

Test Certificate

N° : 1231675-04

Type : MINERA	3-Phase Oil Type Transformer				Page Nr. : 1 of 14 pages			
Customer :								
WPD	Fb Nr : 231675		Mach. Nr : 231675-04					
Standard : IEC 60076-1	Tapping		HV (V)	LV (V)	Values at : 75 °C			
Kind : PT	1		11550		Position : 3			
Service : Continuous	2		11275			Po (kW)	Pk (kW)	Uk (%)
Cooling type : ONAN	3	Un(V)	11000	433	Guaranteed	1.015	11.285	5.5
Rated frequency : 50 Hz	4		10725		Tolerance (%)	0.0	0.0	10
Th.short-circuit current : 35.0 kA	5		10450		Fact.Test	1.000	10.92	5.71
					Result	✓	✓	✓
	Amps. In (A)		78.73	2000.06				
	Sn (kVA)		1500					
	Vector Group		Dyn 11		Oil type : MINERAL OIL			

Measurement of winding resistance : Temp. : 24.4 °C (Ω) IEC 60076-1 § 11.2

Conn. / Tap.	1	3	5					Connection	
1U - 1V	0.4319	0.4086	0.3865					2U - 2V	0.000672
1V - 1W	0.4323	0.4083	0.3870					2V - 2W	0.000695
1W - 1U	0.4315	0.4077	0.3852					2W - 2U	0.000701

Measurement of voltage ratio and check of phase displacement : IEC 60076-1 § 11.3

Vector-group has been checked according to rating plate.

Tapping	1	2	3	4	5								
Connection/Calculated ratio	46.201	45.101	44.001	42.901	41.801								
1U-1V/2U-2N %	0.03	-0.06	0.00	0.07	-0.03								
1V-1W/2V-2N %	0.03	-0.06	0.00	0.07	-0.03								
1W-1U/2W-2N %	0.04	-0.06	0.00	0.07	-0.03								

Measurement of no-load loss and current : Connection : 2U-2V-2W IEC 60076-1 § 11.5

Excitation (%)	Volts U	Frequency Hz	Currents (A)				Io / In (%)	Losses in kW	
			Io u	Io v	Io w	Io average			Po
110	476	50	3.23	2.17	3.35	2.92	0.15		1.234
100	433	50	2.34	1.51	2.49	2.11	0.11		1.000
90	390	50	1.79	1.15	1.93	1.62	0.08		0.786

Measurement of short-circuit impedance and load loss : Connection : 1U-1V-1W Short-circuit : 2U-2V-2W IEC 60076-1 § 11.4

Base (kVA)	Tapping	Frequency 50 Hz		Uk 75 °C (%)	Ikd(LV) (kA)	Losses in kW at 23.2 °C			Losses in kW at 75 °C		
		Amps	Volts			ΣI²R	AC losses	Load loss	ΣI²R	AC losses	Load loss
1500	3	78.73	626.67	5.71	35.0	7.893	1.667	9.560	9.540	1.379	10.919

Applied voltage test :

IEC 60076-3 § 10	kV	Second	Hz	Result
Applied voltage test HV	28	60	50	Passed
Applied voltage test LV	3	60	50	Passed

Induced voltage withstand test : 200 Hz

IEC 60076-3 § 11.2	kV	Second	Result
Induced overvolt. LV	0.866	30	Passed

Leak testing with pressure

IEC 60076-1 § 11.8 & N.1512.0027 rev06	bar	Duration (h)	Result
Applied pressure	0.2	8	Passed

Used Test Equipments :		Test Lab.: ODT	
Resistance Meas. :	Ohmmeter	TETTEX 2293	186676
Ratio Measurements :	Ratiometer	TETTEX 2795	176337
Loss Measurements :	Power Analyser	YOKOGAWA WT3000E	919415746
Insulation Tests :	Peak Voltmeter	HIGH VOLT MU17	916403
	Voltage Divider	MICAFIL	HL8452842
	Insulation Tester	METREL MI2094	17023565
Temp. Measurements :	Thermometer	TESTO 110	33981789/809
Pressure Measurement :	Manometer	KELLER	105207

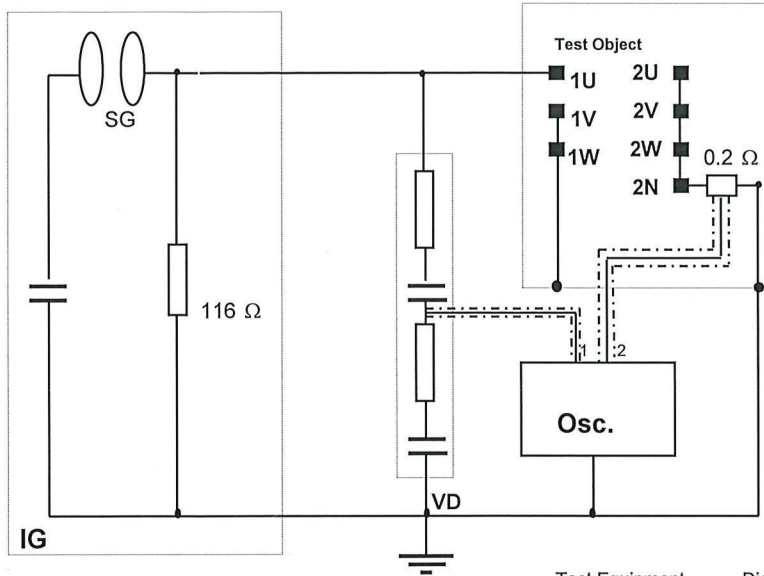
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Tested by : D.ŞENÇİ	Checked by : H.SEVİL	Customer or Representative :	Revision No : -
Test Engineer	Test Team Leader		
Date : 06.05.2022	Date : 06.05.2022	Date :	

Test Certificate

N° : I231675-04

Customer : WPD	Chopped wave lightning impulse test	Page No : 2 of 14 pages
	Standard : IEC 60076-3 (2013-07)	Serial No : 231675-04
Rated Power (kVA) : 1500	Rated Voltage (kV) : 11 / 0.433	Impulse Level : 95 kV



IG Impulse Generator
HAEFELY (SGS 500)

VD Voltage Divider
HAEFELY (Type CS 600-500)

Osc. Digital Impulse
Analyzing System
HIGHVOLT (Type HIRES S4D)

RFW Reduced full wave voltage

RFWC Reduced full wave current

FW Full wave voltage

CFW Chopped full wave voltage

FWC Full wave current

GRD Terminals grounded

Test Equipment Digital Impulse Analyzer System HIGHVOLT HIRES S4D 924368

Terminal lightning impulse applied to	Test	Crest voltage	Wave shape or rate of rise	Oscillogram number	Sweep time or timing wave frequency	Connection of non-impulsed terminals	Percentage	Remarks
1U	RFW	-57.083	1.2/50 μ s	1	100/100 μ s	GRD	60 %	
	FW	-94.212	1.2/50 μ s	2	100/100 μ s		99 %	
	CFW	-104.163	3-6 μ s	3	10 μ s		110 %	
	CFW	-104.940	3-6 μ s	4	10 μ s		110 %	
	FW	-94.612	1.2/50 μ s	5	100/100 μ s		100 %	
	FW	-95.094	1.2/50 μ s	6	100/100 μ s		100 %	
1V	RFW	-57.893	1.2/50 μ s	7	100/100 μ s	GRD	61 %	
	FW	-94.423	1.2/50 μ s	8	100/100 μ s		99 %	
	CFW	-104.603	3-6 μ s	9	10 μ s		110 %	
	CFW	-104.549	3-6 μ s	10	10 μ s		110 %	
	FW	-94.967	1.2/50 μ s	11	100/100 μ s		100 %	
	FW	-94.873	1.2/50 μ s	12	100/100 μ s		100 %	
1W	RFW	-57.494	1.2/50 μ s	13	100/100 μ s	GRD	61 %	
	FW	-94.608	1.2/50 μ s	14	100/100 μ s		100 %	
	CFW	-104.478	3-6 μ s	15	10 μ s		110 %	
	CFW	-104.511	3-6 μ s	16	10 μ s		110 %	
	FW	-94.835	1.2/50 μ s	17	100/100 μ s		100 %	
	FW	-94.862	1.2/50 μ s	18	100/100 μ s		100 %	

The test-object passed the tests without objection

The test oscillograms are found in the following documentation.

