Test Object)

GB : 保护开关 (Generator Breaker)

MB : 操作开关 (Master Breaker)

U : 电压测量(Voltage Measurement)

MS : 合闸开关 (Make Switch)

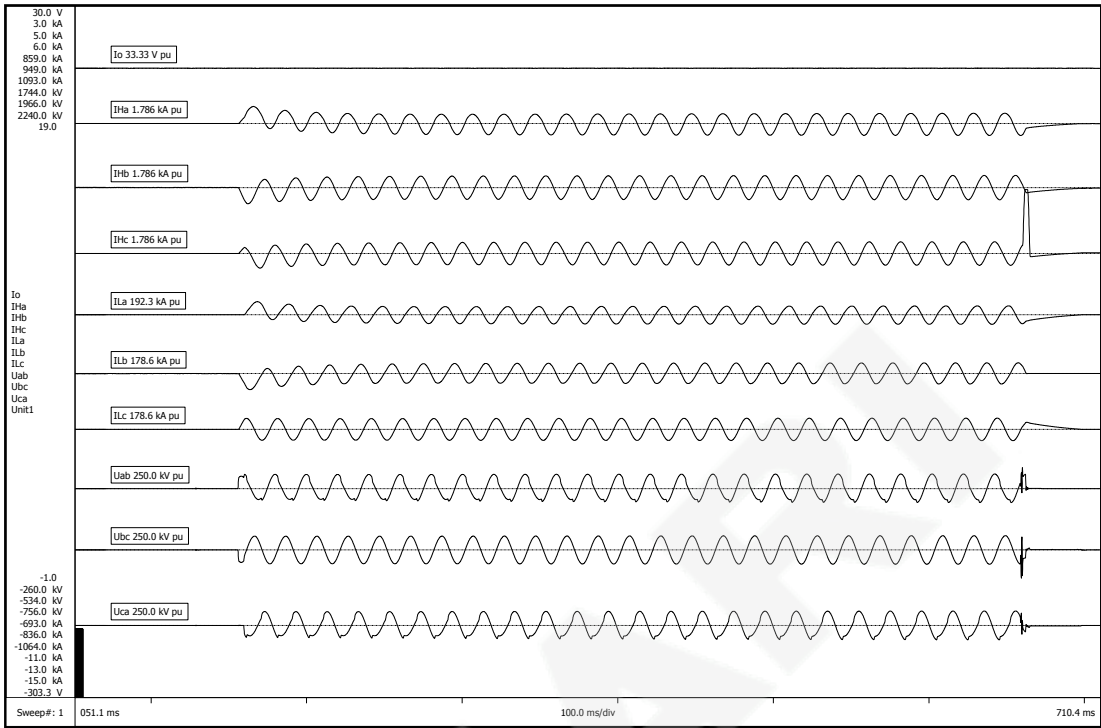
I : 电流测量 (Current Measurement)

T : 变压器 (Transformer)

试验参数 Test parameters:

电源回路参数(Supply circuit)		
容量(Capacity)MVA		1091
频率(Frequency)	Hz	50
相数(Phase)		3
电压(Voltage)	kV	35
电流(Current)	kA	18
阻抗(Impedance)	$\Omega$	1.12
功率因数(Power factor)		<0.15
中性点(Neutral)		接地 (Earthed)

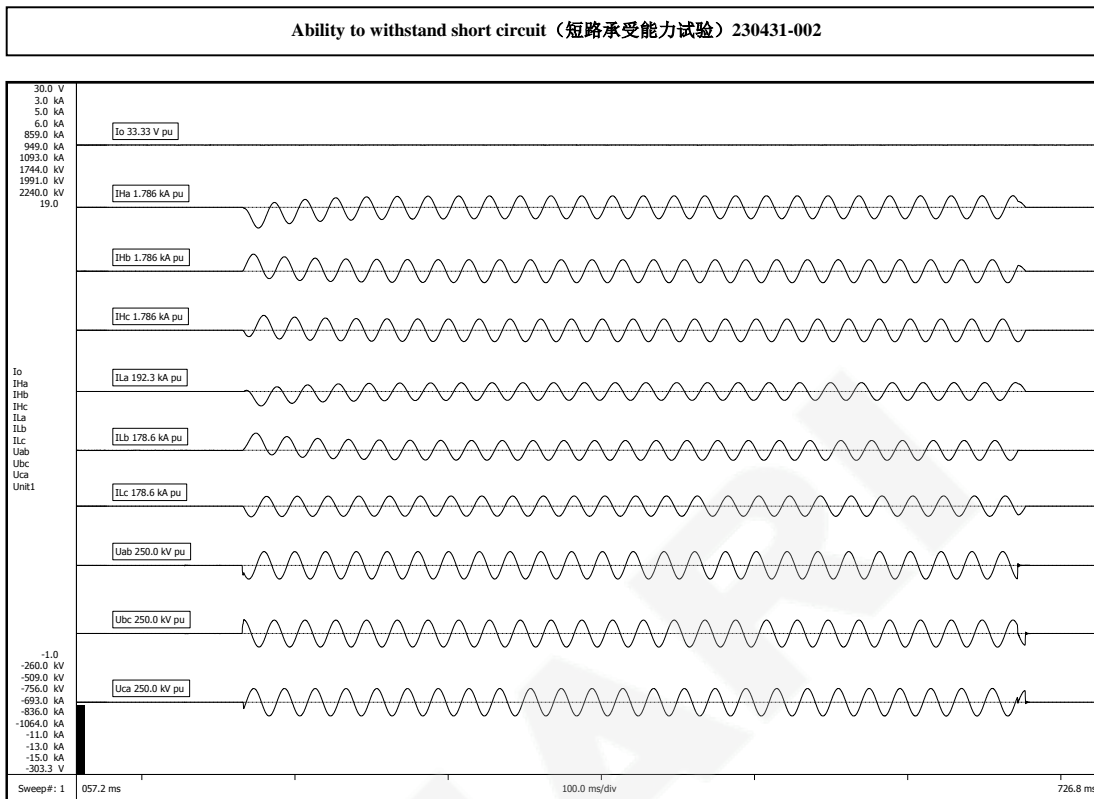
**Ability to withstand short circuit (短路承受能力试验) 230431-001**



Test Parameters (试验参数)					
Time interval since previous test	间隔时间	s	--	--	--
Phase/line	相/线	--	A/AB	B/BC	C/CA
HV-Current, phase value	高压侧试验电流	A	207	211	209
HV-Current, peak	高压侧电流峰值	kA	0.44	-0.42	-0.38
LV-Current, phase value	低压侧试验电流	kA	18.2	18.5	18.6
LV-Current, peak	低压侧电流峰值	kA	36.5	-42.7	28.4
Current duration	电流持续时间	ms	506	506	509
Applied voltage, line value	试验电压	kV	35.3	35.2	35.0

Remarks(备注):

