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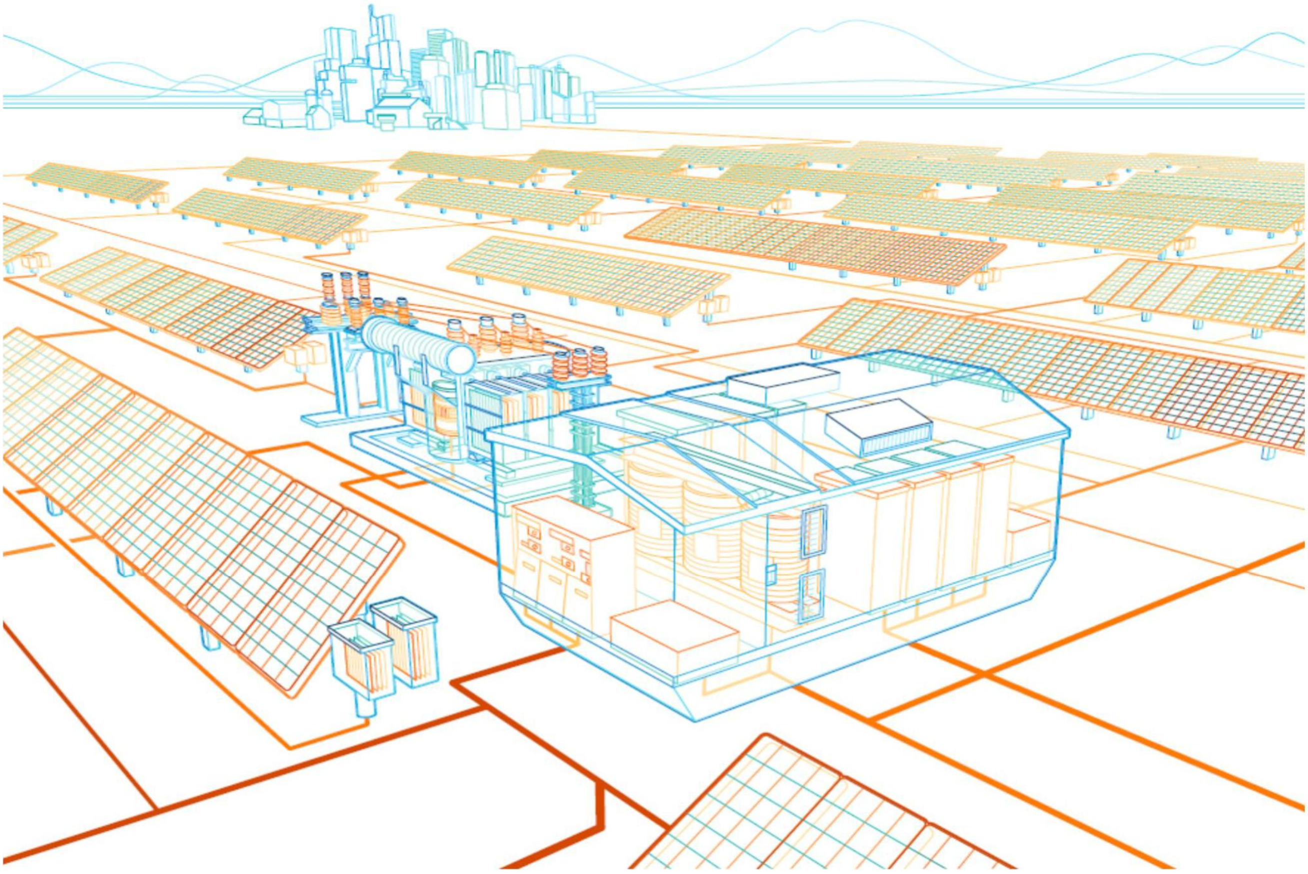
LIST OF DELIVERABLES



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Power and productivity
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Table of contents

1 Transfromer Datasheet

Technical Specification - Item 250 (13Q2141565)

Characteristic

Product name		Liquid-Filled Groundmount Transformer; 3PH, 2200 kVA, HV 23000D , LV 400yn x 400yn
Country of origin		Turkey
Rated power	[kVA]	2200
Insulation Liquid		Mineral Oil
High voltage	[V]	23000
High voltage tappings (DETC)		+2 -2 2.5%
Low voltage at no load	[V]	400(400)
High voltage insulation level	[kV]	LI 170 / AC 70 / Um 36
Low voltage insulation level	[kV]	LI - / AC 3 / Um 1.1
Frequency	[Hz]	50
Number of phases		3
Vector group		Dyn11yn11
Ambient temperature max./monthly/annual average	°C	50 / 40 / 30
Max. average temperature rise (Oil/Winding)	[C/C]	50 / 55
Surface treatment		Painted, RAL 7033, C4-M
Altitude (a.s.l.)	[m]	<1600
Location		Indoor/Outdoor

Performance values

Standards		IEC 60076
Impedance	[%]	6(+-10%)
No load losses	[W]	2300(+15%)
Load losses at 75 °C	[W]	20000(+15%)

Preliminary dimensions and weight

Length	[mm]	2197
Width	[mm]	1976
Height	[mm]	2450
Roller distance (c/c)	[mm]	1070 x 1070
Oil Weight	[kg]	1343
Total weight	[kg]	6247

Type of design

Tank construction	Corrugation, Hermetically sealed
Cooling	ONAN
High voltage winding conductor material	Al
Low voltage winding conductor material	Al

Standard Features/Accessories - Item 250

Off-Load Tap Changer
DIN type and LV bushings (please see attached catalogue page)
Euromold Plug-in Bushing (750S1+MK600+GASKET please see attached catalogue page)
Locking Device for Plug-in Bushing
LV Cable Box Standard
Wheels
RIS Integrated Safety Detector
Pressure Relief Valve

2 Introduction

In the following sections, testing procedures for Distribution Transformers are explained in detailed manner.

The electrical characteristics and dielectric strength of transformers are checked by means of measurements and tests defined by standards.

Unless otherwise is contracted, tests are carried in accordance with IEC60076.

For transformers with a high voltage winding having Um (highest voltage for equipment) equal and smaller than 72,5kV, tests are distinguished in IEC60076-1 as

Routine Tests:

- Verification of voltage ratio and vector group
- Measurement of winding resistance
- Measuring the short-circuit impedance and the load loss
- Measuring the no-load loss and no-load current
- Short duration AC (ACSD) / Induced voltage test
- Separate source AC withstand voltage test / Applied voltage test
- Tests on on-load tap changer, where appropriate

Type Tests:

- Temperature Rise Test
- Lightning Impulse (LI) Test

Special Tests:

- Determination of capacitances windings-to-earth and between windings and dissipation factor (tan δ) measurement
- Measurement of zero sequence impedance
- Determination of sound levels
- Measurement of harmonics of the no-load current
- Measurement of insulation resistances *

* Different from IEC60076, measurement of insulation resistance is performed as a routine test for each individual transformer.

3 Verification of voltage ratio and vector group

The voltage ratio of the transformers is the ratio of voltages (in 3-phase transformers line to line voltages) at no load.

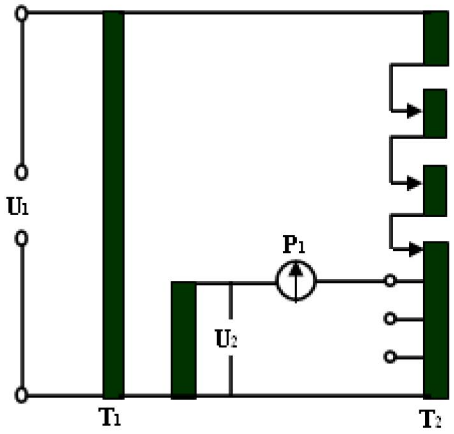
3.1 Test purpose

The purpose of the measurement is to check that the deviation of the voltage ratio from the specified value dos not exceed the limit of ±0.5% (acc. to IEC60076-1)

Measuring the voltage ratio and the vector group are of interest because of their bearing on the parallel operation of two or more transformers.

3.2 Test Method

The voltage ratio is determined by using voltage ratio measuring bridge. The supply voltage is 220V AC. The function of the bridge is shown in Figure 1. The voltages of the transformer to be checked are compared to the corresponding voltages of the regulating transformer, which is provided with a decade display unit and located in the bridge casing. When the bridge is balanced, the voltage ratio of the decade transformer is equal to that of the transformer under test. The result can be seen directly from the numeral display of the bridge.



T1 = Transformer to be measured
T2 = Regulating transformer equipped with a decade display
P1 = Zero indicating voltmeter
U1 = Supply voltage of the bridge
U2 = Secondary voltage of the transformer

Figure 1 Bridge measurement of voltage ratio

Since the measuring device is the single-phase bridge, the voltage ratio of a pair of windings mounted on the same leg is measured at time. It is to be observed that the ratio indicated by the bridge does not always correspond to the ratio of the line-to-line voltages. The result depends on the connection symbol of the transformer. For each winding connected to the bridge it is important to observe whether the number of turns relates to the line-to-line or line-to-neutral voltage.

For example, the voltage ratio of a 33/0,415kV Yd-connected transformer is 33/√3/10.5=45.90978. The reading obtained from the bridge is to be compared to this value.

The connection symbol of the transformer is checked in conjunction with the voltage ratio measurement. When the measuring leads from the transformer are connected to the bridge according to the relevant vector diagram the bridge can be balanced only if the transformer connection is correct.

The voltage ratios are measured for each tapping of the transformer.

In the test report, the connection symbol, the specified tapping voltage ratios and the deviations of the measured ratios from these values are stated.

4 Measurement of winding resistance

Winding resistance is the DC-resistance of a winding in ohms.

4.1 Test purpose

The measured resistances are needed in connection with the load loss measurement when the load losses are corrected to correspond to the reference temperature. The resistance measurement also shows whether the joints are in order and the windings correctly connected.

4.2 Test method

Before the measurement starts the transformer should be standing for 3 hours filled with oil and without excitation. This period is needed to equalize the temperature differences of the transformer and to equalize the oil temperature and winding temperature. The average winding temperature is obtained by determining the average oil temperature.

Measurement is performed by voltmeter-ammeter method. Simultaneous readings of current and voltage are taken via digital data acquisition system.

When switching on the supply voltage E to the measuring circuit the winding inductance L tends to resist the increase of current. The rate of increase depends on the time constant of the circuit:

$$I = \frac{E}{R}\left(1 - e^{-\frac{Rt}{L}}\right)$$

t = time from switch on
L/R = time constant of the circuit
R = total resistance of the circuit

To shorten the time for the current to become steady so high a measuring current is used that the core will be saturated and the inductance will be low. The measuring current is usually 5…10 times the no-load current of the winding. However, the current should be less than 10% of the rated current of the winding; otherwise the temperature rise of the winding caused by the measuring current will give rise to measuring errors. Furthermore the time constant can be reduced by using as high a supply voltage as possible enabling an increased series resistance in the circuit.

After switching on the DC voltage source, micrometer may show overload at first. When the core is saturated the current starts to increase through selected value. When a steady resistance value is reached it is recorded as a winding resistance.

In the report, the terminals between which resistances are measured, the tapping position and the average temperature of the windings during the measurement are stated.

5 Measuring the short-circuit voltage impedance and the load loss

Short circuit voltage is the AC voltage that must be connected to one pair of terminals of a transformer with another pair of terminals shorted, which causes rated current to flow on the two sides of the transformer. The absorbed active power corresponds to the transformer load loss.

5.1 Test purpose

This measurement is carried out to determine the load losses of the transformer and the impedance voltage at rated frequency and rated current.

Current is generally supplied to the HV winding and the LV winding is short circuited.

5.2 Test Method

The voltage of the supply generator is raised until the current has attained the required value (25%...100% of the rated current according to the IEC60076). If the reactive power supplied by the generator is not sufficient, a capacitor bank is used to compensate part of the inductive reactive power taken by the transformer.

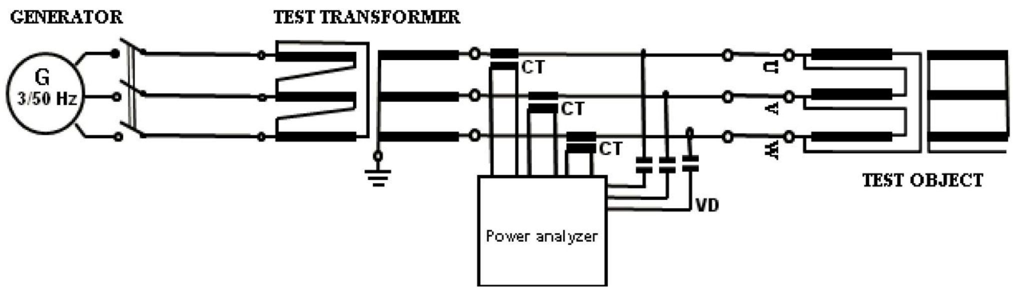


Figure 2 Measurement of short circuit voltage impedance and load loss

The readings have to be taken as quick as possible, because the windings tend to warm up due to the current and the loss values obtained in the measurement. For transformer having voltage difference between taps is greater than 5%, measurements are performed on the principal and extreme taps.

