APPLICATION NOTE

PDC test
Polarisation and Depolarisation Current

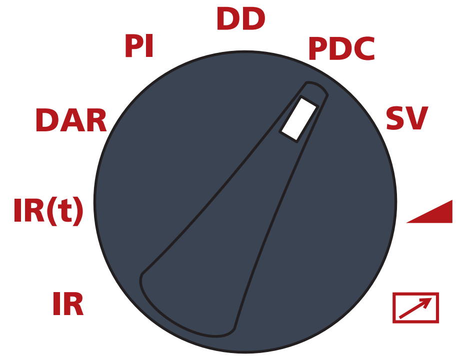
Megger

EN

What is a PDC test?

The Polarisation and Depolarisation Current (PDC) analysis is a non-destructive dielectric testing method that can be used to assess the condition of insulation materials, particularly in rotating machines and transformers. This test can be thought of as a combination of PI (Polarisation Index) test and DD (Dielectric Discharge test), with additional diagnostics capability.

This technique measures the polarisation and depolarisation current to gather insights into the moisture content, aging, and general health of the insulation material. PDC test is a non-destructive method and uses low voltages, it reduces the risk of damaging aged insulation during test and is safer on the equipment than the high-voltage tests like Tn Delta or AC withstand.



The Megger S1 EXPERT range with CertSuite Asset on tablet.

Overview of PDC test

The PDC test comprises of the polarisation and depolarisation current being applied to the test subject and measured for equal time duration. These currents can be defined as:

- **Polarisation current: When a DC voltage is applied to an insulation system, the molecules within the insulating material begin to polarise electrostatically, creating a current, which appears similar to capacitive charging. This polarisation current gradually decreases over time as the material reaches equilibrium.**
- **Depolarisation current: After the DC voltage is removed, and the insulation is discharged and short-circuited, the insulating material relaxes, and a depolarisation current flows in the opposite direction.**

The behaviour of these currents can give valuable information about the insulation's dielectric properties and its ability to recover from electrical stress. These currents are illustrated in the figure below.

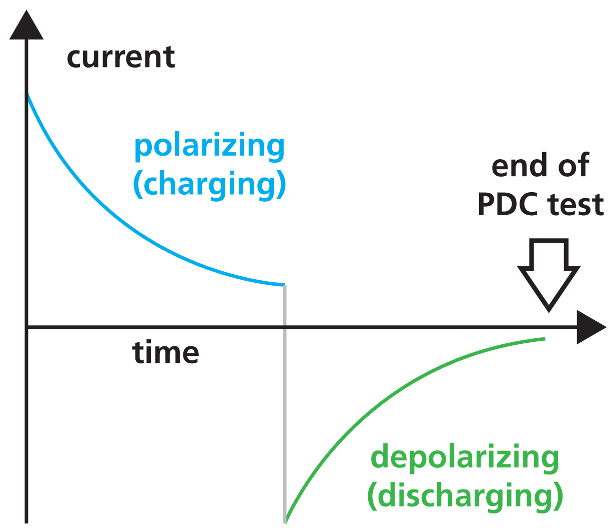


Fig 1: *Polarisation and Depolarisation currents with time*

Which assets can be tested using PDC test?

PDC testing can be performed on various types of high-voltage equipment with solid and liquid insulation. Below are some key assets that are most suitable for PDC testing, given the non-destructive nature of the test that makes it especially suited for these potentially high valued assets:

- **Motors and generators: Large rotating machines benefit from PDC testing in order to accurately assess the condition of insulation in windings, identifying issues such as moisture ingress, dielectric degradation and ageing, and partial discharge activity.**
- **Transformers: PDC testing helps in assessing the insulation quality in power transformers, identifying aging, moisture content, and insulation degradation.**
- **Other insulation: PDC testing also finds its applications for testing of medium- and high-voltage cables to detect insulation deterioration; HV bushings to assess the dielectric condition of insulation; high-voltage capacitors to detect issues such as dielectric losses and insulation aging; power systems to ensure that insulation health is maintained, especially where predictive maintenance is critical.**

How should the testing be performed?

NOTE : Remember to follow the company and national safety procedures before performing any test.