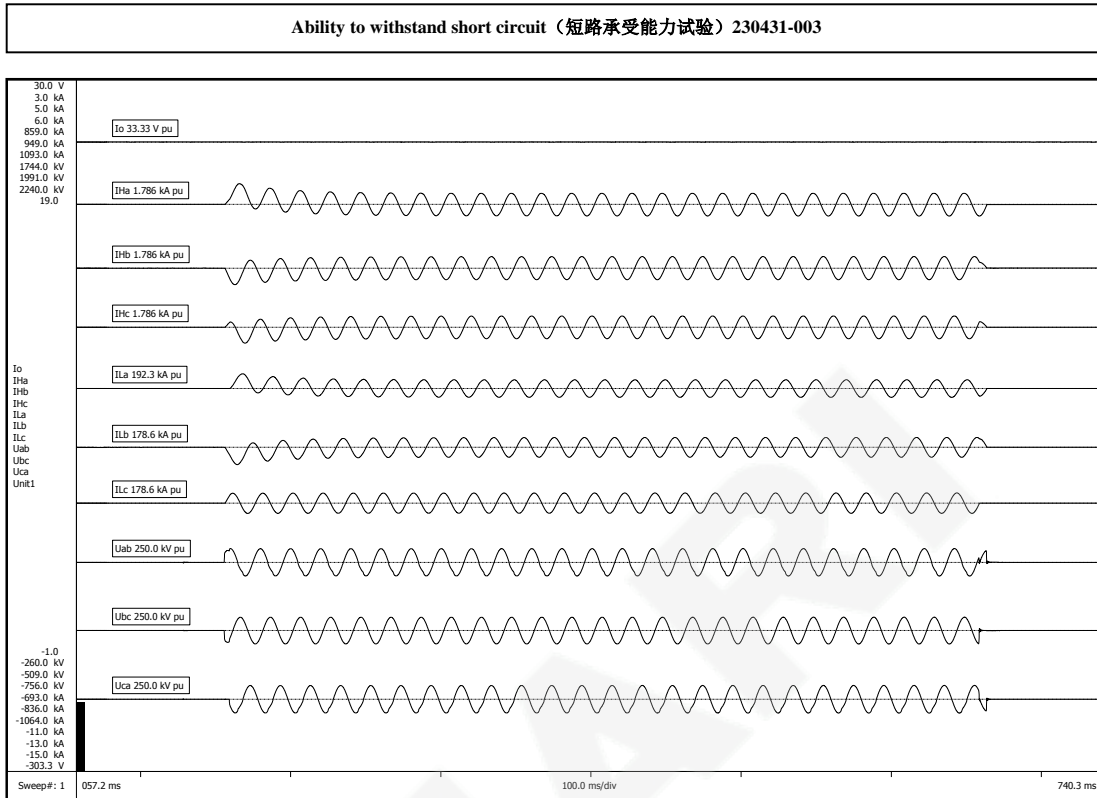




**Test Parameters (试验参数)**

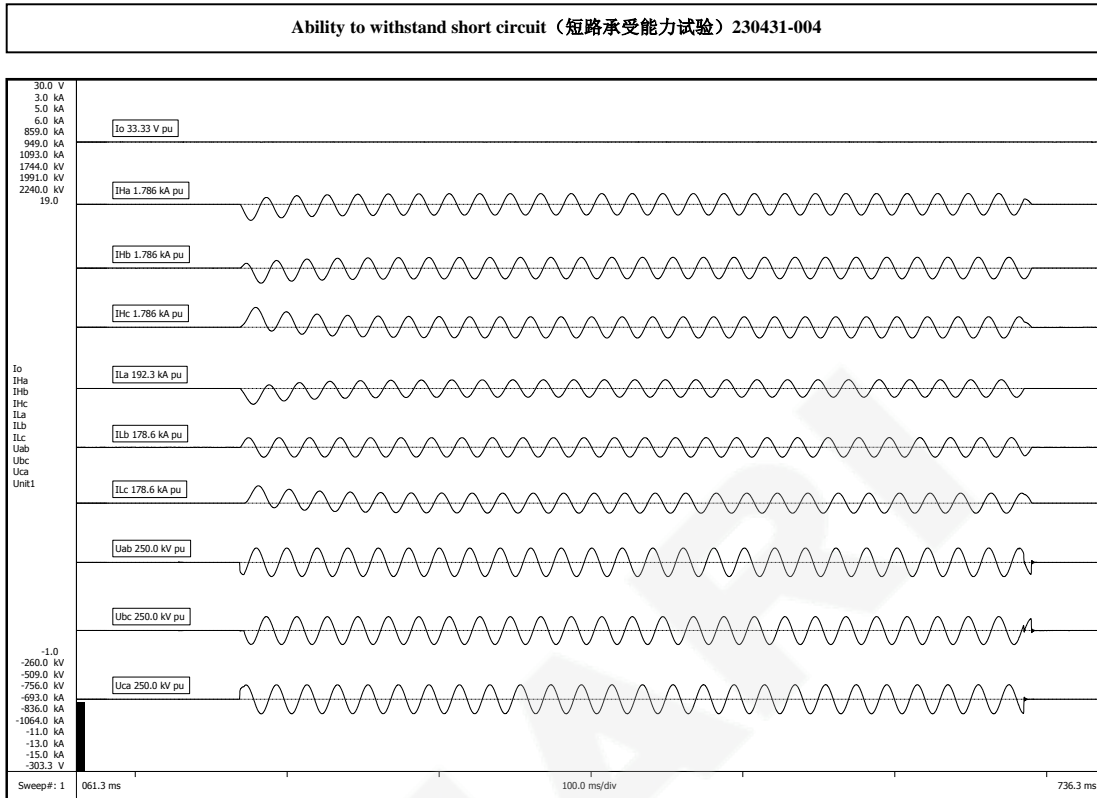
Time interval since previous test	间隔时间	s	--	--	--
Phase/line	相/线	--	A/AB	B/BC	C/CA
HV-Current, phase value	高压侧试验电流	A	211	211	208
HV-Current, peak	高压侧电流峰值	kA	-0.53	0.44	0.39
LV-Current, phase value	低压侧试验电流	kA	18.2	18.1	18.6
LV-Current, peak	低压侧电流峰值	kA	-40.3	43.4	-27.6
Current duration	电流持续时间	ms	510	511	511
Applied voltage, line value	试验电压	kV	35.3	35.0	35.2

Remarks(备注):



Test Parameters (试验参数)					
Time interval since previous test	间隔时间	s	--	--	--
Phase/line	相/线	--	A/AB	B/BC	C/CA
HV-Current, phase value	高压侧试验电流	A	207	212	208
HV-Current, peak	高压侧电流峰值	kA	0.54	-0.43	-0.41
LV-Current, phase value	低压侧试验电流	kA	18.2	18.1	18.6
LV-Current, peak	低压侧电流峰值	kA	41.1	-43.5	-26.7
Current duration	电流持续时间	ms	508	508	508
Applied voltage, line value	试验电压	kV	35.0	35.2	35.3

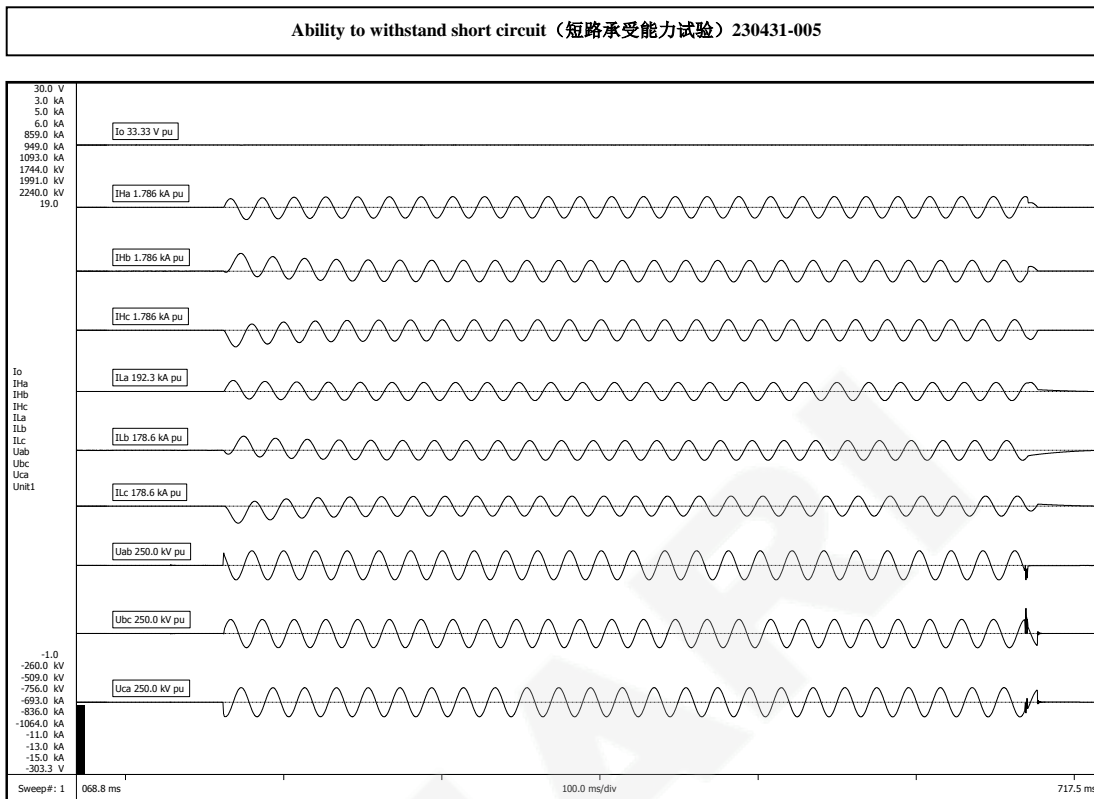
Remarks(备注):



**Test Parameters (试验参数)**

Time interval since previous test	间隔时间	s	--	--	--
Phase/line	相/线	--	A/AB	B/BC	C/CA
HV-Current, phase value	高压侧试验电流	A	197	197	195
HV-Current, peak	高压侧电流峰值	kA	-0.41	-0.39	0.52
LV-Current, phase value	低压侧试验电流	kA	17.9	18.0	18.3
LV-Current, peak	低压侧电流峰值	kA	-43.3	-25.4	44.0
Current duration	电流持续时间	ms	521	521	521
Applied voltage, line value	试验电压	kV	36.9	37.0	37.2