If it has not been possible to take readings at exactly the rated current, correction to the rated will be made according to:

$$Ukr = \frac{In}{Im} \times Ukm \qquad (1)$$

$$Pn = \left(\frac{In}{Im}\right)^2 \times Pm \qquad (2)$$

m = subscript for measured value
n = subscript for rated value
Uk = impedance voltage
I = line current
P = power

The separation of the impedances and the determination of the impedance voltages are made with equations (3) and (4):

$$Ur = \frac{Pn}{Un.In.\sqrt{3}} \qquad (3)$$

$$Ux = \sqrt{(Uz^2 - Ur)^2} \qquad (4)$$

Pn = active power in short circuit test operation at rated conditions
Un = phase-to-phase voltage, rated value
In = line current, rated value
Ur = resistive impedance voltage
Ux = inductive impedance voltage
Uz = total impedance voltage

The total losses during the short circuit test must be recalculated from the actual temperature during the test to the rated temperature. Before this can be done, the losses during the test have to be separated into the so called “Dewinding loss” and eddy current losses, because these change in different ways with the temperature.

The “DC winding loss” is calculated from the measured resistances according to:

$$Pd = k\,(Ip^2.Rp + Is^2.Rs) \qquad (5)$$

Pd = DC winding loss
Ip, Is = line currents, primary & secondary, rated values
Pr, Rs = winding resistance, primary & secondary, average of three-phase phase-to-phase values and recalculated to the temperature at the short circuit test
k = coupling coefficient
= 1 for single phase
= 1,5 for three phase, Y or D connected

If winding resistances are measured line to neutral the “DC winding loss” is calculated as follows:

Now the eddy current losses can be calculated by subtracting the “DC winding loss” from the measured loss reduced to rated value.

$$Pe = Pn - Pd \qquad (7)$$

Pe = eddy current losses

We have now separated the total losses in two components, of which the “DC winding loss” increases with the temperature and the eddy current loss decreases with the temperature.

Recalculation of the total losses to the rated temperature is made as follows:

$$P\Theta n = Pd \frac{C + \Theta n}{C + \Theta m} + Pe \frac{C + \Theta m}{C + \Theta n} \qquad (8)$$

PΘn = total winding losses in short circuit operation, recalculated to rated winding temperature
Θm = temperature during measurement
Θn = rated winding temperature, usually 75ºC
C = temperature constant for material
= 235 for copper
= 225 for aluminum

6 Measuring the no-load loss and no-load current

6.1 Test purpose

In the no-load measurement the no-load losses Po and the no-load current Io of the transformer are determined at rated voltage and frequency.

The harmonics on the no-load current are also measured as a special test on customer’s request.

6.2 Test method

The following losses occur at no-load

- iron losses in the transformer core and other construction parts
- dielectric losses in the insulations
- load losses caused by the no load current

The last two mentioned losses are quite small then they are generally neglected.

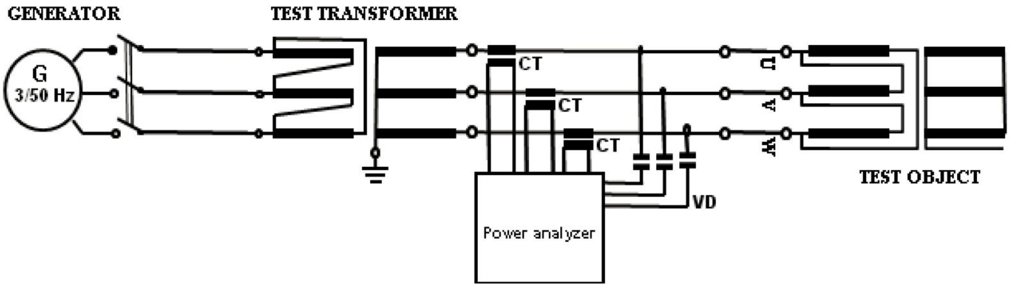


Figure 3 Measurement of no-load loss and no-load current

The following formula is valid for no-load losses:

Po = measured iron losses
k_1 = coefficient related with hysteresis losses
k_2 = coefficient related with eddy-current losses
f = frequency
U' = mean value of voltage x 1.11 (reading of rectifier voltmeter scaled to read the rms value of sinusoidal voltage
U = rms value of voltage

When carrying out the no-load measurement, the voltage wave shape may somewhat differ from the sinusoidal form. This is caused by the harmonics in the magnetizing current which cause additional voltage drops in the impedances of the supply. The readings of the mean value meter and rms meter will be different.

Because the load losses are to be determined under standard conditions, it is necessary to apply a wave shape correction whereby the losses are corrected to correspond to test conditions where the supply voltage is sinusoidal.

In the test voltage is adjusted so that the mean value voltmeter indicates the required voltage value. Then the hysteresis losses correspond to standard conditions, but the eddy-current losses must be corrected.

$$\mathbf{Po} = \frac{\mathbf{Pon}}{\mathbf{100}} \; (\mathbf{P_1} + \mathbf{k.P_2})$$

$$\mathbf{k = U / U'}$$

Pon = losses at sinusoidal voltage under standard conditions
P_1 = ratio expressed as a percentage of hysteresis losses to total iron losses
P_2 = ratio expressed as a percentage of eddy losses to total iron losses

The loss value corresponding to standard conditions is obtained from the measured value Po as follows:

It is assumed that for oriented sheets $P_1 = P_2 = 50\%$

The current and power readings of the different phases are usually different (the power can even be negative in some phase). This is due to the asymmetric construction of the three-phase transformer; the mutual inductances between different phases are not equal.

Test report shows measured and the corrected readings at rated voltage value, as well as the mean values of all three phases.

7 Induced over voltage withstand test

7.1 Test purpose

The induced voltage test is intended to verify the AC withstand strength of each line terminal and its connected winding(s) to earth and other windings; it also verifies the withstand strength between phases and along the winding(s) under test (turn-to-turn insulation)

7.2 Test method

The excitation voltage is applied to the terminals of the low voltage winding. If the winding has a neutral terminal, it is earthed during the test. The other windings are left opencircuited.

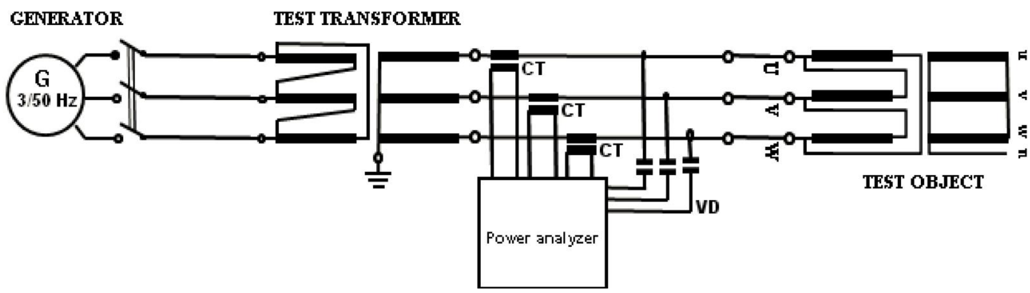


Figure 4 Induced over voltage withstand test circuit

As a rule, the test voltage across an untapped winding of the transformer shall be as close as possible to twice the rated voltage. The phase-to-phase test voltage shall not exceed the rated short duration power-frequency withstand voltage.

Test frequency is usually 150Hz.

The test duration is calculated as follows:

, but not less than 15 s.

The test is successful if no collapse of test voltage occurs.

For transformers with a high voltage winding having Um (highest voltage for equipment) equal and smaller than 72,5kV, no partial discharge measurements are performed during this test.

The test voltage, frequency and test duration are stated in the test report.

8 Separate source AC withstand voltage test / Applied voltage test

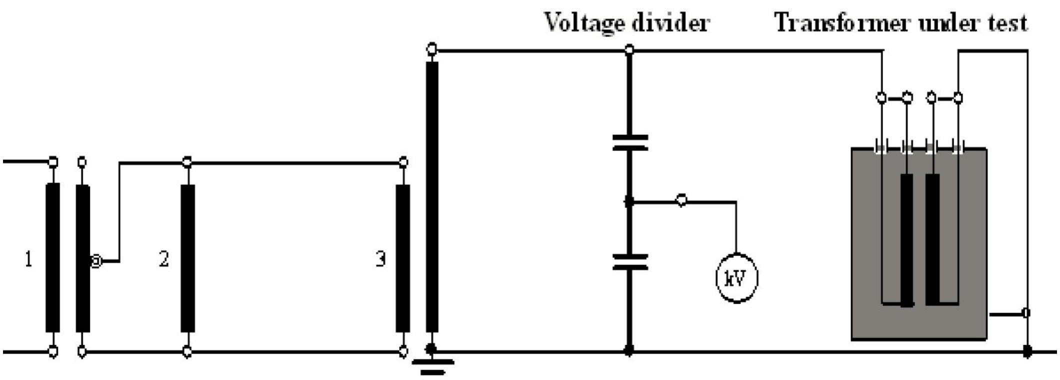
8.1 Test purpose

The purpose of the separate source AC withstand voltage test is to verify the integrity of the main insulation.

This main insulation does not only mean the insulation system between the two windings (major insulation), but also –more generally- the insulation between the winding and earth (end insulation) and all connections to earth and to each other.

8.2 Test method

A separate AC source is applied to the transformer, hence the name "applied voltage test". The transformer is not magnetized for this test, as it is for instance during the induced voltage test.



1 = Regulating transformer
2 = Compensating reactor
3 = Test transformer

Figure 5 Separate source AC withstand voltage test circuit

The separate source AC voltage test is made with single-phase alternating voltage of rated frequency. IEC60076 allows frequencies of not less than 80% of rated frequency. Test duration is 60 seconds.

The test is successful if the test voltage does not collapse.

The test voltage, frequency and test duration are stated in the test report.

9 Tests on on-load tap changer

After the tap changer is fully assembled on the transformer, the following tests are performed:

- 8 complete operating cycles with the transformer not energized, with 100% of the rated auxiliary supply voltage.
- 1 complete operating cycle with the transformer not energized, with 85% of the rated auxiliary supply voltage.
- 1 complete operating cycle with the transformer energized at rated voltage and rated frequency at no-load, with 100% of the rated auxiliary supply voltage.
- 10 tap-change operations with ±2 steps on either side of the principal tapping with as far as possible the rated current of the transformer, with one winding short-circuited, with 100% of the rated auxiliary supply voltage.

10 Temperature rise test

10.1 Test purpose

The purpose of the temperature rise test is to verify guaranteed temperature rises for oil and windings

10.2 Test method

The supply and measuring circuits are the same with the load loss measurement and with the resistance measurement. In addition, thermocouples and data acquisition unit are used for the measurement of oil, cooling medium and ambient temperatures.

10.2.1 Cold resistance measurement

The resistances and the corresponding oil temperature are measured. Resistances are measured between line terminals of between lite-to-neutral terminals. The winding temperature is the same as the oil temperature.

10.2.2 Determination of temperature rise of oil

The power to be supplied to the transformer is the sum of the no-load losses and the load losses on the tapping on which the temperature rise test is to be performed. With this power, the transformer warmed up to thermal equilibrium. The supply values and the temperatures of different points are recorded at suitable time intervals. The oil temperature rise above the cooling medium temperature can be calculated from the equilibrium temperatures.

10.2.3 Determination of the temperature rise of windings

Without interrupting the supply, the current is reduced to the rated current for one hour. The supply values and the temperatures are recorded as above. When the circuit has been cut off, the hot resistance measurement is performed. The test connection is changed for carrying out the resistance measurement and after the inductive effects have disappeared the resistance-time curves are measured for a suitable period of time (zero time is the instant of switching off the supply). The resistance is measured between the same line terminals as in the cold resistance measurement.

The resistances of the windings at shut-down are obtained by extrapolating the resistance-time curves to the instant of switch off. The temperature rises of the windings above the oil temperature are calculated on the basis of the hot and cold resistance values and the oil temperature. The temperature rises of the windings above the cooling medium temperature are found by adding the temperature rise of oil above the cooling medium temperature to the before mentioned winding temperature rises.

For air cooled transformers with natural air circulation the temperature of the cooling medium is the same as ambient temperature. The ambient temperature is measured by means of at least three thermometers and thermocouples in a container filled with oil which has two hours time constant. They are placed at different points around the transformer at a distance defined by the standards approximately half-way up the transformer. For forced air cooled transformers the temperature of the ingoing air is measured. If water is used as cooling medium, the water temperature at the intake of the cooler is the reference temperature.

The top oil temperature is measured by a thermometer placed in an oil-filled transformer pocket on the cover. In addition the temperatures of oil coming in and going out of the cooler are also mentioned by means of thermocouples and a chart recorder.

