Rule SPP 65-30
Tests of transformers according to IEC 76 and EN 60076

List of tests

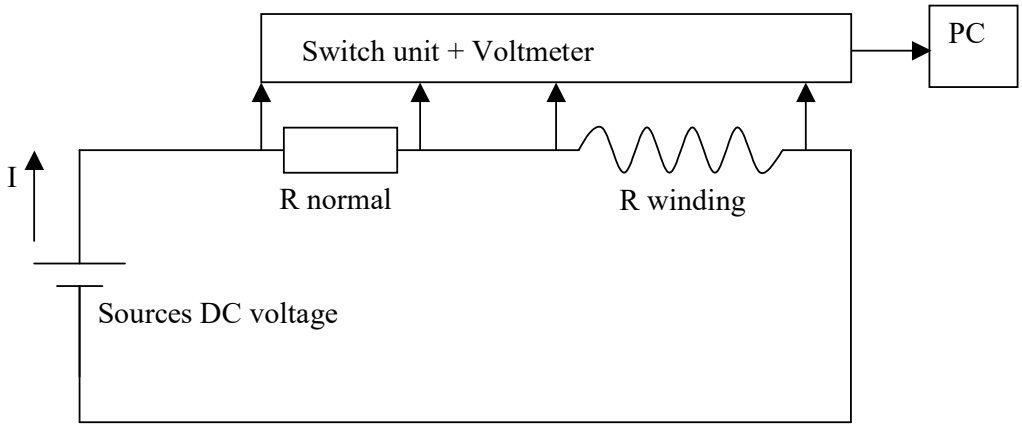
1. Routine tests

1.1 Measurement of winding resistance

Purpose: Sensing of winding resistance on all windings and all taps

Standard: IEC-76 article. 11.2

Chart of measurement:



R winding= U winding / I
I= U normal / R normal
R= 0,01 Ohm 10A ~ 100mV
R winding = U winding * 0.01 / U normal

List of equipment

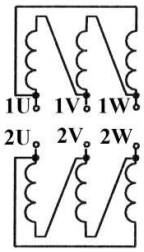
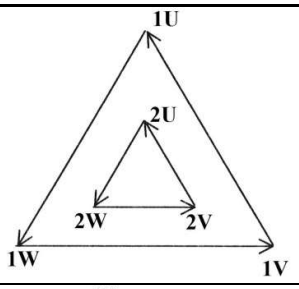
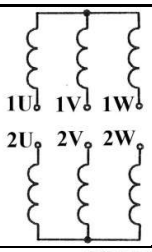
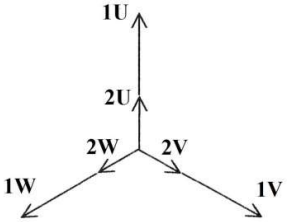
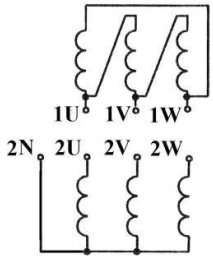
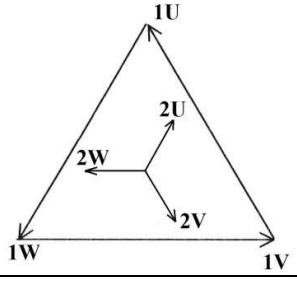
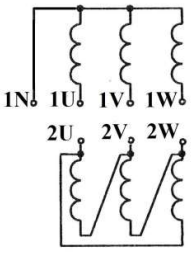
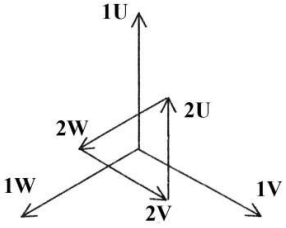
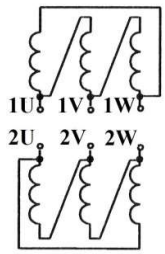
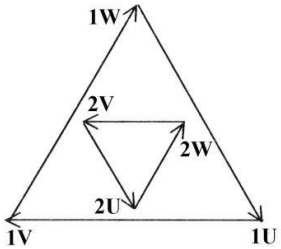
Meters:	Fab. No.:	Cl. [%]:
Voltmeter +Switch unit Agilent 34970A	8337912	0,02
Sources DC voltage		
Systron Donner M7 C160-15A	160V 15A	
Systron Donner M7 C5-130A	5,25V 130A	

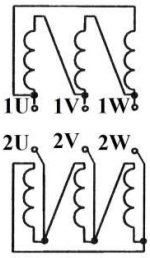
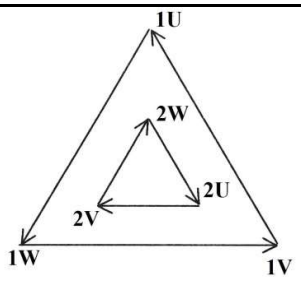
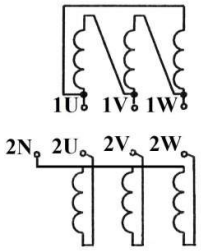
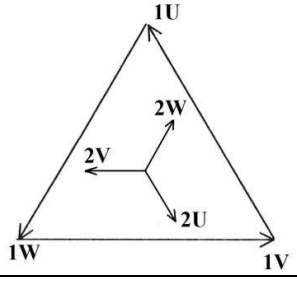
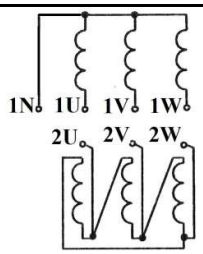
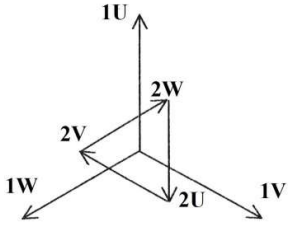
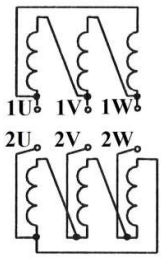
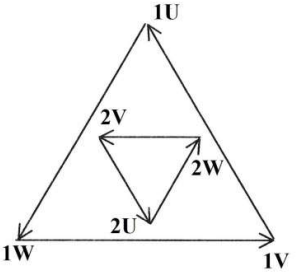
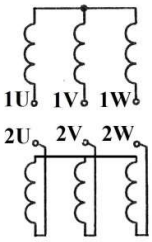
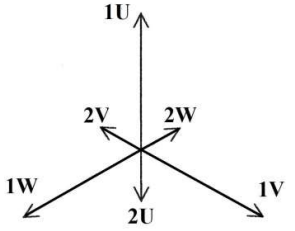
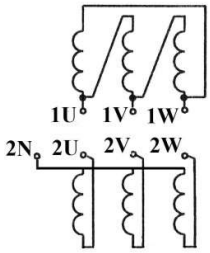
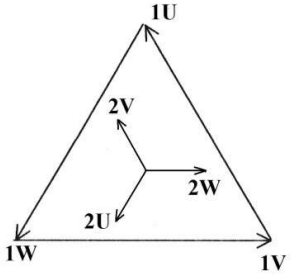
1.2 Measurement of voltage ratio on all taps and checking of connection symbol

