KINGDOM OF CAMBODIA

Nation, Religion, King

ELECTRICITE DU CAMBODGE

TECHNICAL RULE

EDC-TR-008

Distribution Transformers Testing after Repairing

April 2022

ELECTRICITE DU CAMBODGE

Version	Date	Technical Specification Name	Authorized by : (name and signature)
1.0	May, 2022	Distribution Transformers Testing after Repairing	

Version	Drafted/reviewed by	Verified by	Approved by	Date
Draft1	AD			10/2021
Draft 2	EDC/AD			02/2022
Draft 3	EDC/AD			03/2022
Draft 4	EDC/AD			04/2022

ELECTRICITE DU CAMBODGE

Contents

ELECTRICITE DU CAMBODGE

[Blank]

Distribution Transformers Testing after Repairing

1 Scope of Application

This technical rule defines and details the electrical tests that must be carried out on all distribution transformer after repairing of any kind. This document duplicates more or less the text of the IEC 60076-1 and IEC 60076-3.

It gives main principles of testing and should be used as a guide only because for each test to be carried out, it is necessary to refer on the user guide of the testing apparatus and equipment.

2 Preamble

2.1 Testing staff

Technicians performing these electrical tests and inspections shall be trained and experienced concerning the apparatus and systems being evaluated. These individuals shall be capable of conducting the tests in a safe manner and with complete knowledge of the hazards involved. They must evaluate the test data and make a judgment on the serviceability of the specific equipment.

2.2 Safety

This document deals only with electrical measurement and tests to be carried out. The safety rules and procedures are not mentioned in this document.

All parties involved must be cognizant of electricity standard safety procedures. This document does not contain any procedures including specific safety procedures. It is recognized that some of the tests and inspections recommended in this technical rule are potentially hazardous.

Individuals performing these tests shall be qualified and capable of conducting the tests in a safe manner, with complete knowledge of the hazards involved and with complete application of EDC safety procedure.

3 Transformers testing

After transformer repair it is necessary to carry out all electrical tests and oil quality tests in order to be sure that the transformer is in perfect condition to be installed on the network.

Off course, the tests to be carried out must be not destructive so the routine tests and some special tests required by IEC 60076 are carried out. They are as follow:

Routine tests

- Measurement of winding resistance
- Measurement of voltage ratio and check of phase displacement
- Measurement of short-circuit impedance and load loss
- Measurement of no-load loss and current
- Dielectric routine tests

Special tests

- Measurement of insulation resistance to earth of the windings as reference for latter measurements done on site.

3.1 General requirements for routine and special tests

Tests shall be made at any ambient temperature between 10 °C and 40 °C and with cooling water (if required) at any temperature not exceeding 25 °C.

Tests shall be made at EDC workshop or any other testing laboratory.

All external components and fittings that are likely to affect the performance of the transformer during the test shall be in place.

Tapped windings shall be connected on their principal tapping, unless the relevant test clause requires otherwise.

The test basis for all characteristics other than insulation is the rated condition, unless the test clause states otherwise.

All measuring systems used for the tests shall have certified, traceable accuracy and be subjected to periodic calibration.

Where it is required that test results are to be corrected to a reference temperature, this shall be for oil-immersed transformers: 75 °C.

3.2 Measurement of winding resistance

The resistance of each winding, the terminals between which it is measured and the temperature of the windings shall be recorded. Direct current shall be used for the measurement.

In all resistance measurements, care shall be taken that the effects of self-induction are minimized.

For oil immerse transformers: after the transformer has been under oil without excitation for at least 3 h, the average oil temperature shall be determined and the temperature of the winding shall be deemed to be the same as the average oil temperature. The average oil temperature is taken as the mean of the top and bottom oil temperatures.

It is strongly recommended to use a specific testing apparatus for this winding resistance testing. Measures with simple ohmmeter do not give true values and do not allow a real verification of winding troubles during maintenance testing.

The purpose of this test is to measure the D.C. resistance of the transformer windings, this test can be done by a voltmeter and ammeter method.

This test can be done when a transformer is hot or cold, but the temperature of the winding and oil should be recorded during the test. For a transformer with delta/star windings, check the resistance as follows:

- MV winding resistance between phase A and phase B
- MV winding resistance between phase B and phase C
- MV winding resistance between phase A and phase C
- LV winding resistance between phase a and neutral n at Tap 3 (22 000V or 35 000 V)
- LV winding resistance between phase b and neutral n at Tap 3 (22 000V
- LV winding resistance between phase c and neutral n at Tap 3 (22 000V)

It is mentioned that the resistance value varies with the temperature of the transformer (oil).