It is crucial to discharge the item under test, both before and after an insulation resistance test. It should be discharged for a period about four times as long as test voltage was applied in a previous test, or one hour, whichever is longer. Megger instruments are frequently equipped with discharge circuits for this purpose. If a discharge function is not provided, a suitable discharge stick or equivalent method should be used. Leave highly capacitive apparatus (i.e. large windings, long cables etc.) short circuited and connected to ground until ready to re-energise.

It should be noted that capacitance discharge differs from polarisation discharge. The capacitors in the circuit can release the stored electrical energy quickly and hence the duration for capacitance discharge is usually relatively short, whereas the duration for polarisation discharge can be significant as it takes longer time for a reduction in polarised state in a material or device.

PDC Polarisation Depolarisation Current test availability

The **Advanced** and **Expert** ranges of MIT and S1 insulation testers (MIT525/2, MIT1025/2, MIT1525/2, S1-568/2, S1-1068/2 and S1-1568/2) have the ability to perform PDC tests.

The test is performed on these instruments as follows:

PDC test timer setting

Select the PDC test range, and select the spanner (settings range)
The PDC setting screen will be displayed

The T1 (charge time) and T2 (discharge time) are set at the same time as they are always the same duration.
The current set timer duration is displayed together with a green tick to indicate that is the saved setting

Use the up and down arrow keys to select the desired timer setting.
When changed a red cross indicates that the current displayed timer value has not yet been saved
Press the OK button to save the displayed timer value which will confirmed with a green tick

How should the testing be performed?

PDC test operation

Select the PDC test range and select the desired test voltage
The instrument will flash the save icon, USB icon and Bluetooth icon. One of these options has to be selected or connected as the test results have to be graphed to be able to review the test results.

To save the test results into the instruments internal memory please **press the save button** or connect the instrument via Bluetooth or USB cable, to either PowerDB / Lite, or the CertSuite Asset mobile app. This allows the test results to be streamed to the device.

Once the instrument has be safely connected to the item under test press and hold the **TEST** button for more than 3 seconds to start the test.

During the test the applied test voltage, measured insulation resistance and test current will be displayed in the usual manner
During the charge phase of the test the timer displayed in the bottom left of the display will count up until the set time is reached. At that point the test voltage will be switched off the instrument will enter the discharge phase of the test. The final IR value will remain of the display. The timer will now count back down to zero and to the end of the test.

At the end of the test the instrument will display three dashes **'---'.** If internal storage was selected before the test, the memory location that the test was saved in will be displayed. For example **0008**.

The PDC test results can then be graphed using either PowerDB, Power DB Lite or the CertSuite Asset mobile application.

How to interpret the results

Three types of graphical forms can be used to display the polarisation and depolarisation currents:

- **Current vs. Time in linear scales and showing the actual current polarity, positive for polarisation, and negative for depolarisation (Fig. 2a).**
- **Current vs. Time in logarithmic scales with the depolarisation time reset to zero and using a positive value for the depolarisation current (Fig. 2b). This is the most-commonly used representation for further analysis.**
- **The "Current vs. Time in logarithmic scales" is sometimes plotted "normalised" such that the current values are divided by the capacitance of the insulation under test so that the units are (A/F) as in Fig. 2c. The graph looks very similar to Fig. 2b, but the numerical values are normalised with the size of insulation, and with this approach for example a test on a single coil can directly compared with a test on the full winding.**
- **An Insulation Resistance Profiling (IRP) graph which is the ratio of the applied voltage and the current during the charge step (the discharge current is normally not used in this representation) which plots the insulation resistance IR as a function of time in a linear scale (Fig. 2d).**

