University of Tehran

High Voltage Laboratory

Test Report

No:00H313

Temperature rise test of 20/0.9 kV, 4000 kVA oil-immersed transformer
Kian Transfo Ind. Production

Test Report No: 00H313

Test Object:	**Transformer 20/0.9 kV, 4000 kVA**
Serial number:	**14002073**
Cooling type:	**ONAF**
Manufacturer:	**Kian Transfo Industries**
Test Performed on order of:	**Ahar Power Station Services**
Test Scope:	Temperature rise test
Test Procedure:	According to standard IEC 60076-2:2011
Test Object Supplied on:	26-02-2022
Test Performed During:	02-03-2022 ~ 03-03-2022
Test Result:	Indicated in Report The test result refers to the tested object only.

Test participants:

Mr. Bayati	FASBA Co.
Mr. Maghami	FASBA Co.
Mr. Pourghasemi	Ahar Power Station Services
Mr Jokar	Kian Transfo Ind.
Mr.Hasemi	Kian Transfo Ind.
Mr. Hosseini	Kian Transfo Ind.

High Voltage Laboratory Participants:

Test leader: **S. Mohseni**

Head of Laboratory: **A.A. Shayegani Akmal**

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Tehran, 03 March 2022

Temperature rise test of transformer 20/0.9 kV, 4000 kVA, Kian Transfo Ind. production

Picture No.1: Test object at high voltage laboratory, University of Tehran

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1. Description of test object

The test object was 20/0.9 kV, 4000 kVA oil immersed transformer, serial number: 14002073, manufactured by the Kian Transfo Industries (Iran).
The drawings of the transformer are shown in annex to this report.

2. Scope of tests agreed upon

The accepted testing method was conforming to international standards:
IEC 60076-1 “Power transformer, Part1: General”
IEC 60076-2 “Power transformer, Part2: Temperature rise”

3. Measurements of winding resistance

This arrangement was composed of a DC resistance tester. The scheme is shown on Figure 1. The winding under test has been supplied with constant current and the voltage drop has been measured. Then the resistance of winding has been calculated.

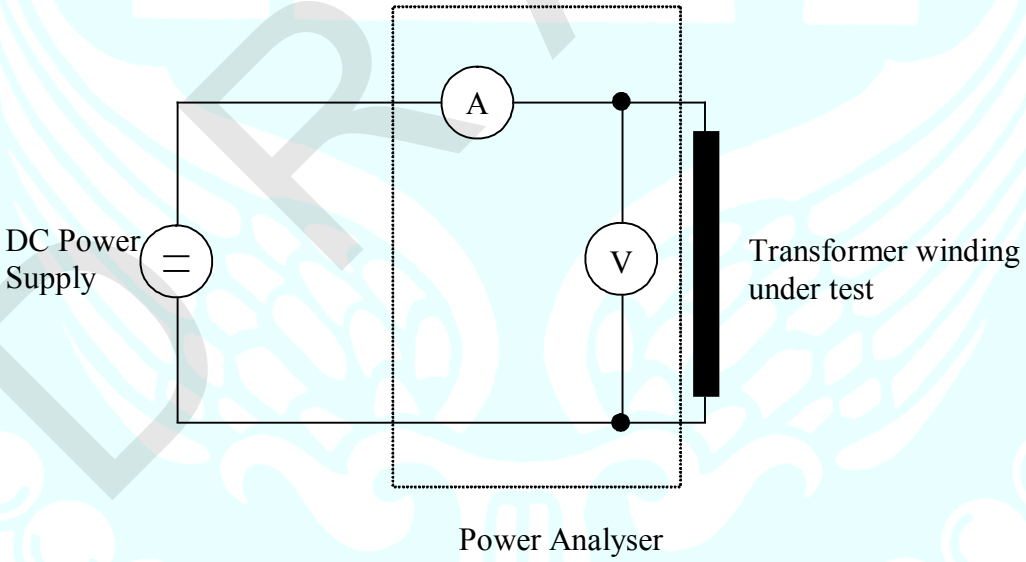


Figure 1: Scheme of measurements of winding resistance

Phase	LV (mΩ)	HV (mΩ)
UV	1.296	704.0
VW	1.362	707.0
WU	1.342	707.1

Table 1: Winding resistance measured at 20°C

4. Temperature-rise test

The purpose is to check that the temperature rises of the oil and windings do not exceed the limits agreed on or specified by the standards.