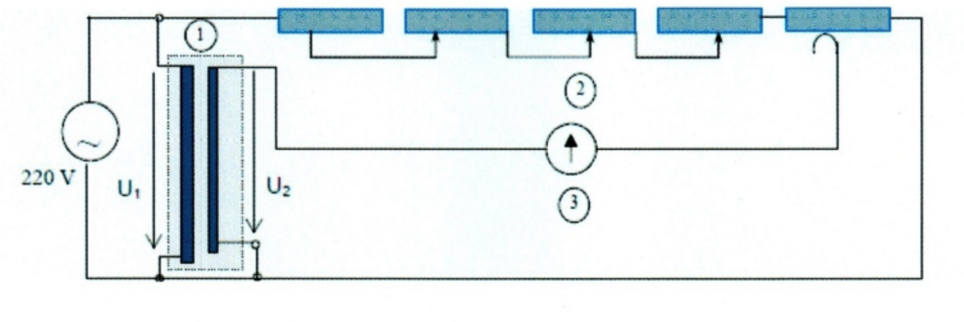
A brief checking with ohmmeter must show that the resistances R:

- RAB≈RAC≈RBC
- Ran≈Rbn≈Rcn

Using a specific testing equipment will allow to compare all measured winding resistances with the values mentioned in the routine test report of the transformer.

3.3 Measurement of voltage ratio and check of phase displacement

The voltage ratio shall be measured on each tapping. The polarity of single-phase transformers and the connection symbol of three-phase transformers shall be checked.



- **1** – Transformer under test
- **2** – Transformer with adjustable range (standard)
- **3** – Zero position indicator
- **U_1** – Applied voltage to the bridge and HV winding (220 V, 50 Hz)
- **U_2** – Induced voltage at the LV winding

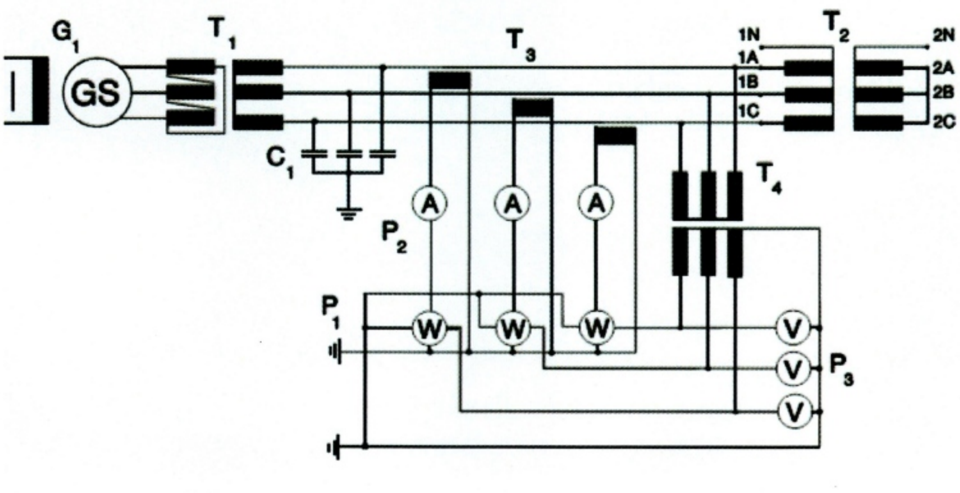
Theoretical turn ratio = HV winding voltage / LV winding voltage

Deviation= $\frac{(Measured\ turn\ ratio)-(expected\ turn\ ratio)}{expected\ turn\ ratio}\ \%100$

The test is considered successful if the deviation does not exceed 0.5%.

3.4 Measurement of short-circuit impedance and load loss

The short-circuit impedance and load loss for a pair of windings shall be measured at rated frequency with approximately sinusoidal voltage applied to the terminals of one winding, with the terminals of the other winding short-circuited, and with possible other windings open-circuited.



The supplied current should be equal to the relevant rated current (tapping current) but shall not be less than 50 % thereof. The measurements shall be performed quickly so that temperature rises do not cause significant errors. The difference in temperature between the top oil and the bottom oil shall be small enough to enable the mean temperature to be determined accurately.

The measured value of load loss shall be multiplied with the square of the ratio of rated current (tapping current) to test current. The resulting figure shall then be corrected to reference temperature. The I^2R loss (R being d.c. resistance) is taken as varying directly with the winding resistance and all other losses inversely with the winding resistance.