Induced voltage and applied voltage test performed following the impulse test. The transformer passed all tests.

Tested By Test Engineer	D.SENCİ	Checked by Test Team Leader	H.SEVİL	Customer or Representative		Revision	
Date :	10.05.2022	Date :	10.05.2022	Date			

Test type: Chopped Wave Lightning Impulse Test
Serial No.: 231675-04

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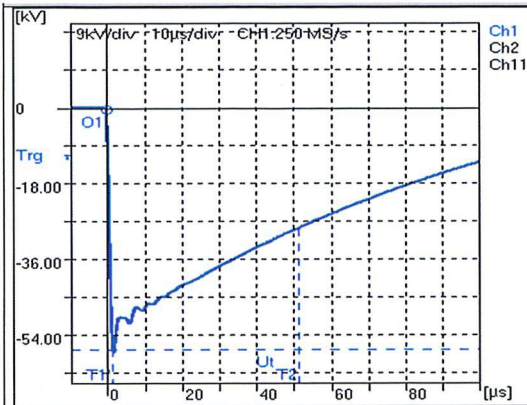
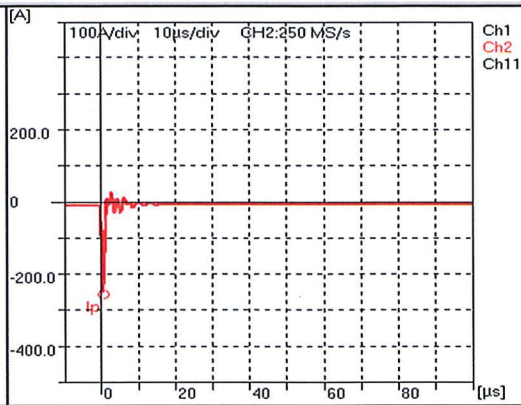


Fig.: 1

Ch1:

$U_t = -57.083 \text{ kV}$
 $T_1 = 1.341 \mu\text{s}$
 $T_2 = 51.543 \mu\text{s}$

Ch2:

$I_p = -250.73 \text{ A}$

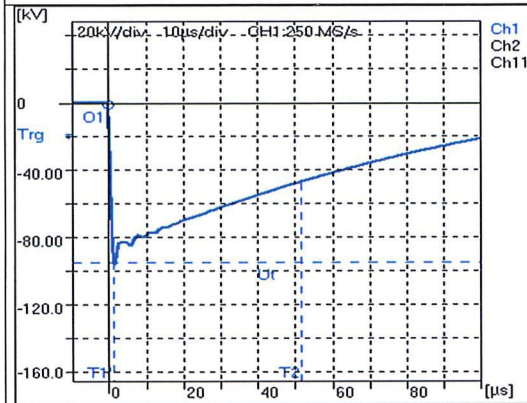
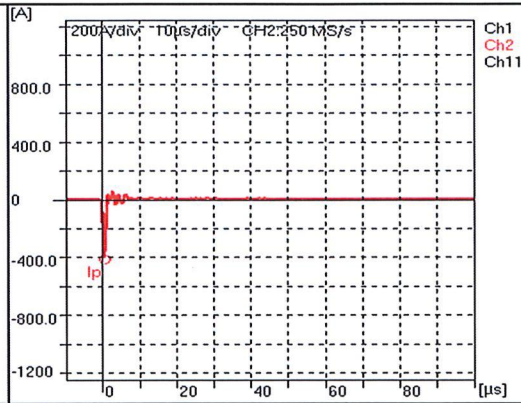


Fig.: 2

Ch1:

$U_t = -94.212 \text{ kV}$
 $T_1 = 1.328 \mu\text{s}$
 $T_2 = 51.836 \mu\text{s}$

Ch2:

$I_p = -404.59 \text{ A}$

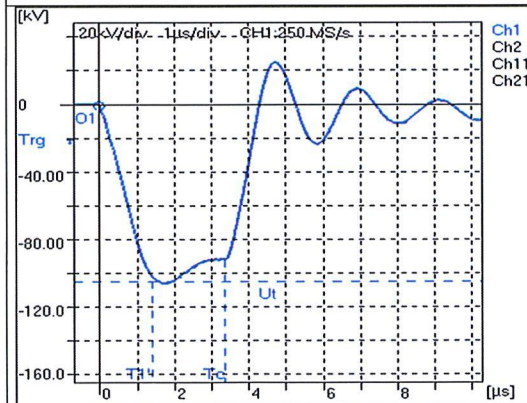
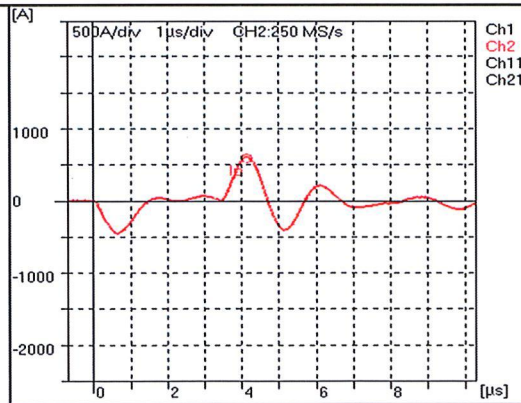


Fig.: 3

Ch1:

$U_t = -104.163 \text{ kV}$
 $T_1 = 1.423 \mu\text{s}$
 $T_c = 3.380 \mu\text{s}$

Ch2:

$I_p = 616.30 \text{ A}$

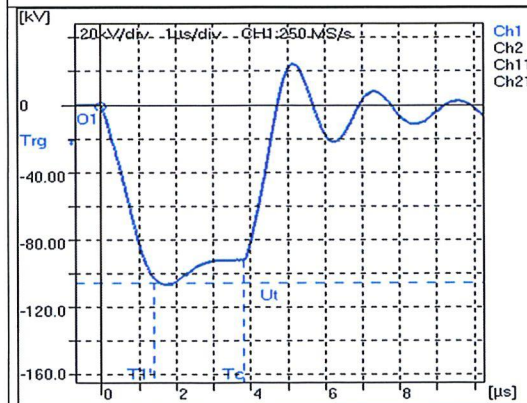
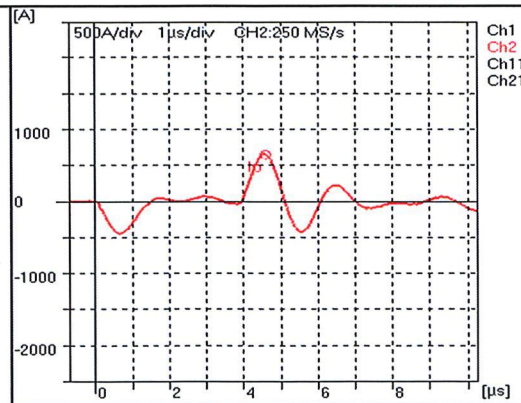


Fig.: 4

Ch1:

$U_t = -104.940 \text{ kV}$
 $T_1 = 1.425 \mu\text{s}$
 $T_c = 3.814 \mu\text{s}$