The supply and measuring facilities as well as the measuring circuits are the same as in the load loss measurement and in the measurement of winding resistance.

This arrangement was composed of a power analyzer NORMA 4000 which measures the 3 phase voltages, 3 phase currents and 3 phase active and reactive power, an autotransformer and 8 thermometers. A thermometer has been fitted on the top of the tank of the transformer (θ_0). 4 thermometers have been installed according IEC60076-2 around of the transformer under the radiators(θ_1, θ_2, θ_3, θ_4). And a thermometer for the bottom liquid temperature (θ_b).

Top oil temperature: θ_0

Average oil temperature (θ_{om}): $(\theta_0+\theta_b)/2$

Ambient temperature (θ_a): $(\theta_1+\theta_2+\theta_3+\theta_4)/4$

Average Windings temperature: θ_w

Top oil temperature rise: $\theta_0-\theta_a$

Average Windings temperature rise ($\Delta\theta_w$): $\theta_w-\theta_a$

Test performed with reduced loss in the range of standard and the measured temperature values are be corrected according to the 7.13 IEC 60076-2. When the top oil temperature rise has been established, the circuit interrupted and the resistances of the windings measured.

The scheme is shown on Figure 2.

Note: If the specified values of power or current have not been obtained during the test, the result shall be corrected according to the following relations. They are valid within a range of ±20% from target of power and ±10% from target value of current. By agreement they may be applied over a wider range.

The oil temperature rise above ambient during the test is multiplied by (for medium and large power transformers (ONAN or ONAF)):

$$\left[\frac{\text{total losses}}{\text{test losses}}\right]^{0.9}$$

The average winding temperature rise over average liquid temperature at shutdown shall be multiplied by:

$$\left[\frac{\text{Rated current}}{\text{test current}}\right]^{1.6}$$

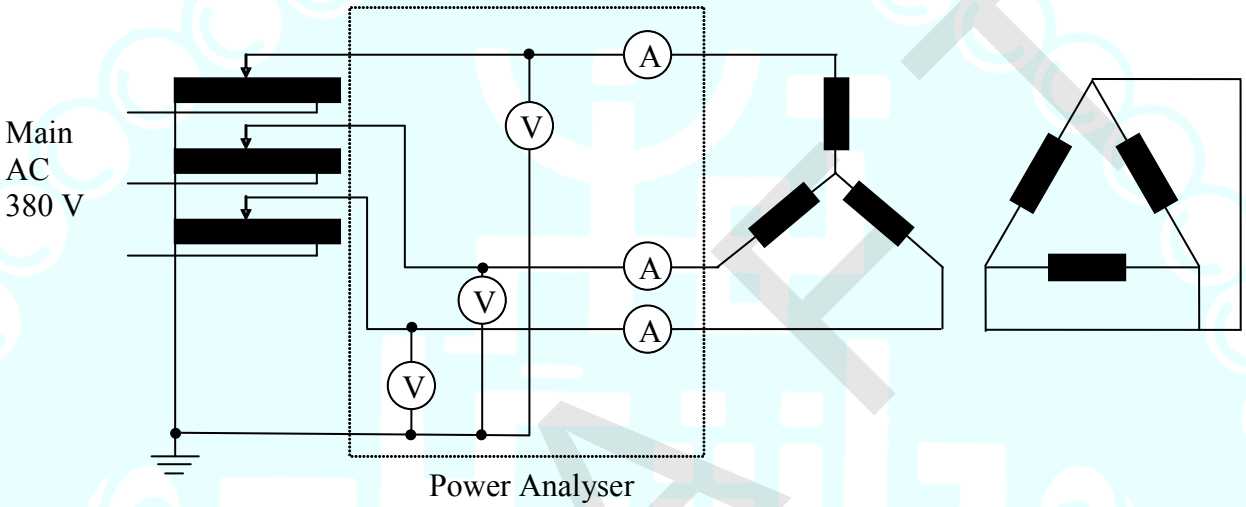


Figure2: Scheme of measurements of short circuit impedance, load loss and temperature rise test

Picture No.2: Test object at high voltage laboratory, University of Tehran

Cooling type: **ONAF**	
P_0+P_k=3.851+37.19 kW = 41.04 kW(at 75°C)	P_{feed}=34 kW
Ambient temperature	23.9°C

Oil temperature rise:

Top oil temperature	68.0°C
Top oil temperature rise	44.1°C
Top oil temperature rise (injected loss power correction)	**52.2°C**
Average oil temperature	58.6°C
Average oil temperature rise	34.7°C