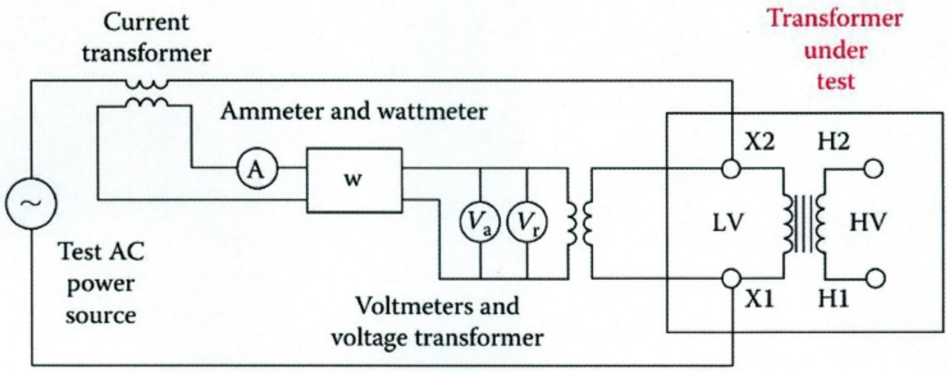
The short-circuit impedance is represented as reactance and a.c. resistance in series. The impedance is corrected to reference temperature assuming that the reactance is constant and that the a.c. resistance derived from the load loss varies as described above.

On transformers having a tapped winding with tapping range exceeding ±5 %, the short-circuit impedance shall be measured on the principal tapping and the two extreme tappings.

On a three-winding transformer, measurements are performed on the three different two winding combinations. The results are re-calculated, allocating impedances and losses to individual windings according IEC 60606. Total losses for specified loading cases involving all these windings are determined accordingly.

3.5 Measurement of no-load loss and current

The no-load loss and the no-load current shall be measured on one of the windings at rated frequency and at a voltage corresponding to rated voltage if the test is performed on the principal tapping, or to the appropriate tapping voltage if the test is performed on another tapping. The remaining winding or windings shall be left open-circuited and any windings which can be connected in open delta shall have the delta closed.



The transformer shall be approximately at factory ambient temperature.

For a three-phase transformer the selection of the winding and the connection to the test power source shall be made to provide, as far as possible, symmetrical and sinusoidal voltages across the three wound limbs.

The test voltage shall be adjusted according to a voltmeter responsive to mean value of voltage but scaled to read the r.m.s. voltage of a sinusoidal wave having the same mean value.

The reading of this voltmeter is U¢.

At the same time, a voltmeter responsive to the r.m.s. value of voltage shall be connected in parallel with the mean-value voltmeter and its indicated voltage U shall be recorded.

When a three-phase transformer is tested, the voltages shall be measured between line terminals, if a delta-connected winding is energized, and between phase and neutral terminals if a YN or ZN connected winding is energized.

The test voltage wave shape is satisfactory if the readings U¢ and U are equal within 3 %.

The measured no-load loss is Pm, and the corrected no load loss is taken as:

$$P_o = P_m (1 + d)$$

$$d = \frac{U' - U}{U'} \text{ (usually negative)}$$

If the difference between voltmeter readings is larger than 3 %, the validity of the test is subject to agreement.

The r.m.s. value of no-load current is measured at the same time as the loss. For a three phase transformer, the mean value of readings in the three phases is taken.

3.6 Dielectric routine tests

The dielectric tests are described in IEC 60076-3. The chapter 9 of the IEC clearly specify:

For transformers which have already been in service and have been refurbished or serviced, dielectric tests according to 7.2, 7.3 and 7.4 shall be repeated at test levels of 80 % of the original values, unless otherwise agreed upon, and provided that the internal insulation has not been modified.

So, as this document deals with refurbished and repaired transformers the dielectric tests level shall be only 80% of the IEC required values. The maximum test voltage is mentioned in this document.

In addition, if the tapping range is less and more than ±5 %, the dielectric tests shall be done with the transformer connected on the principal tapping.

The IEC 60076-3 defines the routine tests to be carried out on transformers, it clearly mentions that Switching impulse test and lightning impulse routine tests are not to be carried out on transformers equal of less than 72kV.