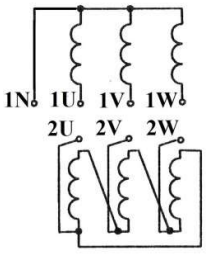
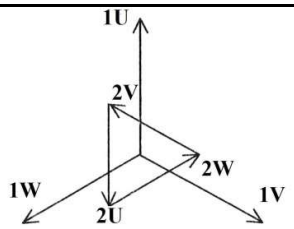
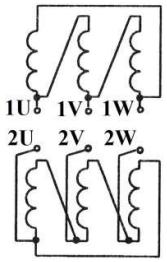
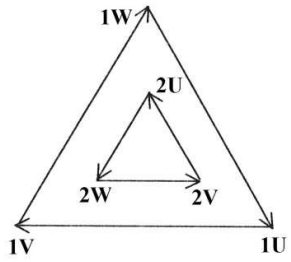
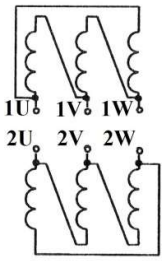
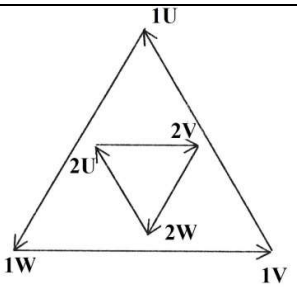
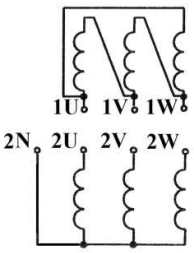
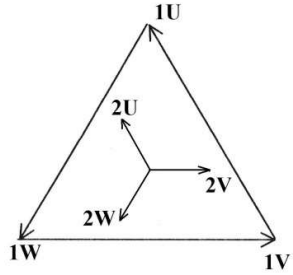
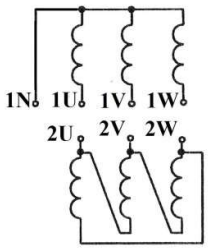
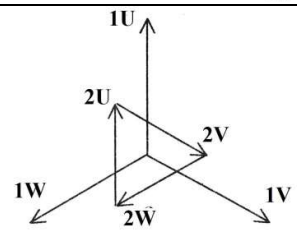
Purpose: Sensing of voltage ratio and connection symbol

Standard: IEC 76 and EN 60076-1 article 11.3

Chart of measurement:

Connection symbol:	connection	Vector group	Compare voltage
Dd0			1U-1V = p• 2U-2V 1V-1W = p• 2V-2W 1W-1U = p• 2W-2U p=voltage ratio
Yy0			1U-1V = p• 2U-2V 1V-1W = p• 2V-2W 1W-1U = p• 2W-2U p= voltage ratio
Dyn1			1U-1V = p• 2N-2V 1V-1W = p• 2N-2W 1W-1U = p• 2N-2U p= voltage ratio
YNd1			1N-1U = p• 2V-2U 1N-1V = p• 2W-2V 1N-1W = p• 2U-2W p= voltage ratio
Dd2			1U-1V = p• 2W-2V 1V-1W = p• 2U-2W 1W-1U = p• 2V-2U p= voltage ratio

Connection symbol:	connection	Vector group	Compare voltage
Dd4			1U-1V = p• 2W-2U 1V-1W = p• 2U-2V 1W-1U = p• 2V-2W p= voltage ratio
Dyn5			1U-1V = p• 2N-2U 1V-1W = p• 2N-2V 1W-1U = p• 2N-2W p= voltage ratio
Ynd5			1N-1U = p• 2U-2W 1N-1V = p• 2V-2U 1N-1W = p• 2W-2V p= voltage ratio
Dd6			1U-1V = p• 2V-2U 1V-1W = p• 2W-2V 1W-1U = p• 2U-2W p= voltage ratio
Yy6			1U-1V = p• 2V-2U 1V-1W = p• 2W-2V 1W-1U = p• 2U-2W p= voltage ratio
Dyn7			1U-1V = p• 2V-2N 1V-1W = p• 2W-2N 1W-1U = p• 2U-2N p= voltage ratio

Connection symbol:	connection	Vector group	Compare voltage
YNd7			1N-1U = p• 2U-2V 1N-1V = p• 2V-2W 1N-1W = p• 2W-2U p= voltage ratio
Dd8			1U-1V = p• 2V-2W 1V-1W = p• 2W-2U 1W-1U = p• 2U-2V p= voltage ratio
Dd10			1U-1V = p• 2U-2W 1V-1W = p• 2V-2U 1W-1U = p• 2W-2V p= voltage ratio
Dyn11			1U-1V = p• 2U-2N 1V-1W = p• 2V-2N 1W-1U = p• 2W-2N p= voltage ratio
YNd11			1N-1V = p• 2U-2V 1N-1W = p• 2V-2W 1N-1U = p• 2W-2U p= voltage ratio

List of equipment:

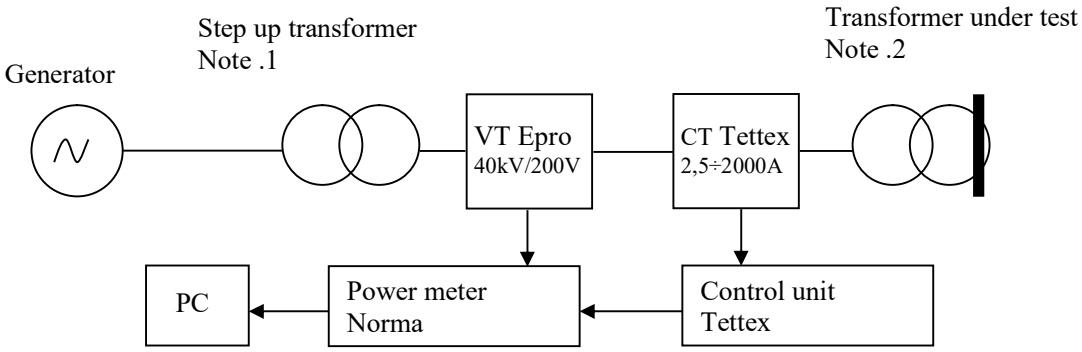
Meters:	Fab. No.:	Cl. [%]:
Transformer Turn Ratio Test Set Megger TTR300	71273	0,1
Ratio and vector group NORMA	1788315	0,1
Source of AC voltage Autotransformer 0-400V		

1.3 Measurement of short-circuit impedance and load loss

Purpose: Sensing of short – circuit impedance and load loss

Standard: IEC 76 and EN 60076-1 article 11.4

Chart of measurement:



CT-current transformers range 2,5; 5; 10; 20; 50; 100; 200; 500; 000; 2000 A to 5A
VT-voltage transformers range 40 000V to 200V
Note 1
Transformer can be supplied direct from generator (without step up transformer).
Note 2
Transformer under test is energized to high voltage winding low voltage winding is short-circuited

List of equipment

Meters:	Fab. No.:	Cl. [%]:
CT Measuring device TETTEX 4874	A32370	0,1
VT Epro Gallspach	2/12/3738-3740	
Power analyser NORMA 5000	WO15590BA	0,02