Ch2:

$I_p = 670.78 \text{ A}$

Test type: Chopped Wave Lightning Impulse Test
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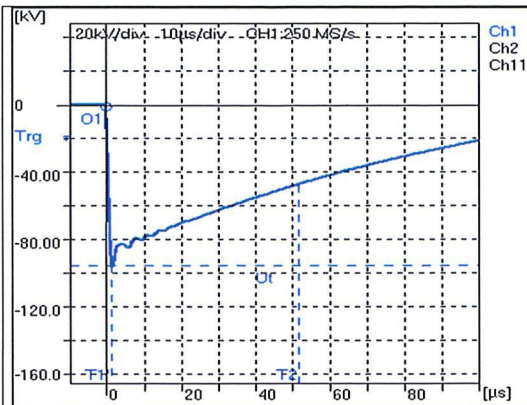
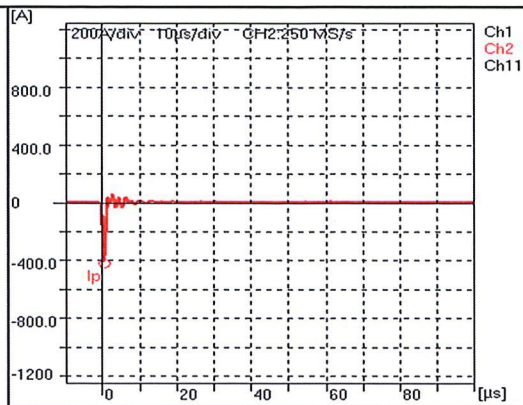


Fig.: 5

Ch1:

$U_t = -94.612 \text{ kV}$
 $T_1 = 1.330 \text{ μs}$
 $T_2 = 51.855 \text{ μs}$

Ch2:

$I_p = -407.71 \text{ A}$

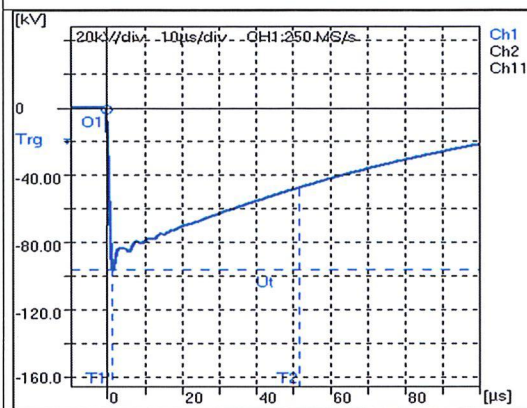
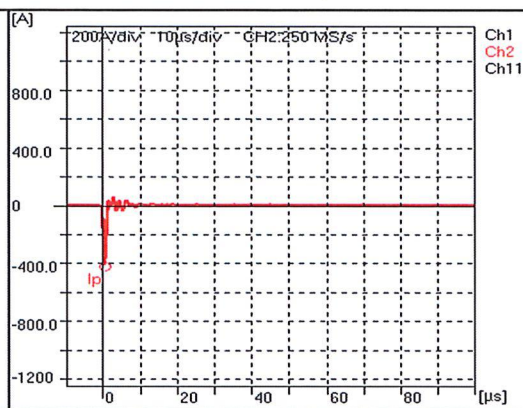


Fig.: 6

Ch1:

$U_t = -95.094 \text{ kV}$
 $T_1 = 1.329 \text{ μs}$
 $T_2 = 51.845 \text{ μs}$

Ch2:

$I_p = -409.62 \text{ A}$

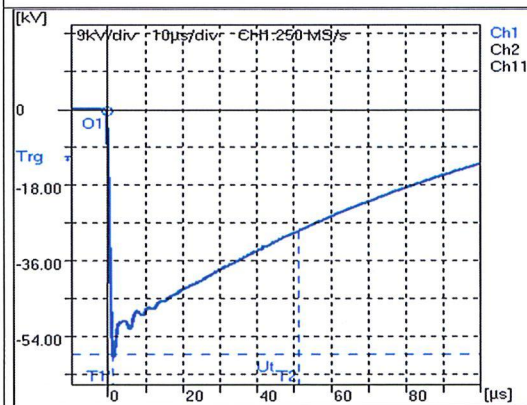
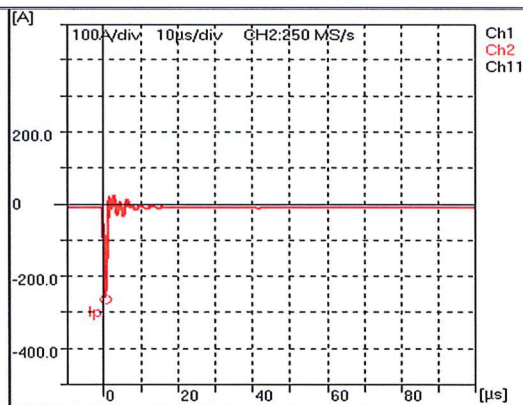


Fig.: 7

Ch1:

$U_t = -57.893 \text{ kV}$
 $T_1 = 1.320 \text{ μs}$
 $T_2 = 51.462 \text{ μs}$

Ch2:

$I_p = -260.83 \text{ A}$

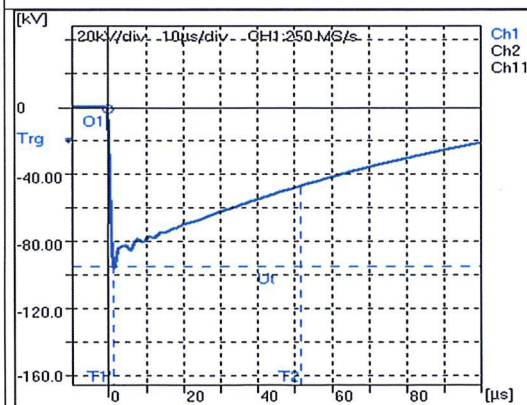
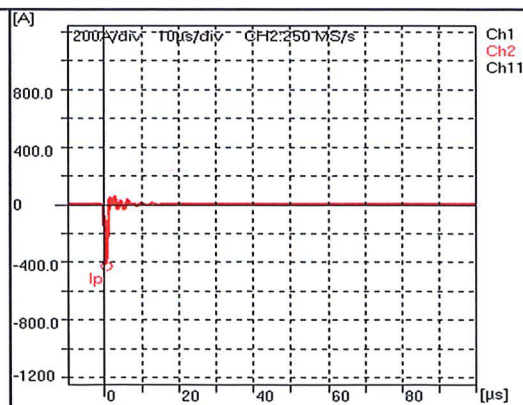


Fig.: 8

Ch1:

$U_t = -94.423 \text{ kV}$
 $T_1 = 1.316 \text{ μs}$
 $T_2 = 51.859 \text{ μs}$

Ch2:

$I_p = -416.56 \text{ A}$

Test type: Chopped Wave Lightning Impulse Test
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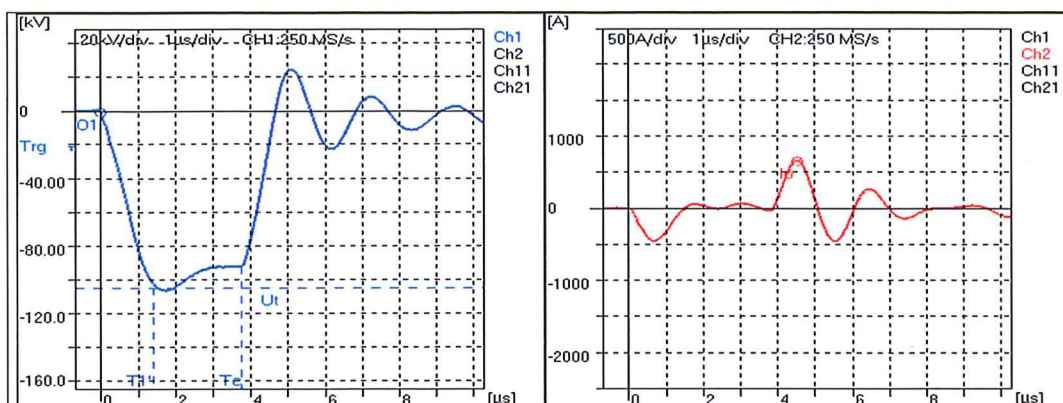