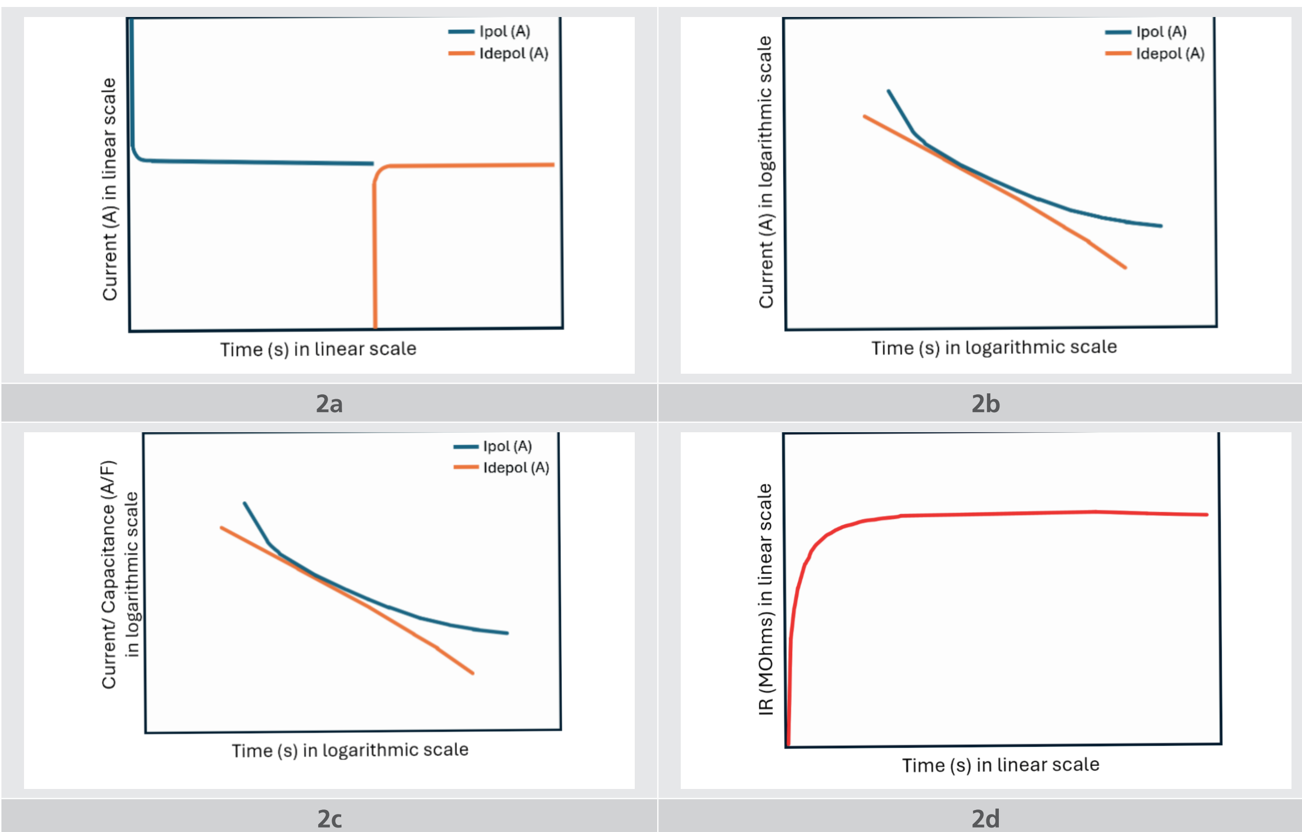


Fig 2: *Different representations of PDC test graphs*

How to interpret the results

For a better understanding of how to interpret the PDC test graphs, it’s beneficial to know the different components that combine to produce the total measured test current. Fig. 3 shows the separated curves for the three components of the total measured test current.

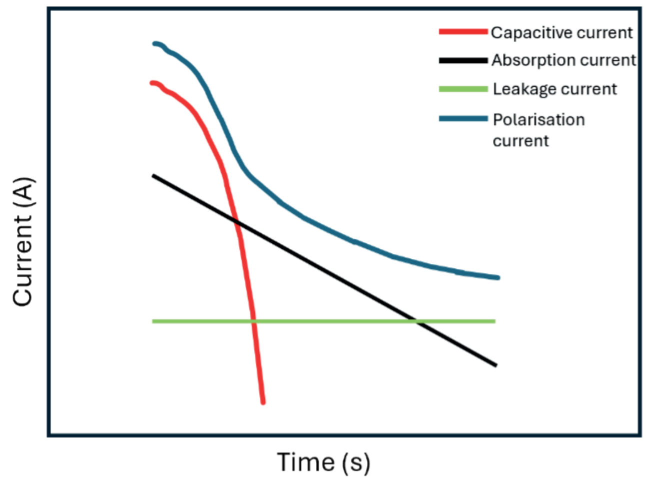
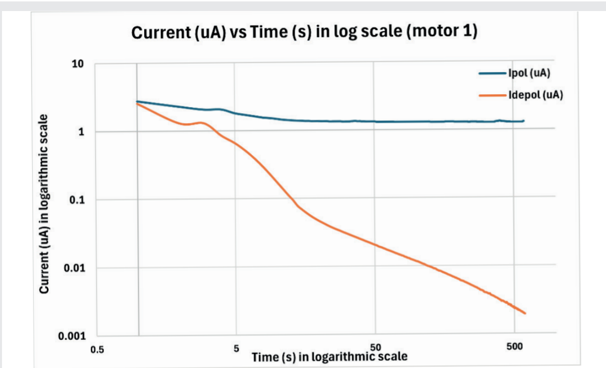


