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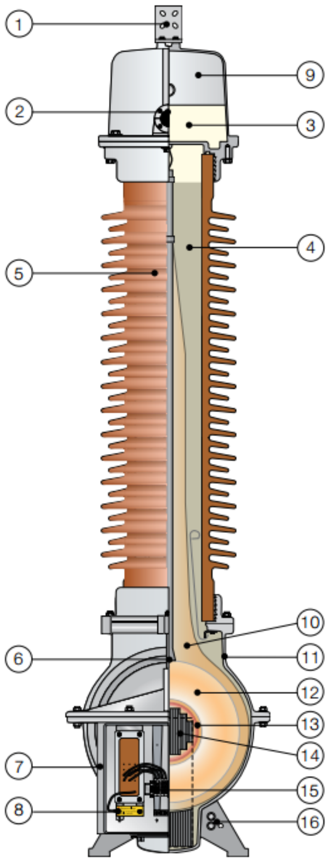

1. Primary terminal
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Figure 1.1: Voltage transformer

Description

The top of the transformer is made of an aluminum alloy and serves as a buffer tank where excess oil is stored that can expand and retract due to temperature changes. The tank has an oil level indicator and an oil filling cap. The primary or high voltage terminal is on top of the tank. The terminal leads down to a capacitive bushing that consist of a porcelain outer casing oil paper insulation leading down to the bottom tank containing the core, primary and secondary windings. The inner components are covered in oil and quartz to give mechanical stability, the oil serves also as protection from moisture and other corrosive elements. Box for measurement outputs are on the bottom tank and earthing terminal.

1.1 Description of dielectric design

This section is to describe the dielectric design of the transformer. This is done by splitting the transformer in to several parts and describing the design from a dielectric point of view.

1.1.1 Ceramic insulator

The most distinctive part of the transformer is the ceramic insulator and is therefore the first to be examined. The ceramic insulator is seen in figure 1.2.

Figure 1.2: A full view of the transformer

The function of the ceramic insulator is to avoid electrical connection between the high potential terminal at the top of the transformer and the foundation at ground potential. The distinctive design of the insulator is made to avoid leakage current at the surface of the insulator, even though the transformer is exposed to rain and dust. This is done by making the surface length of the insulator significant longer than the distance between top and bottom. To secure immunity for dust and water, the surface under the toadstools is curved, making it even harder for the dust and water to settle on the surface of the insulator. Figure 1.3 shows the curved surface under the toadstools

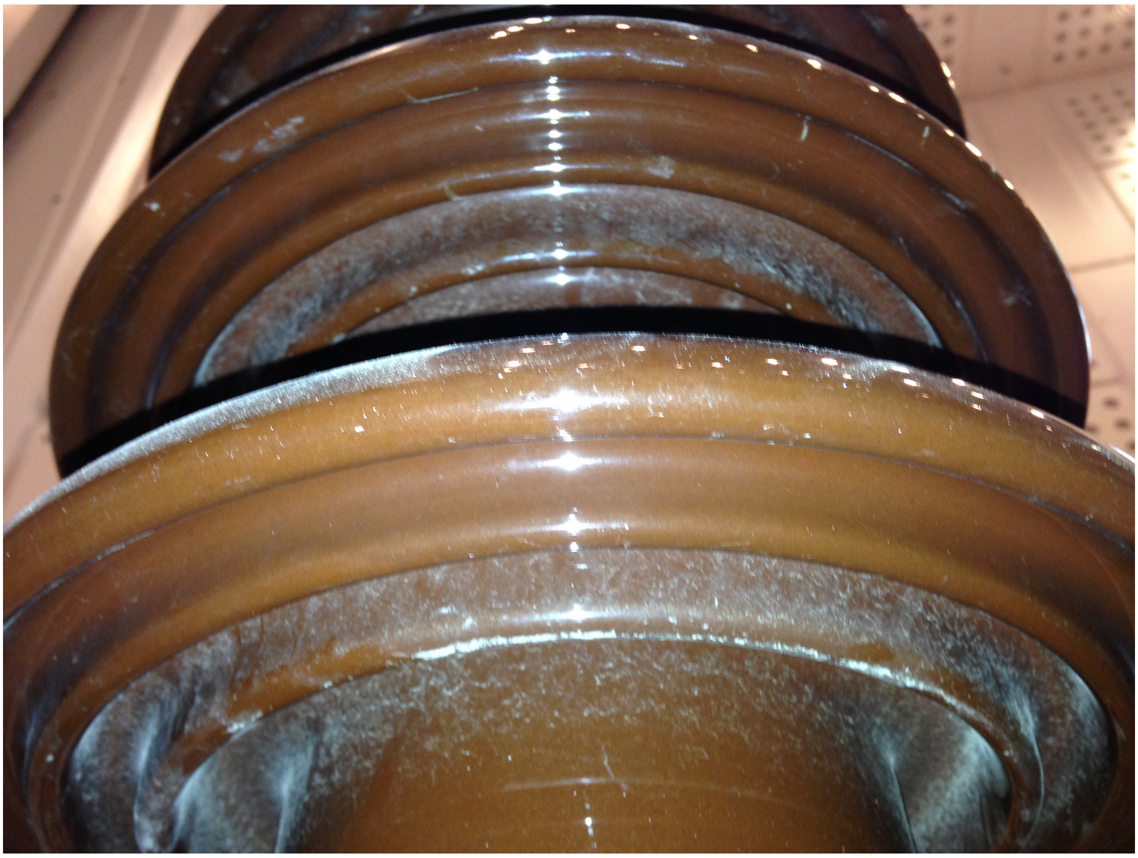


Figure 1.3: A view underneath the toadstools

When looking at the dielectric strength of the material listed in 1.4 it is noticed that the material is approximately four and a half times stronger electrical insulator than that of air.

Material	Dielectric strength (MV/m)
Air	3.0
Alumina	13.4
Mineral oil	15
Fused quartz	25-40
Distilled water	65-70

Figure 1.4: Dielectric strength of different materials (Reference http://en.wikipedia.org/wiki/Dielectric$_strength$)

1.1.2 Insulation under the shell of the transformer

The components inside the transformer needs to be sufficient insulated to avoid any internal short circuits. To do so the transformer is filled with oil.

If the oiled isolating barrier is compared with a gaseous insulation such as air, it is estimated that the gap should be at least 5 times wider. This causes the installation to be designed much smaller then if air was used as insulator. Oil is also a good thermal conductor, which secures that heat from the components is transported to the surface of the transformer without any use of forced convection.