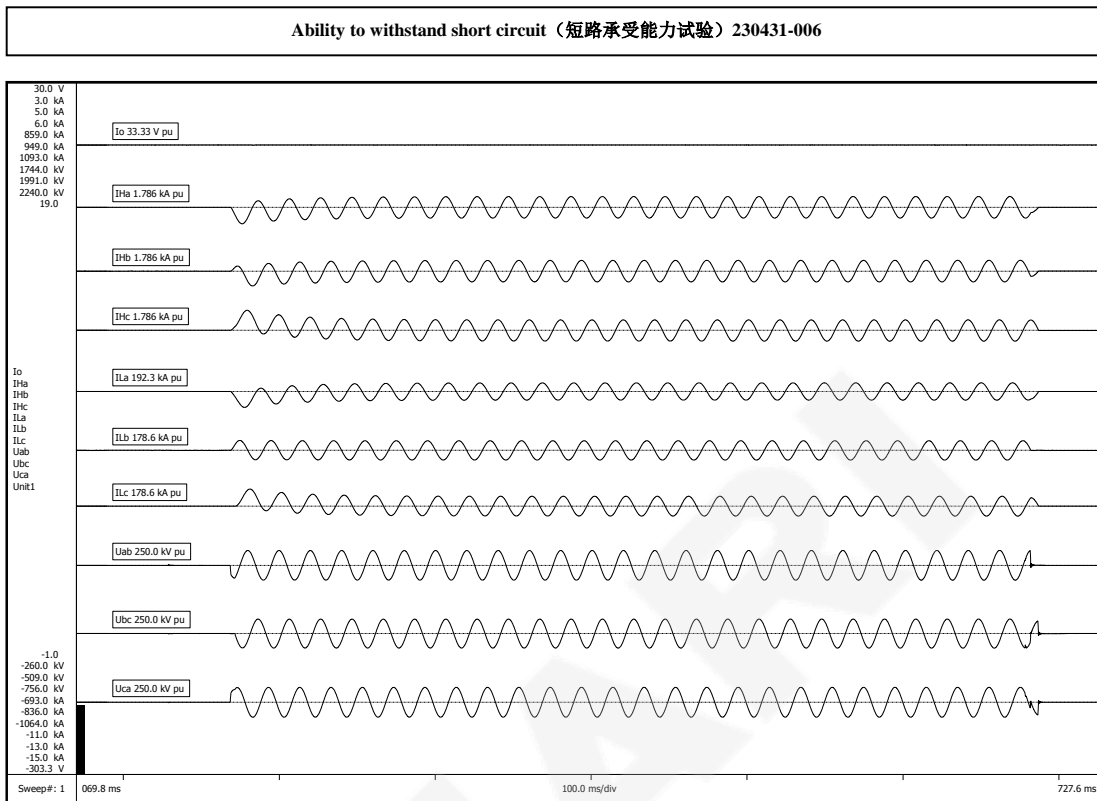
Remarks(备注):



**Test Parameters (试验参数)**

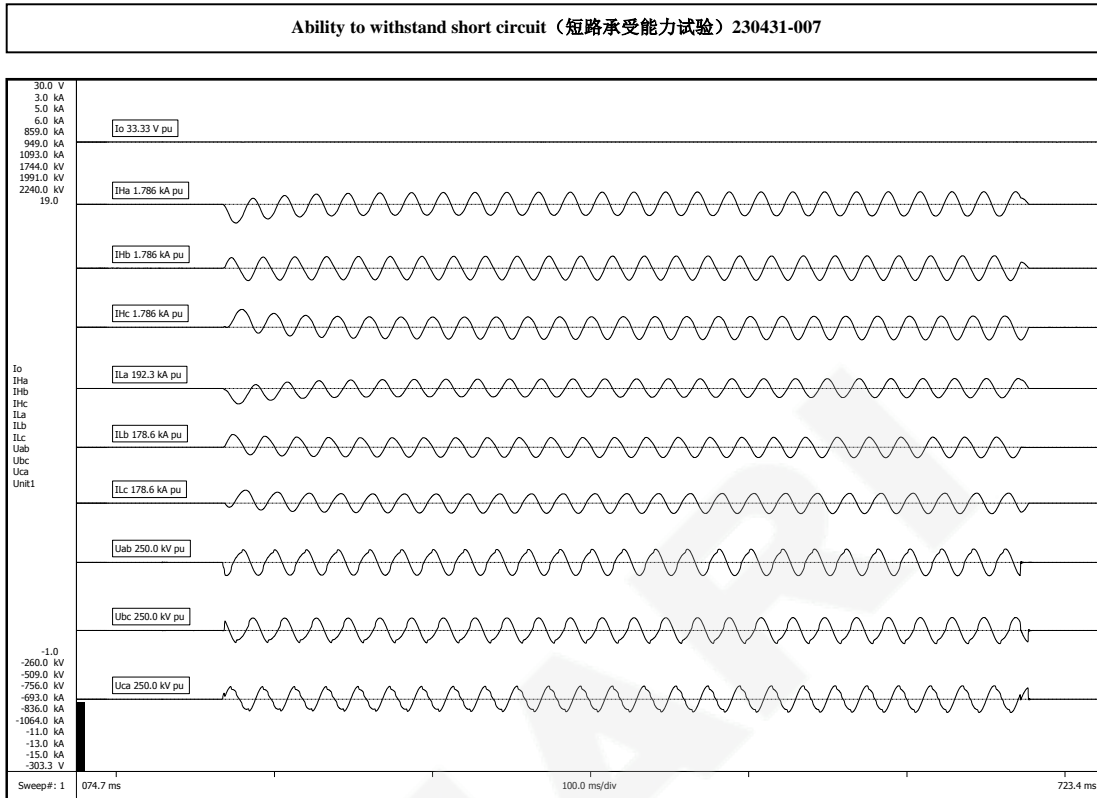
Time interval since previous test	间隔时间	s	--	--	--
Phase/line	相/线	--	A/AB	B/BC	C/CA
HV-Current, phase value	高压侧试验电流	A	197	197	194
HV-Current, peak	高压侧电流峰值	kA	-0.32	0.46	-0.43
LV-Current, phase value	低压侧试验电流	kA	17.9	18.0	18.3
LV-Current, peak	低压侧电流峰值	kA	31.0	36.8	-43.9
Current duration	电流持续时间	ms	515	512	515
Applied voltage, line value	试验电压	kV	37.3	36.3	37.3

Remarks(备注):



Test Parameters (试验参数)					
Time interval since previous test	间隔时间	s	--	--	--
Phase/line	相/线	--	A/AB	B/BC	C/CA
HV-Current, phase value	高压侧试验电流	A	197	197	194
HV-Current, peak	高压侧电流峰值	kA	-0.43	-0.38	0.52
LV-Current, phase value	低压侧试验电流	kA	17.9	18.0	18.3
LV-Current, peak	低压侧电流峰值	kA	-44.0	25.8	44.1
Current duration	电流持续时间	ms	518	518	518
Applied voltage, line value	试验电压	kV	37.3	37.2	37.4

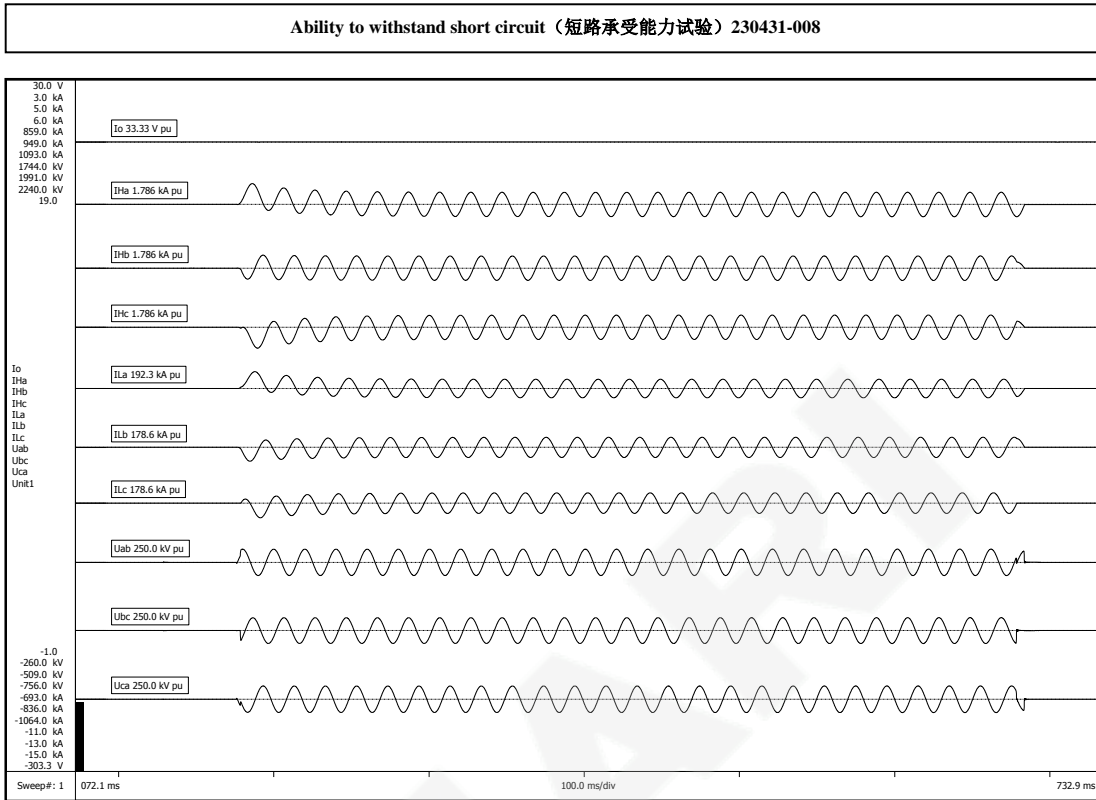
Remarks(备注):