10.3 Temperature rise calculations

$$\Theta_2 = (R_2 / R_1)\,(C+\Theta_1)-235 \qquad (^{\circ}C)$$

$$\Theta_{oy}\,(I_n) = \Theta_{ty}\,(I_n) - (Sg\text{-}S\c{c})/2 \qquad (^{\circ}C)$$

$$\Delta\Theta_{sy} = \Theta_2 - \Theta_{oy}\,(I_n) \qquad (^{\circ}C)$$

$$\Delta\Theta_{oy}\,(I_d) = \Delta\Theta_{ty}\,(I_d) - (Sg\text{-}S\c{c})/2 \qquad (^{\circ}C)$$

$$\Delta\Theta_s = \Delta\Theta_{sy} + \Delta\Theta_{oy}\,(I_d) \qquad (^{\circ}C)$$

Θ_2 = winding temperature (including ambient temperature) when the supply is switched off

R_2 = winding resistance at the instant when the supply is switched off. (derived through extrapolation)

R_1 = winding resistance measured before temperature rise test

C = 235 for copper, 225 for aluminum

Θ_1 = temperature at which winding resistances are measured before temperature rise test

Θ_{oy} (I_n) = average oil temperature of winding while loaded with rated current

$\Delta\Theta_{oy}$ (I_d) = average oil temperature rise

Θ_{ty} (I_n) = top oil temperature while the transformer is loaded with rated current

$\Delta\Theta_{ty}$ (I_d) = top oil temperature rise

$\Delta\Theta_{sy}$ = difference between the winding temperature and the oil temperature of the winding while loaded.

Sg = oil temperature at the inlet of cooling unit

Sç = oil temperature at the outlet of cooling unit

$\Delta\Theta_s$ = winding temperature rise

The test report indicates:

- Cold resistance values and corresponding oil temperature
- Temperatures of oil and cooling medium in thermal equilibrium and the corresponding losses
- Hot resistances at shut-down and resistance curves
- Temperature rises calculated from the measuring results

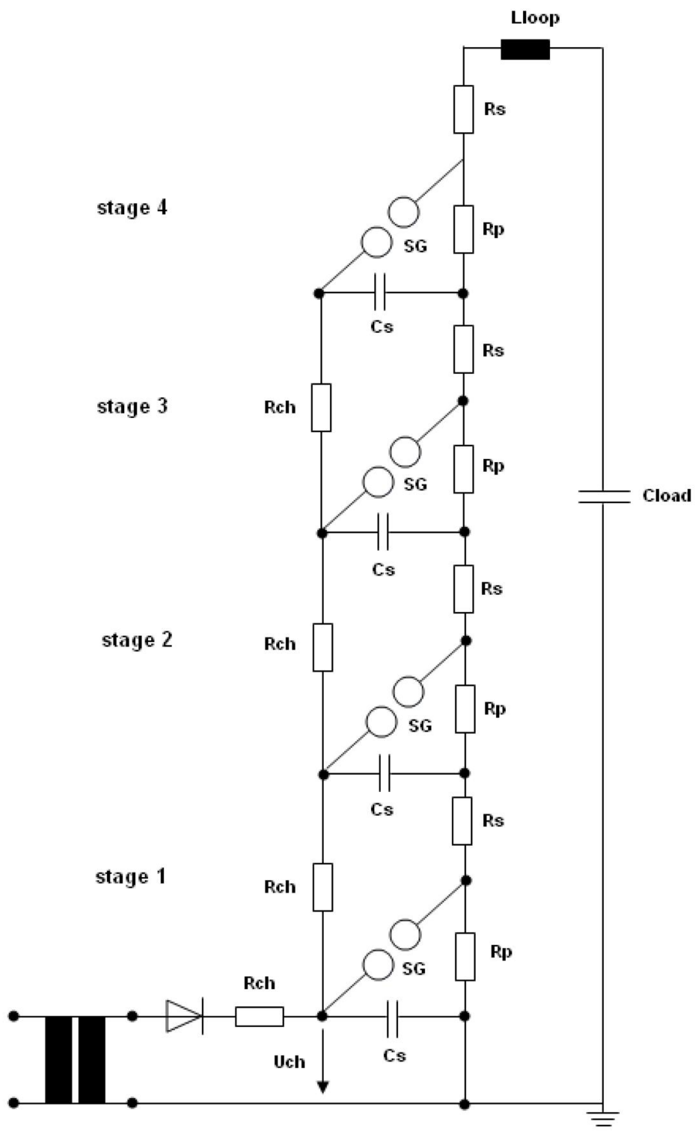
11 Lightning impulse test

11.1 Test purpose

The purpose of the test is to verify the insulation integrity for transient voltages, caused either by atmospheric phenomena (lightning), network disturbances or switching operations.

11.2 Test Method

The impulse generator design is based on the Marx circuit. The basic circuit diagram is shown on Figure 6 below.



Cs = Impulse capacitor
Rs = Front (series) resistor
Rp = Tail (parallel) resistor
Rch = Charging resistor
Cload = Load capacitance (test object+divider+stray capacitance)
Lloop = Inductance of the test circuit
SG = Spark gap

Figure 6 Basic circuit diagram of the impulse generator

All impulse capacitors Cs are charged to a pre-selected DC Uch voltage through the charging rectifier. The capacitors of all the stages are connected in parallel via the charging resistors Rch on one side and via the series network of front (Rs) and tail (Rp) resistors on the other side. The charging voltage is measured in the charging rectifier and reported to the control system.

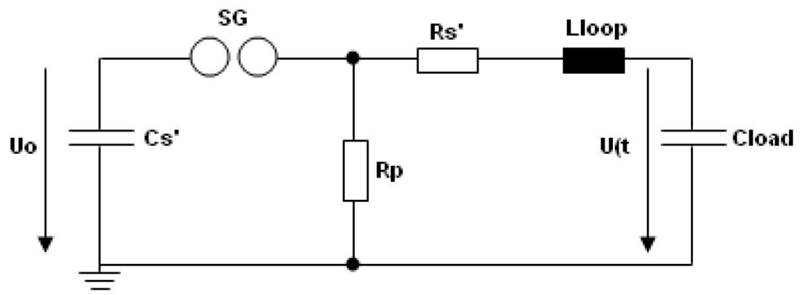
Charging is controlled pursuant to a specified function that depends on the selected charging voltage and impulse interval.

An auxiliary electrode is located on the live sphere of the spark gap of the lowest stage. The trigger pulse from the control system is amplified in a trigger-pulse amplifier to a voltage of 12kV and causes a spark at the auxiliary electrode. This lowers the breakdown voltage of the spark gap so that the lowest stage spark gap breaks down. By charging effects on stray capacitances, the triggering of the first stage generates overvoltages across the gaps of the successive stages. The level of the overvoltage depends on the front and tail resistance values. In the case of a lightning voltage, a special winding pattern is used in the tail resistors to heighten the overvoltages. For a given charging voltage, the overvoltage value determines a maximum spark gap length such that the impulse voltage generator still just fires. This length is called the “triggering threshold”.

The “triggering range” falls between the static spontaneous-breakdown voltage and the “triggering threshold”. For a selected charging voltage, the spark gaps are set to a length within the trigger range (this is done automatically by the control system). The closer the spark gap length to the triggering threshold, the greater is the time dispersion of triggering (jitter) over all stages. The statistical dispersion represents a danger of spontaneous firing if the gap is very near the static breakdown voltage.

Automatic gap setting by the control system insures optimal adjustment – i.e., minimal jitter and avoidance of spontaneous triggering – throughout the operation range of the impulse voltage generator.

For the determination of required values for the series and parallel resistors depending on the capacitance of the test object the multiplexer circuit could be reduced to an equivalent circuit diagram of one stage.



Cs’ = resulting impulse capacitance
Rs’ = Front (series) resistor
Rp’ = Tail (parallel) resistor
Cload = Load capacitance (test object+divider+stray capacitance)
Lloop = Inductance of the test circuit
SG = Spark gap

Figure 7 Equivalent circuit diagram of multiplexer circuit

Cs’, Rs’ and Rp’ could be calculated as follow:

Cs’ = Cs / n

Rs’ = Rs / n

Rp’ = Rp / n

n is the number of stages of the impulse generator. (n = 4 in our case.)

In a fist case the inductance Lloop of the test circuit would be neglected. The value of the circuit elements determines the curve shape of the impulse voltage. The impulse voltage is given by the difference of two exponentially decaying functions with time constants $\tau 1$ and $\tau 2$.

$$u(t) = \frac{Uo}{Rs'. Cload} \cdot \frac{\tau 1 . \tau 2}{\tau 2 - \tau 1} \left[e^{t/\tau 2} - e^{t/\tau 1} \right]$$

With the usually satisfied approximation

Rp’. Cs’ >> Rs’. Cload

The following simple expressions are obtained:

$$\tau 1 \approx Rs' \frac{Cs' . Cload}{Cs' + Cload}$$

$$\tau 2 \approx Rp'. (Cs' + Cload)$$

There exists a correlation between τ 1 and τ 2 and the front and tail time of lightning impulses defined in the IEC standard.

T1 = K1. $\tau 1$ (K1 = 2,96 for 1,2/50µs)

T2 = K2. $\tau 2$ (K2 = 0,73 for 1,2/50µs)

In practice the impulse circuit has got an avoidable inductance (represented by the part Loop in figure 7). This inductance generates oscillations at the peak of the lightning impulse voltage. In order to prevent the disturbing oscillations, the circuit must be periodically damped, i.e. the series resistor Rs’ must have the following value:

$$Rs' \geq 2. \sqrt{Lloop \frac{Cs' . Cload}{Cs' + Cload}}$$

The efficiency factor η is the ratio between the peak value Upeak of the impulse voltage and the total charging voltage U_L=n.Uo of the impulse generator.

η = Upeak / U_L

11.3 Impulse shapes

In high-voltage technology a single, unipolar voltage pulse is termed as an impulse voltage. For testing purposes, double exponential impulse voltages have been standardized; without appreciable oscillation these rapidly reach a maximum, the peak value Upeak, and finally drop less abruptly to zero. In a chopped impulse voltage, the applied voltage is short-circuited to zero after a pre-set time.

Generally test sequence is like listed below:

- One reduced level full impulse (calibration impulse)
- One full level full impulse (LI)
- One or more reduced level chopped impulse(s) (only if specially requested)
- Two full level full impulse

If not otherwise requested, IEC test requirements specify that the chopped wave should have amplitude of 110% of the LI wave.

The integrity of the transformer is confirmed when there is a close similarity between the voltage traces for the applied calibration voltage and all of the applied full test voltages.

The waveform of the impulse is aperiodic as shown in figure 8.

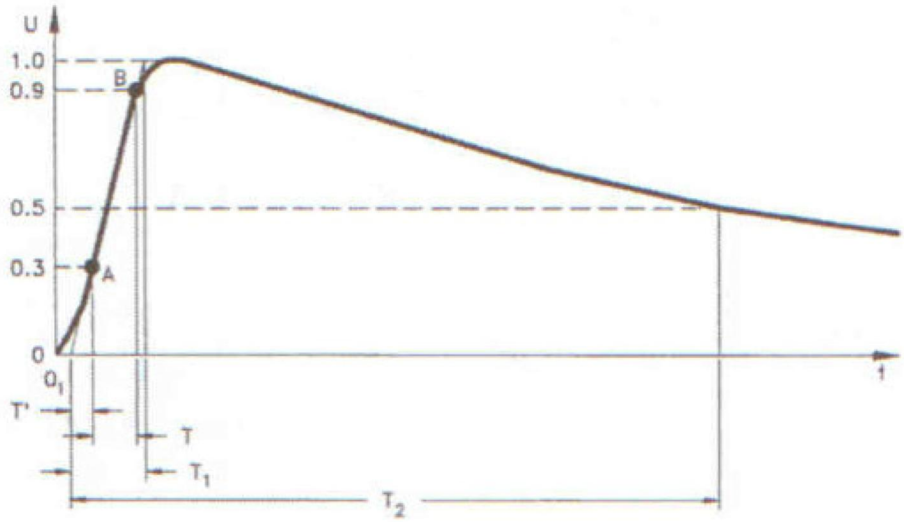


Figure 8 Lightning impulse (LI) curve

The waveform is characterized by certain time parameters for the front and tail.

Front time T1 of a lightning impulse is a virtual parameter defined as 1,67 times the interval T between the instants when the impulse is 30% and 90% of the peak value. (points A and B in figure)

T1 = 1,2µs ±30% (0,84 µs to 1,56 µs)

Tail time (time to half-value) T2 of a lightning impulse is a virtual parameter defined as the time interval between the virtual origin O1 and the instant when the voltage has decreased to half of the peak value.

T2 = 50µs ±20% (40 µs to 1,56 µs)

Regarding to the chopped impulse wave, curve can be seen in figure 9.

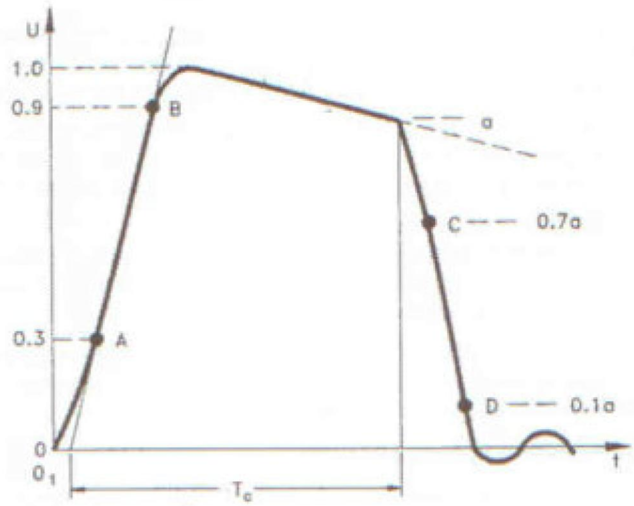


Figure 9 Lightning impulse frontchopped (LIC)

The time to chopping Tc is a virtual parameter defined as the time interval between the virtual origin O1 and the instant of chopping.