Energy resources

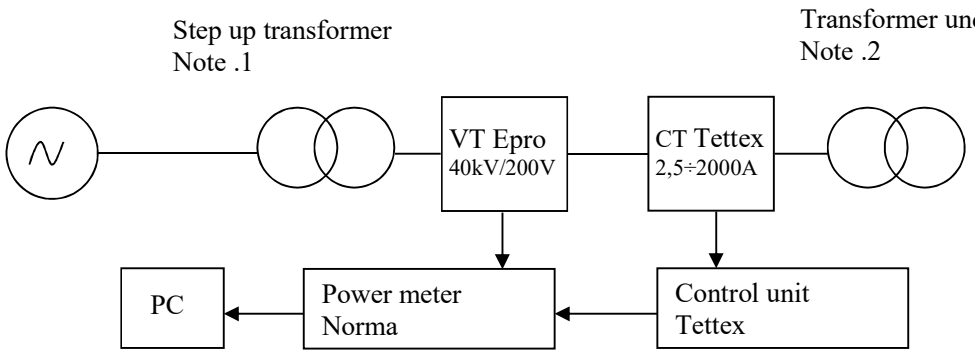
generator G1 5000 kV, 50 Hz	Y 15750V	D 9100V	DD 4550V	YY 7875V			
	184A	320A	635A	316A			
generator G2 630 kVA , 50Hz	Y 1200V	D 700V					
	300A	520A					
step up transformers 15MVA	HV				LV		
	D 20750V	Y 36000V	D 41570V	Y 72000V	Y 12650V	D 6650V	D 3275V
	416A	240A	208A	120A	684A	1000A	2000A
	15MVA	15MVA	15MVA	15MVA	15MVA	11,4MVA	11,4MVA

1.4 Measurement of no-load and current

Purpose: Sensing of no-load and current

Standard: IEC 76 and EN 60076-1 article 11.5

Chart of measurement:



CT-current transformers range 2,5; 5; 10; 20; 50; 100; 200; 500; 000; 2000 A to 5A
VT-voltage transformers range 40 000V to 200V

Note 1
In case that nominal voltage of transformer under test is less than nominal voltage of generator then is not step up transformer used.

Note 2
Transformer under test is energized to low voltage winding other winding are opened.
Measurement characteristics between 90% to 110% nominal voltage.

List of equipment

Meters:	Fab. No.:	Cl. [%]:
CT Measuring device TETTEX 4874	A32370	0,1
VT Epro Gallspach	2/12/3738-3740	
Power analyser NORMA 5000	WO15590BA	0,02

Energy resources

generator G1 5000 kV, 50 Hz	Y 15750V	D 9100V	DD 4550V	YY 7875V			
	184A	320A	635A	316A			
generator G2 630 kVA , 50Hz	Y 1200V	D 700V					
	300A	520A					
step up transformers 15MVA	HV				LV		
	D 20750V	Y 36000V	D 41570V	Y 72000V	Y 12650V	D 6650V	D 3275V
	416A	240A	208A	120A	684A	1000A	2000A
	15MVA	15MVA	15MVA	15MVA	15MVA	11,4MVA	11,4MVA

1.5 Dielectric routine test

Purpose: Verify dielectric strength between windings, between each line terminal, between windings to earth (tank, magnetic core) and along the winding (between turns).

Standard: IEC EN 60076-3

Requirements and tests for different categories of windings
IEC EN 60076-3 article 7.2.1 table 1

Table 1 – Requirements and tests for different categories of windings

	$U_m \leq 72,5$ kV	72,5 kV < $U_m \leq 170$ kV		$U_m > 170$ kV
Insulation	Uniform	Uniform	Non-uniform	Uniform and non-uniform
Full wave lightning impulse test for the line terminals (LI)	Type	Routine	Routine	Not applicable (included in LIC)
Chopped wave lightning impulse test for the line terminals (LIC)	Special	Special	Special	Routine
Lightning impulse test for the neutral terminals (LIN)	Special	Special	Special	Special
Switching impulse test for the line terminal (SI)	Not applicable	Special	Special	Routine
Applied voltage test (AV)	Routine	Routine	Routine	Routine
Induced voltage withstand test (IVW)	Routine	Routine	Routine	Not applicable
Induced voltage test with PD measurement (IVPD)	Special[a]	Routine[a]	Routine[a]	Routine
Line terminal AC withstand voltage test (LTAC)	Not applicable	Special	Routine[b]	Special
Auxiliary wiring insulation test (AuxW)	Routine	Routine	Routine	Routine

[a] The requirements of the IVW test can be incorporated in the IVPD test so that only one test is required.

[b] The LTAC test for this category of transformers can be replaced by a switching impulse test by agreement between manufacturer and purchaser.

Test of voltage for windings of transformer: IEC EN 60076-3 article 7.2.2 table 2, 3

1.6 Test on on-load tap-changers

Purpose: Verify of function the tap-changers

Standard: IEC 76 and EN 60076-1 article 11.7

Test on OLTC is carried out during of the voltage ratio measurement, measurement of winding resistance, short-circuit impedance and load loss measurement and no-load loss and current measurement.

1.7 Leak testing with pressure tests for liquid-immersed transformers (tightness test)

Purpose: Verification of transformer oil tightness

Standard: IEC 76 and EN 60076-1 article 11.8

40kPa above the normal oil pressure 48hours. The entire transformer is monitored for oil leakage.

1.8 Check of the ratio and polarity of bulit-in current transformers

Purpose: Verification of functions current transformer

Standard: IEC 76 and EN 60076-1 article 11.1.2.1 i

The test is carried out in the short-circuit impedance and load loss or temperature rise test, the accuracy of the transformer shall be confirmed by the manufacturer's test report.

1.9 Check of core and frame insulation for liquid immersed transformers with core or frame insulation.

Purpose: Verify that the magnetic circuit and its frame are insulated from the transformer vessel.

Standard: IEC and EN 60076-1 čl. 11.12

Perform test: Measurement of insulation resistance is performed DC voltage 2,5kV (5kV) and measure values after 15 and 60 seconds.

List of equipment:

Meters:	Fab. No.:
Megaohmeter Ch.A. 6547	100927CAH
Megaohmeter Ch.A. 6545	140682EDH

1.10 Measurement of DC insulation resistence each winding to earth and between windings

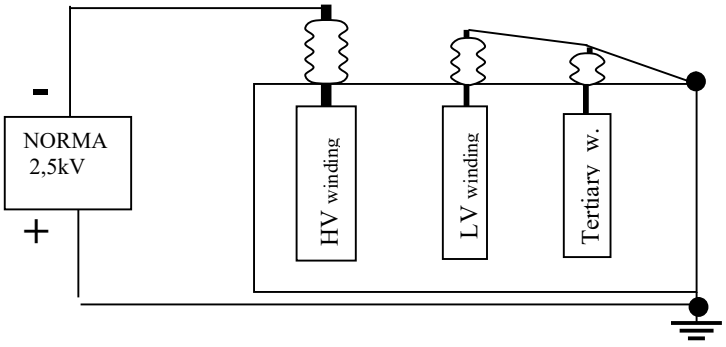
Purpose: These are reference values for comparison with later measurement in the field ane are needed for diagnostic monitoring quality of insulation system of transformer. No limitations for the values are given there.

Standard: IEC 76 and EN 60076-1 article 11.1.4

Perform test: Measurement of insulation resistance is performed DC voltage 2,5kV (5kV) and measure values after 15 and 60 seconds.