**Test Parameters (试验参数)**

Time interval since previous test	间隔时间	s	--	--	--
Phase/line	相/线	--	A/AB	B/BC	C/CA
HV-Current, phase value	高压侧试验电流	A	224	223	226
HV-Current, peak	高压侧电流峰值	kA	-0.48	-0.32	0.46
LV-Current, phase value	低压侧试验电流	kA	18.6	18.8	18.9
LV-Current, peak	低压侧电流峰值	kA	-43.9	33.5	33.6
Current duration	电流持续时间	ms	509	509	507
Applied voltage, line value	试验电压	kV	33.6	33.5	33.5

Remarks(备注):

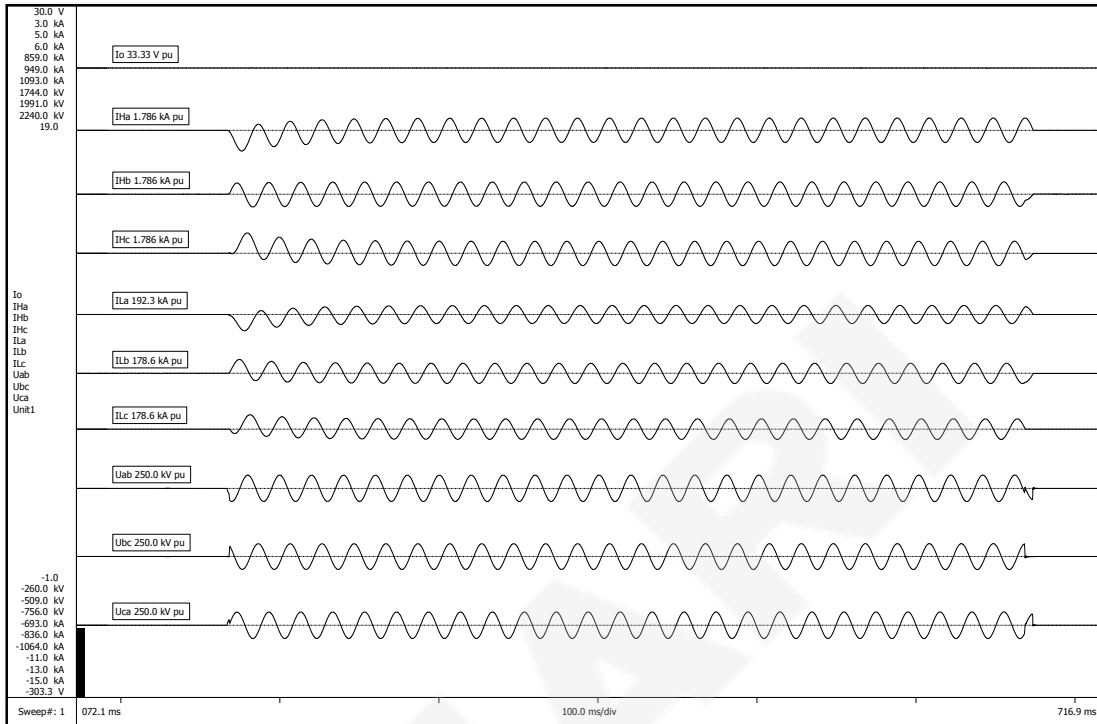


**Test Parameters (试验参数)**

Time interval since previous test	间隔时间	s	--	--	--
Phase/line	相/线	--	A/AB	B/BC	C/CA
HV-Current, phase value	高压侧试验电流	A	223	223	223
HV-Current, peak	高压侧电流峰值	kA	0.54	0.34	-0.54
LV-Current, phase value	低压侧试验电流	kA	18.6	18.5	18.8
LV-Current, peak	低压侧电流峰值	kA	45.2	-35.9	-37.9
Current duration	电流持续时间	ms	506	506	503
Applied voltage, line value	试验电压	kV	33.7	33.5	33.6

Remarks(备注):

**Ability to withstand short circuit (短路承受能力试验) 230431-009**



**Test Parameters (试验参数)**

Time interval since previous test	间隔时间	s	--	--	--
Phase/line	相/线	--	A/AB	B/BC	C/CA
HV-Current, phase value	高压侧试验电流	A	223	223	223
HV-Current, peak	高压侧电流峰值	kA	-0.53	-0.33	0.53
LV-Current, phase value	低压侧试验电流	kA	18.5	18.6	18.8
LV-Current, peak	低压侧电流峰值	kA	-45.3	36.1	37.3
Current duration	电流持续时间	ms	506	506	503
Applied voltage, line value	试验电压	kV	33.8	33.5	33.8

Remarks(备注):



试验后照片 Photos after test:



ZP237039G-M-08



ZP237039G-M-09



ZP237039G-M-10



ZP237039G-M-11



ZP237039G-M-12



ZP237039G-M-13

1、试验后状态 Condition after test:

试品突发短路过程中无异常。Externally no visible change during test.

试验后，试品外观检查正常，吊心检查未发现如标记位移、铁心片移动、绕组及连接线和支撑结构变形等明显缺陷，无放电痕迹。After test, appearance is intact. No obvious defects were found, such as mark displacement, core plate movement, winding, connection wire and support structure deformation, and no trace of discharge.

2、变压器电抗 Reactance of transformer:

时间 Time	分接位置 Tapping	相电抗 Reactance ( $\Omega$ )			相电抗变化率 reactance change rate (%)		
		A 相	B 相	C 相	A 相	B 相	C 相
试验前 Before test	3	95.51	95.21	97.00	-	-	-
	1	105.0	106.2	106.8	-	-	-
	5	84.13	83.66	85.00	-	-	-
第1次 NO.1	3	95.81	95.31	97.05	0.30	0.21	0.05
第2次 NO.2		95.91	95.51	97.11	0.40	0.30	0.11
第3次 NO.3		95.92	95.53	97.10	0.41	0.32	0.10
第4次 NO.4	1	105.9	106.1	106.4	0.90	-0.10	-0.40
第5次 NO.5		106.3	106.6	107.0	1.30	0.40	0.20
第6次 NO.6		107.1	106.6	107.5	2.10	0.40	0.25
第7次 NO.7	5	84.34	83.66	85.01	0.21	0.00	0.01
第8次 NO.8		84.40	83.86	85.33	0.27	0.20	0.33
第9次 NO.9		84.33	83.86	85.38	0.20	0.20	0.38
试验后 After test	3	95.95	95.54	97.12	0.44	0.33	0.12
	1	107.5	107.0	108.8	2.50	0.80	2.00
	5	84.37	83.86	85.39	0.24	0.2	0.39

试验后短路相电抗值与原始值之差不大于 7.5%。Short-circuit reactance values in ohms do not differ from original values by more than 7.5%.

分接位置 Tap	次数 NO.	相别 Phase	非对称短路电流第一峰值 I(peak) of asymmetric short-circuit current			对称短路电流方均根值 I(r.m.s) of asymmetric short-circuit current			持续时间 Time (ms)	示波图 编号 Oscillogram number
			规定值 Rated (kA)	实测值 Measurement(kA)	实测值与计算值之比 Percentage (%)	规定值 Rated (kA)	实测值 Measurement(kA)	实测值与计算值之比 Percentage (%)		
3	1	a	42.52	36.50	85.84	18.03	18.20	100.9	506	-001
		b		42.70	100.4		18.50	102.6		
		c		28.40	66.79		18.60	103.2		
	2	a		40.30	94.78		18.20	100.9	508	-002
		b		43.40	102.1		18.10	100.4		
		c		27.60	64.91		18.60	103.2		
	3	a		41.10	96.66		18.20	100.9	508	-003
		b		43.50	102.3		18.10	100.4		
		c		26.70	62.79		18.60	103.2		
1	4	a	42.05	43.30	103	17.75	17.90	100.8	521	-004
		b		25.40	60.4		18.00	101.4		
		c		44.00	104.6		18.30	103.1		
	5	a		31.00	73.72		17.90	100.8	515	-005
		b		36.80	87.51		18.00	101.4		
		c		43.90	104.4		18.30	103.1		
	6	a		44.00	104.6		17.90	100.8	518	-006
		b		25.80	61.36		18.00	101.4		
		c		44.10	104.88		18.30	103.1		
5	7	a	43.28	43.90	101.4	18.49	18.60	100.6	509	-007
		b		33.50	77.4		18.80	101.7		
		c		33.60	77.6		18.90	102.2		
	8	a		45.20	104.4		18.60	100.6	506	-008
		b		35.90	82.26		18.50	100.1		
		c		37.90	87.57		18.80	101.7		
	9	a		45.30	104.7		18.50	100.1	528	-009
		b		36.10	83.41		18.60	100.6		
		c		37.30	86.18		18.80	101.7		

试验电压及电流波形无异常迹象。There is no abnormal phenomenon in the test voltage and current waveform.

**绕组对地及绕组间直流绝缘电阻测量**  
**Measurement of d.c. insulation resistance between winding to earth**

试验日期 Test date: 2023-09-07

试验数据 Test data:

油温 Oil temperture: 28.9℃; 相对湿度 Relative humidity: 50.9%;

试验电压 Test voltage: DC2500V

测量项目 Measured content	$R_{15}(G\Omega)$	$R_{60}(G\Omega)$	$R_{60}/R_{15}$
高压对低压及地 HV windings to LV and earth	37.4	50.3	1.34
低压对高压及地 LV windings to HV and earth	15.4	34.2	2.22
高压及低压对地 HV and LV windings to earth	16.7	27.1	1.62

试验结果 Result: 通过 Passed.