Tc = 2 µs … 6µs

In principle, the lightning impulse test is applied to all windings. The impulse test sequence is applied successively to each of the line terminals of the tested winding, while other non-tested line terminals are short-circuited and solidly earthed. If the specified half-time of the tail can not be achieved, the winding may be earthed via resistors. During the test of line terminals, neutral terminal must be solidly earthed or earthed via a low impedance shunt.

In case of the impulse test on neutral terminal, direct application is generally used, which means that the impulses are applied directly to the neutral while all line terminals are earthed.

Waveforms and impulse circuit details are listed in test report.

12 Capacitance and dissipation factor (tan δ) measurement

12.1 Test purpose

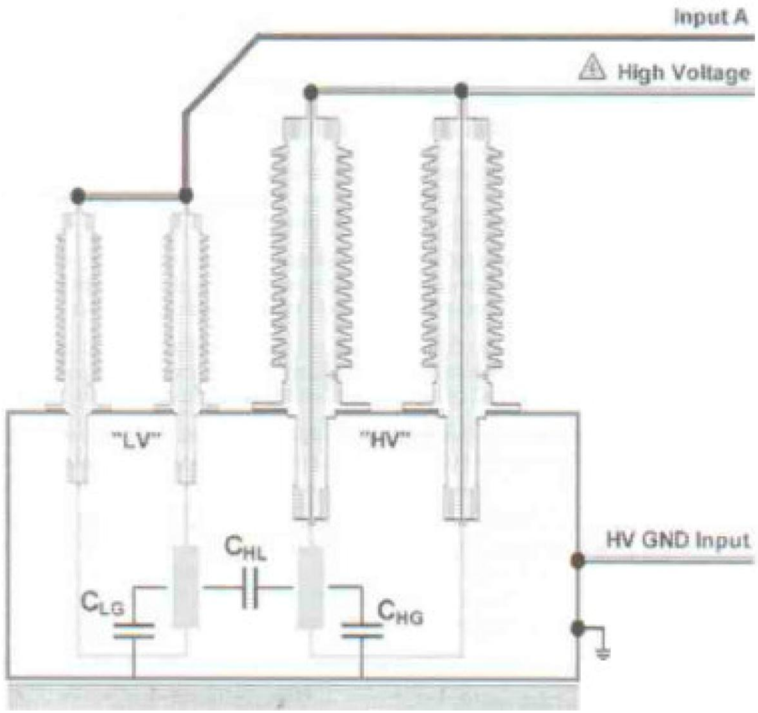
The purpose of the measurement is to determine the capacitances between the windings and the earthed parts and between the different windings of the transformer.

The dissipation factor which is measured with capacitance gives idea about the insulation level of the transformer. It is a very comprehensive test for detecting moisture, carbonization and other forms of contamination of windings, bushings and liguid insulations.

12.2 Test method

To eliminate any effect of winding inductance on the insulation measurements all terminals of each winding, including neutrals must be connected together.

Connections between the transformer and measuring bridge and measured capacitances are shown on figure 10 below.



Sequence	Test	INPUT A to	INPUT HV GND to	Test Mode	High Voltage to
1	C_{HL}	LV	Tank GND	UST A	HV
2	C_{HG}	LV	Tank GND	GST gA+B	HV
3	C_{LG}	HV	Tank GND	GST gA+B	LV
4	C_{LG}+C_{HG}	-	Tank GND	GST gA+B	LV + HV

Figure 10 Measurement connections of a two winding transformer (3 phase)

Capacitances and dissipation factor (tan δ) are given in test report.

13 Measurement of zero-sequence impedance

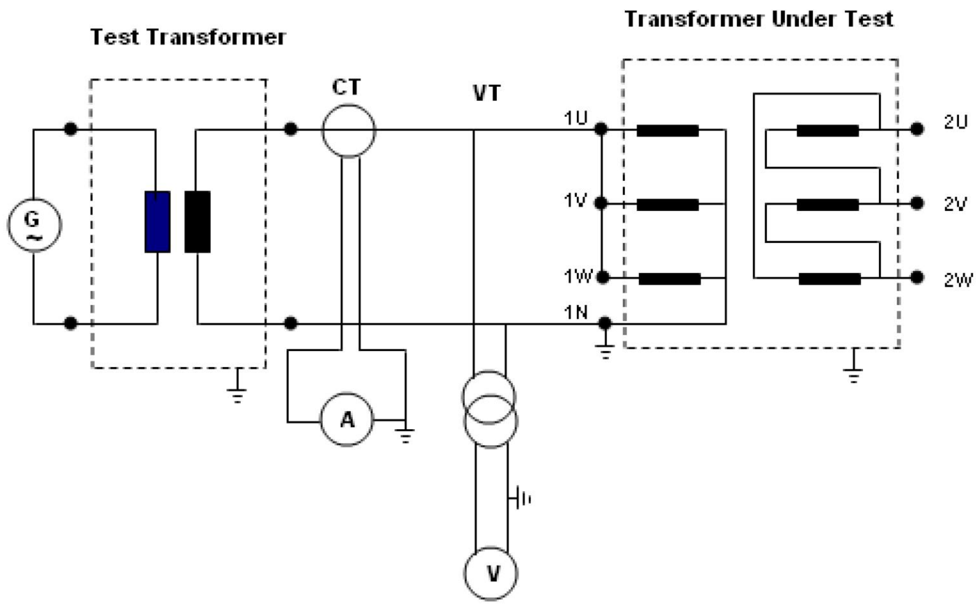
13.1 Test purpose

Modern technique in the calculation of system fault conditions demands not only the knowledge of symmetrical components, but also the phase sequence impedances of the individual components, for instance for transformers.

13.2 Test method

The zero-sequence impedance is the impedance measured between phase terminaş and neutral when the three phase terminals are connected together. The zero-sequence impedance can only develop in star connected or zig-zag connected windings in three phase transformers. The zero sequence impedance to be attributed to each individual phase is three times the measured value.

The general test circuit is shown in figure 11, the measurement is performed in rated frequency.



G = Voltage source (single phase)
CT = Current transformer
V = Voltage transformer

Figure 11 General measuring circuit for zero-sequence impedance measurement, star-star connected transformer as an example

The zero-sequence impedance is dependent on the current flowing through the winding. Usually the value corresponding to rated current Ir is stated. This implies that the measurement is carried out with a test current of 3 x Ir. However, this is not always possible in practice. Since the current must be limited to avoid excessive temperature of metallic constructional parts and due to the current flow capacity of neutral terminal. Because of this reason, the zero-sequence impedance is measured as a fı-unction of test current and when necessary the final result is obtained by extrapolation.

The zero-sequence impedance is usually given as a percentage of the rated phase impedance. When the transformer has a delta-connected winding, the zero-sequence impedance is 0,8 … 1,0 times the corresponding short circuit impedance.

In the test report the zero-sequence impedance values at the principal tapping is stated.

14 Determination of sound level

14.1 Test purpose

The purpose of the sound level measurement is to check that the sound level of the transformer meets the specification requirements, i.e., the requirements given in relevant standards or guarantee values given by the manufacturer.

14.2 Test method

Immediately after the background measurements, A-weighted sound pressure level measurements are carried out for each measuring position located around the transformer as detailed in the IEC standard. According to the standard, for the distribution transformers whose height is less that 2,5m, microphone position in the vertical direction is on the half of the tank height. If the transformer height is greater that 2,5m, the measurements are conducted at 1/3 and 2/3 of the height. In both cases, the microphone is directed perpendicularly against the surface of the transformer (the principal radiator surface).

Measurement is carried out at rated voltage and frequency.

After the measurement, a second background measurement is carried out.

By taking background level and environmental corrections into account, the sound pressure level and sound power level of the transformer are calculated and stated in the test report.

15 Measurement of the harmonics of the no-load current

15.1 Test purpose

Harmonic content is interesting for customers especially for the transformer protection relays' adjustment.

15.2 Test method

The measuring circuit is exactly the same as for the measurement of no-load losses and no load current performed with a power analyzer. The only difference is that a harmonic analyzer is used additionally.

16 Measurement of insulation resistance

16.1 Test purpose

Insulation resistance tests (Megger tests) are performed to determine the insulation resistance from individual windings to earth or between individual windings. Knowledge of the insulation resistance is of value when evaluating the condition of the transformer insulation.

16.2 Test method

Insulation resistance is measured by means of Megger at a DC voltage of 1000V and 5000V.

The test is conducted with all terminals of each winding system connected together. The resistance readings are taken after 15, 30, 45 and 60 seconds.

The test voltage, temperature and measured insulation resistance values in megaohms are stated in the test report.

17 Routine tests results

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TÜRKAK
Test
TS EN ISO/IEC 17025
AB-0538-T

TRABB DENEY LABORATUVARI
DENEY RAPORU
TEST REPORT

AB-0538-T
1LTR0030613
15.10.2015

Müşterinin adı/adresi *Customer name/address*	: ABB Elektrik A.Ş. Dağıtım Transformatörleri Satış Bölümü
Deney talep numarası *Test order no.*	: 1LTR0030613
Numunenin tanımı *Sample description*	: 2200 kVA 23000 / 400 / 400 V 50 Hz Dyn11yn11 15191/900 Yağlı Tip Transformatör - Oil Immersed Transfromer
Numunenin kabul tarihi *The date of receipt of test item*	: 15.10.2015
Deney standartları *Test standarts*	: IEC 60076-1
Testin yapıldığı tarih *Date of test*	: 15.10.2015
Raporun sayfa sayısı *Number of pages of the report*	: 7

Türk Akreditasyon Kurumu (TÜRKAK) deney raporlarının tanınması konusunda Avrupa Akreditasyon Birliği (EA) ve Uluslararası Laboratuvar Akreditasyon Birliği (ILAC) ile karşılıklı tanınma antlaşmasını imzalamıştır.
The Turkish Accreditation Agency (TURKAK) is signatory to the multilateral agreements of the European co-operation for the Accreditation (EA) and of the International Laboratory Accreditation (ILAC) for the Mutual recognation of test reports.

Deney ve /veya ölçüm sonuçları, genişletilmiş ölçüm belirsizlikleri (olması halinde) ve deney metodları bu sertifikanın tamamlayıcı kısmı olan takip eden sayfalarda verilmiştir .
The test and/or measurement results, the uncertainties (if applicable) with confidence probability and test methods are given on the following pages which are part of this report.

Mühür	**Tarih**	**Raporu hazırlayan**	**Kontrol Eden ve Onaylayan**
Stamp	*Date*	*Prepared by*	*Checked and Approved By*
	15.10.2015	Raşit ŞAHİN	Enver Murat Altıner

(*) İşaretli deneyler akreditasyon kapsamı dahilinde değildir.
(*) *The marked tests are not included in the Scope of the Accreditation.*

DENEY RAPORU

TEST REPORT

MAKİNA NO	- Serial No		:	**1LTR0030613**
SİPARİŞ NO	- Order No		:	**202003768**
TİP NO	- Type Number	(TSPH)	:	**15191/900**
GÜÇ	- Rated Power	(kVA)	:	**2200 (1100 / 1100)**
GERİLİM	- Rated Voltage	(kV)	:	**23 (0,400 / 0,400)**
FREKANS	- Frequency	(Hz)	:	**50**
GRUP	- Vector Group		:	**Dy11y11**
STANDART	- Standard		:	**IEC 60076-1**
MÜŞTERİ	- Customer		:	**ABB FRANCE**

Istanbul, 15.10.2015

DENEY RAPORU

TEST REPORT

İÇİNDEKİLER - CONTENTS :

Sayfa no - Page no

ABB	# DENEY RAPORU *TEST REPORT*	AB-0538-T 1LTR0030613 15.10.2015

DATA OF THE TRANSFORMER

Serial no	:	1LTR0030613	Cooling Type	: ONAN	Phases		: 3			R.Power (kVA) :	1100			
Order no	:	202003768	Temp. Rise	: Oil	:	50			(°K)	Voltages (V)	:	23000	/	400
Customer	:	ABB FRANCE		: Wind.	:	55			(°K)	Currents (A)	:	27,61	/	1588
Type (TSPH)	:	15191/900	Insul. Level	: (HV) LI	125	AC	50		(kV)	Vector group	:	Dyn11		
Standard	:	IEC 60076-1		: (LV1 LI	-	AC	3,0		(kV)	Frequency (Hz) :	50			

MEASUREMENT OF VOLTAGE RATIOS

					1	2	3	4	5
Nominal tap	:	3	Taps :		1	2	3	4	5
H.Voltages (V)	:	23000	+2 -2	%2,50	21850	22425	23000	23575	24150
L.Voltages (V)	:	400	-		400	400	400	400	400
Ratios	:	U1x√3/U2			94,61	97,10	99,59	102,08	104,57
Deviations (‰)	:	1U-1V	2u-2n		+ 0,50	+ 0,44	+ 0,54	+ 0,65	+ 0,78
Deviations (‰)	:	1V-1W	2v-2n		+ 0,26	+ 0,28	+ 0,45	+ 0,55	+ 0,66
Deviations (‰)	:	1W-1U	2w-2n		+ 0,26	+ 0,38	+ 0,44	+ 0,61	- 0,72