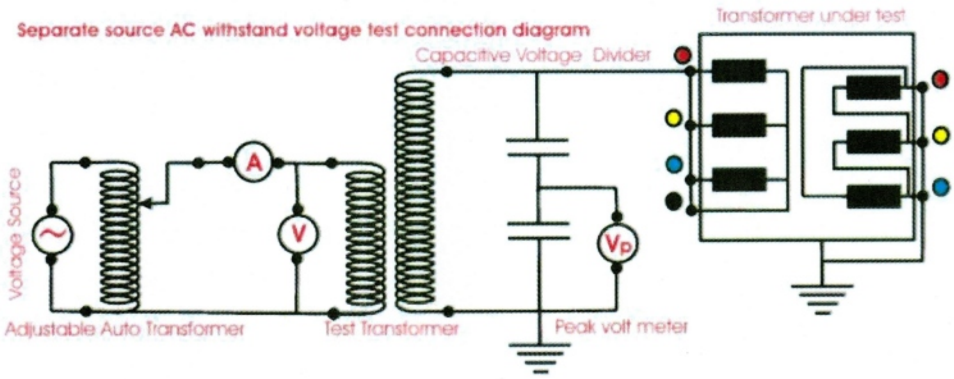
So, the following dielectric routine test shall be carried out on repaired transformers:

- Applied voltage test (AV)
- Induced voltage withstand test (IVW))

3.6.1 Applied voltage test (AV)

The test described afore is **the only method for applied voltage test requested by IEC 60076-3 (2013).**

The test shall be carried out on each separate winding of the transformer in turn. The full test voltage shall be applied for 60 s between all accessible terminals of the winding under test connected together and all accessible terminals of the remaining windings, core, frame and tank or casing of the transformer, connected to earth.



The test shall be made with an approximately sinusoidal single-phase alternating voltage at not less than 80 % of the rated frequency. The peak value of voltage shall be measured. The peak value divided by 2 shall be equal to the test value.

NOTE: Approximately sinusoidal can be taken to mean that the peak value divided by 2 does not differ from the r.m.s value of the waveform by more than about 5 % (see IEC 60060-1), but wider deviations may be accepted.

The test shall commence at a voltage not greater than one-third of the specified test value, and the voltage shall be increased to the test value as rapidly as is consistent with measurement.

At the end of the test, the voltage shall be reduced rapidly to less than one-third of the test value before switching off.

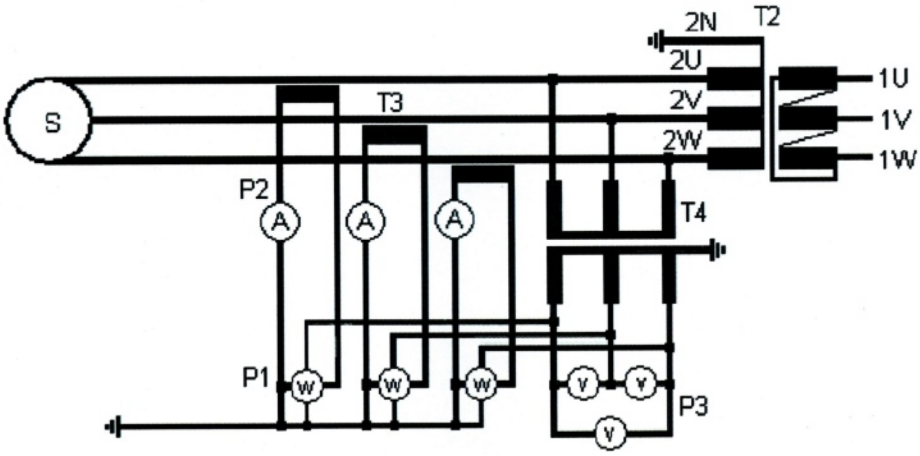
The test is successful if no collapse of the test voltage occurs.

As mentioned afore, the test voltage is:

Rated system voltage (kV)	AC withstand voltage (kV r.m.s)	Specified Test voltage (80%) on Repaired or refurbished Transformers
1.1kV	3 kV	2.4 kV
22 kV	50 kV	40 kV
35 kV	70 kV	56 kV

3.6.2 Induced voltage withstands test (IVW)

The test described afore is the only method for applied voltage test requested by IEC 60076-3 (2013). It is applied on secondary side of windings.



3.6.2.1 General

The test shall be carried out with any accessible neutral terminals and any other terminals that are normally at earth potential in service earthed. For three phase transformers a symmetrical three phase test voltage shall be used. Any line terminals not connected to the test supply shall be left open.