Fig.: 9

Ch1:

$U_t = -104.603$ kV
 $T_1 = 1.419$ μs
 $T_c = 3.752$ μs

Ch2:

$I_p = 668.79$ A

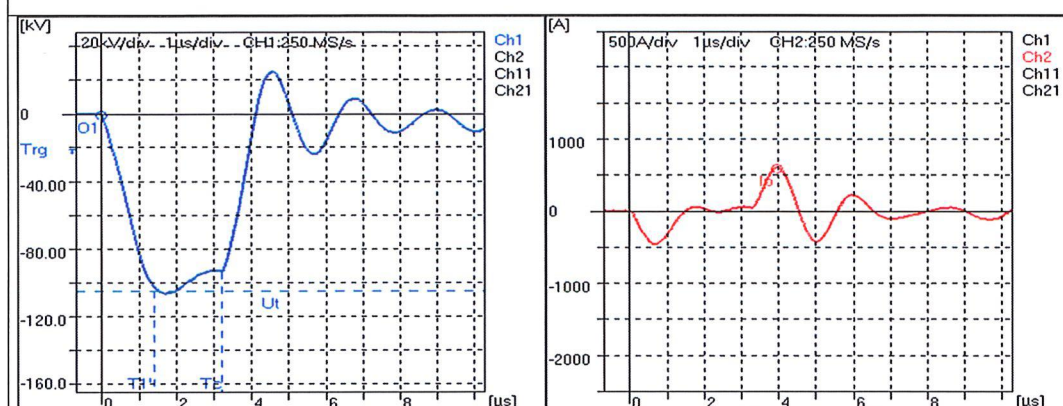


Fig.: 10

Ch1:

$U_t = -104.549$ kV
 $T_1 = 1.414$ μs
 $T_c = 3.218$ μs

Ch2:

$I_p = 609.44$ A

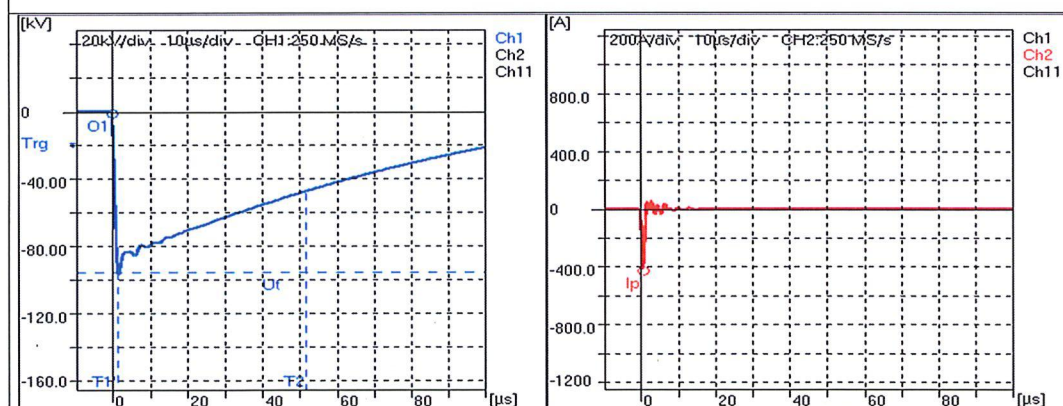


Fig.: 11

Ch1:

$U_t = -94.967$ kV
 $T_1 = 1.319$ μs
 $T_2 = 51.742$ μs

Ch2:

$I_p = -416.26$ A

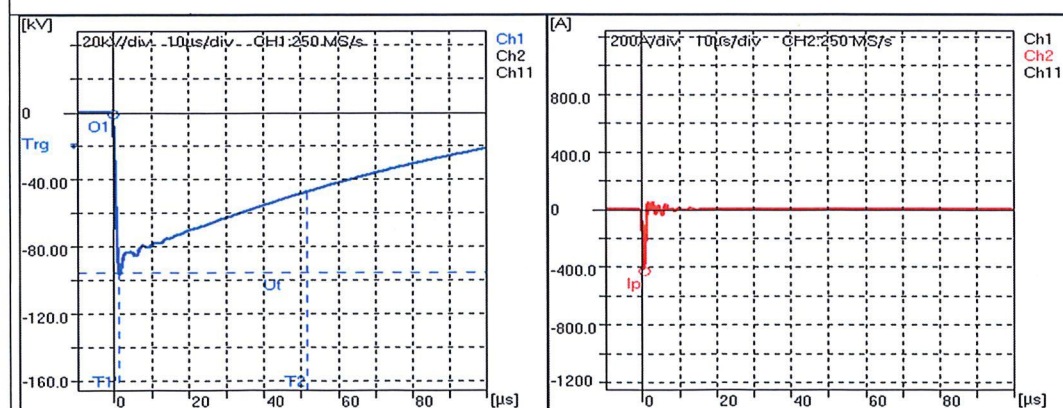


Fig.: 12

Ch1:

$U_t = -94.873$ kV
 $T_1 = 1.317$ μs
 $T_2 = 51.814$ μs

Ch2:

$I_p = -416.87$ A

Test type: Chopped Wave Lightning Impulse Test
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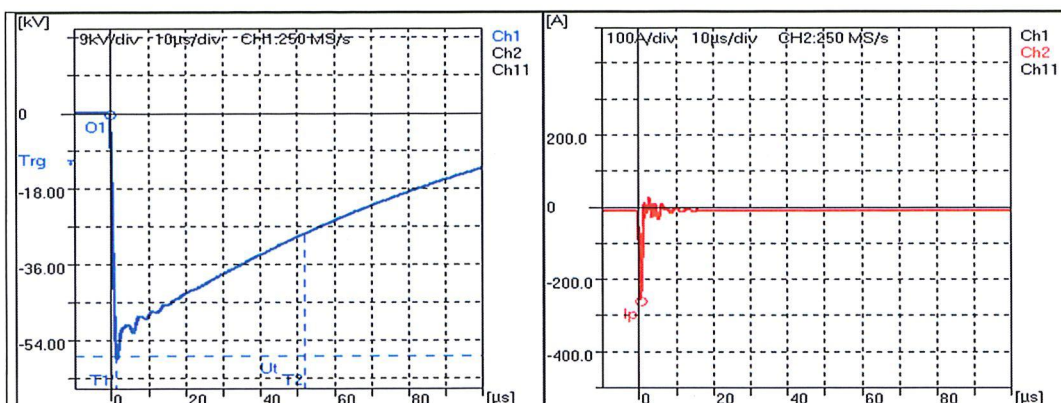


Fig.: 13

Ch1:

$U_t = -57.494$ kV
 $T_1 = 1.321$ μ s
 $T_2 = 52.149$ μ s

Ch2:

$I_p = -258.18$ A

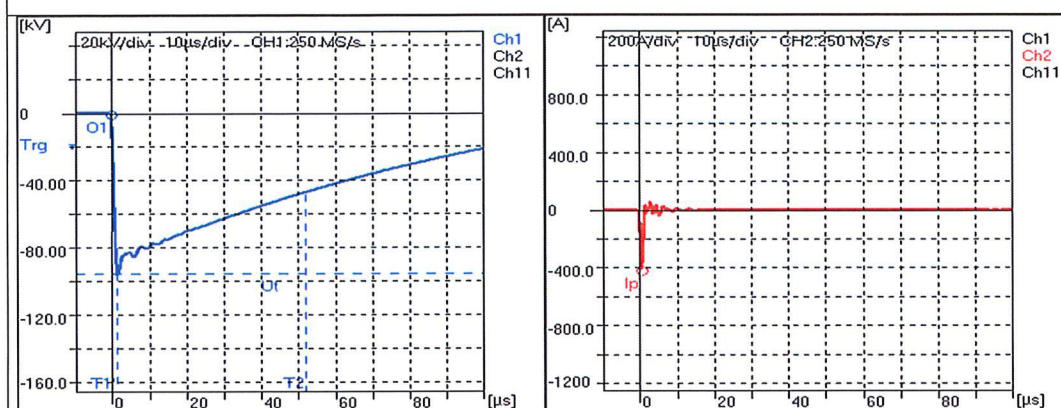


Fig.: 14

Ch1:

$U_t = -94.608$ kV
 $T_1 = 1.311$ μ s
 $T_2 = 52.180$ μ s

Ch2:

$I_p = -408.71$ A

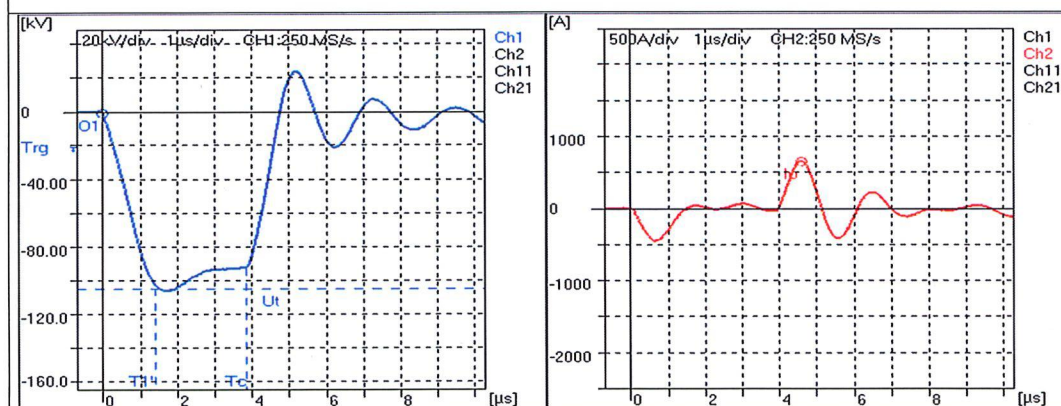


Fig.: 15

Ch1:

$U_t = -104.478$ kV
 $T_1 = 1.413$ μ s
 $T_c = 3.864$ μ s

Ch2:

$I_p = 669.56$ A

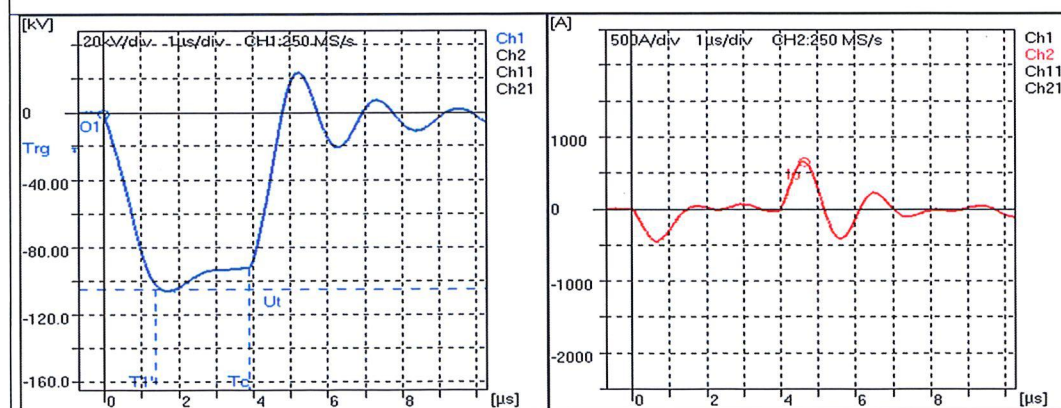


Fig.: 16

Ch1:

$U_t = -104.511$ kV
 $T_1 = 1.412$ μ s
 $T_c = 3.899$ μ s

Ch2:

$I_p = 666.96$ A

Test type: Chopped Wave Lightning Impulse Test
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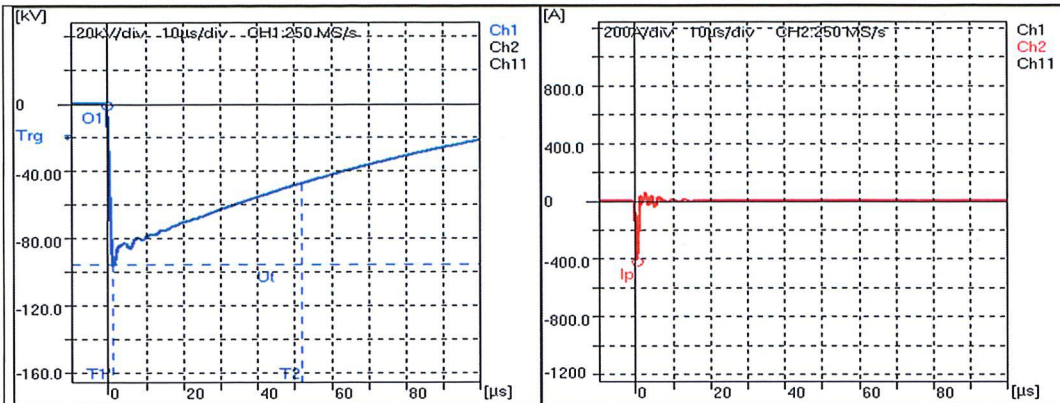


Fig.: 17

Ch1:

$U_t = -94.835$ kV
 $T_1 = 1.317$ μs
 $T_2 = 52.228$ μs

Ch2:

$I_p = -410.23$ A

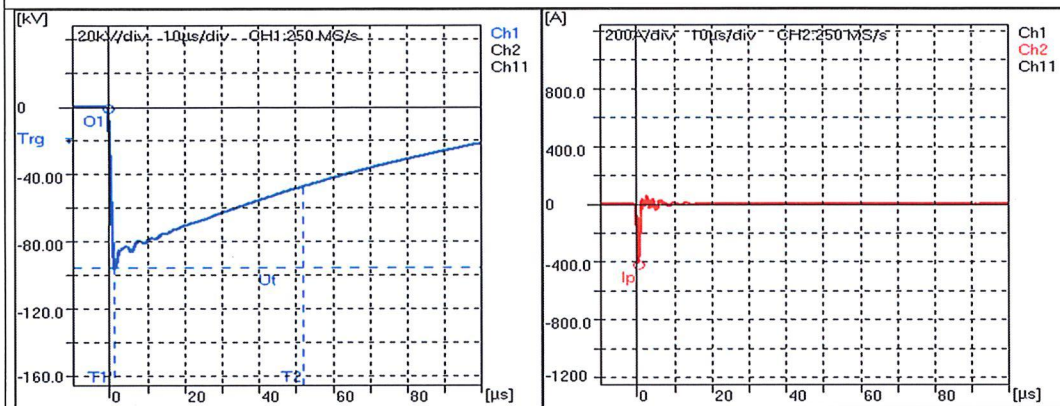


Fig.: 18

Ch1:

$U_t = -94.862$ kV
 $T_1 = 1.314$ μs
 $T_2 = 52.214$ μs

Ch2:

$I_p = -409.93$ A

Test Certificate

N° : 1231675-04

Type : MINERA

Customer :

WPD

Temperature Rise Test (ONAN)

Standard : IEC 60076-2 (2011-02)

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Mach. Nr : 231675-04

Connection : 1U-1V-1W Short-Circuit : 2U-2V-2W

Winding	:		HV	LV
Rated Power	:	(kVA)	1500	1500
Tapping	:		3	
Tap Current	:	(A)	78.73	2000.1
Tap. Voltage	:	(kV)	11	0.433
Measured Load Loss	:	(kW)	10.919	
Measured No-Load Loss	:	(kW)	1.000	
Total Loss	:	(kW)	11.919	

Rated frequency 50 Hz $\pm$ % 0.2

Used Test Equipment:

	Type :	Serial No
Power Analyzer :	YOKOGAWA 2533	49AU1243
Temp. Press. Rec.	FLUKE HYDRA II	8441011
Ohmmeter	RAYTECH WR50-12	283-106
	RAYTECH WR50-12	283--107

Hours	Volt	Amp.	kW	Temperature Values (°C)												Δtk (K)
				Ambients				Oil		HV		LV		Average		
				tm 1	tm 2	tm 3	tm 4	tü 1	tü 2	te	ta	te	ta	tm	tü	
Cold Resistances				23.4	23.5	23.6	23.4	25.0	-	23.9	23.6	24.2	23.5	23.5	25.0	1.5
15:00	691	86.8	12.2	23.5	23.6	23.8	23.5	36.3	-	29.6	24.7	31.7	24.2	23.6	36.3	12.7
16:00	674	84.6	12.0	24.0	24.3	24.4	24.4	48.9	-	42.9	33.4	44.7	33.3	24.3	48.9	24.6
17:00	664	83.3	11.9	24.4	24.6	24.7	24.3	58.9	-	51.5	38.7	53.0	38.7	24.5	58.9	34.4
18:00	668	83.8	12.2	24.4	24.7	24.9	24.3	64.8	-	57.0	43.0	58.5	43.0	24.6	64.8	40.2
19:00	657	82.4	11.9	24.6	24.8	25.0	24.4	69.6	-	60.9	46.0	62.4	46.0	24.7	69.6	44.9
20:00	658	82.4	12.0	24.4	24.6	24.9	24.2	72.8	-	63.8	47.9	65.2	48.0	24.5	72.8	48.3
21:00	653	81.9	11.9	23.9	23.9	24.4	23.5	74.9	-	65.3	49.0	66.9	49.1	23.9	74.9	51.0
22:00	652	81.7	11.9	24.1	24.3	24.7	23.9	76.5	-	67.0	50.5	68.5	50.5	24.3	76.5	52.3
23:00	655	82.0	12.0	23.7	23.7	24.0	23.0	78.0	-	67.5	50.1	69.4	50.2	23.6	78.0	54.4
00:00	655	81.9	12.0	23.1	23.0	23.5	22.4	78.6	-	68.3	51.3	70.2	51.2	23.0	78.6	55.6
01:00	647	80.9	11.7	22.5	22.4	22.9	21.7	79.1	-	68.7	50.9	70.4	51.8	22.4	79.1	56.7
02:00	654	81.9	12.1	23.1	23.4	23.6	22.8	79.9	-	69.6	53.1	71.4	53.2	23.2	79.9	56.7
03:00	650	81.4	11.9	23.6	23.8	24.0	23.3	80.7	-	70.4	53.4	72.2	53.3	23.7	80.7	57.0
04:00	648	81.1	11.8	23.8	24.0	24.3	23.5	81.5	-	70.8	53.6	72.6	53.8	23.9	81.5	57.6
05:00	646	80.8	11.7	23.9	24.0	24.3	23.5	81.8	-	70.9	53.6	72.9	53.6	23.9	81.8	57.9
06:00	655	81.9	12.1	23.8	24.0	24.3	23.4	81.8	-	71.0	53.6	72.7	53.7	23.9	81.8	57.9
07:00	646	80.8	11.8	23.8	24.0	24.3	23.4	81.9	-	71.2	53.7	73.0	53.8	23.9	81.9	58.0
08:00	655	81.9	12.1	24.1	24.2	24.6	23.7	82.1	-	71.5	54.5	73.2	54.1	24.2	82.1	58.0
Supplied with rated current.																
08:00	629	78.8	11.2	24.1	24.2	24.6	23.7	82.1	-	71.5	54.5	73.2	54.1	24.2	82.1	58.0
09:00	627	78.4	11.1	23.7	23.7	24.3	23.2	81.4	-	70.9	53.5	72.5	53.7	23.7	81.4	57.7
HV and LV winding resistances have been measured.																
Temperature values have been recorded after winding resistance measurement																
09:25	-	-	-	23.9	24.0	24.5	23.6	80.1	-	68.4	49.8	70.9	51.2	24.0	80.1	56.1

Notice:

tm1. tm2 . tm3 .tm4 : Ambient temperatures
tü1. tü2 : Top oil temperature
te : Radiators upper temperature
ta : Radiators lower temperature

Tested by : D.SENCİ
Test Engineer

Checked by : H.SEVİL
Test Team Leader

Customer or Representative :

Revision No : -

Date : 09.05.2022

Date : 09.05.2022

Date :

Test Certificate

N° : I231675-04

Type : MINERA

Customer :

WPD

Temperature Rise Test (ONAN)

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Mach. Nr : 231675-04

Standard : IEC 60076-2 (2011-02)

Cold Resistances measurements :1U - 1V : 0.4117 Ω 2U - 2V : 0.6780 m Ω Hot Resistances measurements : (Extrapolated values)1U - 1V : 0.5077 Ω 2U - 2V : 0.8367 m Ω θ_1) Average winding temp. at the beginning of the test:

$$\frac{25.0 + (23.6 + 23.5) / 2}{2} = 24.3 \text{ }^{\circ}\text{C}$$

 θ_{om1}) Ave. oil temp.at the end of the first part of the test:

$$\frac{82.1 + (54.5 + 54.1) / 2}{2} = 68.2 \text{ }^{\circ}\text{C}$$

 θ_{om2}) Ave. oil temp. at the end of the sec. part of the test :

$$\frac{81.4 + (53.5 + 53.7) / 2}{2} = 67.5 \text{ }^{\circ}\text{C}$$

 θ_{om3}) Ave. oil temp. at the end of the cooling curve :

$$\frac{80.1 + (49.8 + 51.2) / 2}{2} = 65.3 \text{ }^{\circ}\text{C}$$

 $\Delta\theta_{fm}$) Fall of the temperature of ave.oil during the 1 h test at rated current : ($\theta_{om1} - \theta_{om2}$) : 68.2 - 67.5 = 0.7 KCALCULATION OF HV WINDING TEMPERATURE RISE : θ_{2HV}) Ave. winding temperature at the end of the test :

$$T_2 = \frac{0.5077}{0.4117} (225 + 24.3) - 225 = 82.4 \text{ }^{\circ}\text{C}$$

gHV) Ave. winding to ave. oil temperature gradient:

$$(\theta_{2HV} - \theta_{om2}) : 82.4 - 67.5 = 14.9 \text{ K}$$

 θ_a) External cooling medium temperature at the end of the first part of the test :

$$\theta_a = 24.2 \text{ }^{\circ}\text{C}$$

 $\Delta\theta_{wHV}$) Ave. winding temperature rise :

$$(\theta_{2HV} + \Delta\theta_{fm} - \theta_a) : 82.4 + 0.7 - 24.2 = 59.0 \text{ K}$$