Some of the components are separated with paper, such as the windings. When the oil is poured in the transformer it is done in vacuum, ensuring that the oil fills the small gaps and paper, and thereby turns the paper in to a good insulator. Besides providing stability the quartz is also a good insulator as showed in figure 1.4.

The disadvantage of using oil as an insulator is that the shell needs to be 100 percent tight which makes service and maintenance complicated. Another disadvantage is that the oil is combustive which increases the hazards under break down and fire.

1.2 The nameplate

The nameplate is an important part of a voltages transformer. It contains information about the transformer e.g. voltage, current, frequency, voltage factor etc. that the machine is approved for. Furthermore the nameplate gives information about the manufacturer, approval standard used, manufactures specified type and serial number. Other information useful for testing, transporting and setup like total mass, year of manufacturing, connection diagram for the terminals, when this machine was transported or stored and that the transformer has to be erected no less than 30° from vertical. This data is important because when building an distribution net the maximum calculated data has to match the chosen components nameplate in order not to break down the distribution net.

Normally a certifications are stamped on the nameplate to display which standards the machine is approved for. For this particular nameplate the only marking is 'CE' which is mandatory for all components and machinery used in the EU. By marking the machine with 'CE', the manufacture states that this machine complies with all applicable standards and regulations in the EU as well as any national and local additions.

In the following table 1.1 all data described on the nameplate is listed.

	Text	**Size**	**Unit**
1)	ABB Switchgear / Made in Sweden		-
2)	Voltage transformer		-
3)	Type	EMFC 72	-
4)	Number	8350834	-
5)	Isolation level	140-350	kV
6)	Max constant voltage	72.5	kV
7)	Frequency	50	Hz
8)	Norm	IEC 186	-
9)	Voltage factor	1.9/8	H
10)	Total mass	190	kg
11)	Production year	1998	$Year$

Table 1.1: All data described on the nameplate

Moreover on the nameplate there is shown a terminal connections diagram, with identification for the terminals. Related to this diagram is a table where data for these terminals is described.

In the following table 1.2 this data is listed for the specified voltage transformer.

12)	**A - N**	**1a - 1n**	**2a - 2n**	**da - dn**
13)	$60000/\sqrt{3}$	$110/\sqrt{3}$	$110/\sqrt{3}$	$110/\sqrt{3}$
	-	-	-	-
14)	Load	1 - 15	1 - 65	75
15)	Class	0.2	0.2	3P

Table 1.2: Data described the terminal diagram

All the listed data from 1 to 15 will now be described separately.

1.2.1 Manufacture No.1

The name of the company and it subsidiary were this machine is produced and from which country this is made.

1.2.2 Name No.2

The name on the specified machine.

1.2.3 Type No.3

The company specified type name for the machine, this name normally also describe what size it is.

1.2.4 Number No.4

The company specified serial number for the machine, this is a unique number for the specified machine and it is used to identify components for maintenance or to order a new mashing voltage transformer.

1.2.5 Isolation level No.5

This is the combination of voltage values, which characterize the insulation of the machines, with the regards to its capability to withstand dielectric stresses. According to IEC the described value is only valid for altitudes lower than 1000 m above sea level and for ABB voltage transformer a correction factor has to be used for higher altitudes.

1.2.6 Max constant voltage No.6

The Max constant voltage is the (phase to phase) voltage expressed inkV_{RMS} for the machine, also known as the maximum system voltage.

1.2.7 Frequency No.7

The frequency is the nominal frequency this machine operational frequency. The standard frequencies are 50 Hz and 60 Hz.

1.2.8 Norm No.8

The norm is the specific standard this machine is tested and approved by.

1.2.9 Voltage factor No.9

Voltage transformers are usually connected between a phase and neutral/earth. If an event or an disturbance, like a net switching or a disconnected phase in a three-phase network occurs, the voltage across the machine may sometimes be increased even up to the voltage factor, which is the vf. times the nominal voltage. According to IEC the specified voltage factor is 1.9 for systems not solidly grounded and 1.5 with solid ground. In Denmark normally the star point of an transformer is grounded through a Peterson coil, the system is therefore not solidly grounded and can have a fault for longer time before damaging the transformer. The 8 on the nameplate is the maximum hour the machine can have a voltage factor of 1.9 across the transformer, before the insulation in the machine begins to break down.

1.2.10 Total mass No.10

This is the total weight of the voltage transformer, this is used when moving the component or transporting it.

1.2.11 Production year No.11

The year this voltage transformer was produced.

1.2.12 Terminal description No.12

This is the used marks on the terminal, which identify the specific terminal on the voltage transformer and the related data to these terminals is then listed under the specific marks.

1.2.13 Terminal voltage No.13

This is the nominal voltage on the terminal for the voltage transformer, which tells the ratio between the primary and secondary windings and what size the voltage has on specified terminal.

1.2.14 Terminal load No.14

This is the apparent power in VA at the rated secondary voltage the specified terminal is design for. This is another way to expressed the nominal external impedance in the secondary circuit. If this is exceeded the life time of the transformer will be reduced or can lead to a break down.

1.2.15 Terminal class No.15

This is the accuracy class for the measuring terminals according to the specification in the IEC standard this voltage transformer is approved by.

1.3 Transformer ratio

From the nameplate it can be calculated that the voltage ratio between the primary and the secondary side of the transformer, is:

$$\frac{60000V}{110V} = 545.45 \tag{1.1}$$

But in order to verify the ratio, and to see if it is linear, 10 measurements are made from 4 kV to 40 kV. The resulting graph can be seen in Figure 1.5.