Example connection three windings transformer:

Single measurement:
HV: (LV+Ter.+tank)
LV: (HV + Ter.+ tank)
Ter.: (HV + LV + tank)
(HV + LV): (Ter.+ tank)
(HV + Ter.): (LV + tank)
(S+N): (HV + tank)
(HV + LV + Ter.): tank



Note: In case that magnetic core is connected to bushing is measured: magnetic core: (HV+LV+Ter.+tank)

List of equipment:

Meters:	Fab. No.:
Megaohmeter Ch.A. 6547	100927CAH
Megaohmeter Ch.A. 6545	140682EDH

1.11 Measurement of dissipation factor tg δ and capacitances of windigs and bushings

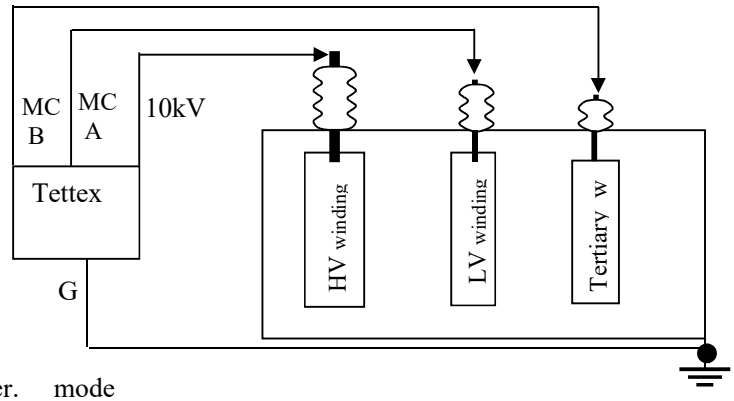
Purpose: These are reference values for comparison with later measurement in the field ane are needed for diagnostic monitoring quality of insulation system of transformer. No limitations for the values are given there.

Standard: IEC 76 and EN 60076-1 article 11.1.4

Measurement is performed AC voltage 10kV. If this voltage does not suit the insulating level of the measured voltage, the test voltage lower (0.5-1-2-5 kV) shall be used, taking into account that the insulating level of the measured voltage does not exceed the test voltage lower on the winding voltage level.

Connection:

G-earth
MCA-measurement cable A
MCB- measurement cable B



Single measurement:HV LV Ter. mode

HV : (LV+Ter.+tank)	10kV	MCA	MCB	GST A+B
HV : (Ter.+tank)	10kV	MCA	MCB	GSTg A
HV : LV	10kV	MCA	MCB	UST A
HV : Ter.	10kV	MCA	MCB	UST B
HV : (LV+Ter.)	10kV	MCA	MCB	UST A+B
HV : (LV+tank)	10kV	MCA	MCB	GSTg B
HV : tank	10kV	MCA	MCB	GSTg A+B
LV : (HV+Ter.+tank)	MCA	10kV	MCB	GST A+B
LV : (Ter.+tank)	MCA	10kV	MCB	GSTg A
LV : HV	MCA	10kV	MCB	UST A
LV : Ter.	MCA	10kV	MCB	UST B
LV : (HV+Ter.)	MCA	10kV	MCB	UST A+B
LV : (HV+tank)	MCA	10kV	MCB	GSTg B
LV : tank	MCA	10kV	MCB	GSTg A+B
Ter : (HV+LV+tank)	MCA	MCB	10kV	GST A+B
Ter : (LV +tank)	MCA	MCB	10kV	GSTg A
Ter : HV	MCA	MCB	10kV	UST A
Ter : LV	MCA	MCB	10kV	UST B
Ter : (HV+ LV)	MCA	MCB	10kV	UST A+B
Ter : (HV+tank)	MCA	MCB	10kV	GSTg B
Ter : tank	MCA	MCB	10kV	GSTg A+B

List of equipment:

Meters:	Fab.No.:
Megger Delta 4100	17771014
Tettex 2816/5284u	145663

1.12 Measurement of dissolved gasses in dielectric liquid

Purpose:	Determination of the content of individual gases in the insulating liquid
Standard:	IEC 60567, IEC 60599, IEC 60475

Gas analysis by adsorption gas chromatography with thermal conductivity detector (TCD) and flame ionization detector (FID) headspace method. Sample taken: 15 ml of oil in a vial

List of equipment:

Meters:	Fab.No.:
Gas chromatograf AGILENT 7890B	CN 18073060

1.13 Measurement dielectric strength of oil

Purpose:	Determination of electric strength of oil
Standard:	IEC and EN 60156

List of equipment:

Meters:	Fab.No.:
Dieltest of oil BAUR DTA 100	952922008

1.14 Determination of water content in oil

Purpose:	Determination of water content in oil in ppm
Standard:	IEC and EN 60814

List of equipment:

Meters:	Fab.No.:
Aquametr BAUR KFM 1000 S	959713011

2. Type tests

Test performed on a transformer representing other transformers.

2.1 Temperature rise test

Purpose:	Determining the temperature and temperature rise of winding of oil	
Standard:	IEC 76 and EN 60076-2	
Temperature rise limits:	IEC 76 and EN 60076-2 article 4.1	
	Top oil temperature rise	60K
	Average winding temperature rise for transformer identified as ON or OF	65K
	for transformer identified as OD	70K

Identification symbols according to cooling method: IEC EN 60076-2 chapter 4.1

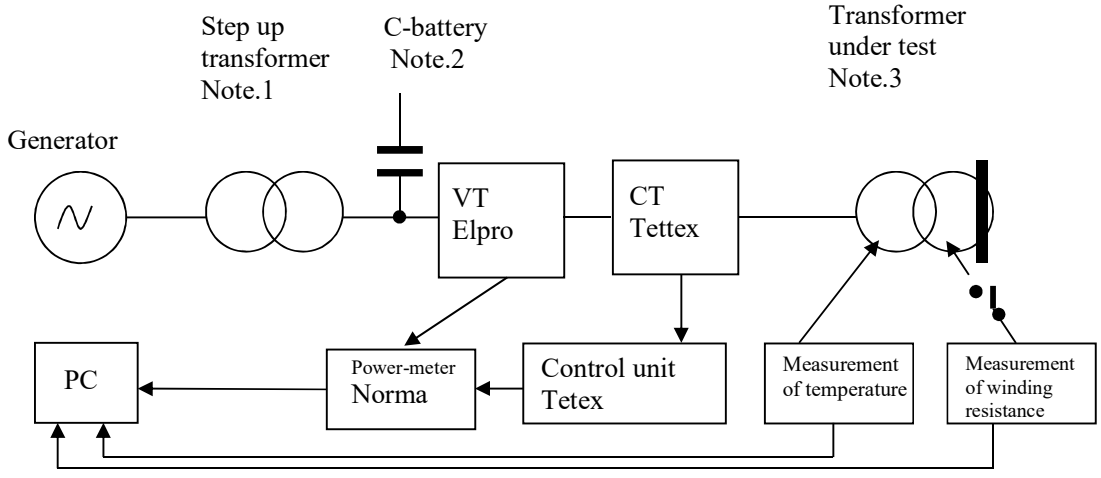
First letter - internal cooling medium in contact with the windings
O-mineral oil or synthetic insulating liquid with fire point <= 300°C
K- insulating liquid with fire point > 300°C

Second letter - circulation mechanism for internal cooling system
N-natural thermo siphon flow through cooling equipment and in window
F-forced circulation through cooling equipment
D- forced circulation through cooling equipment, direct from the cooling equipment into at least the main windings

Third letter - external cooling medium
A – air
W – water

Fourth letter - circulation mechanism for external cooling medium
N - natural convection
F - forced circulation (fans, pumps)

Chart of connection:



Note 1
Transformer can be supplied direct from generator (without step up transformer).
Note 2
Transformer can be supplied direct from generator (without C-battery).
Note 3
Transformer under test is energized to high voltage winding low voltage winding is short-circuited.