注 Note: 该试验为突短试验后的检查试验。 This test is a condition check after short circuit test.

## 绕组电阻测量 Measurement of winding resistance

试验日期 Test date: 2023-09-07

试验数据 Test data:

油温 Oil temperature: 28.9°C;

测量绕组 Winding measured	分接位置 Tap position	测量电阻值 Resistance Measured value			最大不平衡率(%) Max unbalance ratio among the resistance	不平衡率允许值(%) Allowed unbalance ratio
		$R_{AB}$	$R_{BC}$	$R_{CA}$		
高压 HV( $\Omega$ )	1	9.925	9.938	9.942	0.17	$\leq 2$
	2	9.664	9.676	9.680		
	3	9.394	9.406	9.410		
	4	9.133	9.144	9.143		
	5	8.865	8.877	8.875		
低压 LV (m $\Omega$ )	/	$R_{ab}$	$R_{bc}$	$R_{ca}$	0.78	$\leq 2$
		1.3627	1.3539	1.3645		
		$R_{ao}$	$R_{bo}$	$R_{co}$	1.22	$\leq 4$
		0.7196	0.7235	0.7284		

试验结果 Result: 通过 Passed.

注 Note: 该试验为突短试验后的检查试验。 This test is a condition check after short circuit test.

## 电压比测量和联结组标号检定

### Measurement of voltage ratio and check of phase displacement

试验日期 Test date: 2023-09-07

试验数据 Test data:

测量绕组 Winding measured	分接位置 Tap position	实测电压比偏差(%) Measured ratio error			联结组标号 Connection symbol
		AB/ab	BC/bc	CA/ca	
高压对低压 HV/LV	1	+0.02	+0.07	+0.07	Dyn11
	2	+0.03	+0.09	+0.09	
	3	+0.01	+0.07	+0.07	
	4	-0.01	+0.08	+0.05	
	5	+0.00	+0.09	+0.06	

试验结果 Result: 通过 Passed。

注 Note: 该试验为突短试验后的检查试验。 This test is a condition check after short circuit test.



## 雷电冲击试验 Lightning impulse test

试验日期 Test date: 2023-09-07

大气条件 Atmospheric conditions: P=96.97kPa t=30.4℃ RH: 50.9%

试验要求 Test requirements:

一次降低电压(50%~70%电压)的全波冲击 Once step-down(50%~70% voltage) full wave lightning impulse;

一次 100%电压的全波冲击 Once full voltage full wave lightning impulse;

一次降低电压(50%~70%电压)的截波冲击 Once step-down(50%~70% voltage) chopped wave lightning impulse;

两次 100%电压的截波冲击 Twice full voltage chopped wave lightning impulse;

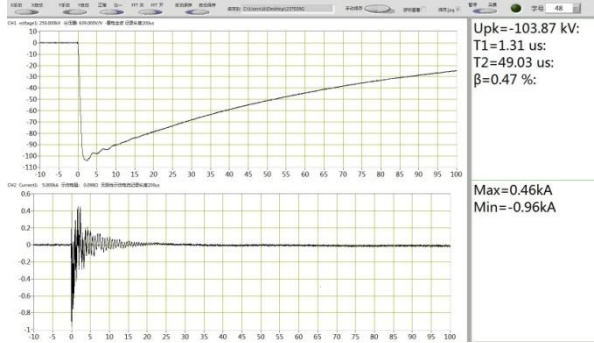
两次 100%电压的全波冲击 Twice full voltage full wave lightning impulse;

试验数据 Testing data record:

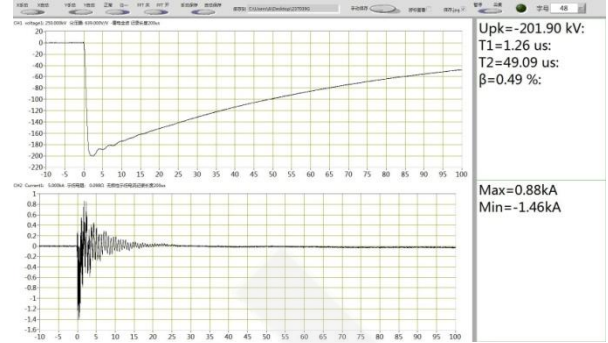
加压端 Terminals applied voltage		分接位置 Tap position	全波冲击耐受电压试验 Full lightning impulse			截波冲击耐受电压试验 Chopped lightning impulse		
			应施电压 Expected voltage Uc(kVp)	实际电压 Measured voltage U <sub>t</sub> (kV <sub>p</sub> )	示波图 T-OSC Shape number	应施电压 Expected voltage Uc(kVp)	实际电压 Measured voltage U <sub>t</sub> (kV <sub>p</sub> )	示波图 T-OSC Shape number
高压 绕组 HV	A	3	(50~70)% Uc	-103.87	01	-220	-124.14	03
			-200	-201.90	02		-218.33	04
				-201.32	05		-218.27	05
				-201.16	07			
	B	3	(50~70)% Uc	-104.15	08	-220	-127.47	10
			-200	-199.90	09		-216.22	11
				-200.37	13		-219.19	12
				-200.16	14			
	C	3	(50~70)% Uc	-103.86	15	-220	-125.98	17
			-200	-198.20	16		-221.30	18
				-199.37	20		-220.18	19
				-198.20	21			

试验结果 Test result: 通过 Passed.

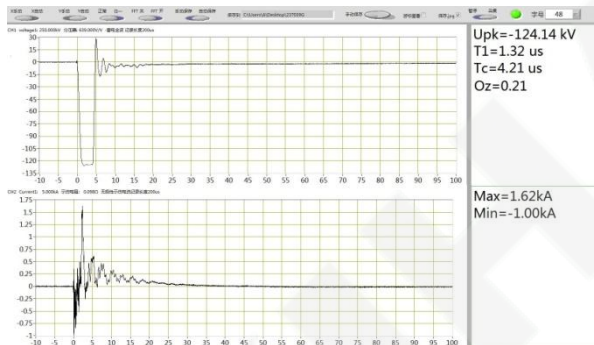
# 示波图 Oscillogram



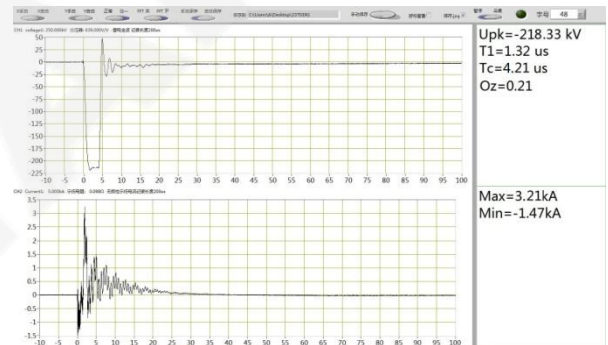
IPVBT237039G-M-01



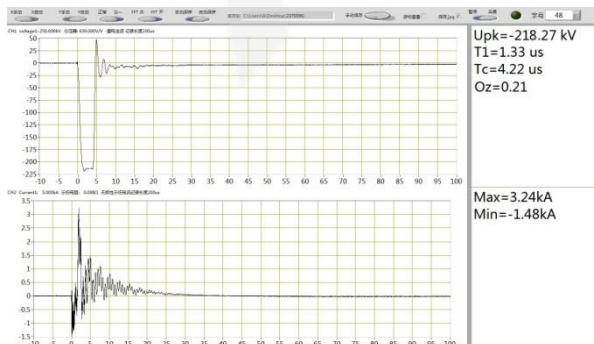
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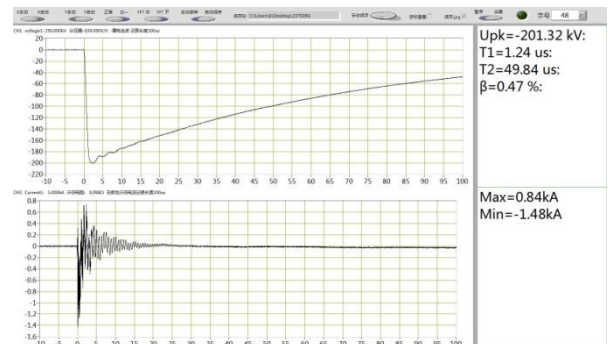
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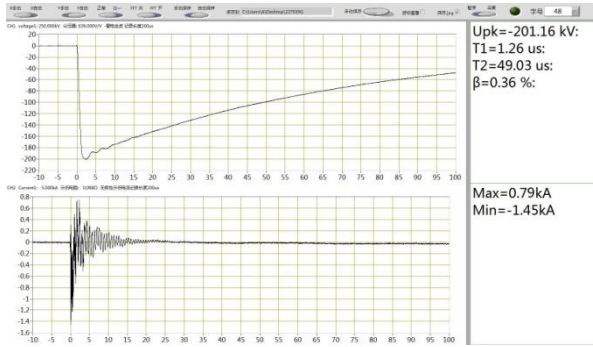
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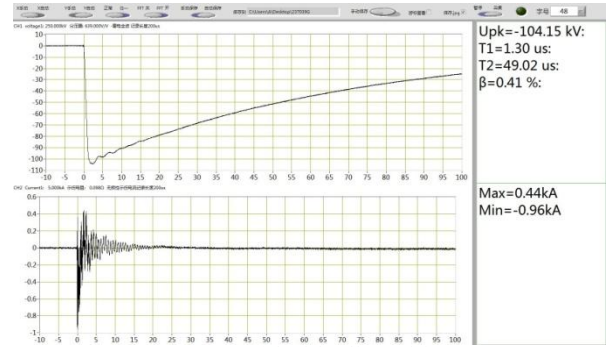
IPVBT237039G-M-05