Cooling medium temperature	23. 9°C

HV Winding temperature rise:

Measured HV resistance at highest temperature rise	850.4 mΩ
Average oil temperature	58.6°C
Measured HV resistance at initial temperature (19°C)	701.2 Ω
Average Windings temperature	73.1°C
Average Windings temperature (injected current correction)	74.5°C
Average Windings temperature rise (injected current correction)	**50.6°C**

Calculation of average winding Temperature:

$$\frac{235+\theta}{235+19}=\frac{850.4}{701.2}=1.2128$$

$$\theta=73.1\,°C$$

$$(73.1-58.6)(\frac{115.5}{109})^{1.6}=15.9$$

Guaranteed average winding temperature rise: 55 °C

Guaranteed top oil temperature rise: 50 °C

LV Winding temperature rise:

Measured LV resistance at highest temperature rise	1.582 mΩ
Average oil temperature	58.6°C
Measured LV resistance at initial temperature (19°C)	1.291 mΩ
Average Windings temperature	76.2°C
Average Windings temperature (injected current correction)	77.9°C
Average Windings temperature rise (injected current correction)	**54.0 °C**

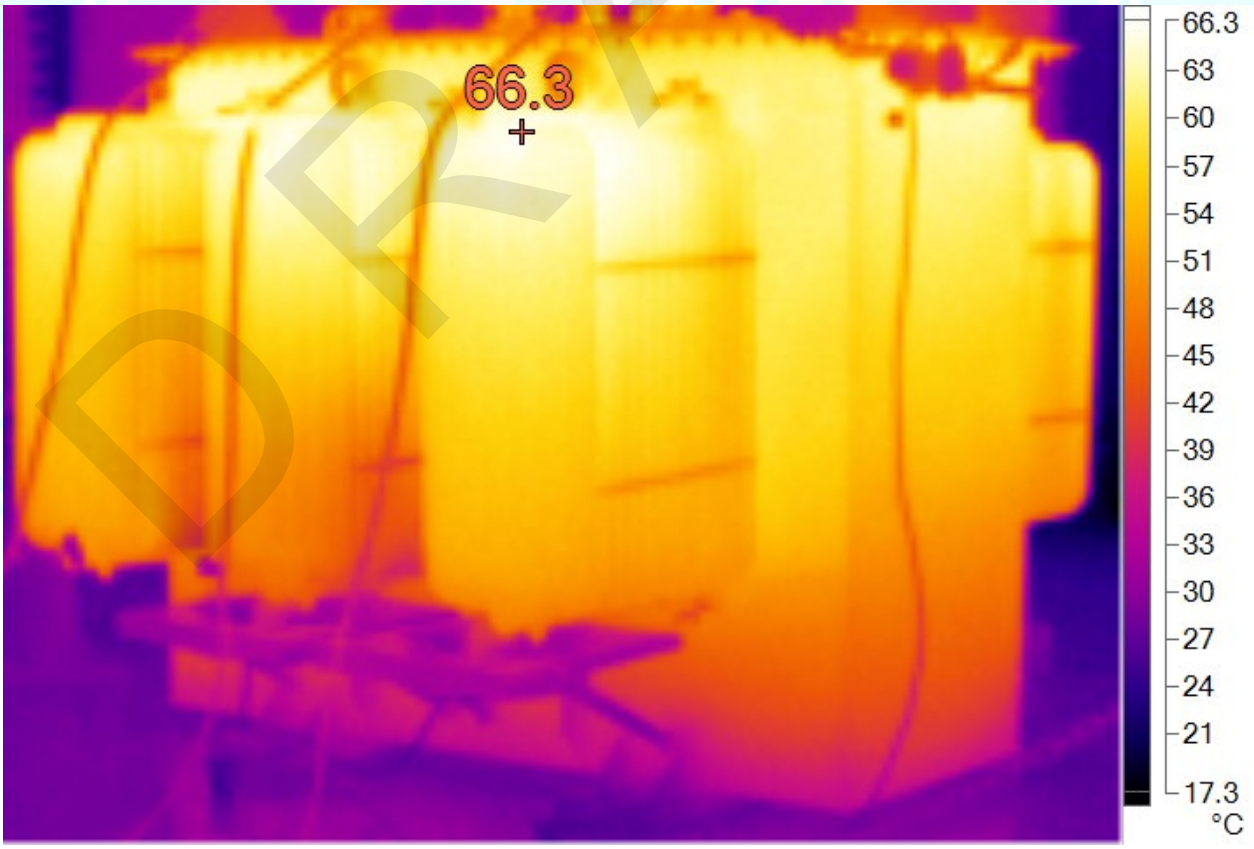
Calculation of average winding Temperature:

$$\frac{235+\theta}{235+19}=\frac{1.582}{1.291}=1.225$$

$$\theta = 76.2\,^{\circ}\mathrm{C}$$

$$(76.2-58.6)\left(\frac{115.5}{109}\right)^{1.6}=19.3$$

Guaranteed average winding temperature rise: 55 °C

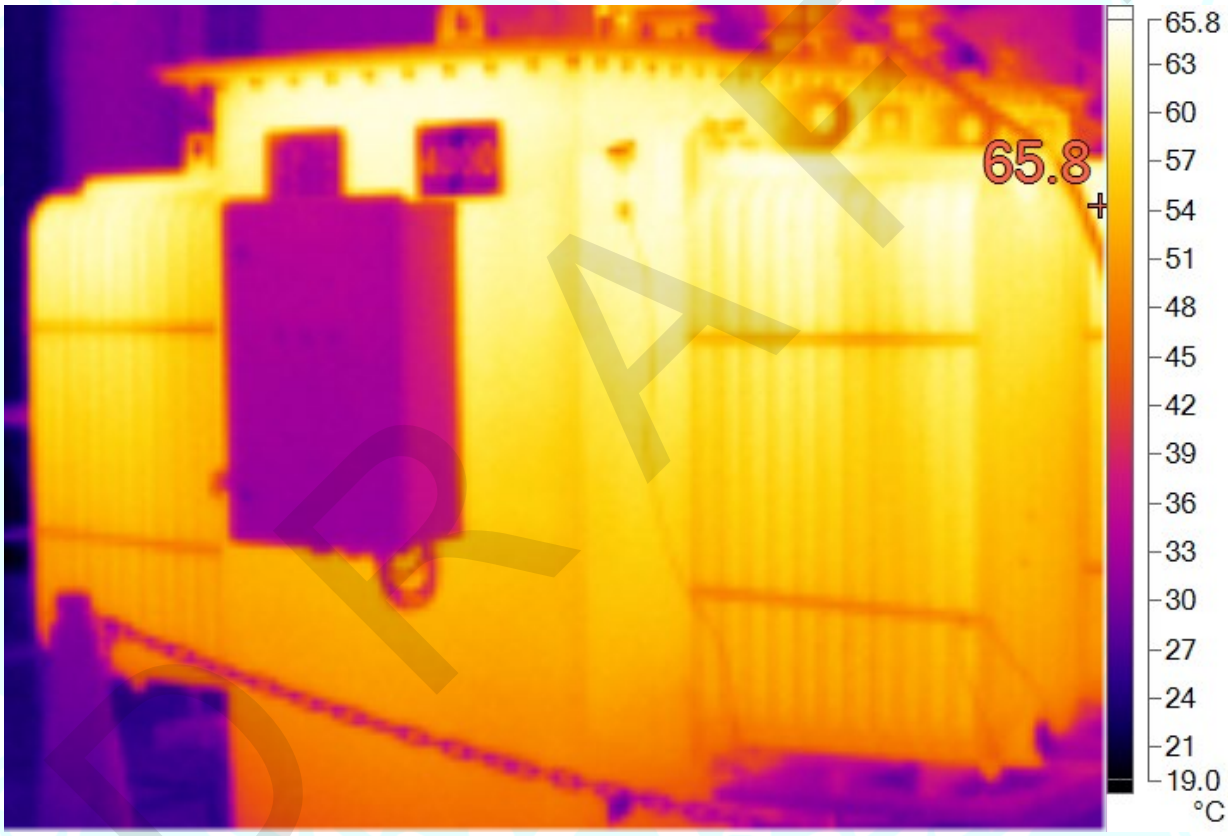


Picture No. 3: Thermal image of transformer

5. Summery

Winding temperature rise test is PASSED

Note: In IEC 60076-7, it is stated that the top-oil temperature limit for the normal cyclic loading of transformers is 105°C. Therefore, the temperature rise of 52.2°C for the top-oil (top-oil equals to 102.2°C by considering 50°C for the environment) might be accepted in this case.



Picture No. 4: Thermal image of transformer

Annex 1
Drawing supplied by the manufacture