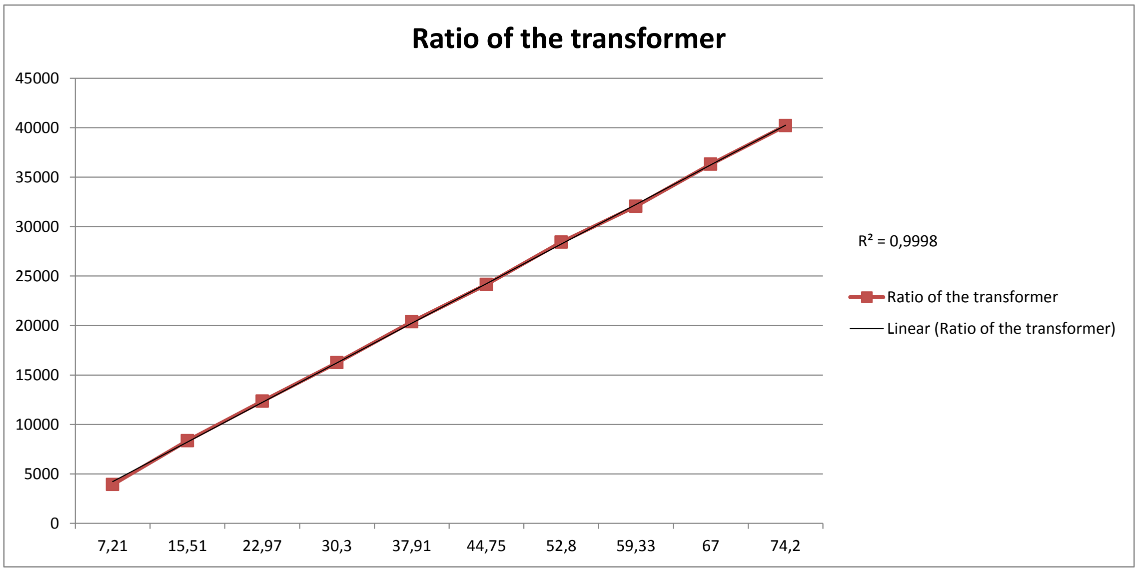


Figure 1.5: Voltage ratio

Measurements of partial discharges 2

When estimating the condition of dielectric materials in different electrical components, nondestructive methods is preferred. By measuring the level of partial discharges of the component it is possible to estimate the condition of the dielectric material in the electric machine. In practice the electric device is measured for partial discharges several times during the service lifetime. By looking at the progress of the amount of partial discharges it is possible to estimate the condition of the insulation in the device.

2.1 External and internal partial discharges

Small electrical breakdown of dielectric material is called partial discharges. When partial discharges forms, the dielectric material is ionized when some of the molecules liberates an electron. When the molecules reconnect other chemicals may be formed, such as ozone for partial discharges in air. These new bindings of molecules can be quit reactive so that the dielectric material is destroyed over time.

There are two types of partial discharges, internal and external. The internal discharges forms in caves in solid insulators as illustrated in figure 2.1. The equivalent circuit for a such arrangement is showed in figure 2.2.

The other type of partial discharge is the external partial discharge, which often is referred to as corona. Corona can, in cases with very high electric field gradients, be seen with the naked eye since light is emitted when the molecules changes from a high to a lower energy state. External partial discharges can also be heard. The external discharge is illustrated in figure 2.3, where two electrodes at different potentials are insulated with air. The equivalent circuit of the arrangement is showed in figure 2.4.

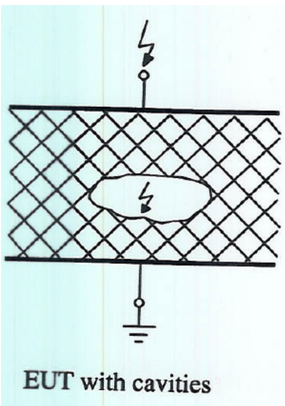


Figure 2.1: Illustration of internal partial discharge

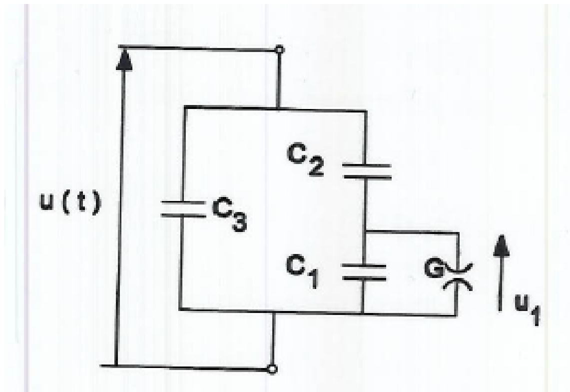


Figure 2.2: The equivalent circuit for internal partial discharges

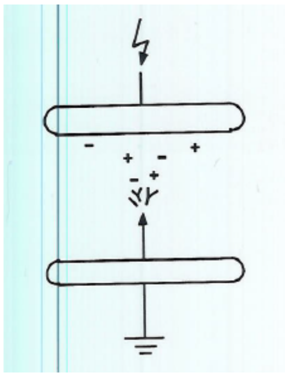


Figure 2.3: Illustration of external partial discharge

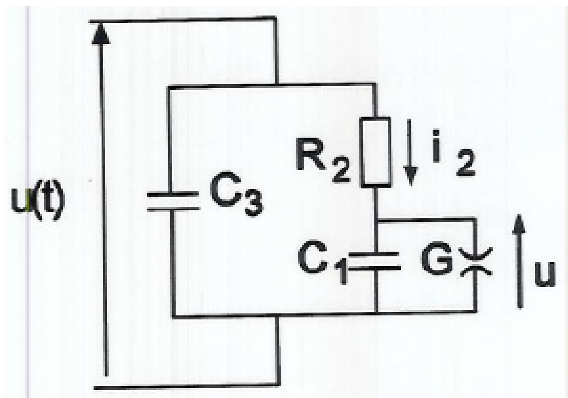


Figure 2.4: The equivalent circuit for external partial discharges

The way to measure partial discharges is to apply a voltage difference over the dielectric material and measuring the voltage drop over the measuring resistor when charges flow through it. The schematic for measuring partial discharges is showed in figure 2.5.

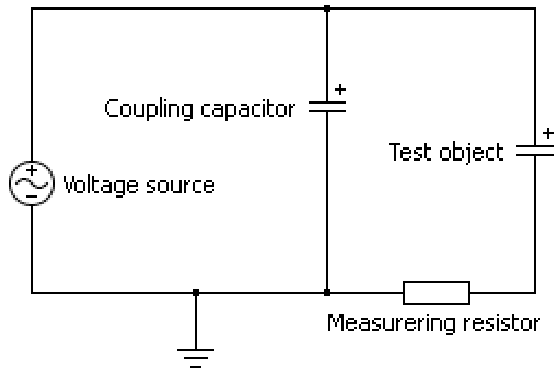


Figure 2.5: The circuit for measuring partial discharges

It is important that the coupling capacitor is as ideal as possible to avoid disturbances when measuring. When looking at the measurment readout of partial discharges it is possible to clarify whether there are internal or external discharges by looking at the angle when the discharging occurs. When looking at the equivalent circuit for internal discharges in figure 2.2, one can see that the load is purely capacitive, resulting in the current to be 90 degree shifted from the voltage. In other words, internal partial discharges is only measured at zero crossing of the voltage. Looking at the schematic for external discharges in figure 2.4, one sees that the load is partly resistive and partly capacitive, so that the partial discharges is measured right after the voltage peak.