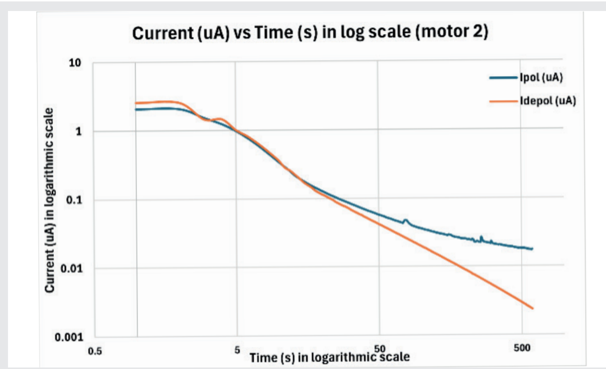
Fig 3: *Separated curves for the three components of the polarisation curve*

The totl measured test current curve can be separated into three components, namely: Capacitive current, Absorption/ Polarisation current, and resistive leakage current. Looking at the PDC test graph and keeping in mind the three components can help getting insight into the asset characteristics under test.

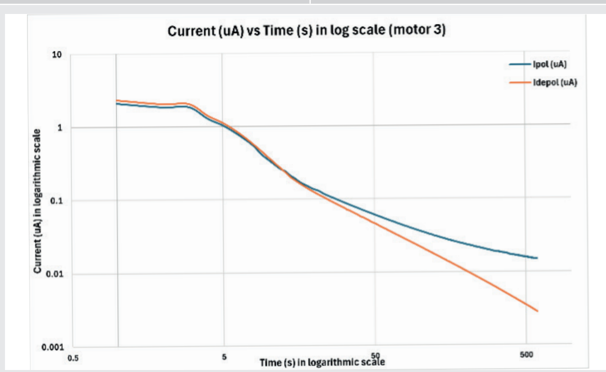
Let’s take an example of PDC test graphs plotted based on the PDC test data of three identical motors.



4a



4b



4c

Fig 4: *Current vs Time in logarithmic scales with the depolarisation time reset to zero and using a positive value for the depolarisation current*

How to interpret the results

At a glance, it is evident that the first motor (Fig 4a) is not similar in behaviour to the other two motors (Fig 4b and Fig 4c). The polarisation curve in for the first motor is almost parallel to the horizontal axis, which indicates that there exists a high leakage current in the motor (compare with Fig. 3).

Another way to assess the leakage current is to subtract the depolarisation current from the polarisation current as shown in Fig. 5.