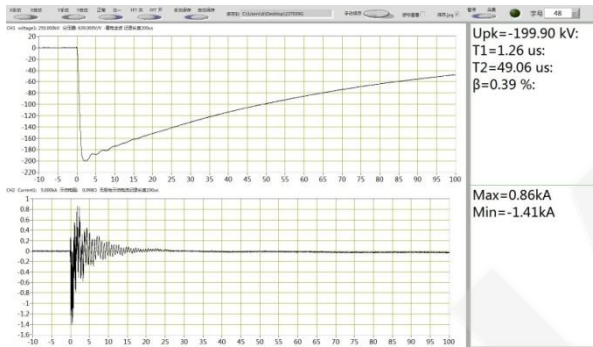
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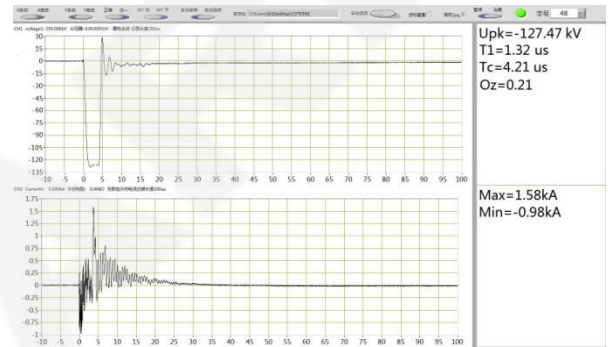
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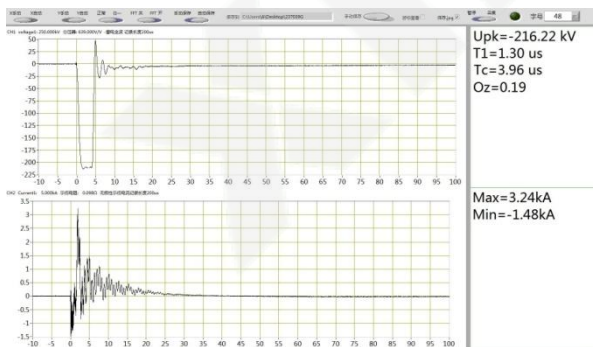
IPVBT237039G-M-08



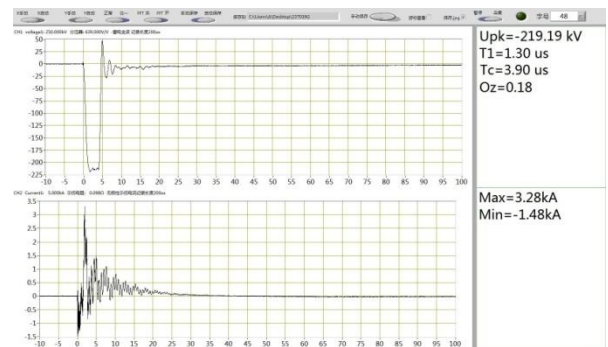
IPVBT237039G-M-09



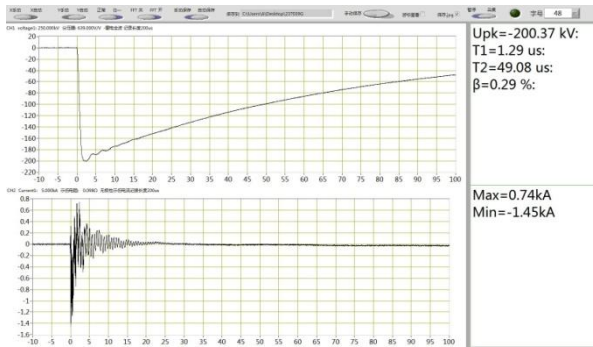
IPVBT237039G-M-10



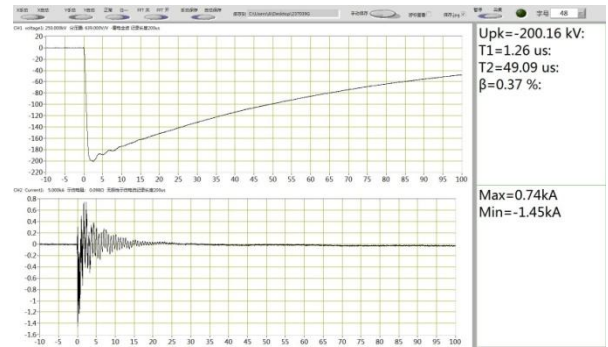
IPVBT237039G-M-11



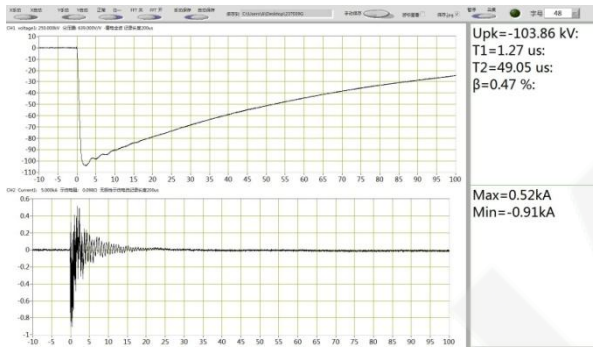
IPVBT237039G-M-12



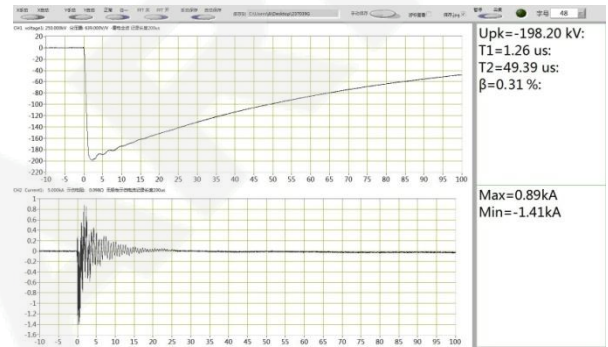
IPVBT237039G-M-13



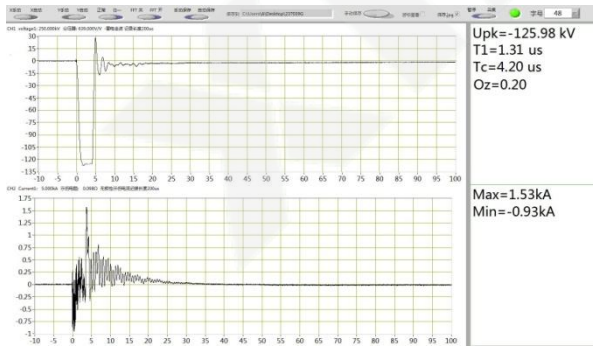
IPVBT237039G-M-14



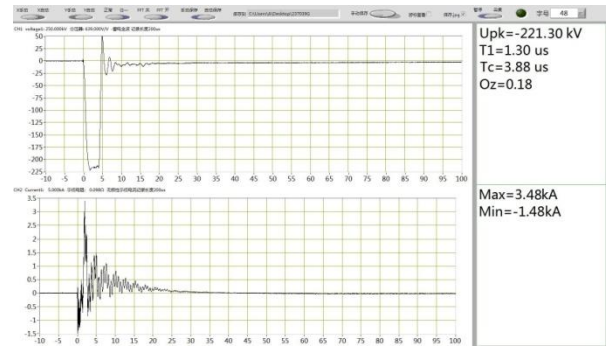
IPVBT237039G-M-15



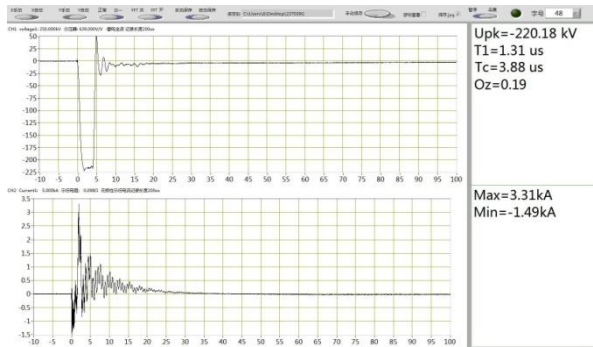
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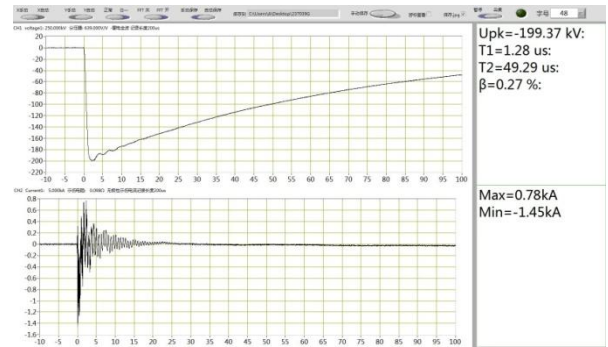
IPVBT237039G-M-17