2.2 Partial discharge test of point-plane configuration

The configuration where partial discharges are measured is a point-plane configuration with a voltage difference of approximately 24kV. The test setup is showed in figure 2.6 and the resulting measurements is presented in figure 2.7.

Figure 2.6: The test setup for measuring partial discharges

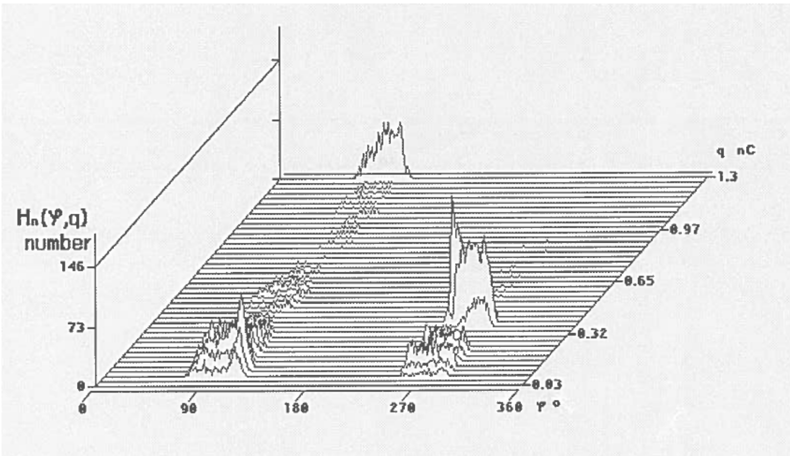


Figure 2.7: The measurements of partial discharges

Seen on the three dimensional graph the angle at when the partial discharges is detected is at the peak voltages. It can therefore be concluded that there is only external partial discharges. It can also be seen that when the point is negative and the plane is positive, there is a lot of partial discharges. When the point is positive and the plane is negative the biggest discharges are detected.

2.3 Partial discharge test of measured transformer

The test was utilized on the measuring transformer to detect corona or internal discharges. The test results are presented in figure 2.8.

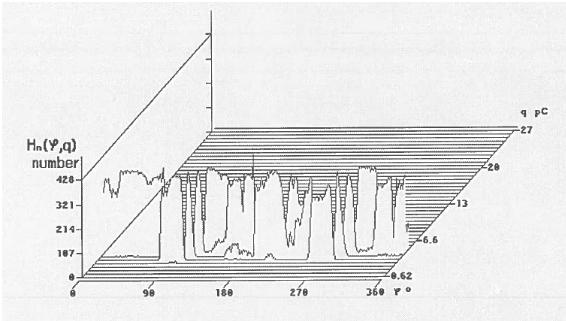


Figure 2.8: The measurement results from measuring partial discharges on the transformer

As seen from the results in the figure, the partial discharges is detected all over the sinus voltage in somewhat equal intensity and quantity. From this observation it is concluded that the readings is the background current from background radiation and cosmic radiation. The dielectrics of the transformer is concluded to be in sufficient condition for further operation.

Dielectric Loss Angle 3

The assessment of dielectric loss of an insulator is a critical for the determination of its quality. Dielectric loss angle is used to express the power dissipation. A simple equivalent circuit can be used to explain the complicated physical relations by means of electrical condition. In the figure below the equivalent circuit for dielectrics is shown.

dielectric$_losses.png$

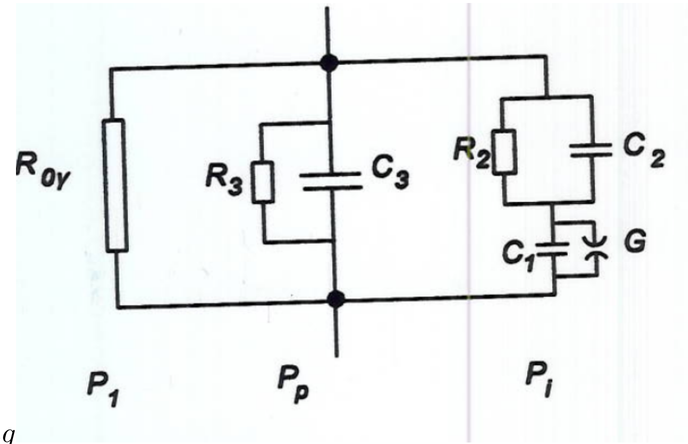


Figure 3.1: Equivalent circuit of dielectric losses

P1 illustrates the conductive losses and they appear by means of parallel resistor R_0. P_p is used to illustrate the polarizations losses. For an ideal dielectric only C3 exists, whereas for non-ideal R3 simulates the real component of the capacitive current caused by those losses. Pi is used to illustrate the ionization losses and they are used to represent the partial discharges (PD). R2 is in parallel with C2 their total impedance is in series with faulty PD cavity (C1). C1 is the partial element which breaks down during partial discharge and G is the gaseous partial discharge. The total dielectric losses are given in the equation 3.1.

$$P_{diel} = P_1 + P_p + P_l \tag{3.1}$$

When the total dielectric losses are calculated the dielectric loss factor (dissipation factor) $tg\delta$ can be derived. The $tg\delta$ is expressed as ratio between the active current I_w and reactive current I_{wl}. The dielectric loss factor $tg\delta$ is given in the equation 3.2.

$$tg\delta = \frac{I_w}{I_{wl}} = \frac{P_{diel}}{Q} \tag{3.2}$$

The equation above leads to a new formula which is also used to estimate the dielectric losses.

$$P_{diel} = Q \cdot tg\delta = \omega \cdot C \cdot tg\delta \cdot V^2 \tag{3.3}$$

Another way to calculate the loss angle is by simple equivalent circuit a resistor in series and parallel with a capacitor. Figures and equations below illustrates those to scenario.