2.2 Type dielectric tests

Standard: IEC EN 60076-3

2.3 Determination of sound levels

Purpose: Verification that transformer do not exceed determinate sound levels

Standard: IEC EN 60076-10

The noise of the transformer (depending on the guaranteed value) is measured at short circuit impedance and no-load current. The measurement is carried out according to IEC EN 60076-10 chapter 11 method of acoustic pressure. Total acoustic performance L_{WA_SN} is intended according to chapter 14.

List of equipment:

Meters:	Fab.No.:
Analyzator NTi Audio XL2	A2A-08124-EO
Microfon NTi Audio M2230	3335

2.4 Measurement of the power taken by the fan and oil pumps motors

Purpose: Verification of losses on the ventilatorsand pumps

Standard: IEC EN 60076-1 chapter 11.1.3 d

3. Special tests

Other of tests than type or routine, agreed between the manufacturer and the customer.

3.1 Dielectric special test

Standard: IEC EN 60076-3

3.2 Measurement of temperature rise hot-spot winding

Purpose: Detecting peak temperatures at the top of the winding.

Standard: IEC EN 60076-7, 8.1.3

The highest temperature is in part of winding, where is maximum of dispersal field . Optic probes are used for directly measure in part of winding.

3.3 Determination of transmission characteristics of transient voltages

Purpose: Verification of the ratio of transfer of surge voltage.

Standard: IEC EN 60076-3, appendix B

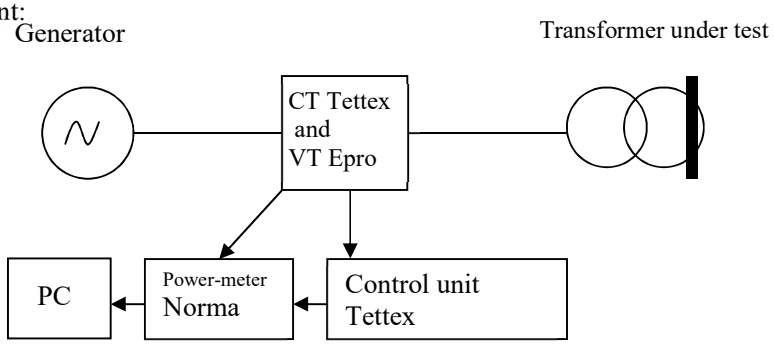
Low voltage recurrent surge generator is used for measurement. Investigation of overvoltage transferred from the HV winding to a LV winding. Test condition is needed exactly specification (loading capacity, resistance).

3.4 Measurement of zero-sequence impedance(s) on three-phase transformers

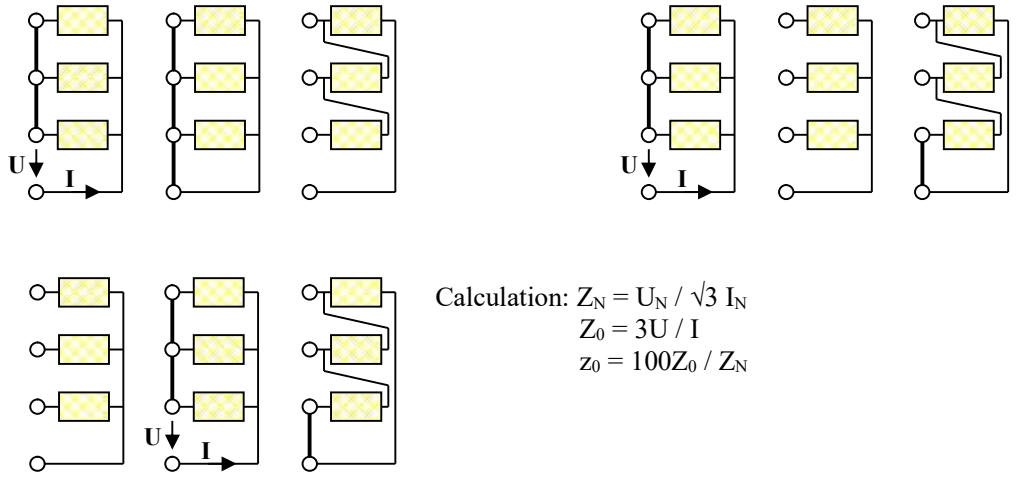
Purpose: Sensing of zero-sequence impedance. These values are necessary for setting outside protections of transformer.

Standard: IEC EN 60076-1 chapter 11.6

Chart of measurement:



Connection:



Calculation: $Z_N = U_N / \sqrt{3}\, I_N$

$Z_0 = 3U / I$

$z_0 = 100 Z_0 / Z_N$

List of equipment:

Meters:	Fab.No.:	Cl. [%]:
Measurement device TETTEX 4874	A32370	0,1
VT Epro Gallspach	2/12/3738-3740	
Power analyser Norma 5000	WO15590BA	0,02

Energy resources

generator G1 5000 kV, 50 Hz	Y 15750V	D 9100V	DD 4550V	YY 7875V			
	184A	320A	635A	316A			
generator G2 630 kVA , 50Hz	Y 1200V	D 700V					
	300A	520A					
step up transformers 15MVA	HV				LV		
	D 20750V	Y 36000V	D 41570V	Y 72000V	Y 12650V	D 6650V	D 3275V
	416A	240A	208A	120A	684A	1000A	2000A
	15MVA	15MVA	15MVA	15MVA	15MVA	11,4MVA	11,4MVA

3.5 Short-circuit withstand test

Purpose: Verification of short-circuit stability.

Standard: IEC EN 60076-5

This test is not performed in our testing room but we can arrange performance in special testing room for example Praha-Běchovice.

3.6 Vacuum deflection test on liguid immersed transformers

Purpose: Verification of the transformer tank in vacuum test

Standard: IEC EN 60076-1, chapter 11.9

Verification of deformation of the transformer tank. The deflection values are compared with the values before the test begins.

3.7 Pressure deflection test on liguid immersed transformers

Purpose: Verification of deformation of the transformer tank at overpressure

Standard: IEC EN 60076-1, chapter 11.10

A suitable reference point is chosen in the place where the largest vessel is swelled. (the point is independent of the transformer vessel). The distance is measured between the vessel and the reference point. The required overpressure is created in the vessel. The distance is measured between the vessel and the reference point again. When the overpressure is canceled, the measurement is repeated one more time.
For tanks that are specifically designed to be flexible for liquid expansion (corrugated), this test is not applicable

3.8 Vacuum tightness test on site on liquid immersed transformers

Purpose: Verification of tightness test

Standard: IEC EN 60076-1, chapter 11.11

This test is applicable to transformers designed to be vakuum filled in their own tanks on the site. Avacuum to the highest level required by the site operation shall be applied for a period of two hours or until a stable vakuum level is obtained. The vakuum pump shall then be stopped and the transformer sealed. The vakuum inside the transformer shall then monitored, using a suitable vakuum gauge until a steady rate of change of vakuum is observed. The increase in pressure shall be less than 0,2 kPa per hour measured over a period o fat least 30 min.