The VECTOR GROUP is also checked at the same time. Tolerance (‰ ± 5)

MEASUREMENT OF WINDING RESISTANCES

Tap	:	3	High Voltage			Low Voltage					
Temp.	:	25,5 °C	1U-1V :	1,7837	Ω	2U-2V :	0,00049415 Ω	I^2.R Ohmic loss (HV)	:	2039	(W)
			1V-1W :	1,7818	Ω	2V-2W :	0,00048115 Ω	I^2.R Ohmic loss (LV1)	:	3670	(W)
			1W-1U :	1,7841	Ω	2W-2U :	0,00048125 Ω	ΣI^2.R Total ohmic loss	:	5709	(W)

MEASUREMENT OF NO-LOAD LOSSES and NO LOAD CURRENT

Phases		$U'_{20}(V_{rm})$	$U_{20}(V_{rms})$	$I_{20}(A_{rms})$	P_m (W)		Guaranteed	Tolerance	Measured
2u-2v	:	399,6	400,7	6,369	2290	P_o (W)	2300	% + 15	2285
2v-2w	:	400,0	400,4	5,385		I_o (%)	-	% + -	0,39
2w-2u	:	399,4	400,2	6,606		$P_o = P_m (1 + d)$	$d = U'-U/U'$		
Avarage:	:	399,6	400,4	6,120					

The measured no-load loss is P_m, and the corrected no-load loss is taken as (P_o) :

MEASUREMENT OF LOAD LOSSES and IMPEDANCE VOLTAGE

Phases :		$U_{1km}(V_{rms})$	$I_{1km}(A_{rms})$	P_{km} (W)		Tap :	3		Corrected(Pr)	Measured (Pr)
1U-1V	:	1250,0	25,16	5730					(I1km-rated)	Reference temp.
1V-1W	:	1248,0	25,27	P_a (W)		Guaranteed		Tol.	Temp. 25,4 °C	75 °C
1W-1U	:	1242,0	25,04	1195	PkN (W) 75 °C	-	%	+ -	6904	7837
Avarage	:	1246,7	25,16		UkN (%) 75 °C	6,00	%	± 10	5,95	5,96

SEPARATE-SOURCE VOLTAGE WITHSTAND TEST (kVPeak)

Supply	Against	U_m	AC	Hz	Time
HV	LV1+Tank	24,0	50	50 Hz	60 sec
LV1	HV+Tank	1,1	3,0	50 Hz	60 sec

INDUCED OVERVOLTAGE WITHSTAND TEST (kVPeak)

Supply	Voltage (kV)	Freq.	Time	Nom.Tap
HV	46,0	150 Hz	40 sec	3
LV1	0,80	150 Hz	40 sec	-

EFFICIENCY (%)

n (load factor) :		1/4	2/4	3/4	4/4
Cosφ : 1	:	99,00	99,23	99,20	99,09
Cosφ : 0.8	:	98,75	99,04	99,00	98,86

VOLTAGE REGULATION (%)

n (load factor :		1/4	2/4	3/4	4/4
Cosφ : 1	:	0,189	0,400	0,633	0,887
Cosφ : 0.8	:	1,036	2,083	3,142	4,213

DENEY RAPORU *TEST REPORT*	AB-0538-T 1LTR0030613 15.10.2015

DATA OF THE TRANSFORMER

Serial no : 1LTR0030613	Cooling Type : ONAN Phases : 3	R.Power (kVA) : 1100
Order no : 202003768	Temp. Rise : Oil : 50 (°K)	Voltages (V) : 23000 / 400
Customer : ABB FRANCE	: Wind. : 55 (°K)	Currents (A) : 27,61 / 1588
Type (TSPH) : 15191/900	Insul. Level : (HV) LI 125 AC 50 (kV)	Vector group : Dyn11
Standard : IEC 60076-1	: (LV2 LI - AC 3,0 (kV)	Frequency (Hz) : 50

MEASUREMENT OF VOLTAGE RATIOS

				1	2	3	4	5
Nominal tap	:	3	Taps :	1	2	3	4	5
H.Voltages (V)	:	23000	+2 -2 %2,50	21850	22425	23000	23575	24150
L.Voltages (V)	:	400	-	400	400	400	400	400
Ratios	:	U1x√3/U2		94,61	97,10	99,59	102,08	104,57
Deviations (‰)	:	1A-1B	3A-3N	+ 0,64	+ 0,36	+ 0,54	+ 0,68	+ 0,77
Deviations (‰)	:	1B-1C	3B-3N	+ 0,39	+ 0,43	+ 0,45	+ 0,58	+ 0,67
Deviations (‰)	:	1C-1A	3C-3N	+ 0,35	+ 0,42	+ 0,51	+ 0,62	+ 0,73

The VECTOR GROUP is also checked at the same time. Tolerance (‰ ± 5)

MEASUREMENT OF WINDING RESISTANCES

Tap : 3 — Temp. : 25,5 °C

High Voltage		Low Voltage - LV2			
1A-1B :	1,7837 Ω	3U-3V :	0,00049845 Ω	I^2.R Ohmic loss (HV) :	2039 (W)
1B-1C :	1,7818 Ω	3V-3W :	0,00049290 Ω	I^2.R Ohmic loss (LV2) :	3740 (W)
1C-1A :	1,7841 Ω	3W-3U :	0,00049285 Ω	ΣI^2.R Total ohmic loss :	5779 (W)

MEASUREMENT OF NO-LOAD LOSSES and NO LOAD CURRENT

Phases	$U'_{2o}(V_{rm})$	$U_{2o}(V_{rms})$	$I_{2o}(A_{rms})$	P_m (W)
3A-3B :	399,6	400,7	6,369	2290
3B-3C :	400,0	400,4	5,385	
3C-3A :	399,4	400,2	6,606	
Avarage: :	399,6	400,4	6,120	

	Guaranteed	Tolerance	Measured
P_o (W)	2300	% + 15	2285
I_o (%)	-	% + -	0,39

$P_o = P_m (1 + d)$ d = U'-U/U'

The measured no-load loss is P_m, and the corrected no-load loss is taken as (P_o) :

MEASUREMENT OF LOAD LOSSES and IMPEDANCE VOLTAGE

Phases :	$U_{1km}(V_{rms})$	$I_{1km}(A_{rms})$	P_{km} (W)
1A-1B :	1214,0	25,26	5712
1B-1C :	1213,0	25,35	P_a (W)
1C-1A :	1206,0	25,10	1059
Avarage :	1211,0	25,24	

Tap : 3

	Guaranteed	Tol.	Corrected(Pr) (I1km-rated) Temp. 25,4 °C	Measured (Pr) Reference temp. 75 °C
PkN (W) 75 °C	-	% + -	6838	7807
UkN (%) 75 °C	6,00	% ± 10	5,76	5,77

SEPARATE-SOURCE VOLTAGE WITHSTAND TEST (kV)

Supply	Against	Um	AC	Hz	Time
HV	LV2+Tank	24,0	50	50 Hz	60 sec
LV2	HV+Tank	1,1	3,0	50 Hz	60 sec

INDUCED OVERVOLTAGE WITHSTAND TEST (kV)

Supply	Voltage (kV)	Freq.	Time	Nom.Tap
HV	46,0	150 Hz	40 sec	3
LV2	0,80	150 Hz	40 sec	-

EFFICIENCY (%)

n (load factor) :	1/4	2/4	3/4	4/4
Cosφ : 1 :	99,00	99,24	99,20	99,09
Cosφ : 0.8 :	98,76	99,05	99,00	98,87

VOLTAGE REGULATION (%)

n (load factor :	1/4	2/4	3/4	4/4
Cosφ : 1 :	0,188	0,396	0,625	0,874
Cosφ : 0.8 :	1,006	2,024	3,052	4,090

DENEY RAPORU

TEST REPORT

AB-0538-T
1LTR0030613
15.10.2015

DATA OF THE TRANSFORMER

Serial no	: 1LTR0030613	Cooling Type	: ONAN Phases : 3	R.Power (kVA)	: 2200 (### / 1100)
Order no	: 202003768	Temp. Rise	: Oil : 50 (°K)	Voltages (V)	: 23000 / 400 / 400
Customer	: ABB FRANCE		: Wind. : 55 (°K)	Currents (A)	: 55,22 / 1588 / 1588
Type (TSPH)	: 15191/900	Insul. Level	: (HV) LI 125 AC 50 (kV)	Vector group	: Dy11yn11
Standard	: IEC 60076-1		: (LV) LI - AC 3,0 (kV)	Frequency (Hz)	: 50

MEASUREMENT OF WINDING RESISTANCES

Tap : 3

Temp. : 25,5 °C

High Voltage			Low Voltage 1		Low Voltage 2	
1U-1V :	1,7837	Ω	2U-2V :	0,49415	3U-3V :	0,49845
1V-1W :	1,7818	Ω	2V-2W :	0,48115	3V-3W :	0,49290
1W-1U :	1,7841	Ω	2W-2U :	0,48125	3W-3U :	0,49285

I^2.R Ohmic loss (HV)	:	D	25,5 °C	8158	W
I^2.R Ohmic loss (LV_1)	:	yn11	25,5 °C	3672	W
I^2.R Ohmic loss (LV_2)	:	yn11	25,5 °C	3741	W
Toplam bakır kaybı	:		25,5 °C	15571	W

MEASUREMENT OF LOAD LOSSES and IMPEDANCE VOLTAGE

Phases :	$U_{1km}(V_{rms})$	$I_{1km}(A_{rms})$	P_{km} (W)
1U-1V :	1830,0	37,94	9470
1V-1W :	1830,0	38,02	P_a (W)
1W-1U :	1822,0	37,73	4544
Avarage :	1827,3	37,90	

Tap : 3

	Guaranteed		Tol.	Corrected(Pr) (I1km-rated) Temp. 25,4 °C	Measured (Pr) Reference temp. 75 °C
PkN (W) 75 °C	20000	%	+ 15	20108	22440
UkN (%) 75 °C	-	%	± -	11,58	11,59

SEPARATE-SOURCE VOLTAGE WITHSTAND TEST (kVPeak)

Supply	Against	Um	AC	Hz	Time
HV	LV+Tank	24,0	50	50 Hz	60 sec
LV	HV+Tank	1,1	3,0	50 Hz	60 sec

INDUCED OVERVOLTAGE WITHSTAND TEST (kVPeak)

Supply	Voltage (kV)	Freq.	Time	Nom.Tap
HV	46,0	150 Hz	40 sec	3
LV	0,80	150 Hz	40 sec	-

EFFICIENCY (%)

n (load factor) :	1/4	2/4	3/4	4/4
Cosφ : 1 :	99,75	99,49	99,24	98,99
Cosφ : 0.8 :	99,68	99,37	99,05	98,74

VOLTAGE REGULATION (%)

n (load factor :	1/4	2/4	3/4	4/4
Cosφ : 1 :	0,297	0,676	1,140	1,686
Cosφ : 0.8 :	1,958	3,963	6,014	8,112

ACCESSORIES

1. Integrated safety dedector(RIS)
2. Pressure relief valve

Filling & Sealing Temp. 25 °C

DIMENSIONS(mm) and WEIGHTS (kg)

Width :	1976	Length :	2197	Height :	2450
Active part :	2710	Oil :	1343	Total :	6247