Series circuit:

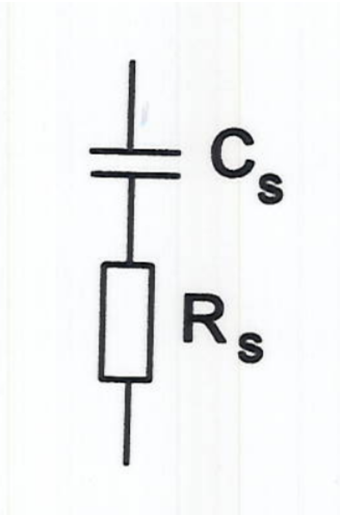


Figure 3.2: Equivalent circuit of a capacitor and resistor in series

$$tg\delta_s = R_s \cdot \omega \cdot C_s \tag{3.4}$$

Parallel circuit:

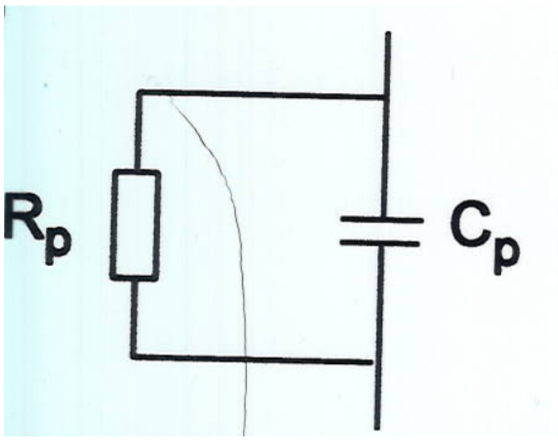


Figure 3.3: Equivalent circuit of a capacitor and resistor in parallel

$$tg\delta_p = \frac{1}{R_s \cdot \omega \cdot C_p} \tag{3.5}$$

Another way to determine the dielectric loss angel is by using a well known test method called Schering-bridge. The figure below shows the layout for this test.

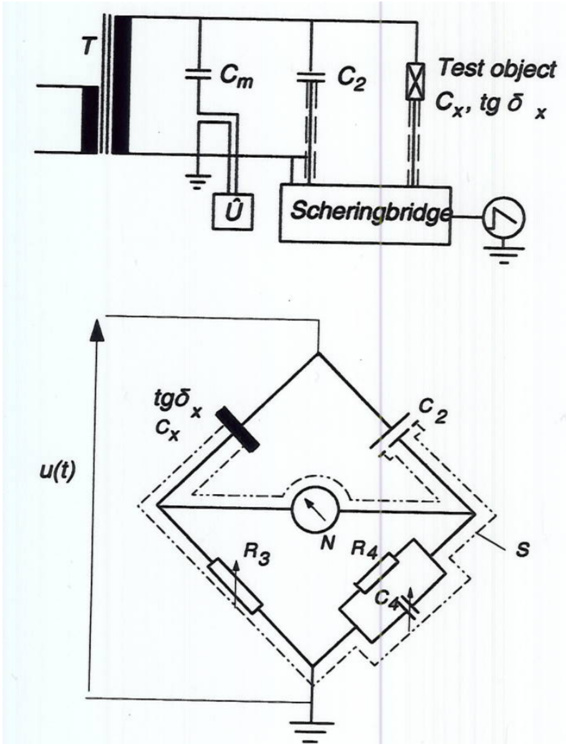


Figure 3.4: The layout of the Schering-bridge

The Schering-bridge contains some adjustable components as; R_3, R_4 and C_4. The unknown C_x and normal capacitor C_2 are connected to the HV side. After some voltage calculations the value of the capacitor C_x and the $tg\delta$ can be derived. The value of the C_x and $tg\delta$ depends on the connection of the setup (if it is series or parallel connected). Based on the equations below the value of C_x and $tg\delta$ for a parallel connection can be calculated.

$$tan\varphi_4 = R_4 \cdot \omega \cdot C_4 = tan\delta_x \tag{3.6}$$

$$C_x = C_2 \frac{R_4}{R_3 \cdot (1 + tg^2\delta_x)} = C_2 \frac{R_4}{R_3} \tag{3.7}$$

3.1 Test setup

The tests contains measurements of the capacitor and the ABB voltage transformer. The measuring device is connected between the primary terminals and ground. The device used to find the dielectric loss angle and the capacitance between these terminals is a Schering bridge. The transformer is used in this experiment to illustrate the Rx and a capacitance Cx, which is unknown. To find these unknown parameters a gas capacitor C2, which represents an ideal capacitor, is connected in parallel with the transformer and both branches are connected to the measuring device. This device has two variable resistances and a variable capacitor which adjust until the system is in balance, meaning that the voltage potential is the same in both branches. When the balance in the system is achieved different voltages are applied. The measuring device gives both the value of the C_x and $tg\delta$ of every applied voltage. The test will be conducted with different voltage levels starting at from 5 kV and moving up to 45 kV with step size of a 5 kV.

3.2 Results and discussions

In the table below the results of the loss angle for the 60 kV transformer are presented.

kV	$tg\delta$	C_x	$I_x uA$
5	0,2689	58,18	93,3
10	0,089	77,756	249
14,65	0,0207	85,638	394,5
19,84	-0,0232	89,955	560,5
24,53	-0,0488	91,5	705,6
29,82	-0,0659	91,41	857,8
34,55	-0,072	89,502	972,2
39,66	-0,062	84,135	1050
44,45	-0,0095	73	1021

Table 3.1: Test results for measuring the voltage transformer

As it can be seen from the measurements the loss angle behaves as expected from, 5 kV to 15 kV which means the angle is positive, but it can be seen that from 19 kV to 45 kV the loss angle is negative which is unexpected. A purely capacitive load should always be positive whereas if purely inductive it should always be negative. Reactive power is proportional to the voltage and by increasing the voltage the reactive power should increase as well. So, a rise in the capacitance is expected. A continuous increase of the capacitance by increasing the voltage is only double, for certain value, until the capacitor reaches its maximum value after that the value of the capacitor will decrease. As it can be seen from the measurements the value of C_x slightly increase from 5 kV to 30 kV after that it starts to decrease. It is assumed that the capacitor has reached maximum value at about 30 kV. Another thing observed from this test is that the loss angle decreases when the capacitance increases. This is in accordance with the equations derived above where the test object is connected in parallel. Therefor no clear conclusion can be based on this experiment. A new experiment was made to verify this assumption. For this experiment a pure capacitor is chosen as test object. The voltage level chosen for the second experiment is from 2.5 kV and 20 kV with a step size of a 2.5 kV.

kV	$tg\delta$	C_x	$I_x uA$
2,51	0,0203	19,826	15,65
5,03	0,02	19,874	31,5
7,57	0,0204	19,9	47,35
10,1	0,0208	19,924	63,1
12,58	0,0204	19,33	79
15,14	0,0206	19,943	94,985
17,13	0,0214	19,955	107,575
319,7	0,0215	19,961	123,75

Table 3.2: Test results of the first experiment

As it can be seen from the measurements the loss angle has a positive value and slightly increases from start to finish. This tells us that the test object is purely capacitive. Another observation is that the capacitance is slightly increased due to increasing voltage.