3.9 SFRA analysis

Purpose: Evaluation the mechanical integrity of core, windings and clamping structures within power transformers by measuring their electrical transfer functions over a wide frequency range.

Standard: IEC EN 60076-18

Example connection three windings transformer:

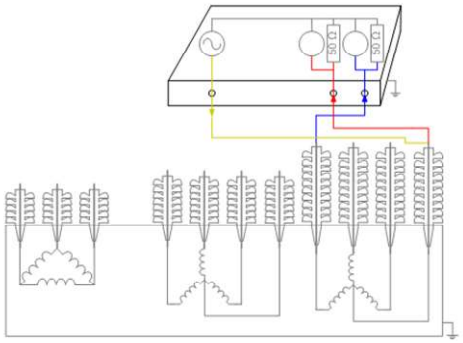


Fig. 01
End-to-end test with other terminals floating

Yelow cable: source of ac voltage
Red cable: source of reference signal
Blue cable: source of response signal

It is a comparing measurement and is also important to have an initial measurement to compare.

List of equipment:

Meters:	Fab.No.:
Sfra M5400 DOBLE	061000312

3.10 Check of external coating

Purpose: Check of external coating

Standard: ISO 2178, ISO 2409

The thickness of the paint is randomly controlled at several points. Measured values must fulfil from the customer specification.

3.11 Measurement of the harmonics of the no-load current

Purpose: Determining the proportion of higher harmonic components.

Standard: IEC EN 60076-1

This measurement is carry out during no-load loss and current measurement. The harmonics of the no-load current are measured and the magnitude of the harmonics is expressed as a percentage of the fundamental component.

4.Dielectric tests

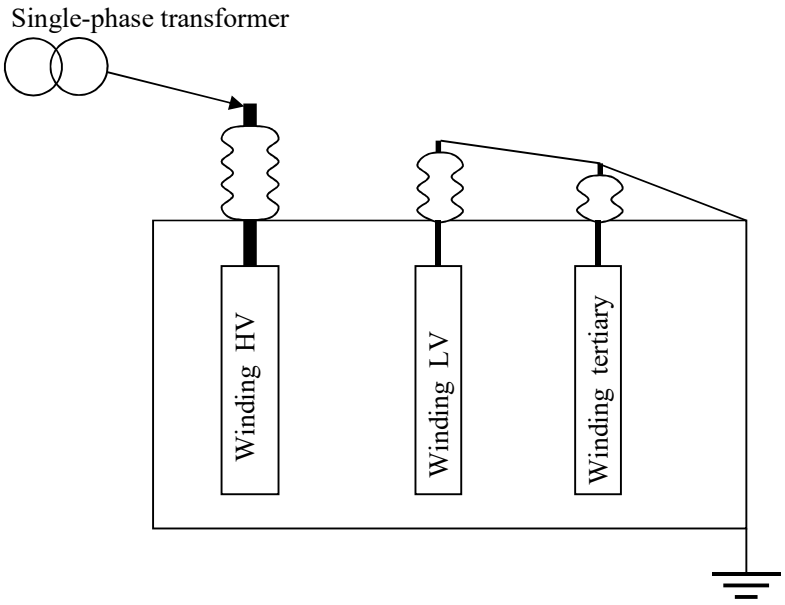
Description of tests in IEC 60076-3

4.1 Separate source AC withstant voltage test

Purpose: Verification of the insulation strength of the individual windings against the ground and against other windings.

Standard: IEC EN 60076-3 chapter 11

Verify dielectric strength between windings and between windings to earth (tank, frame and magnetic core) at single-phase voltage of the rated frequency.
Routine test for all windings all voltage levels.
Example connection three winding transformer:



Note.: Winding under voltage is short-circuited other windings are connected together and connect to tank.

List of equipment:

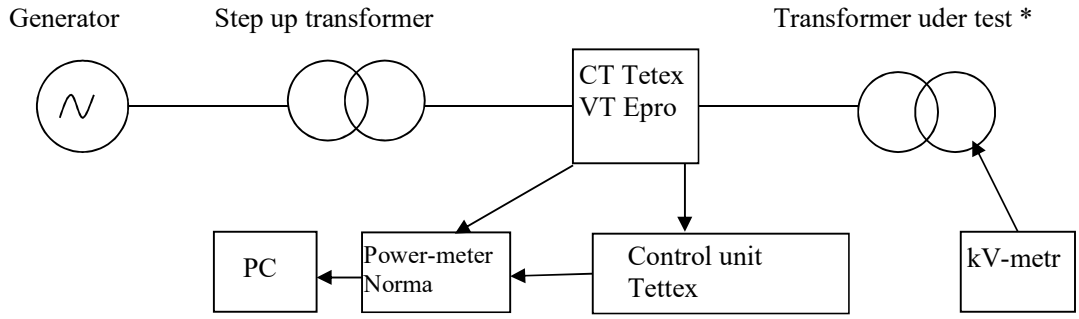
Meters:	Fab. No.:
kV-meter 100kV	22822a
kV-meter Highvolt MU17	884764
dividers	
Divider kV-meter 250 kV HIGH VOLT	884 766, 884767
Divider Highvolt 1000kV - AC	903334, 903335
Single-phase transformers	
T1	600V / 100 000V
T2	10 500V / 1 200 000V

4.2 Induced voltage withstand test (IVW)

Purpose: Verification of the isulation strength of the interfacial insulation

Standard: IEC EN 60076-3 chapter 11.2

Routine test for transformer with voltage U_m < 170kV
There is two times the nominal voltage induced between the phase terminals
Chart of measurement:



*) Transformer under test is energized to low voltage winding other winding are opened and one outlet is connected to kV-meter

List of equipment:

Meters:	Fab.No.:	Cl. [%]:
CT TETTEX 4874	A32370	0,1
VT Epro Gallspach	2/12/3738-3740	
Power analyser Norma 5000	WO15590BA	0,02

Energy resources

generator G1 5000 kV, 50 Hz	Y 15750V	D 9100V	DD 4550V	YY 7875V			
	184A	320A	635A	316A			
generator G2 630 kVA , 50Hz	Y 1200V	D 700V					
	300A	520A					
step up transformers 15MVA	HV				LV		
	D 20750V	Y 36000V	D 41570V	Y 72000V	Y 12650V	D 6650V	D 3275V
	416A	240A	208A	120A	684A	1000A	2000A
	15MVA	15MVA	15MVA	15MVA	15MVA	11,4MVA	11,4MVA

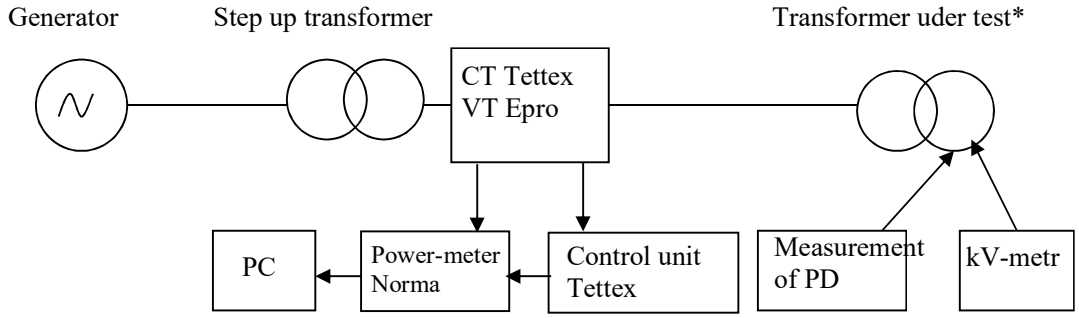
4.3 Induced voltage test with PD measurement (IVPD)