NOTE 1: When voltage is induced in a winding with no neutral connection, the voltages with respect to earth at each terminal of this winding will depend on the capacitances to earth and other windings. Any flashover from one of the line terminals to earth during the test can result in voltages exceeding the applied voltage test level appearing at the other terminals of the winding. Suitable precautions can be required to take account of this possibility.

During the test, the test voltage appropriate to a winding without voltage variation shall appear at the terminals of that winding so that the voltages between turns and between phases will have the same ratio between test voltage and rated voltage. The voltage shall either be measured on the highest voltage terminals, or if this is not practical the voltage shall be measured at the terminals of the transformer connected to the supply.

For transformers with tappings, the test shall be carried out with the transformer on principal tap.

The test shall be performed with the transformer excited exactly as it will be for service. The voltage may be induced from any winding or from a special winding or taps provided for test purposes.

An alternating voltage shall be applied to the terminals of one winding of the transformer. The form of the voltage shall be as nearly as possible sinusoidal and its frequency shall be sufficiently above the rated frequency to avoid excessive magnetizing current during the test.

The peak value, as defined in IEC 60060-1 divided by 2 and the r.m.s. value of the induced test voltage shall be measured and the lower of the peak value divided by 2 and the r.m.s. value shall be taken as the test value.

3.6.2.2 Test

The test time at full test voltage shall be 60 s for any test frequency up to and including twice the rated frequency, unless otherwise specified. When the test frequency exceeds twice the rated frequency, the test time in seconds of the test shall be:

$$120 \times \frac{test\ frequency}{rated\ frequency} \text{ but not less than 15 s.}$$

The test shall commence at a voltage not greater than one-third of the specified test value, and the voltage shall be increased to the test value as rapidly as is consistent with measurement.

At the end of the test, the voltage shall be reduced rapidly to less than one-third of the test value before switching off.

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

The phase-to-phase test voltage shall not exceed the rated induced AC withstand voltages in the table after:

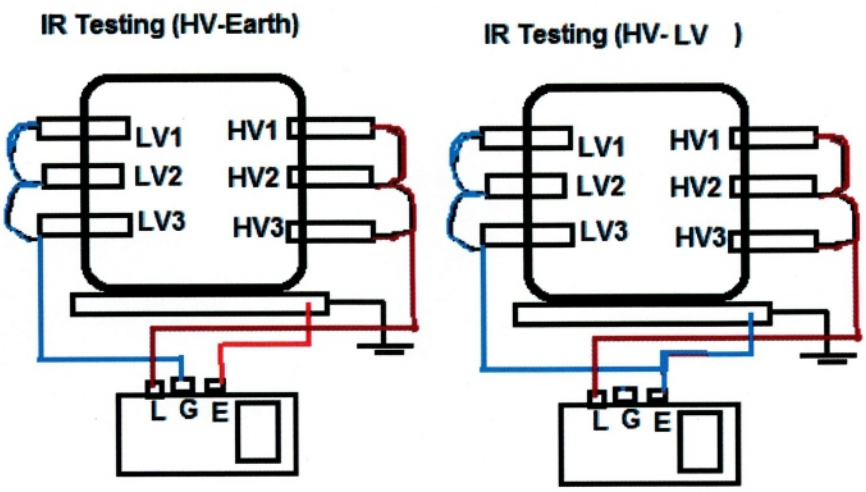
	Induced voltage withstand test (IVW)
22 kV transformer	800 V
35 kV transformer	800 V

As a rule, the test voltage across an untapped winding of the transformer shall be as close as possible to twice the rated voltage. Normally, no partial discharge measurements are performed during this test.

3.7 Measurement of insulation resistance to earth of the windings as reference for latter measurements done on site

Even this insulation testing can be done with a 5kV DC mega ohm meter, it is strongly recommended to do this test with a specific tester for transformer and more especially for maintenance/verification tests developed in another document.

The purpose of this test is to determine the insulation resistance of the high-voltage winding to the ground, low-voltage winding to the ground, and the high-voltage winding to the low voltage winding.



The operating guide of the testing apparatus must be strictly followed.

The measurement is done until the tester reach stability but shall not exceed 10 mn duration.

This test should be done between the windings as follows:

- MV windings to the Earth
- LV windings to the Earth same as MV/Earth but the connection will be between LV-Earth.
- The MV windings to the LV windings.