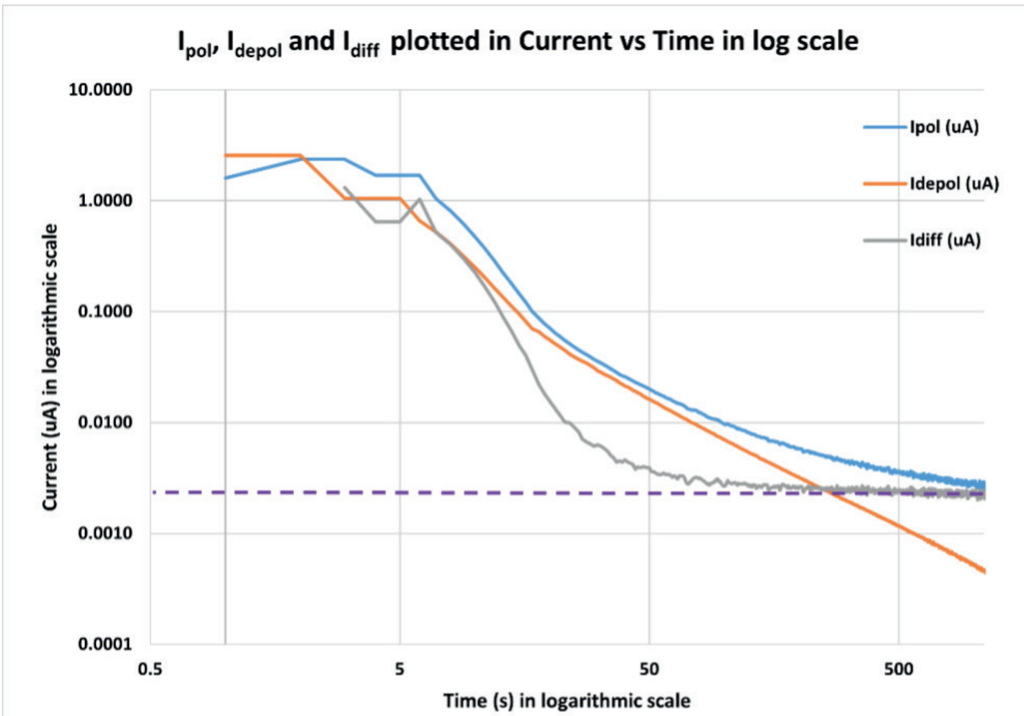


Fig 5: *Polarisation, depolarisation and their difference plotted in the same graph*

The difference between the polarisation and depolarisation current reaches a steady state and typically tends to a horizontal asymptote after the initial transient period. This value represents the DC leakage current value, and it is sometimes referred to as “separation” between the P and D curves.

In some instances, the depolarisation current line can begin to curve downwards indicating that the charging time was not long enough to fully polarise the insulation. If this is the case, then the test time might need to be extended accordingly, especially if mathematical decomposition of the current components is required.

How long should you do the test?

10+10 vs. 30+30?

PDC test is also referred to as "10+10" or "30+30" test, where the first half represents duration of polarisation phase and the second half depolarisation phase in minutes.

Choosing the correct time duration for the test can depend on various factors, such as:

Size of test object

- **For large equipment (like power transformers, high voltage cables) that has thicker insulation, a longer test time, like 30+30 minutes, is preferred. This is to ensure more accurate measurement since larger insulation systems take more time to polarise and depolarise.**
- **The slower polarisation and depolarisation of large equipment mean that shorter test duration (10+10 minutes) may not capture the full behaviour of insulation.**
- **For smaller equipment (e.g., motors, low voltage cables) with thinner insulation, 10+10 minutes can be sufficient as these are quicker to polarise and depolarise.**

Insulation condition and ageing

- **If the test object is older or suspected to have deteriorated insulation, a 30+30 test is preferred. Aging and moisture-related issues become more evident when sufficient time is provided for polarisation and depolarisation.**
- **For a newer equipment or recently serviced insulation, a 10+10 test can suffice as the insulation is expected to be in good condition unless trying to establish a long-term baseline.**

Test objective

- **For a quick diagnostic test to detect major issues (e.g., major moisture ingress or insulation breakdown), 10+10 may be adequate. This is useful in time-constrained situations or when frequent testing is performed.**
- **For an in-depth analysis of insulation's health, especially for trending or condition-based monitoring, 30+30 test is better. Longer duration of test provides more detailed data on the insulation conditions.**

A 10+10 test can be chosen to minimise downtime. This can be especially important for industrial operations or power plants where outages are costly. It can also be used as a quicker way to check for any major shifts in insulation behaviour when performing regular condition monitoring and there is already a baseline. However, any anomalies may require follow-up testing with longer duration.

A 30+30 test accompanied by mathematical models can be used for in-depth analysis of the insulation conditions.

While 10+10 and 30+30 are the most common, test durations can range from 5+5 minutes for a very quick checks (especially if used with Polarisation Index Predictor), to 120+120 minutes (or longer) for detailed analysis of large equipment. The duration should be selected based on the size, insulation type, condition and testing objective.

For more information

To view the User Guides please click on or scan the QR code

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