TYPE OF INSULATING OIL : NYNAS NYTRO TAURUS

	TEST RAPORU *TEST REPORT*	AB-0538-T 1LTR0030613 15.10.2015

Kullanılan Cihazlar / *Equipment Used*

	Cihaz Tanımı	*Equipment Description*	Marka *Make*	Seri Numarası *Serial Number*
X	**Gerilim Transformatörü**	*Voltage Transformer*	Ritz Messwandler	76/338664
X	**Gerilim Transformatörü**	*Voltage Transformer*	Ritz Messwandler	76/338665
X	**Gerilim Transformatörü**	*Voltage Transformer*	Ritz Messwandler	76/338666
X	**Gerilim Transformatörü**	*Voltage Transformer*	Ritz Messwandler	76/338667
X	**Gerilim Transformatörü**	*Voltage Transformer*	Ritz Messwandler	76/338668
X	**Gerilim Transformatörü**	*Voltage Transformer*	Ritz Messwandler	76/338669
X	**Akım Tansformatörü**	*Current Transformer*	Ritz Messwandler	86/388972
X	**Akım Tansformatörü**	*Current Transformer*	Ritz Messwandler	86/388973
X	**Akım Tansformatörü**	*Current Transformer*	Ritz Messwandler	86/388974
X	**Geniş Bant Güç Analizörü**	*Wide Band Power Analyzer*	LEM NORMA	M033719RR
X	**Direnç Köprüsü**	*Winding Resistance Meter*	Raytech	293-100
X	**Direnç Köprüsü**	*Winding Resistance Meter*	Raytech	301-145
X	**Yüksek Gerilim Test Cihazı**	*Hipot AC Withstand Test Set*	Haefely	51-080624-06-84
X	**Yüksek Gerilim Test Cihazı**	*Hipot AC Withstand Test Set*	American HVTS	85-680
	Ses Seviyesi Ölçer	*Sound Pressure Level Meter*	Brüel & Kjaer	1211018
	AC YG Ve C/Tand Ölçüm Cihazı	*Insulation Analysis System*	Tettex	170310
	Güç Kalitesi Analizörü	*Power Analyzer*	Fluke	DM9451041
X	**Kronometre**	*Chronometer*	Catiga	12-07557
X	**Kronometre**	*Chronometer*	Catiga	11-05241
	Oran Ölçer	*Turns Ratio Meter*	Tettex	171354
X	**Oran Ölçer**	*Turns Ratio Meter*	Tettex	170790
	Oran Ölçer	*Turns Ratio Meter*	Tettex	156315
	Oran Ölçer	*Turns Ratio Meter*	H&B	25557
X	**Kızılötesi Termometre**	*Infrared Thermometer*	Fluke	94102665
	DC Yalıtım Direnci Ölçer	*DC Insulation Resistance Meter*	Megger	9609901050 0996
X	**DC Yalıtım Direnci Ölçer**	*DC Insulation Resistance Meter*	Megger	071107/1712
	DC Yalıtım Direnci Ölçer	*DC Insulation Resistance Meter*	Megger	080508/1748
	Direnç Köprüsü	*Winding Resistance Meter*	ABB	5
	Veri Kaydedici	*Data Logger*	HP	MY41005672
X	**Direnç Köprüsü**	*Winding Resistance Meter*	Tettex	156495
X	**Geniş Bant Güç Analizörü**	*Wide Band Power Analyzer*	Fluke	U4-97959-SS
X	**PT100 Termometre**	*PT100 Thermometer*	LEMO	FFA.25
	Kısmi Deşarj Kalibratörü	*Partial Discharge Calibrator*	Power Diagnostix	1264
	Darbe Üreteci ve Ölçme Sistemi	*Impulse Generator & Measurement System*	Tettex	05101219.50.1/153647
	Nem & Sıcaklık Ölçer	*Humidity & Temperature Meter*	AZ 8857	9544851
	Multimetre	*Multimeter*	Fluke	165701116

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1LTR0030613-01
15.10.2015

Müşterinin adı / adresi *Customer name / address*	: ABB Elektrik A.Ş. Dağıtım Transformatörleri Satış Bölümü
Deney talep numarası *Test order no.*	: 1LTR0030613-01
Numunenin tanımı *Sample description*	: 2200 kVA 23000 / 400 V Dyn11 50 Hz 15191/900 *Yağlı Tip Transformatör - Oil Immersed Transformer*
Müşteri seri numarası *Customer Tag Number*	:
Numunenin kabul tarihi *The date of receipt of test item*	: 15.10.2015
Deney standartları *Test standards*	: IEC 60076-1
Testin yapıldığı tarih *Date of test*	: 15.10.2015
Raporun sayfa sayısı *Number of pages of the report*	: 11

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The test and/or measurement results, the uncertainties (if applicable) with confidence probability and test methods are given on the following pages which are part of this report.

Mühür *Stamp*	**Tarih** *Date*	**Raporu hazırlayan** *Prepared by*	**Kontrol Eden ve Onaylayan** *Checked and Approved By*
	15.10.2015	Necmi DEMİREL	Enver Murat Altıner

(*) İşaretli deneyler akreditasyon kapsamı dahilinde değildir.
(*) *The marked tests are not included in the Scope of the Accreditation.*

DENEY RAPORU

TEST REPORT

İÇİNDEKİLER - CONTENTS :

SICAKLIK ARTIŞI TESTİ

TEMPERATURE RISE TEST

Güç	-	Rated Power	:	**2200**	**kVA**
Gerilim	-	Rated Valtage	:	**23,00 / 0,40**	**kV**
Ölçülen boşta kayıp	-	Measured no-load losses	:	**2285**	**W**
Ölçülen yükte kayıp	-	Measured load loss (at 75 °C)	:	**22440**	**W**
Toplam kayıplar	-	Total losses	:	**24725**	**W**
Kademe pozisyonu	-	Tap changer position no	:	**3**	
Anma akımı	-	Rated current	:	**55,22 / 3175**	**A**
Soğutma tipi	-	Type of cooling	:	**ONAN**	

Saat	**Test sırasındaki değerler** Values during test			**Çevre sıcaklığı** Ambient temperature **(°C)**					**Trf. Sıcaklığı** -Temp.of the Trf. **Soğutucular** - Coolers (°C)				**Tepe yağ** Top oil	**Sıc.Art.** Temp.Rise
Hour									**AG tarafı**-LV Side		**YG tarafı**-HV Side		θ_{ty}	$\Delta\theta_{ty}$
	Watt	**Volt**	**Amp.**	t_1	t_2	t_3	t_4	t_o	**Sg**	**Sç**	**Sg**	**Sç**	**°C**	**°K**
20:40	24814	2971,0	61,38	25,4	25,2	25,2	25	25,3	25,8	25,2	25,2	25,1	25,5	0,2
21:00	24996	2939,0	60,64	25,4	25,2	25,2	25	25,3	28,7	27,2	25,9	26,3	25,6	0,3
21:20	24692	2889,0	59,63	25,3	25,2	25,2	25	25,3	37,2	27,8	33,7	26,8	30,9	5,6
21:40	24795	2884,0	59,52	25,3	25,2	25,3	25	25,3	43,5	28,5	39,9	27,5	37,8	12,5
22:00	24691	2864,0	59,03	25,3	25,3	25,3	25	25,3	49,3	30,4	45,6	29,3	44,3	19,0
22:20	24707	2853,0	58,82	25,3	25,3	25,3	26	25,4	53,0	32,2	49,6	31,0	49,0	23,7
22:40	24721	2845,0	58,60	25,3	25,3	25,3	26	25,4	56,3	33,9	52,8	32,8	52,8	27,5
23:00	24955	2850,0	58,66	25,3	25,4	25,4	26	25,4	59,0	35,7	55,7	34,3	56,0	30,6
23:20	24940	2840,0	58,51	25,3	25,4	25,5	26	25,5	60,9	37,0	57,7	35,6	58,2	32,8
23:40	24917	2833,0	58,33	25,4	25,5	25,5	26	25,5	62,8	38,3	59,8	36,5	60,6	35,1
00:00	24601	2808,0	57,87	25,4	25,5	25,5	26	25,5	64,4	39,6	61,5	38,1	62,5	37,0
00:20	24478	2799,0	57,64	25,4	25,5	25,6	26	25,6	65,6	40,6	62,8	39,2	64,0	38,4
00:40	24655	2805,0	57,77	25,4	25,6	25,6	26	25,6	66,5	41,6	63,8	40,1	65,2	39,6
01:00	24661	2805,0	57,70	25,5	25,6	25,7	26	25,7	67,4	42,4	64,7	40,9	66,2	40,5
01:20	24856	2812,0	57,87	25,5	25,6	25,7	26	25,7	68,3	43,4	65,6	41,9	67,3	41,6
01:40	24937	2813,0	57,90	25,5	25,7	25,7	26	25,7	69,1	44,2	66,5	42,8	68,3	42,6
02:00	24759	2800,0	57,63	25,5	25,8	25,8	26	25,8	69,8	45,0	67,3	43,5	69,1	43,3
02:20	24717	2795,0	57,56	25,5	25,7	25,8	26	25,8	70,3	45,6	67,8	44,1	69,7	44,0
02:40	24828	2800,1	57,65	25,5	25,8	25,8	26	25,8	70,7	46,2	68,2	44,6	70,2	44,4
03:00	24934	2806,3	57,74	25,6	25,8	25,8	26	25,8	71,3	47,0	68,9	45,6	70,9	45,1
03:20	24844	2799,0	57,60	25,6	25,8	25,9	26	25,9	71,8	47,6	69,3	46,1	71,4	45,5
03:40	24964	2804,6	57,70	25,6	25,8	25,9	26	25,9	72,3	48,2	69,7	46,7	72,2	46,3
04:00	24890	2805,0	57,72	25,6	25,8	25,9	26	25,9	72,4	48,5	69,9	47,0	72,4	46,4
04:20	24853	2801,2	57,65	25,6	25,9	25,9	26	25,9	72,7	49,0	70,3	47,5	72,5	46,5
04:40	24873	2802,6	57,66	25,6	25,9	25,9	26	25,9	73,0	49,3	70,5	47,8	72,8	46,9
05:00	24767	2772,6	57,07	25,6	25,9	25,9	26	25,9	73,2	49,6	70,7	48,2	73,1	47,2
05:20	24785	2774,8	57,11	25,6	25,9	25,9	26	25,9	73,4	50,0	70,9	48,5	73,2	47,3
05:40	24726	2769,4	57,02	25,6	25,9	26	26	25,9	73,7	50,2	71,0	48,7	73,3	47,4
06:00	24738	2774,3	57,10	25,6	25,9	26	26	25,9	73,9	50,4	71,0	49,0	73,4	47,5
06:20	24775	2774,1	57,10	25,7	25,9	26	26	26,0	74,1	50,6	71,2	49,2	73,5	47,5

SICAKLIK ARTIŞI TESTİ
TEMPERATURE RISE TEST

Güç	-	Rated Power	:	**2200**	**kVA**
Gerilim	-	Rated Valtage	:	**23,00 / 0,40**	**kV**
Ölçülen boşta kayıp	-	Measured no-load losses	:	**2285**	**W**
Ölçülen yükte kayıp	-	Measured load loss (at 75 °C)	:	**22440**	**W**
Toplam kayıplar	-	Total losses	:	**24725**	**W**
Kademe pozisyonu	-	Tap changer position no	:	**3**	
Anma akımı	-	Rated current	:	**55,22 / 3175**	**A**
Soğutma tipi	-	Type of cooling	:	**ONAN**	

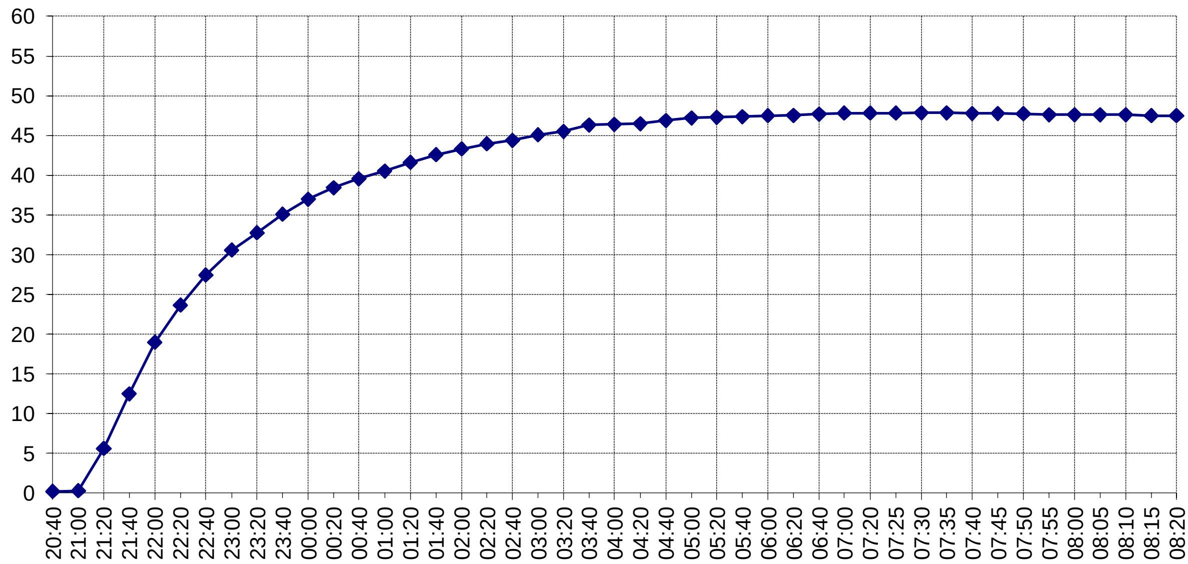
	06:40	24796	2790,5	57,33	25,7	26	26	26,3	26,0	74,2	50,8	71,3	49,4	73,7	47,7
	07:00	24923	2800,1	57,54	25,7	26	26	26,3	26,0	74,4	51,1	71,3	49,6	73,8	47,8
t	07:20	**24797**	**2788,0**	**57,40**	**25,7**	**26**	**26**	**26**	26,0	**74,4**	**51,2**	**71,4**	**49,7**	**73,8**	47,8
	Nominal akıma inildi - Reduce to Rated Current														
	07:20	23169	2696,0	55,48	25,7	26	26	26,3	26,0	74,4	51,2	71,4	49,7	73,8	47,8
	07:25	23535	2718,0	55,95	25,7	26	26	26,3	26,0	74,4	51,1	71,5	49,7	73,8	47,8
	07:30	23480	2715,0	55,88	25,7	26	26,1	26,3	26,0	74,4	51,2	71,4	49,7	73,9	47,9
	07:35	23434	2712,0	55,84	25,7	26	26,1	26,4	26,1	74,3	51,2	71,4	49,7	73,9	47,9
	07:40	23311	2705,0	55,69	25,7	26	26,1	26,3	26,0	74,3	51,2	71,4	49,8	73,8	47,8
	07:45	23413	2711,0	55,82	25,7	26	26	26,4	26,0	74,2	51,2	71,3	49,8	73,8	47,8
	07:50	23507	2717,0	55,93	25,8	26	26,1	26,4	26,1	74,2	51,2	71,3	49,8	73,8	47,7
	07:55	23433	2713,0	55,84	25,8	26	26,1	26,4	26,1	74,2	51,2	71,2	49,8	73,7	47,6
	08:00	23418	2712,0	55,82	25,8	26	26,1	26,4	26,1	74,1	51,2	71,2	49,9	73,7	47,6
	08:05	23377	2713,0	55,77	25,8	26,1	26,1	26,4	26,1	74,1	51,3	71,2	50,0	73,7	47,6
	08:10	23319	2708,0	55,70	25,8	26,1	26,1	26,4	26,1	74,1	51,3	71,3	50,0	73,7	47,6
	08:15	23291	2704,0	55,69	25,8	26,1	26,1	26,4	26,1	74,1	51,3	71,2	49,9	73,6	47,5
n	**08:20**	**23338**	**2706,0**	**55,74**	**25,8**	**26,1**	**26,1**	**26**	**26,1**	**74,0**	**51,3**	**71,2**	**49,8**	**73,6**	**47,5**

Sargı dirençleri ölçüldü - Winding resistances were measured.