As practical guide the following table may be applied:

Voltage	Test Voltage (DC) LV side	Test Voltage (DC) MV side	Minimum insulation resistance value (Approx.)
11KV to 33KV (22kV)	1000V	5KV	5000MΩ
33KV to 66KV (35kV)	1000V	5KV	5000MΩ

(1): care the value varies with oil temperature.

For any **transformer with new oil**, the insulation resistance measured shall not be less than:

- MV – Earth: 5000 MΩ (Approx.)
- LV – Earth: 4000 MΩ (Approx.)
- MV – LV: 5000 MΩ (Approx.)

For transformer with without oil replacement (change of gasket, bushing, etc.), the insulation resistance measured shall not be less than:

- MV – Earth: 1000 MΩ (Approx.)
- LV – Earth: 500 MΩ (Approx.)
- MV – LV: 1000 MΩ (Approx.)

In case, the measured values are less than requested, the oil must be changed by treated one.

4 Test recording

All tests carried out on the repaired transformers shall be recorded in a data base.

Additionally, the characteristic plate of the transformer shall be verified and modified if necessary. The transformer shall bear another indelible plate mentioning:

TRANSFORMER REPAIRED ON: Date

5 Oil for transformers

5.1 Repairing that does not need to remove oil

In those cases, as example for replacing bushings of cover gaskets there is no need to change the oil nevertheless this one must only be tested (dielectric withstand) and treated if necessary.

5.2 Repairing that need oil removing

The oil used for filling repaired transformers must be NEW and conform to IEC 60296:2020. Utilization of treated used oil is accepted provided this oil, as per transformer date, is less than 30 years old.

Older oil is forbidden even treated with local means because in order to remove all contaminants and possible PCB in used oil the process MUST be done by specific plant.

For new oil use, only a testing of dielectric withstand according IEC 60156 is required.

Nevertheless, everybody must be aware that the insulation paper used in the transformer windings absorbs humidity from the ambient air especially in the wet atmosphere of Cambodia and when the

transformer is filled this humidity passes to the oil and this fact decrease the dielectric withstand of the transformer oil.

So, it is strongly recommended that active parts of transformers been dried inside vacuum ovens. Compared to standard drying processes, drying times and energy consumption are optimized (2 to 3 times faster than a traditional atmospheric solution).

In case, transformers are filled without windings drying, the dielectric withstand of the oil will decrease drastically after some weeks.

So, in case EDC do not use ovens for drying windings, the transformers shall be filled with oil possessing more than 60kV of dielectric withstand.

The following process is to be applied:

1/ filling of the transformer with 60kV dielectric withstand oil,

2/ the transformer is then stored during 3 weeks,

3/ the oil is then tested again in order to know its dielectric withstand,

- If the oil dielectric withstand is less than 40 kV, this oil is then replaced again by 60 kV dielectric withstand one or treated in order to reach a dielectric withstand of 55 kV.
- If the dielectric withstand of the oil is more than 50 kV, the transformer can then be installed on the network.

No transformer shall be allowed to leave the workshop if the oil dielectric withstand is less than 50 kV.

Any oil used in repaired transformer shall be treaded in order to remove water contain, and dielectrically tested. Dissolve Gasses analysis of old oil testing is optional but strongly recommended.

6 Annex 1: Temperature correction of load loss

Extract from IEC 60076-1

Annex E
(normative)

Temperature correction of load loss

List of symbols

Index 1	Refers to measurement of 'cold winding resistance' (10.2).
Index 2	Indicates conditions during measurement of load loss (10.4).
r	Indicates conditions at 'reference temperature' (10.1).
R	Resistance.
θ	Winding temperature in °C.
P	Load loss.
I	Specified load current for loss determination (rated current, tapping current, other specified value related to a particular loading case).
P_a	'Additional loss'.

The winding resistance measurement is made at a temperature θ_1. The measured value is R_1.

The load loss is measured with the winding at an average temperature θ_2. The measured loss referred to specified current I, is P_2. This loss is composed of 'ohmic loss': I^2R_2 and 'additional loss': P_{a2}

$$R_2 = R_1 \frac{235 + \theta_2}{235 + \theta_1} \text{ (copper)} \qquad R_2 = R_1 \frac{225 + \theta_2}{225 + \theta_1} \text{ (aluminium)}$$

$$P_{a2} = P_2 - I^2R_2$$

At reference temperature θ_r, the winding resistance is R_r, the additional loss P_{ar}, the whole load loss P_r.