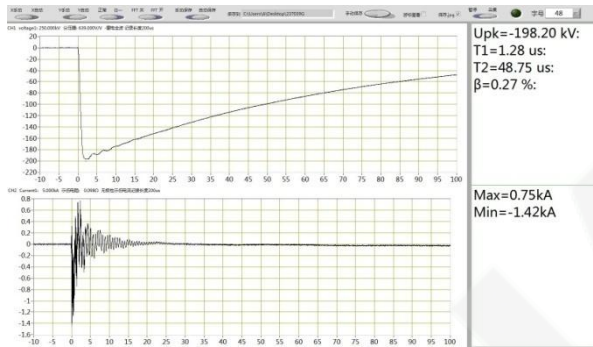
IPVBT237039G-M-18



IPVBT237039G-M-19



IPVBT237039G-M-20



IPVBT237039G-M-21

## 空载损耗和空载电流测量

### Measurement of no-load loss and current

试验日期 Test date: 2023-09-07

试验布置 Test arrangement:

变压器以额定频率在低压侧三相励磁，高压绕组开路。

The three-phase AC voltage at the rated frequency shall be applied to the LV winding of transformer, the high windings shall be open.

试验数据 Test data:

励磁相电压(V) Excited phase voltage			励磁电 流(A) Exciting current	功率 (kW) Loss	空载损耗 (kW) No-load Loss	No-load Current 空载电流 (%)
U/U <sub>r</sub>	平均值 Average value	有效值 r.m.s				
		U'	U	I <sub>LV</sub>	P <sub>m</sub>	P = P <sub>m</sub> (1+d); d = (U' - U)/U'
1.0	230.9	231.2	1.741	0.726	0.726	0.151

试验结果 Test result: 通过 Passed.

注 Note: 该试验为突短试验后的检查试验。 This test is a condition check after short circuit test.

## 短路阻抗和负载损耗测量

### Measurement of short-circuit impedance and load loss

试验日期 Test date: 2023-09-07

试验布置 Test arrangement:

高压侧送电，低压侧短接。

The transformer's h.v. side is energized with rated frequency, l.v. side are short-circuit.

试验数据 Test data:

油温 Oil temperature: 29.0℃;

分接位置 Tap position	施加电流 supply current (A)	测量电压 Measured voltage(V)	测量损耗 Measured loss(kW)	负载损耗 $P_{k75^{\circ}\text{C}}$ Load loss(kW)	短路阻抗 $Z_{k75^{\circ}\text{C}}$ Short-circuit impedance		总损耗 Total losses $P_{\text{总}}$ (kW)
					(%)	(Ω/相)	
1	9.85	1861	3.532	6.535	6.48	109.4	—
3	10.2	1718	3.478	6.629	6.37	97.54	7.355
5	11.02	1633	3.749	6.780	6.21	85.82	—

试验结果 Test result: 通过 Passed.

注 Note: 该试验为突短试验后的检查试验。 This test is a condition check after short circuit test.

**感应耐压试验(IVW)**  
**Induced voltage withstand test**

试验日期: 2023-09-08

试验数据 Test data:

大气条件 Atmospheric conditions: P=97.14kPa t=31.7℃ RH: 57.4%

分接位置 Tap position	加压部位 Supply winding	试验电压 2Ur Test voltage		持续时间 Duration (s)	频率 Frequency (Hz)
		低压 LV (kV)	高压 HV (kV)		
3	低压端 LV	0.800	70.0	30	200

试验结果 Result: 通过 Passed.

注 Note: 该试验为突短试验后的检查试验。This test is a condition check after short circuit test.



## 外施耐压试验(AV)

### Applied voltage test

试验日期: 2023-09-08

试验数据 Test data:

大气条件 Atmospheric conditions: P=97.14kPa t=31.7°C RH: 57.4%

试验部位 Test position	加压部位 Applied voltage position	接地部位 Earthed terminal	应施电压 U <sub>c</sub> (kV)	实测电压 U <sub>t</sub> (kV)	持续时间 Duration (s)
高压绕组 HV	ABC	abcoF	85.0	85.0	60
低压绕组 LV	abco	ABCF	5.0	5.0	60

试验结果 Result: 通过 Passed.

注 Note: 该试验为突短试验后的检查试验。 This test is a condition check after short circuit test.

## 绝缘油试验

### Insulation oil test

试验日期: 2023-09-08

大气条件 Atmospheric conditions: P=97.14kPa t=31.7°C RH: 57.4%

	测量值 Measured value	规定值 Specified value
击穿耐压 breakdown voltage (kV/2.5mm)	64.5	≥ 40.0
介损 (90°C) tanδ at 90°C (%)	0.151	≤ 1.0

试验结果 Result: 通过 Passed.

注 Note: 该试验为突短试验后的检查试验。 This test is a condition check after short circuit test.