4 Overvoltage test

Explaining the overvoltage test made in the laboratory requires some initial explanation, which will be presented in the following sections.

4.1 Impulse voltages

There are two kinds of impulse voltages, lightning and switching. Lightning impulse occur from lightning strikes on lines or outdoor busbars and have very high voltages, in the order of 1 MV and currents of 0.1 MA. When the amplitudes are that high, there is a chance that some insulation immediately breaks down creating a front chopped power surge. These steep waves can cause severe damage to transformers and other high voltage equipment. The other kind is the switching impulse, which the name indicates is generated from switching. These switching events can occur do to lightning, where the grid is trying to protect itself by shutting certain areas off, but in so doing creating a potentially dangerous impulse voltage albeit not as high as the lighting surge.

High voltage insulation can be made out of several types of dielectric materials which in turn can be made from solids, gases or liquids. This means that when making voltage stress tests the results can be quite random, meaning they have to be statistically analysed. These random discharges can be modelled if a large number of stress tests have been made, where a part of these create a discharge, D, and the rest of them W, for withstand, as seen in Equation 4.1.

$$W = (1 - D) \tag{4.1}$$

Noting that the time to discharge also varies, the probability of discharge is then a function of stress, S, and time ,t. Which can be written as Equation 4.2.

$$p(V) = p(t, S) \tag{4.2}$$

$$P(V) = \frac{1}{\sigma \cdot \sqrt{2 \cdot \pi}} \cdot \int_{-\infty}^{+\infty} e^{\frac{-(V - V_{50}^2}{2 \cdot \sigma^2}} \tag{4.3}$$

Where P is the probability of discharge, V is the applied voltage, σ is the standard deviation and V_{50} is 50 % probability of discharge. This means that if V_{50} and σ is known, the probability of of discharge for any voltage can be calculated. A graphical representation of $p(V)$ can be seen in 4.1.

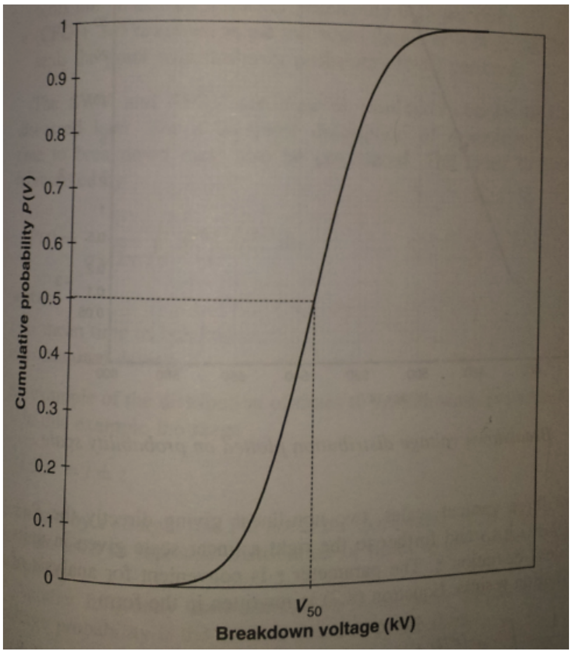


Figure 4.1: Gaussian cumulative distribution function

Figure 4.1 shows the breakdown voltage curve. In order to generate something similar, a series of tests have to be made.

4.2 Laboratory tests

Since there was limited laboratory time 40 measurements were made at four different voltage settings, in this case 72.2 kV, 69.6 kV, 70.9 kV and 73.5 kV. The idea is that a 10 measurements are made at a set voltage and then noting how many breakdowns, if any, occur. The average of these measured voltages is then calculated and the percentage of how often a breakdown occurs. This can be seen in Table 4.1.

Set point [kV]	**Voltage [kV]**	**Breakdown**
72.2	58.15	No
72.2	58.65	Yes
72.2	58.21	Yes
72.2	58.67	No
72.2	58.23	Yes
72.2	58.02	No
72.2	58.24	Yes
72.2	58.19	No
72.2	58.29	No
72.2	58.21	Yes
#	**Avg. [kV]**	**% breakdown**
10	58.30	50

Table 4.1: One set of measurements

A table with the results can be seen in Table 4.2.

Set point [kV]	**Voltage [kV]**	**Breakdown %**
72.2	58.30	50
69.6	55.97	0
70.9	57.31	0.2
73.5	59.30	0.09

Table 4.2: Compiled test results

Since only four separate voltages are measured, a proper graph cannot be generated but the tendency of the results can be seen. Figure 4.2 shows the results.

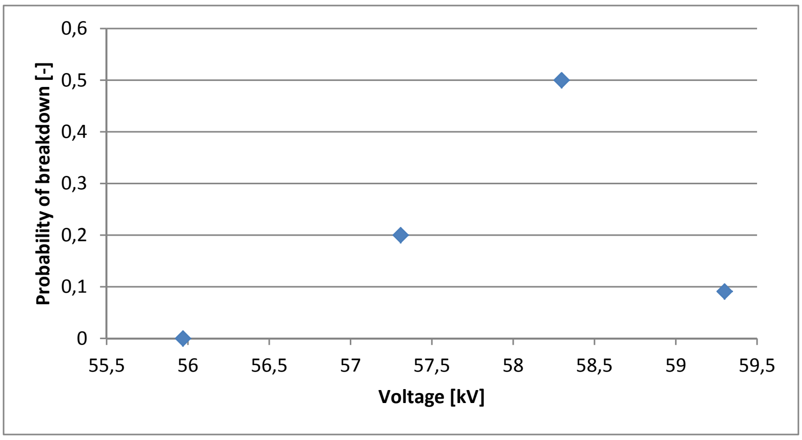


Figure 4.2: Over voltage test results

Figure 4.2 shows the four measurement results. It can be seen that the first three points follow the expected curve, but that the fourth one falls down to a 10 % chance of discharge at 59.3 kV. This is not expected, but since the 59.3 kV test was the last one made, there might be an explanation for it. The electric field lines between the breakdown capacitor, the pointy rods, are dependent on their psychical appearance. Meaning that after a certain number of arc flashes, the points themselves could have changed shape, they could become slightly rounder and thus increasing the voltage needed to generate and arc flash.