Purpose: Verification of the isulation strength of the interfacial insulation

Standard: IEC EN 60076-3 chapter 11.3

Routine test for transformer with voltage U_m > 72,5kV

Chart of measurement:



List of equipment:

Meters:	Fab.No.:	Cl. [%]:
CT TETTEX 4874	A32370	0,1
VT Epro Gallspach	2/12/3738-3740	
Power analyser Norma 5000	WO15590BA	0,02
MPD 600-3 3-canal PD OMICRON		
MPD600	GK298E-300E	
3pc measurement of impedance (4-pól)		
CLP542 (0,5A)		
Controller MCU502	HL343B	
Calibrator OMICRON CAL 542B	GB324B	
(1pC – 100pC)		
Calibrator PD Tettex 3216WG	143595	

Energy resources

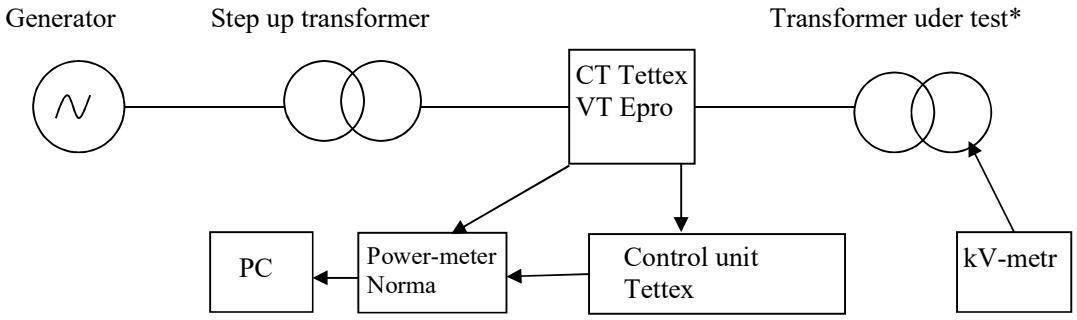
generator G1 5000 kV, 50 Hz	Y 15750V	D 9100V	DD 4550V	YY 7875V			
	184A	320A	635A	316A			
generator G2 630 kVA , 50Hz	Y 1200V	D 700V					
	300A	520A					
step up transformers 15MVA	HV				LV		
	D 20750V	Y 36000V	D 41570V	Y 72000V	Y 12650V	D 6650V	D 3275V
	416A	240A	208A	120A	684A	1000A	2000A
	15MVA	15MVA	15MVA	15MVA	15MVA	11,4MVA	11,4MVA

4.5 Line terminal AC withstand voltage test (LTAC)

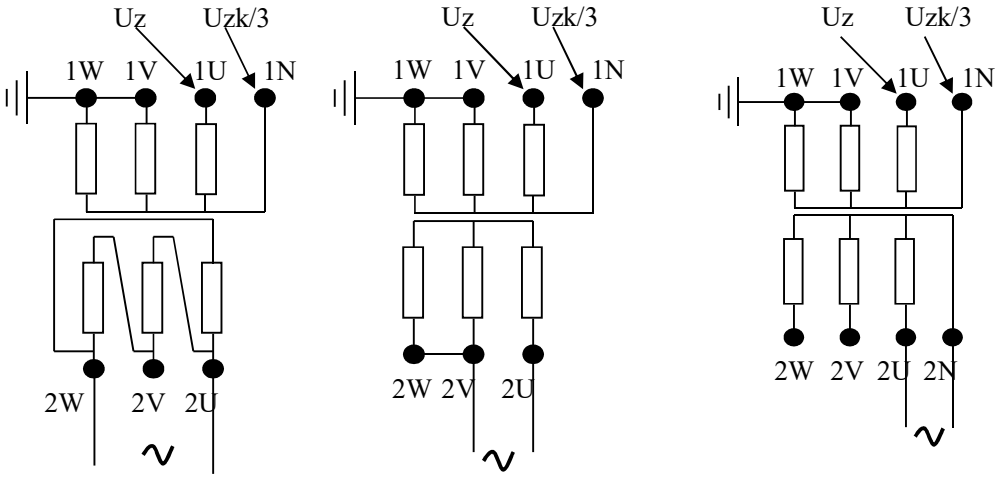
Purpose: The test verifies the strength of the phase insulation against the ground

Standard: IEC EN 60076-3 chapter 12

Routine test on transformers with reduced insulation windings with insulation level.
72,5<Um >170kV.
Chart of measurement:



*) the lower voltage side is powered one-phase, the higher voltage side is disconnected, one output is connected on kV-meter
Examples of connections:



List of equipment:

Meters:	Fab.No.:	Cl. [%]:
CT TETTEX 4874	A32370	0,1
VT Epro Gallspach	2/12/3738-3740	
Power analyser Norma 5000	WO15590BA	0,02
MPD 600-3 3-canal PD OMICRON MPD600	GK298E-300E	
3pc measurement of impedance (4-pól) CLP542 (0,5A)		
Controller MCU502	HL343B	
Calibrator OMICRON CAL 542B (1pC – 100pC)	GB324B	
Calibrator PD Tettex 3216WG	143595	

Energy resources							
generator G1 5000 kV, 50 Hz	Y 15750V	D 9100V	DD 4550V	YY 7875V			
	184A	320A	635A	316A			
generator G2 630 kVA , 50Hz	Y 1200V	D 700V					
	300A	520A					
step up transformers 15MVA	HV				LV		
	D 20750V	Y 36000V	D 41570V	Y 72000V	Y 12650V	D 6650V	D 3275V
	416A	240A	208A	120A	684A	1000A	2000A
	15MVA	15MVA	15MVA	15MVA	15MVA	11,4MVA	11,4MVA

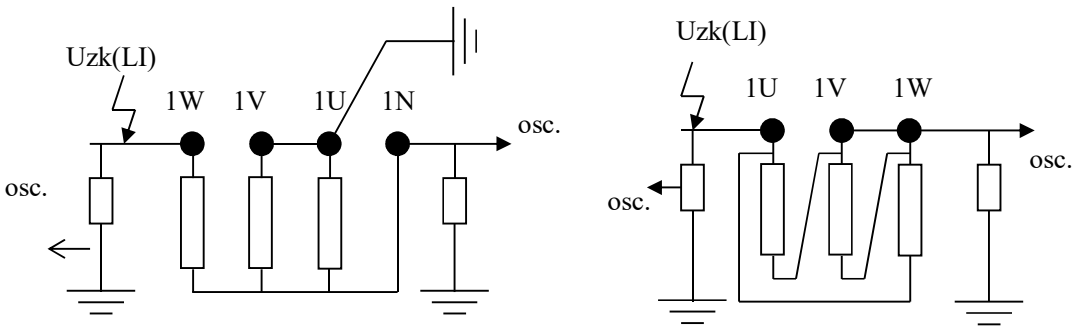
4.6 Lighting impulse (LI) test

Purpose: The test is intended to verify the impulse withstand strength of the transformers under test, when the impulse is applied to its line terminals.