CALCULATION OF LV WINDING TEMPERATURE RISE : θ_{2LV}) Ave. winding temperature at the end of the test :

$$T_2 = \frac{0.8367}{0.6780} (225 + 24.3) - 225 = 82.6 \text{ }^{\circ}\text{C}$$

gLV) Ave. winding to ave. oil temperature gradient:

$$(\theta_{2LV} - \theta_{om2}) : 82.6 - 67.5 = 15.1 \text{ K}$$

 $\Delta\theta_{wLV}$) Ave. winding temperature rise :

$$(\theta_{2LV} + \Delta\theta_{fm} - \theta_a) : 82.6 + 0.7 - 24.2 = 59.2 \text{ K}$$

Test Result : ONAN

	Guaranted	Measured	Result
Oil Temperature Rise	: 60 K	58.0 K	PASSED
Winding Temperature Rise	: HV 65 K	59.0 K	PASSED
	: LV 65 K	59.2 K	PASSED

Tested by : D.SENCİ
Test EngineerChecked by : H.SEVİL
Test Team Leader

Customer or Representative :

Revision No : -

Date : 09.05.2022

Date : 09.05.2022

Date :

Test Certificate**N° : I231675-04**

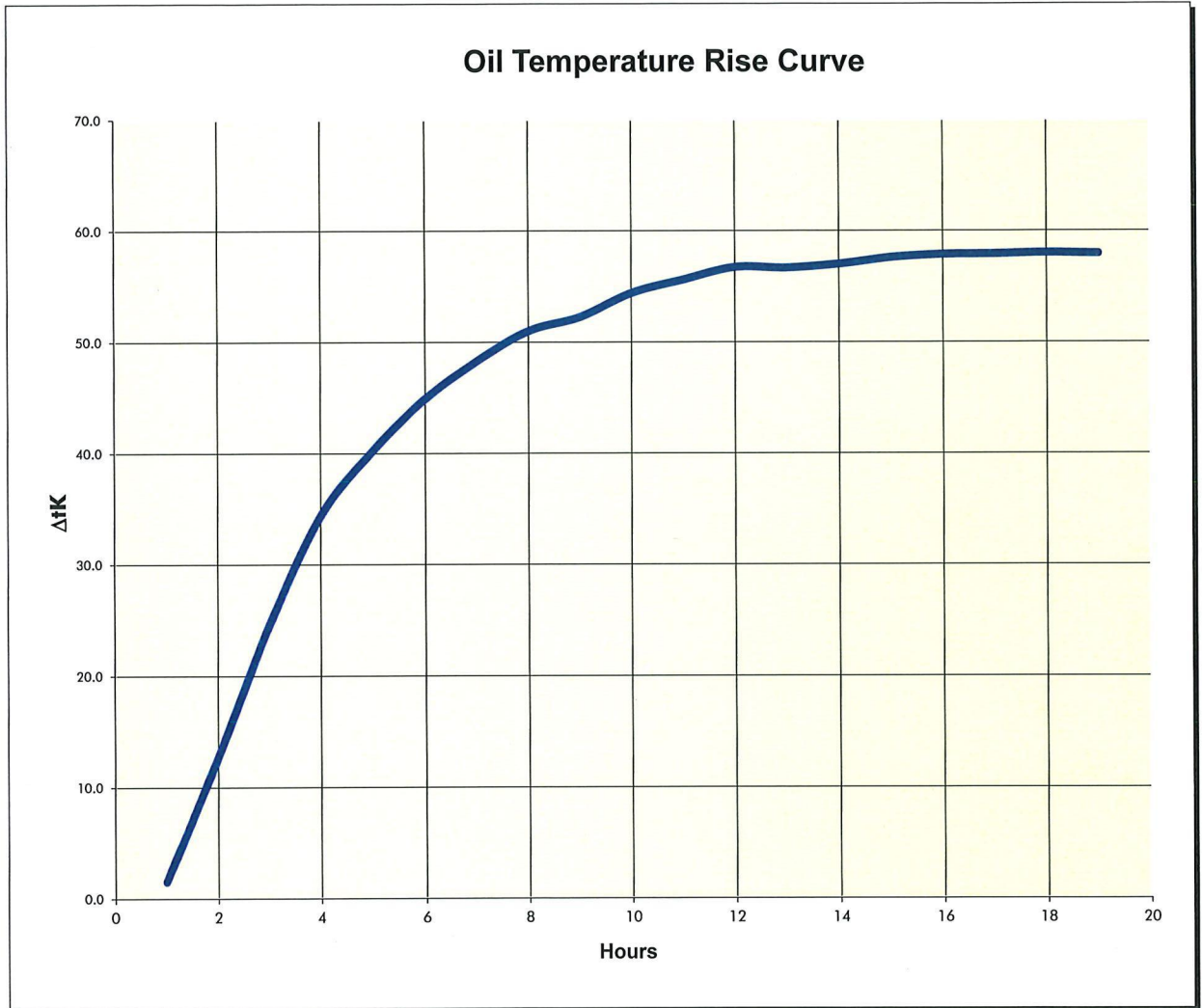
Type : MINERA

Customer :

WPD

Temperature Rise Test (ONAN)

Standard : IEC 60076-2 (2011-02)

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Mach. Nr : 231675-04Tested by : D.SENCİ
Test EngineerChecked by : H.SEVİL
Test Team Leader

Customer or Representative :

Revision No : -

Date : 09.05.2022

Date : 09.05.2022

Date :

Test Certificate

N° : I231675-04

Type : MINERA

Customer :

WPD

Temperature Rise Test (ONAN)