$t_1 \ldots t_3$	**: Çevre sıcaklığı**	- Ambient temperature	**Sc_{1-2}**	**: Soğutucu çıkış sıcaklığı**	- Cooler outlet temperature
t ort.	**: Ortalama çevre sıcaklığı**	- Average ambient temperature	Θ_{ty}	**: Tepe yağ sıcaklığı**	- Top oil temperature
Sg_{1-2}	**: Soğutucu giriş sıcaklığı**	- Cooler inlet temperature	$\Delta\Theta_{ty}$	**: Tepe yağda sıcaklık artışı**	- Top oil temperature rise

TEPE YAĞDA SICAKLIK ARTIŞI

SOĞUTMA TİPİ / COOLING TYPE **: ONAN**

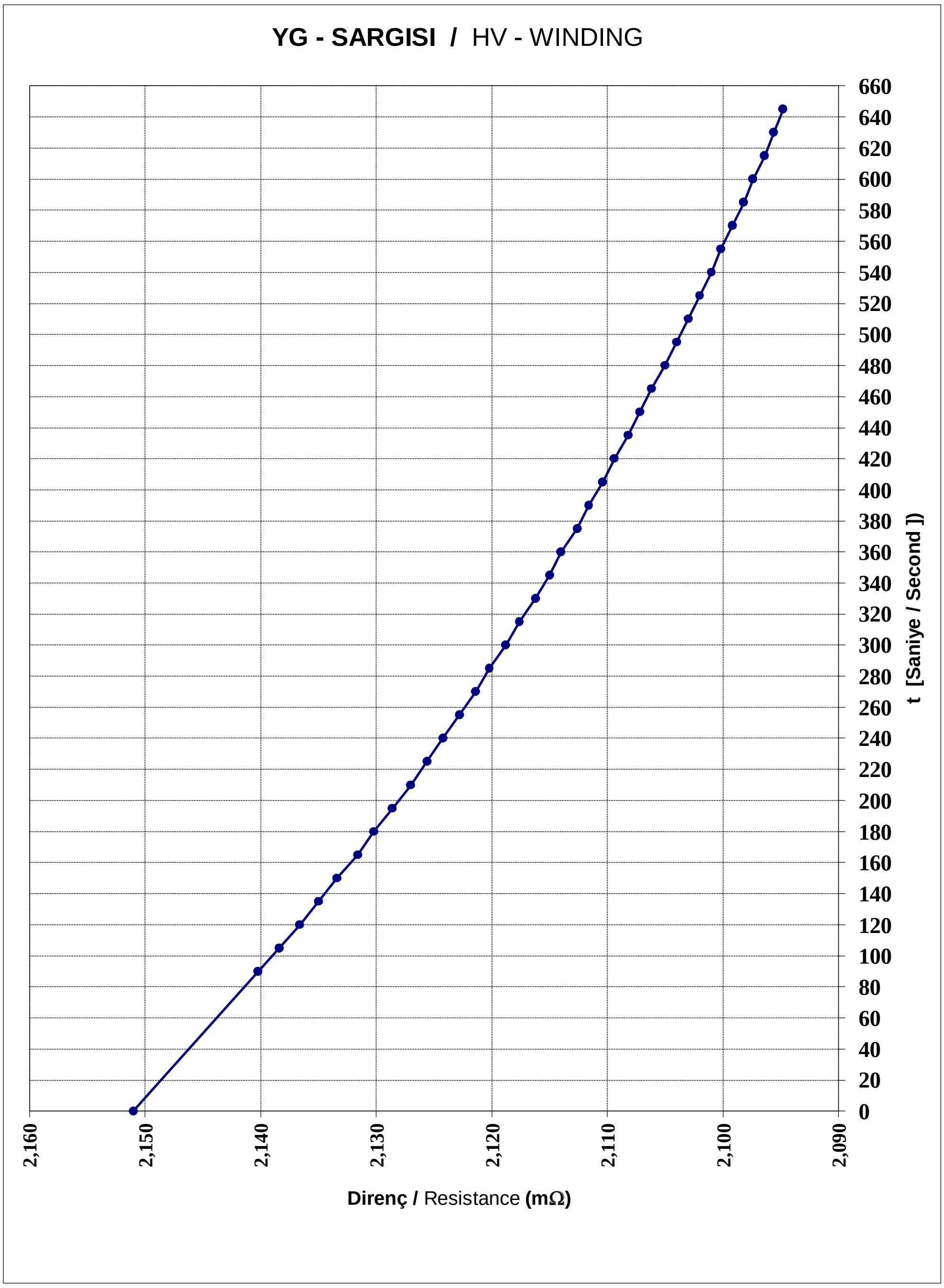


Tepe yağda sıcaklık artışı-Top oil temperature rise	:	**47,7**	**K**
Garanti - Guaranteed	:	**50**	**K**

DİRENÇ - ZAMAN EĞRİLERİ / RESISTANCE - TIME CURVES

SOĞUTMA TİPİ / COOLING TYPE : ONAN

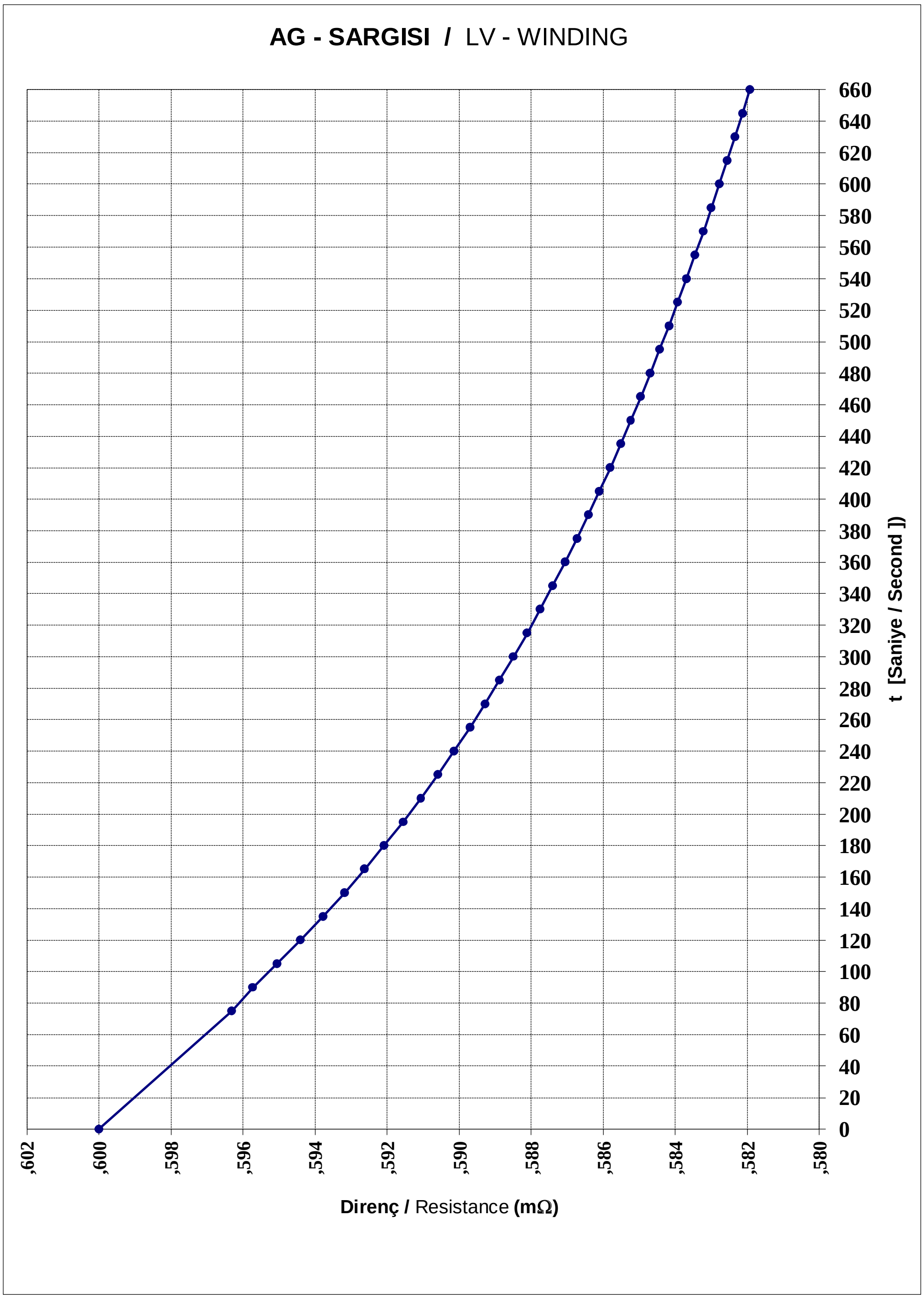
Saniye Seconds	Hot resistances 1V-1W (Ω)
0	2,1510
90	2,1402
105	2,1384
120	2,1366
135	2,1350
150	2,1334
165	2,1316
180	2,1302
195	2,1286
210	2,1270
225	2,1256
240	2,1242
255	2,1228
270	2,1214
285	2,1202
300	2,1188
315	2,1176
330	2,1162
345	2,1150
360	2,1140
375	2,1126
390	2,1116
405	2,1104
420	2,1094
435	2,1082
450	2,1072
465	2,1062
480	2,1050
495	2,1040
510	2,1030
525	2,1020
540	2,1010
555	2,1002
570	2,0992
585	2,0982
600	2,0974
615	2,0964
630	2,0956
645	2,0948