Standard: IEC EN 60076-3 chapter 13.2

Type test for transformers with Um<= 72,5kV

Examples of connections:



Note: Terminals others windings are connected together and earthed.

List of equipment:

Meters:	Fab.No.:
Kilovoltmeter Haefely 2000kV	12100015.60.1-2 12100015.65.1
Measurement system Haefely HiAS 743 shunt 0,1; 1 Ohm	176631-3

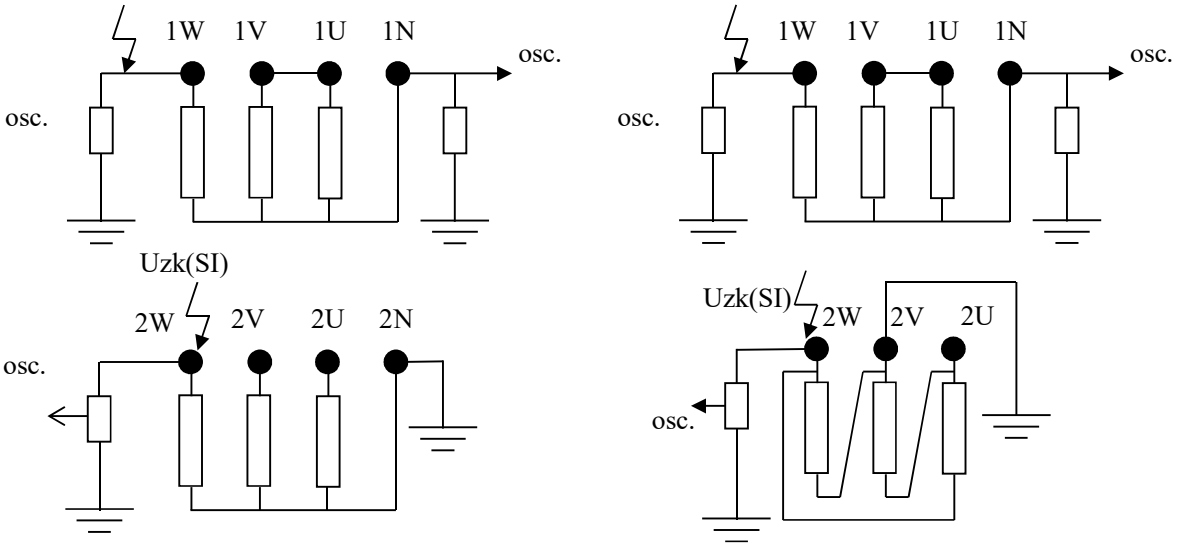
4.7 Switching impulse test for the line terminal (SI)

Purpose: The test is to verify the strength of the individual windings against the ground and other windings, the insulation strength between the phases and between the threads of the individual windings, at the switching impulse.

Standard: IEC EN 60076-3 chapter 14

Routine test is designed for windings having Um> 170kV. The impulses are either applied directly to the phase winding of the test winding or to the low voltage winding so that the induced voltage being tested is transferred to the test winding.

Examples of connections:



List of equipment:

Meters:	Fab.No.:
Kilovoltmeter Haefely 2000kV	12100015.60.1-2 12100015.65.1
Measurement system Haefely HiAS 743	176631-3
Condenzator100nF, 200nF	
Shunt 0,1; 1 Ohm	

4.8 Auxiliary wiring insulation test (AuxW)

Purpose: Verification of insulation strength of accessories and transformer cabling.

Standard: IEC EN 60076-3 chapter 9

Test of voltage: AC 2kV /60sec,
Test of transformer current: AC 2,5kV /60sec
(if the magnetization knee voltage is greater than 2 kV, then the test voltage is: AC 4kV /60sec).
Devices having a lower insulating level are disconnected in the test.

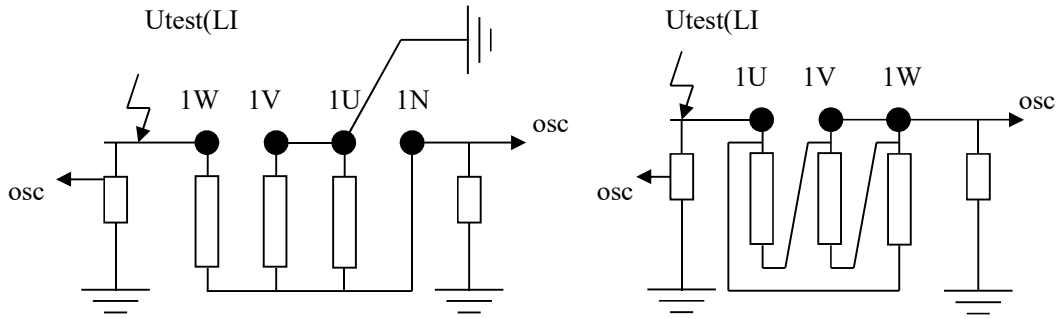
4.9 Test with lightning impulse chopped on the tail (LIC)

Purpose: The test is intended to verify the impulse withstand strength of the transformers under test, when the impulse is applied to its line terminals.

Standard: IEC EN 60076-3 chapter 13.3

Procedure similar to the LI test between the impact generator and the test lead is connected to a spark gap.

Examples of connections:



Note: Terminals others windings are connected together and earthed.

List of equipment:

Meters:	Fab.No.:
Kilovoltmeter Haefely 2000kV	12100015.60.1-2 12100015.65.1
Measurement system Haefely HiAS 743 shunt 0,1; 1 Ohm	176631-3

4.10 Lighting impulse test for the neutral terminals (LIN)

Purpose: The same procedure of test like LI

Standard: IEC EN 60076-3 chapter 13.4

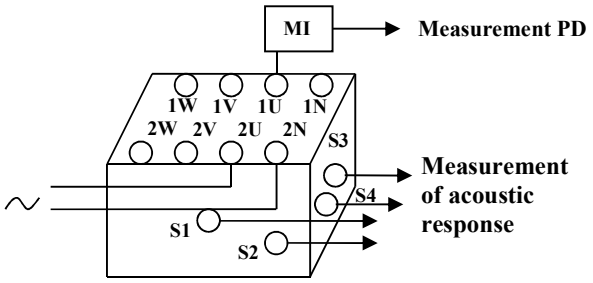
The same procedure of test like LI

4.11 Measure of ultrasonic emission

Localization of source the PD inside the transformer tank.

Measurement of the ultrasonic emission of the PD is measured at no-load current with measure PD (level of voltage is about nominal voltage). The highest detected partial discharge level then starts ultrasonic response measurement. The source of PD are gradually counted from measurement of response.

Chart of measurement:



S1,S2,S3,S4-probes of acoustic
MI-measurement of impedance

List of equipment:

Meters:	Fab.No.:	Cl. [%]:
CT TETTEX 4874	A32370	0,1
VT Epro Gallspach	2/12/3738-3740	
Power analyser Norma 5000	WO15590BA	0,02
4 canal system for measurement of acoustic response		
OMICRON PDL 650		
PDL 650	BL189F	
PDL 550	BL196U	
4 pc piezoelektric probes		

Dr. Michael Amon
Digitálně podepsal Dr. Michael Amon
Datum: 2023.06.30 14:36:51 +02'00'