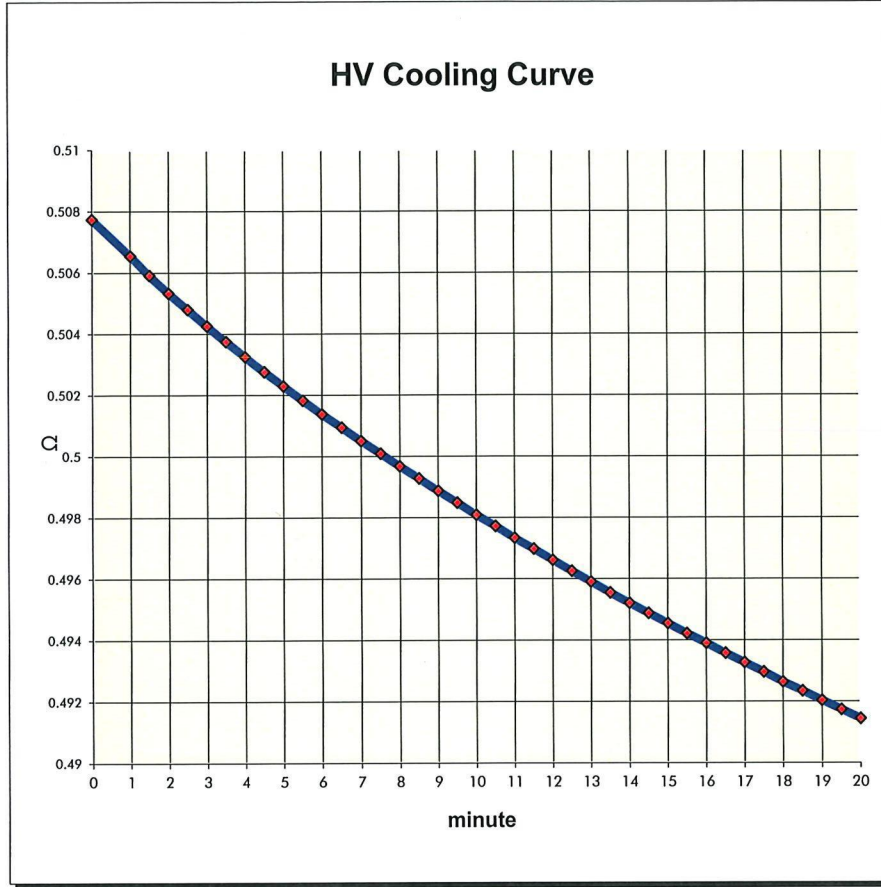
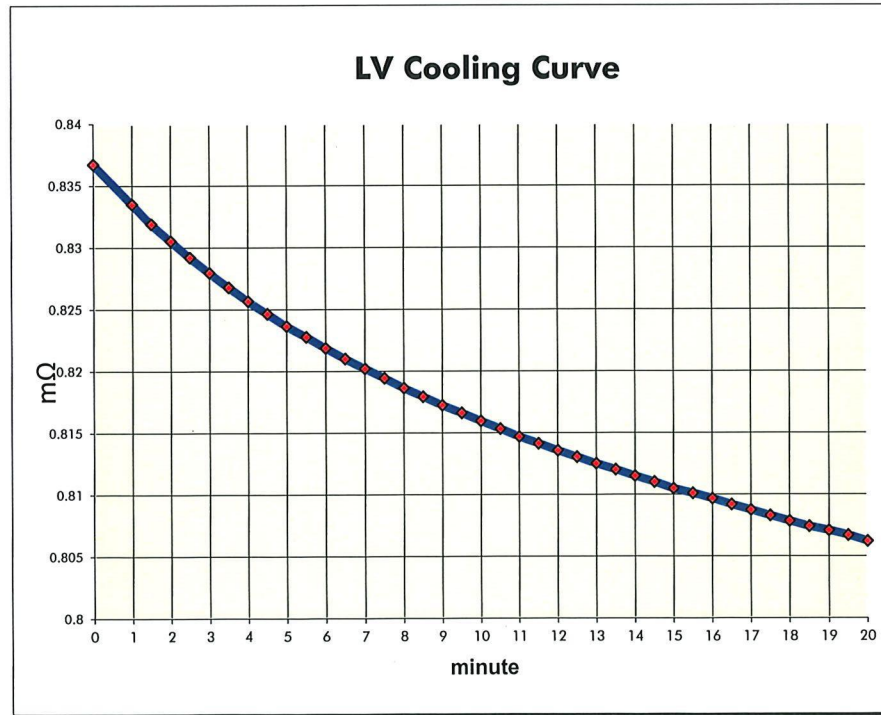
Standard : IEC 60076-2 (2011-02)

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Mach. Nr : 231675-04

Cooling curves :

$R_{HV} = 0.5077 \Omega$ $R_{LV} = 0.8367 m\Omega$



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Test Engineer

Checked by : H.SEVİL
Test Team Leader

Customer or Representative :

Revision No : -

Date : 09.05.2022

Date : 09.05.2022

Date :

Test Certificate

N°: 1231675-04

Type : MINERA

Customer :

WPD

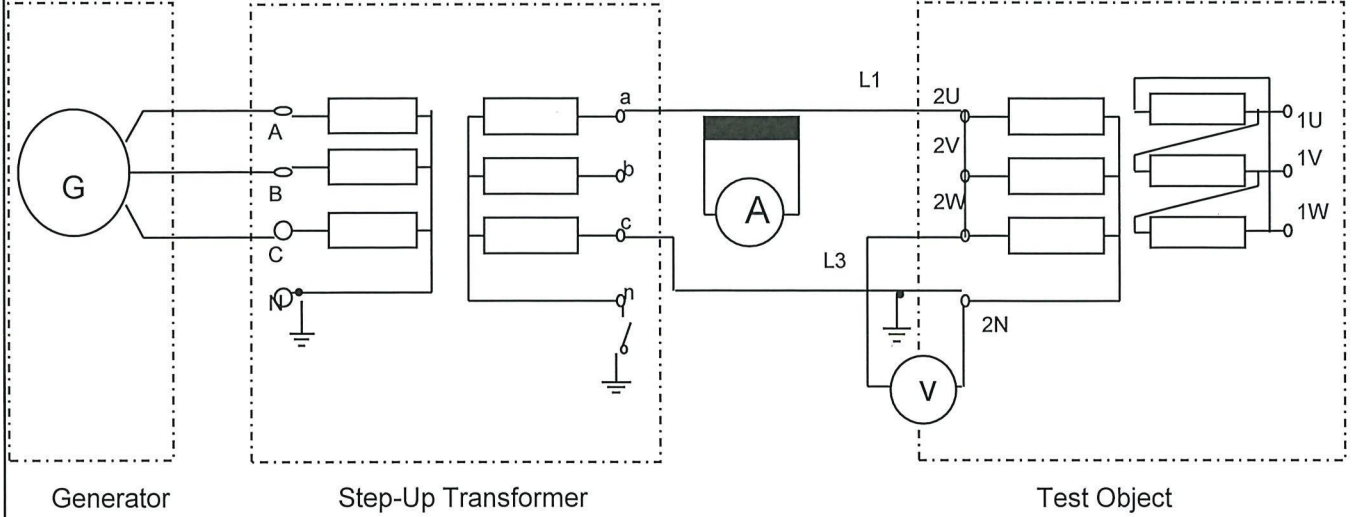
Measurement of Zero Sequence

Fb Nr : 231675

Mach. Nr : 231675-04

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Standard IEC 60076-1§11.6

Test Circuit :Formula :

$$z_0 = 3 \times \frac{\text{Test Voltage}}{\text{Test Current}} \quad (\Omega/\text{Ph})$$

$$z_0 \% = z_0 \times \frac{\text{Tap Current}}{\text{Tap Voltage}^{\sqrt{3}}} \times 100$$

Tap Current : 2000.1 Amps

Tap Voltage / : 433 Volts

Test Values :

HV Tap.	Neutral Current (A)	Phase-Neutral Voltage (V)	Z0 Ω/Ph	Z0 %
1	430.18	1.155	0.008	6.44
3	423.47	1.109	0.008	6.29
5	425.01	1.089	0.008	6.15

Used Test Equipments : Test Lab.: ODT

Power Analyser : YOKOGAWA WT3000

Serial No : 91KB11116

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Test Engineer :

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N°: A231675-04

Type : MINERA

Measurement of no-load harmonics

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Customer :

WPD

Fb Nr : 231675

Mach. Nr : 231675-04

Standard: -

Transformer supplied with rated voltage from LV side.

Current Harmonics :

Phase	Voltage (V)	I ₀ (A)	3 rd Harmonic	5 th Harmonic	7 th Harmonic	9 th Harmonic
			I ₀₃ / I _{0N} (%)	I ₀₅ / I _{0N} (%)	I ₀₇ / I _{0N} (%)	I ₀₉ / I _{0N} (%)
2U	433/√3	2.305	7.436	9.706	3.932	0.186
2V	433/√3	1.521	28.633	12.226	5.536	0.090
2W	433/√3	2.490	12.346	9.826	3.701	0.176

Voltage Harmonics :

Phase	Voltage (V)	3 rd Harmonic	5 th Harmonic	7 th Harmonic	9 th Harmonic
		V ₃ / V _N (%)	V ₅ / V _N (%)	V ₇ / V _N (%)	V ₉ / V _N (%)
2U	433/√3	0.097	1.001	1.018	0.019
2V	433/√3	0.219	1.026	1.010	0.020
2W	433/√3	0.199	1.020	1.020	0.022

Used Test Equipment: Test Lab.: ODT

Power Analyser : YOKOGOWA WT3000

Serial Number : 91KB11116

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