DİRENÇ - ZAMAN EĞRİLERİ / RESISTANCE - TIME CURVES

SOĞUTMA TİPİ / COOLING TYPE : **ONAN**

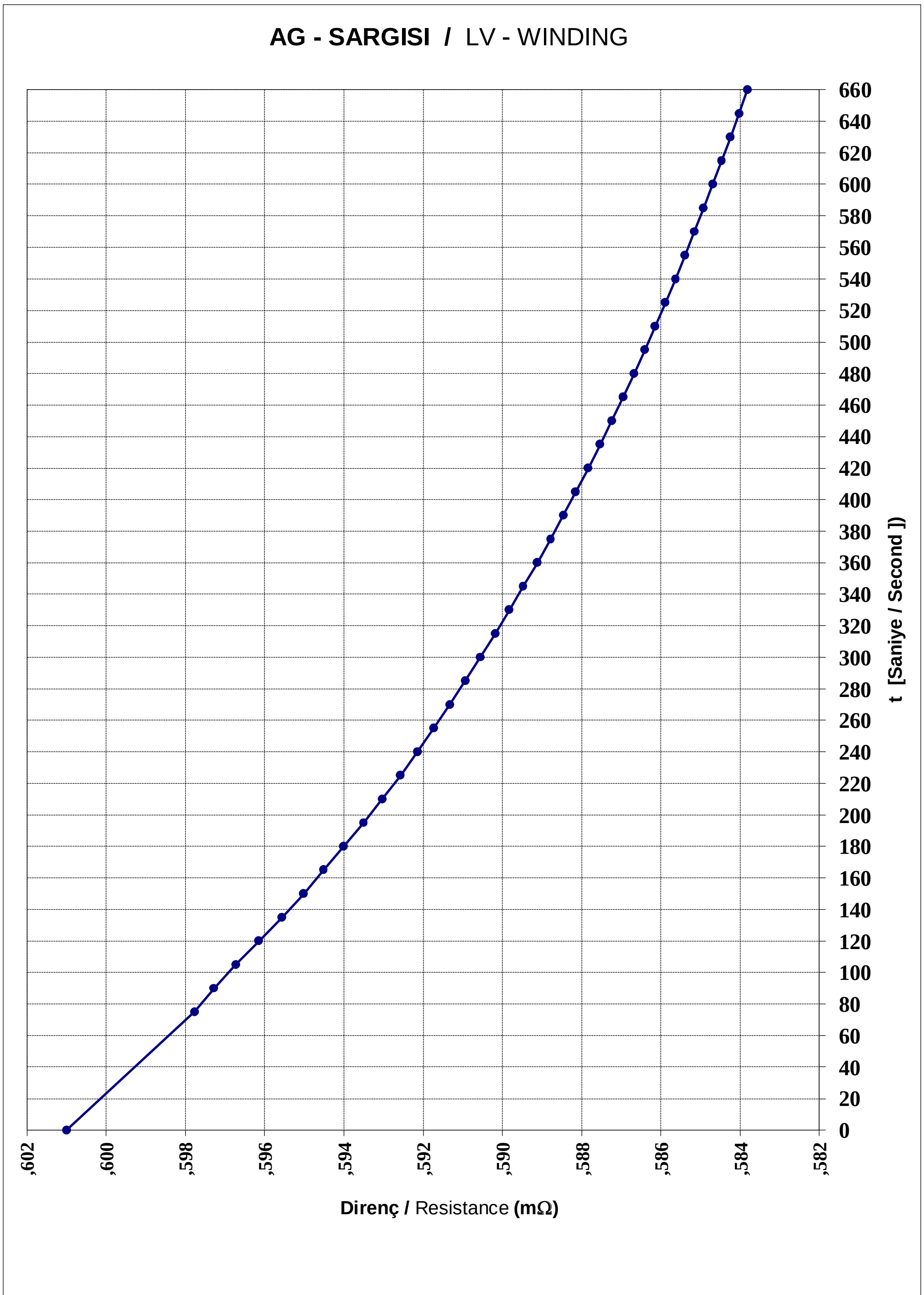
Saniye Seconds	Hot resistances 2v-2n (mΩ)
0	0,6000
75	0,5963
90	0,5957
105	0,5951
120	0,5944
135	0,5938
150	0,5932
165	0,5926
180	0,5921
195	0,5916
210	0,5911
225	0,5906
240	0,5901
255	0,5897
270	0,5893
285	0,5889
300	0,5885
315	0,5881
330	0,5877
345	0,5874
360	0,5871
375	0,5867
390	0,5864
405	0,5861
420	0,5858
435	0,5855
450	0,5852
465	0,5850
480	0,5847
495	0,5844
510	0,5842
525	0,5839
540	0,5837
555	0,5835
570	0,5832
585	0,5830
600	0,5828
615	0,5826
630	0,5823
645	0,5821
660	0,5819



DİRENÇ - ZAMAN EĞRİLERİ / RESISTANCE - TIME CURVES

SOĞUTMA TİPİ / COOLING TYPE **: ONAN**

Saniye Seconds	Hot resistances 3v-2n (mΩ)
0	0,6010
75	0,5978
90	0,5973
105	0,5967
120	0,5961
135	0,5956
150	0,5950
165	0,5945
180	0,5940
195	0,5935
210	0,5930
225	0,5926
240	0,5921
255	0,5917
270	0,5913
285	0,5909
300	0,5906
315	0,5902
330	0,5898
345	0,5895
360	0,5891
375	0,5888
390	0,5885
405	0,5881
420	0,5878
435	0,5875
450	0,5872
465	0,5870
480	0,5867
495	0,5864
510	0,5861
525	0,5859
540	0,5856
555	0,5854
570	0,5852
585	0,5849
600	0,5847
615	0,5845
630	0,5842
645	0,5840
660	0,5838



SICAKLIK ARTIŞI TESTİ - TEMPERATURE RISE TEST

Yağ sıcaklık artışının tayini	-	Determination of oil temperature rise		ONAN		
Toplam kayıpta tepe yağ sıcaklığı	-	Top oil temperature at the total losses		73,8		°C
Test sırasında çevre sıcaklığı	-	Ambient temperature during test		26,0		°C
Tepe yağ sıcaklık artışı	-	Top oil temperature rise		47,8		°K
Düzeltilen tepe yağ sıcaklık artışı	-	Corrected top oil temperature rise	**(x)**	47,7		°K
Soğutucu giriş sıcaklığı (1)	-	Cooler inlet temperature (side 1)		74,4		°C
Soğutucu giriş sıcaklığı (2)	-	Cooler inlet temperature (side 2)		71,4		°C
Ortalama	-	Average		72,9		°C
Soğutucu çıkış sıcaklığı (1)	-	Cooler outlet temperature (side 1)		51,2		°C
Soğutucu çıkış sıcaklığı (2)	-	Cooler outlet temperature (side 2)		49,7		°C
Ortalama	-	Average		50,5		°C
Ortalama yağ sıcaklığı	-	Average oil temperature		36,5		°K
Düzeltilen ortalama yağ sıcaklığı	-	Corrected average oil temperature	**(x)**	**36,4**		°K

Sargı sıcaklık artışının tayini	-	Determination of winding temperature	**ONAN**	**ONAF**	
Anma akımında tepe yağ sıcaklığı	-	Top oil temperature at the rated current	73,6		°C
Soğutucu giriş sıcaklığı (1)	-	Cooler inlet temperature (side 1)	74,0		°C
Soğutucu giriş sıcaklığı (2)	-	Cooler inlet temperature (side 2)	71,2		°C
Ortalama	-	Average	72,6		°C
Soğutucu çıkış sıcaklığı (1)	-	Cooler outlet temperature (side 1)	51,3		°C
Soğutucu çıkış sıcaklığı (2)	-	Cooler outlet temperature (side 2)	49,8		°C
Ortalama	-	Average	50,6		°C
Ortalama yağ sıcaklığı	-	Average oil temperature	62,6		°K

Sargılar - Windings		**YG** - HV	**AG** - LV	
Soğuk dirençler - Cold resistances at	25,3 °C	1,7794 Ω	0,49585 mΩ	
Enerji kesildiği anda sargı dirençleri Winding resistances at switch off	LV1	2,1510 Ω	0,60000 mΩ	
	LV2		0,06010	mΩ
	ONAF			
Enerji kesildiği anda sargı sıcaklıkları Winding temperatures at switch off	LV1	77,6	77,9	°C
	LV2	77,6	80,3	°C
	ONAF			°C
Sargı sıcaklığı ile ortalama yağ sıcaklığı arasındaki fark Difference between winding and average oil temperatures	LV1	15,0	15,3	°K
	LV2	15,0	17,7	°K
	ONAF			°K
Sargı sıcaklığı ile ortalama yağ sıcaklığı arasındaki fark Difference between wndg. and average oil temperature. **(Düzeltilen)** (corrected) **(y)**	LV1	14,8	15,1	°K
	LV2	14,8	17,4	°K
	ONAF			°K
Sargı sıcaklık artışı Windings temperature rise	LV1	50,5	50,8	°K
	LV2	50,5	53,1	°K
	ONAF			°K

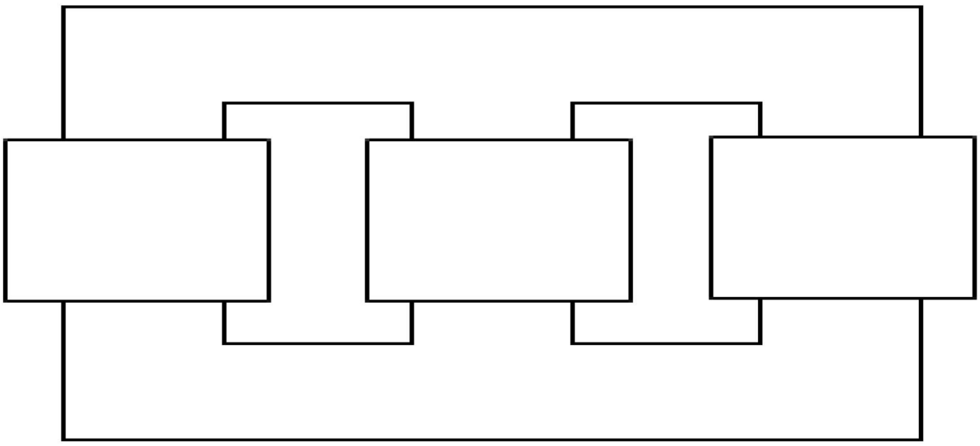
Düzeltme faktörü - Correction factor	
x = 0,9	y = 1,6

Garantiler / Guaranteed			
Garantiler Guaranteed (ONAN)	**Tepe yağ** - Top oil	**50**	°K
	Sargı - Winding	**55**	°K
Garantiler Guaranteed (ONAF)	**Tepe yağ** - Top oil		°K
	Sargı - Winding		°K

Not - Note : Dirençler Ω,mΩ , sıcaklıklar °C ' dir.
The resistances and temperatures are in Ω,mΩ and °C.

MANYETİK BALANS TESTİ (AG)

MAGNETIC BALANCE TEST FROM LV SIDE



Besleme	Terminal	Gerilimler (V)
Supply	**Terminals**	**Voltage (V)**
2U	2U-2N	227,2
	2V-2N	161,3
	2W-2N	66,6

Besleme	Terminal	Gerilimler (V)
Supply	**Terminals**	**Voltage (V)**
2V	2U-2N	114,6
	2V-2N	228
	2W-2N	115,7

Besleme	Terminal	Gerilimler (V)
Supply	**Terminals**	**Voltage (V)**
2W	2U-2N	73,4
	2V-2N	165,8
	2W-2N	230,5

ABB	# TEST RAPORU *TEST REPORT*	AB-0538-T 1LTR0030613-01 15.10.2015

Kullanılan Cihazlar / *Equipment Used*

	Cihaz Tanımı	*Equipment Description*	Marka *Make*	Seri Numarası *Serial Number*
X	**Gerilim Transformatörü**	*Voltage Transformer*	Ritz Messwandler	76/338664
X	**Gerilim Transformatörü**	*Voltage Transformer*	Ritz Messwandler	76/338665
X	**Gerilim Transformatörü**	*Voltage Transformer*	Ritz Messwandler	76/338666
X	**Gerilim Transformatörü**	*Voltage Transformer*	Ritz Messwandler	76/338667
X	**Gerilim Transformatörü**	*Voltage Transformer*	Ritz Messwandler	76/338668
X	**Gerilim Transformatörü**	*Voltage Transformer*	Ritz Messwandler	76/338669
X	**Akım Tansformatörü**	*Current Transformer*	Ritz Messwandler	86/388972
X	**Akım Tansformatörü**	*Current Transformer*	Ritz Messwandler	86/388973
X	**Akım Tansformatörü**	*Current Transformer*	Ritz Messwandler	86/388974
X	**Geniş Bant Güç Analizörü**	*Wide Band Power Analyzer*	LEM NORMA	M033719RR
X	**Direnç Köprüsü**	*Winding Resistance Meter*	Raytech	293-100
X	**Direnç Köprüsü**	*Winding Resistance Meter*	Raytech	301-145
X	**Yüksek Gerilim Test Cihazı**	*Hipot AC Withstand Test Set*	Haefely	51-080624-06-84
	Yüksek Gerilim Test Cihazı	*Hipot AC Withstand Test Set*	American HVTS	85-680
	Ses Seviyesi Ölçer	*Sound Pressure Level Meter*	Brüel & Kjaer	3002754
	AC YG Ve C/Tand Ölçüm Cihazı	*Insulation Analysis System*	Tettex	170310
	Güç Kalitesi Analizörü	*Power Analyzer*	Fluke	DM9451041
X	**Kronometre**	*Chronometer*	Catiga	12-07557
X	**Kronometre**	*Chronometer*	Catiga	11-05241
	Oran Ölçer	*Turns Ratio Meter*	Tettex	171354
X	**Oran Ölçer**	*Turns Ratio Meter*	Tettex	170790
	Oran Ölçer	*Turns Ratio Meter*	Tettex	156315
	Oran Ölçer	*Turns Ratio Meter*	Tettex	173328
	Oran Ölçer	*Turns Ratio Meter*	H&B	25557
	DC Yalıtım Direnci Ölçer	*DC Insulation Resistance Meter*	Megger	9609901050 0996
X	**DC Yalıtım Direnci Ölçer**	*DC Insulation Resistance Meter*	Megger	071107/1712
	DC Yalıtım Direnci Ölçer	*DC Insulation Resistance Meter*	Megger	080508/1748
	Direnç Köprüsü	*Winding Resistance Meter*	ABB	5
	Veri Kaydedici	*Data Logger*	HP	MY41005672
	Direnç Köprüsü	*Winding Resistance Meter*	Tettex	156495
	Geniş Bant Güç Analizörü	*Wide Band Power Analyzer*	Fluke	U4-97959-SS
	PT100 Termometre	*PT100 Thermometer*	LEMO	FFA.25
	Kısmi Deşarj Kalibratörü	*Partial Discharge Calibrator*	Power Diagnostix	1264
	Darbe Üreteci ve Ölçme Sistemi	*Impulse Generator & Measurement System*	Tettex	05101219.50.1/153647
	Nem & Sıcaklık Ölçer	*Humidity & Temperature Meter*	AZ 8857	9544851
	Kızılötesi Termometre	*Infrared Thermometer*	Fluke	94102665
	Multimetre	*Multimeter*	Fluke	165701116