$$R_r = R_1 \frac{235 + \theta_r}{235 + \theta_1} \text{ (copper)} \qquad R_r = R_1 \frac{225 + \theta_r}{225 + \theta_1} \text{ (aluminium)}$$

$$P_{ar} = P_{a2} \frac{235 + \theta_2}{235 + \theta_r} \qquad P_{ar} = P_{a2} \frac{225 + \theta_2}{225 + \theta_r}$$

For oil-immersed transformers with reference temperature 75 °C the formulae become as follows:

$$R_r = R_1 \frac{310}{235 + \theta_1} \text{ (copper)} \qquad R_r = R_1 \frac{300}{225 + \theta_1} \text{ (aluminium)}$$

$$P_{ar} = P_{a2} \frac{235 + \theta_2}{310} \qquad P_{ar} = P_{a2} \frac{225 + \theta_2}{300}$$

Finally: $P_r = I^2R_r + P_{ar}$

7 Annex 2 Transformer Failure Analysis

ELECTRICITE DU CAMBODGE	Transformer Failure Analysis	Business and Distribution Department Workshop Unit

Three - Phase Distribution Transformer

Section A – General Data

Substation No:	Location:	Test Date:
Manufacturer:	Serial Number:	Manufacturing:
Capacity:	Rated Voltage:	Rate Current:
Phases:	Tapping:	Power Frequency:
Vector Group:	Cooling Type:	Imp. Voltage:
Date of Installation:	Date of Failure:	

Section B – Visual Inspection

Check Points	Note	
1. Peak load on distribution transformer	HV: Amp.	LV: Amp.
2. Indication of temperature controller if any		
3. Distributer fault frequency		
4. Last date of transformer oil filtration if any		
5. Oil leakage noticed if any		
6. oil level status		
7. Did protection operate?	HV side:	LV side:
8. Whether lightening arresters is provided?		
9. Condition of lightening arrester of the time of the failure		
10. Number of earth pits provided for the transformer & size of earth wire used.		
11. Peak load reached so far or prior to failure		
12. Total connected on the equipment		
13. Period from which it is in service at present situation		
14. Apparent causes of failure		
15. Was there climatic condition i.e., any thunder storm activity, in the vicinity of the transformer?		
16. If it is due manufacturing defects		

17. Has the transformer failed within the guarantee period & if so, has it been taken with the supplier	
18. Whether experienced any faults simultaneously with failure of T/F either on HT/LT side, if yes pleasure state the exact details	
19. Particulars of the last maintenance	
a. Oil test results & data	
b. Insulation test rest & data	
20. Details of other maintenance	
21. Past history of failure of transformer	
22. Any comment	

Section C – Site testing report

1. Insulation Resistance Test T= °C Humidity : %

Connection	MV to Earth		LV to Earth		MV to LV	
Insulation Resistance value at time 1min						
Polarization Index (10:1min ratio)						

2. Winding Resistance Measurement at T= °C

	Primary Side R_{MV} (Ω)			Secondary Side R_{LV} (mΩ)		
Tap	A-B	B-C	C-A	a-b	b-c	c-a
1						
2						
3 (main)						
4						
5						

3. Present Test

Section D – Details Lab Test Report

1. Insulation Resistance Test T= °C, Humidity : %

Connection	MV to Earth		LV to Earth		MV to LV	
Insulation Resistance value at time 1min						
Polarization Index (10:1min ratio)						

2. Oil Dielectric Strength Test

Breakdown Voltage	

3. Winding Resistance Measurement at T= °C, Humidity : %							4. Turn Ratio Test		
Tap	Primary Side R_{MV} (Ω)			Secondary Side R_{LV} (mΩ)			Error (%)		
	A-B	B-C	C-A	a-b	b-c	c-a	Phase A	Phase B	Phase C
1									
2									
3									
4									
5									

Comment:

Test by: ____________________________

Version TRFA20001

8 Annex 3 Transformer Testing Report after Repairing

ELECTRICITE DU CAMBODGE	Transformer Test Report after Repairing	Business and Distribution Department Workshop Unit

Three- Phase Distribution Transformer

1. Technical Parameters

Capacity	kVA	Standard		Vector Group
Primary Voltage	V	Primary Current	A	Serial Number
Secondary Voltage	V	Secondary Current	A	Brand Name
Frequency	Hz	Type of Cooling		Material
Tapping Range	%	Manufacturing		% Imp. voltage