Dielectric spectroscopy test 5

The dielectric spectroscopy test measures the dielectric frequency response of the test material over a wide frequency range. This method can give an assessment of moisture contained in the oil and gives a condition diagnose of the insulation.

5.1 Dielectric spectroscopy

DIRANA from OMICRON is a device provided by AAU and is used to conduct the dielectric spectroscopy test for oil-paper-insulated power transformers. The DIRANA can conduct a frequency sweep from 0.0001 Hz to 1000 Hz, measures the response from the different dielectric materials of the transformer and the interfacial polarization effect between them. The results are given by the dissipation factor over the frequency sweep. An example showing the dissipation factor of different materials is shown in figure 5.1

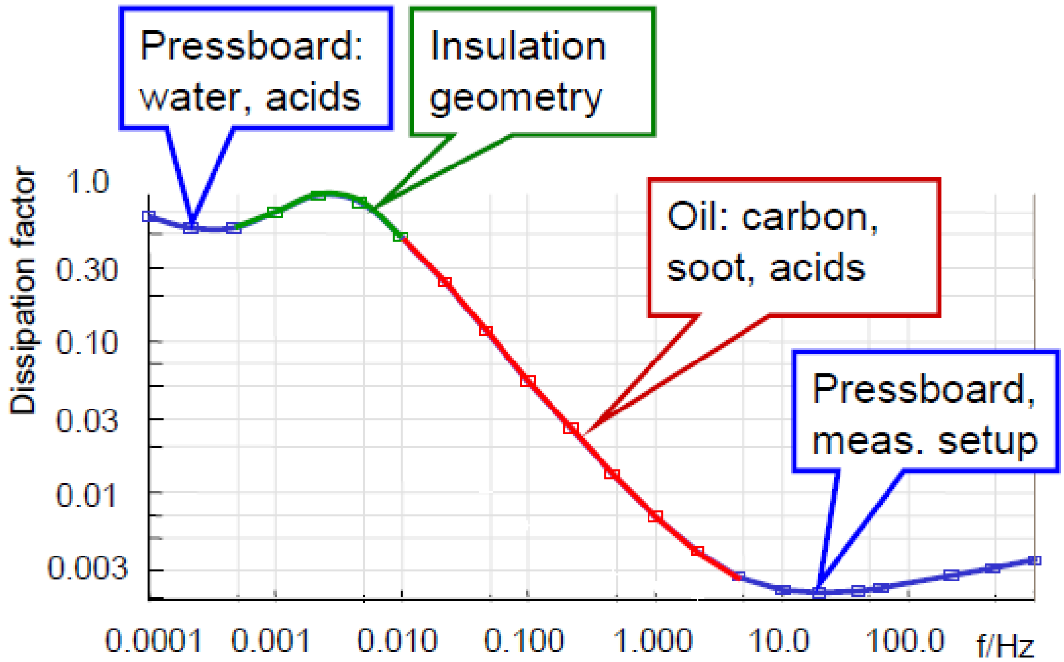


Figure 5.1: Dissipation factor of pressboard and oil together with interfacial polarization effect

There are number of different parameters that can influence the dielectric response i.e. geometry,temperature, moisture, insulation and oil conductivity.

5.1.1 Dissipation factor

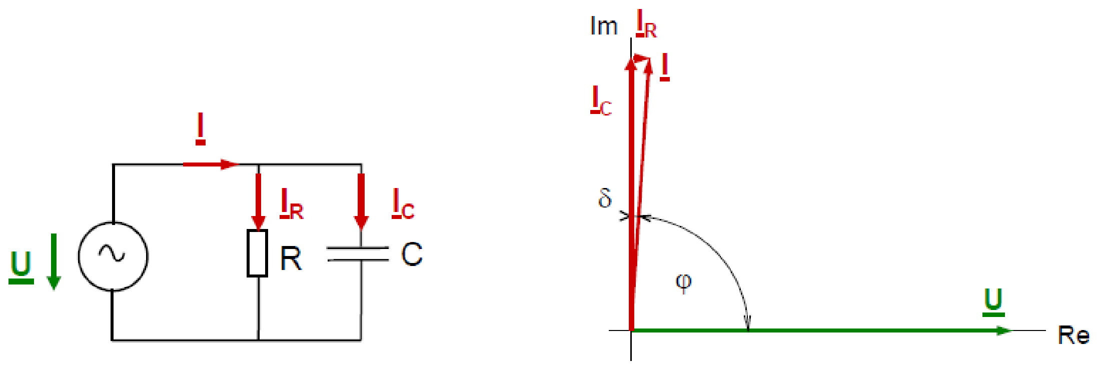


Figure 5.2: Equivalent circuit for insulation material and corresponding vector diagram

The left part of figure 5.2 is an equivalent circuit of insulation material and the right part is the corresponding vector diagram. The sum of the resistor current within the different material for a transformer decides the angle between the capacitive current and the total current. This angle is the measured dissipation factor for that given material. If the angle is zero or purely capacitive the isolation could be considered perfect. For further explanation of the dissipation factor see chapter 3

5.2 Test setup

Figure 5.3 illustrates the setup where DIRANA is on the right with its output connected to primary terminal of the voltage transformer and the input is connected to the transformer secondary winding terminals. A PC is connected to the DIRANA device which serves as interface and data storage for the device.