试验照片  
Photograph



ZP237039G-M-14



ZP237039G-M-15

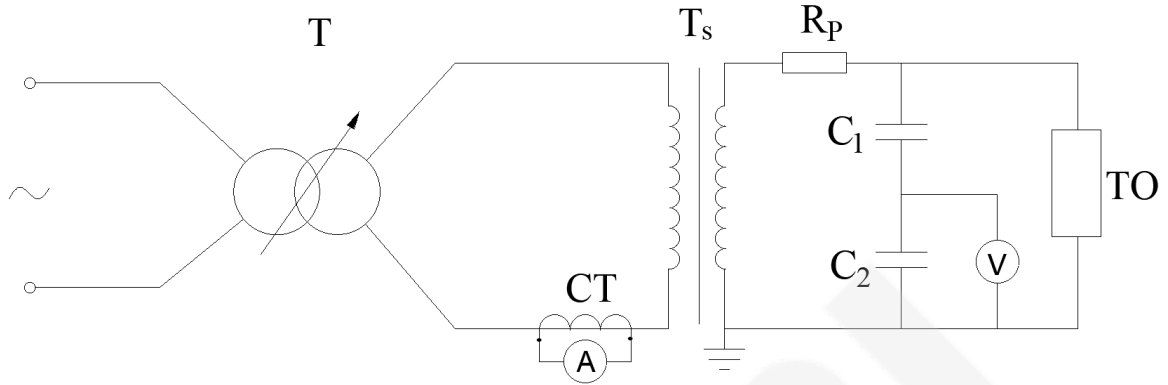


ZP237039G-M-16



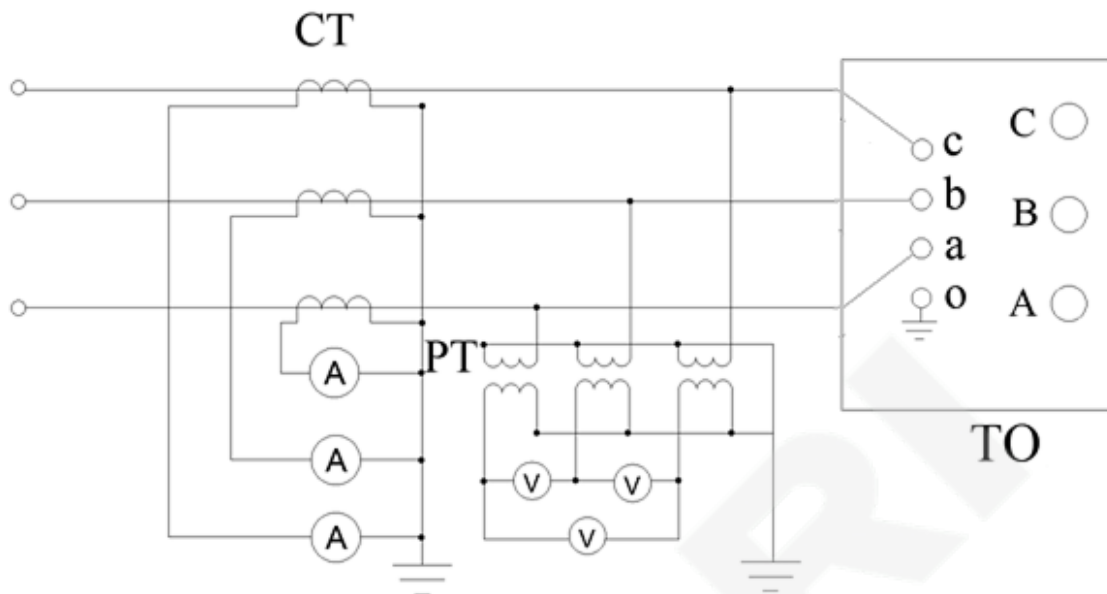
ZP237039G-M-17

外施耐压试验线路图  
Applied voltage test circuit



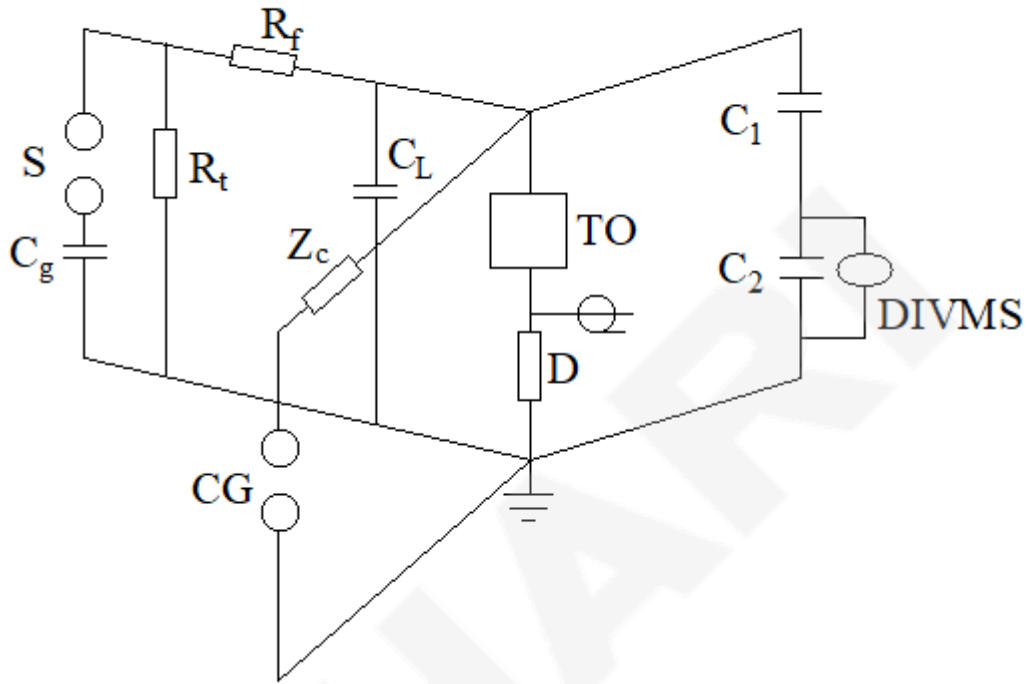
T	调压器 Voltage regulator	R <sub>p</sub>	保护电阻 Protection resistance
CT	电流互感器 Current transformer	T <sub>s</sub>	试验变压器 Test transformer
TO	试品 Test object	A	电流表 Ammeter
C <sub>1</sub>	高压臂电容 H.V arm capacitance	C <sub>2</sub>	低压臂电容 L.V arm capacitance
V <sub>1</sub>	峰值电压 Peak voltmeter 型号 Type: pv2-1A 编号 SN: 3901573		
150kV/150kVA 工频电压试验系统 Power frequency voltage test system			

感应耐压试验线路图  
Induced voltage withstand test circuit



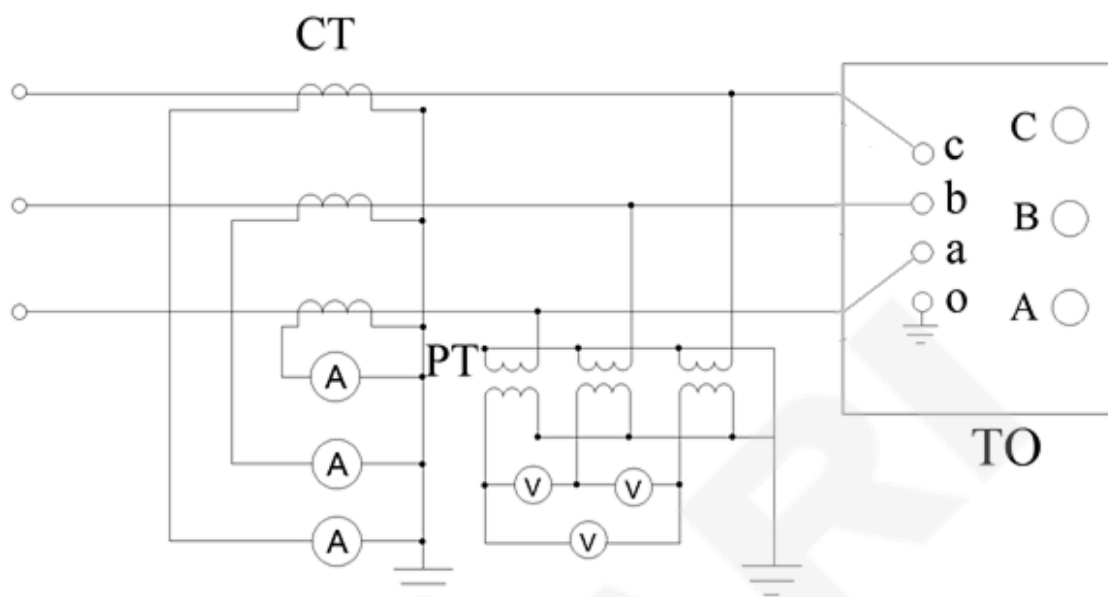
TO	试品 Test object	CT	电流互感器 Current transformer
PT	电压互感器 Voltage transformer	A	电流表 Ammeter
V	电压表 Voltmeter		

雷电冲击试验线路图  
Lightning impulse test circuit



S	冲击点火球隙 Sphere gap	C <sub>g</sub>	冲击发生器主电容 IG capacitance
R <sub>f</sub>	波头电阻 Front resistance	R <sub>t</sub>	波尾电阻 Tail resistance
C <sub>L</sub>	负载电容 Load capacitance	Z <sub>C</sub>	附加阻抗 Additional impedance
C <sub>1</sub>	高压臂电容 H.V arm capacitance	C <sub>2</sub>	低压臂电容 L.V arm capacitance
TO	试品 Test object	D	分流器 Diverter
CG	截波球隙 Chopping gap		
DIVMS	冲击电压测量系统 Impulse voltage measurement system		
600kV/45kJ 冲击电压试验系统			
600kV/45kJ Impulse voltage test system			

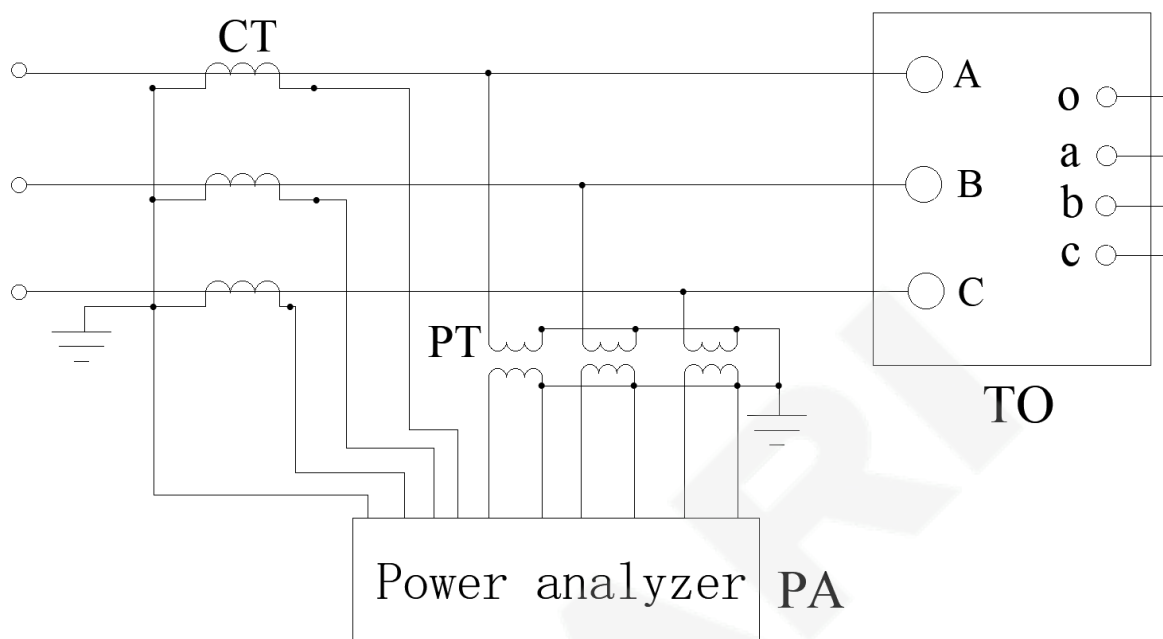
空载损耗及空载电流测量线路图  
No-load loss and current measurement circuit



TO	试品 Test object	CT	电流互感器 Current transformer
PT	电压互感器 Voltage transformer	PA	功率分析仪 Power analyzer



短路阻抗及负载损耗测量线路图  
short circuit impedance and onload loss measurement circuit



TO	试品 Test object	CT	电流互感器 Current transformer
PT	电压互感器 Voltage transformer	PA	功率分析仪 Power analyzer