2. Resistance Winding at Test Temperature: °C, Humidity : %

	Primary Side R_{MV} (Ω)			Secondary Side R_{LV} (mΩ)		
Tap	A-B	B-C	C-A	a-b	b-c	c-a
1						
2				HV Connection:	MV Material:	
3				LV Connection:	LV Material:	
4				R_{MV} [Ω] in average at tap 3:		Ω
5				R_{LV} [Ω] in average:		mΩ

3. Insulation Resistance (GΩ) at Ambient Temperature: °C, Humidity : %

Connection	Test Voltage	30 Sec.	1 Min.	10 Min.	DAR	PI
MV to Earth, LV Grounded	5000 V					
LV to Earth, MV Grounded	1000 V					
MV to Earth, Earth Grounded	1000 V					

4. Voltage ratio and check of phase displacement Criteria +/-0.5% and Vector group: Dyn11

Tap Position	High	Low	Ratio		Measurement & Deviation %						Vector Group
					Phase A	%	Phase B	%	Phase C	%	
1											
2											
3											
4											
5											

5. No Load Lost Test at Test Temperature: °C, Humidity : %

Input Voltage		V	% Excitation Current		%	Guarantee Value [W]
Current		A	No load Loss		W	
Power Factor						

6. Load Lost Test at Test Temperature °C, Humidity : %						
Input Voltage		V	Load loss at Test temp.		W	Guarantee Value [W]
Current		A	Load Loss at 75°C		W	
Power Factor						
Tap position			Total Loss		W	

7. Withstand Voltage Test at Ambient Temperature: °C, Humidity : %				
Winding	Voltage [kV]	Frequency [Hz]	Time [sec.]	Result
MV to Earth				
LV to Earth				

8- Voltage Breakdown Test at Ambient Temperature: °C, Humidity : %							
Step	1	2	3	4	5	Average	Result
Withstand Voltage							

9. Weight			**10- Dimension (mm)**		
Core and Coil	Oil quality	App. Total Weight	Length	Width	Height

Date of Test:

Tested by: **Checked by:** **Chief of Workshops:**

Version: RT21002

ELECTRICITE DU CAMBODGE	Transformer Test Report after Repairing	Business and Distribution Department Workshop Unit

Single- Phase (2 Bushings) Distribution Transformer

1. Technical Parameters

Capacity	kVA	Standard		Vector Group	
Primary Voltage	V	Primary Current	A	Serial Number	
Secondary Voltage	V	Secondary Current	A	Brand Name	
Frequency	Hz	Type of Cooling		Material	
Tapping Range	%	Manufacturing		% Imp. voltage	

2. Resistance Winding at Test Temperature °C, Humidity : %

	Primary Side R_{MV} (Ω)			Secondary Side R_{LV} (mΩ)	
Tap	A-B	B-C	B-C	a-n	b-n
1					
2				MV Connection:	MV Material:
3				LV Connection:	LV Material:
4				R_{MV} [Ω] in average at tap 3:	Ω
5				R_{LV} [Ω] in average:	mΩ

3. Insulation Resistance (GΩ) at Ambient Temperature: °C, Humidity : %

Connection	Test Voltage	30 Sec.	1 Min.	10 Min.	DAR	PI
MV to Earth, LV Grounded	5000 V					
LV to Earth, MV Grounded	1000 V					
MV to Earth, Earth Grounded	1000 V					

4. Measurement of voltage ratio and check of phase displacement

Criteria +/-0.5% and Vector group:

Tap Position	High	Low	Ratio		Measurement & Deviation %		Vector Group
					Phase A	%	
1							
2							
3							
4							
5							

5. No Load Lost Test at Test Temperature: °C, Humidity : %

Input Voltage		V	% Excitation Current		%	Guarantee Value [W]
Current		A	No load Loss		W	
Power Factor						

6. Load Lost Test at Test Temperature °C, Humidity : %						
Input Voltage		V	Load loss at Test temp.		W	Guarantee Value [W]
Current		A	Load Loss at 75°C		W	
Power Factor						
Tap position			Total Loss		W	

7. Withstand Voltage Test at Ambient Temperature: °C, Humidity : %				
Winding	Voltage [kV]	Frequency [Hz]	Time [sec.]	Result
MV to Earth				
LV to Earth				

8- Voltage Breakdown Test at Ambient Temperature: °C, Humidity : %							
Step	1	2	3	4	5	Average	Result
Withstand Voltage							

9. Weight			10- Dimension (mm)		
Core and Coil	Oil quality	App. Total Weight	Length	Width	Height

Date of Test:

Tested by: Checked by: Chief of Workshops:

Version: RT21002