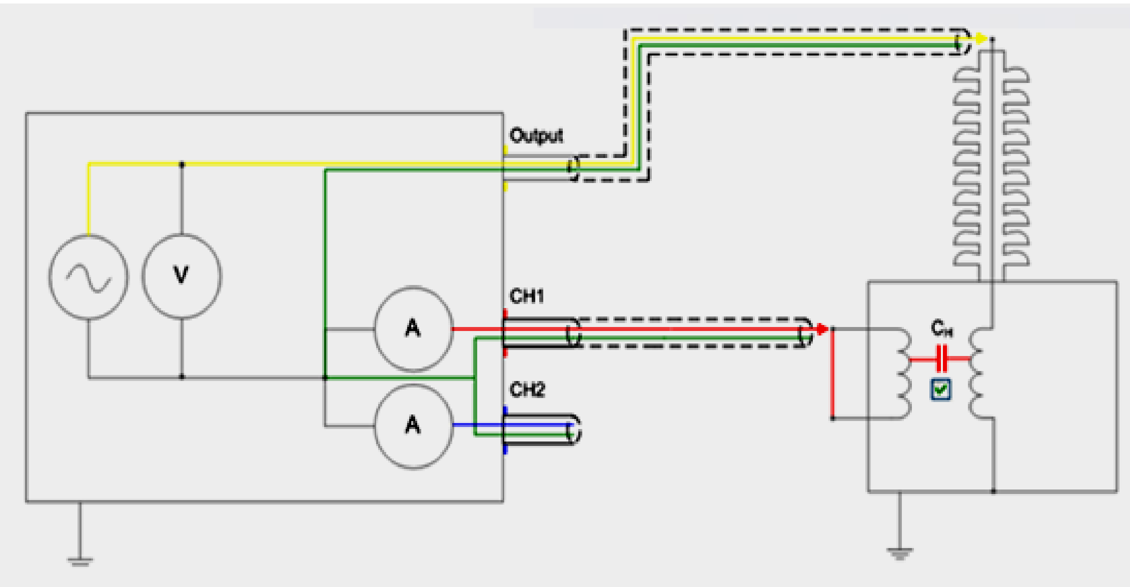
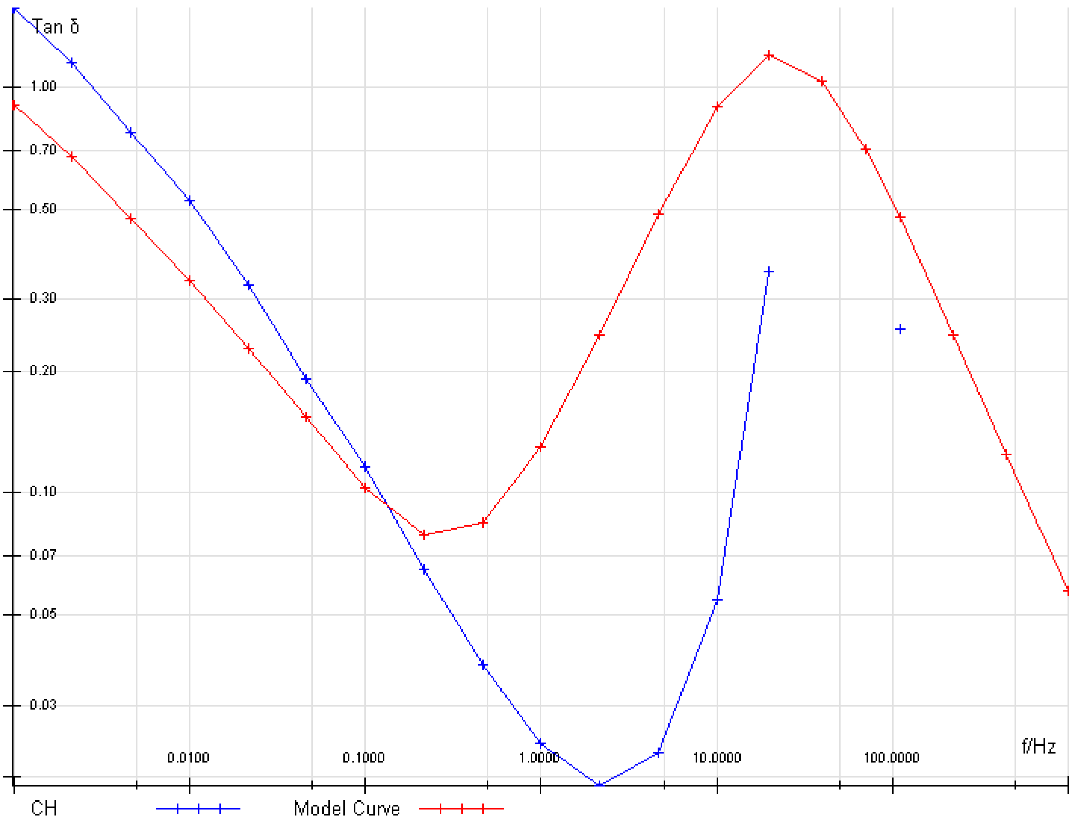


Figure 5.3: Dielectric spectroscopy test setup

5.3 Test result

To get an increasingly accurate results a model has to be implemented into the program for reference the model has to include parameters such as transformer type and age. The test results will become more accurate every time the system is checked as the reference model will be based on more data. When testing the transformer external conditions can influence the test results i.e weather conditions, air temperature and air humidity. The results from measuring the voltage transformer type EMFC 72 dissipating factor, is depicted in figure 5.4 and table 5.1.



in

Figure 5.4: Dissipation factor over frequency range

Description	**Value**	**Unit**
Mode	UST	$[-]$
Switch frequency	100	$[mHz]$
FDS Voltage	100	$[V]$
PDC Voltage	200	$[V]$
Switch Frequency	100	$[mHz]$
Calculated Moisture	1.0	[%]
Moisture Category	dry	$[-]$
Oil temperature	20	[°C]
Oil Conductivity	10	$[nS/m]$
Capacitance @ 50 Hz	-272.1398	$[pF]$
Tanδ @ 50 Hz	-1.0610	$[-]$
Capacitance @ 60 Hz	-178.6066	$[pF]$
Tanδ @ 60 Hz	-0.9399	$[-]$
Barriers	20	[%]
Spacers	15	[%]

Table 5.1: Test results

The table 5.2 labels the procent range of moisture contained in the transformer. It is extensively researched that when moisture content of a transformer exceeds 3% the breakdown voltage will be greatly reduced and the insulation strength between windings can be compromised.

Mosture catagories	**Value**
Dry	$< 2.2\%$
Moderately wet	$\geq 2.2\%$ and $< 3.7\%$
Wet	$\geq 3.7\%$ and $< 4.8\%$
Extremely wet	$\geq 4.8\%$

Table 5.2: Moisture catagories

Looking at the graph in figure 5.4 blue curve is the DIRANA measurement and the red is instrument reference model. The result shows that the instrument does not know the measured transformer characteristic since there is a large difference between the two curves. This difference may lie in the reference model, that does not include quarts in the oil. This structural difference will have an influence on the characteristic dissipation factor. In order to make the right validation of this specific voltage transformer, it is necessary to have the correct reference model. A reference model can be built by using previous tests of the same transformer and gradually build an aging curve.