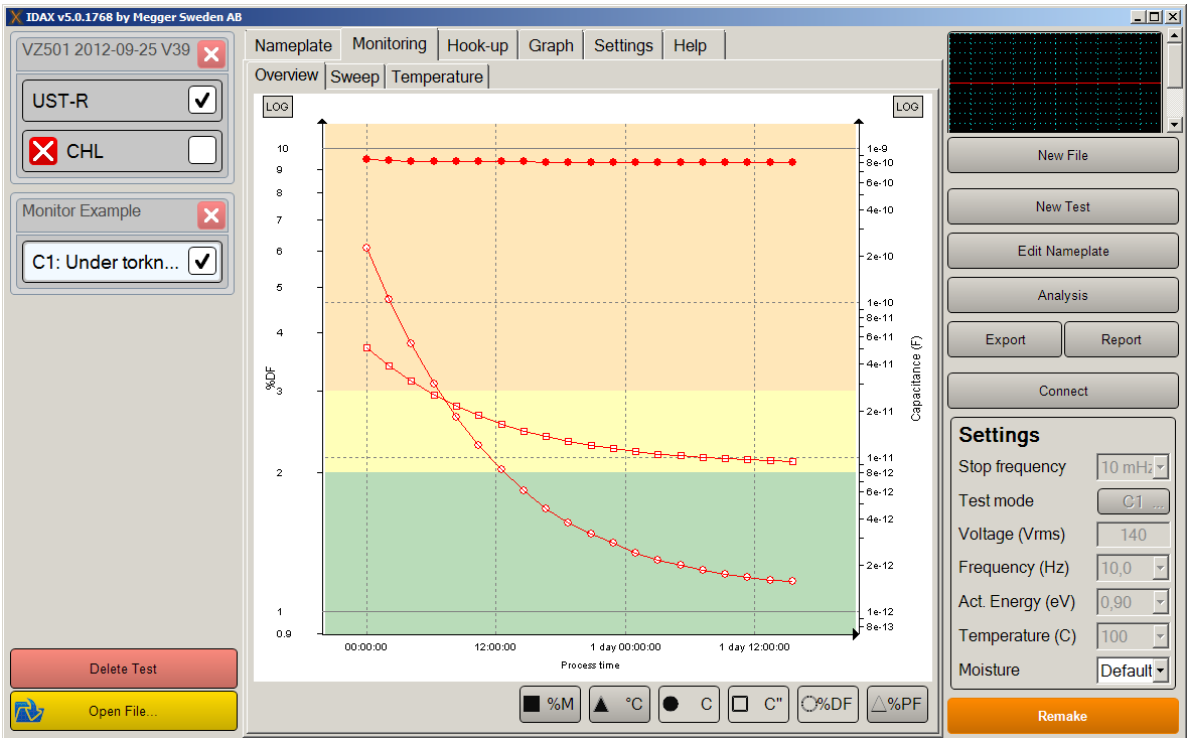
IDAX Monitoring

SW to monitor processes using Dielectric Frequency Response

User's Manual



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1 Introduction

IDAX Monitoring is an additional feature to IDAX 5.0 SW to make it possible use a IDAX 300 to monitor processes using DFR (Dielectric Frequency Response). Examples of processes to be monitored are:

- Dry-outs, reduction of moisture content, of un-impregnated as well as impregnated cellulose in e.g. power transformers. For such processes ITC (Individual Temperature Corrected) dissipation factor are most commonly used
- Impregnation, e.g. impregnation of dry cellulose with insulation liquids or resins. For such processes ITC (individual Temperature Corrected) capacitance may be used; however, be aware of that temperature change the geometry and the effect of geometry is not corrected in the ITC.
- Curing of resins. Curing status strongly affect the dielectric properties of the insulation material and therefore monitor of such process is possible. See e.g. "Analysis of Dielectric Response Measurement Methods and Dielectric Properties of Resin-Rich Insulation During Processing" by Anders Helgeson

IDAX Monitoring can be used in factory environment as well as in the field.

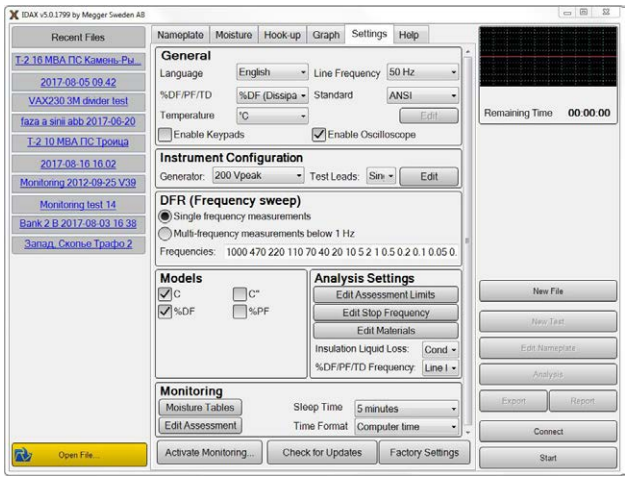
The connection to a PC or other intelligent system is the same as for IDAX via the USB port and/or the Ethernet port on the IDAX front panel.

The IDAX may be connected to the PC or other intelligent system operation, however, you may disconnect and reconnect at a later occasion during the monitoring process. Then IDAX Monitoring SW automatically collect all data points collected.

Software Installation

Monitoring functionality is installed during installation of IDAX 5.0 software, but it is disabled by default. In order to enable this functionality a licence code must be obtained.

Monitoring functionality can be activated by entering user name and corresponding activation code.

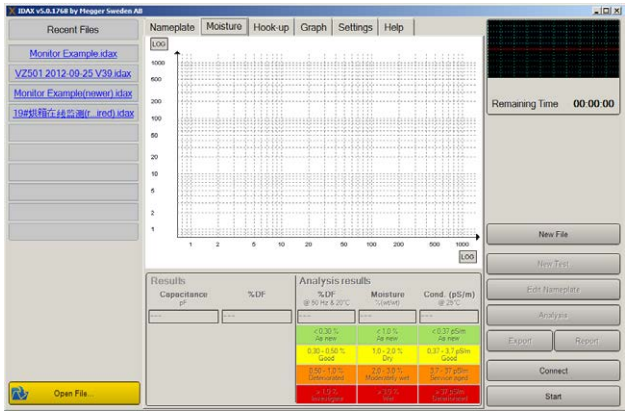


2 Getting Started

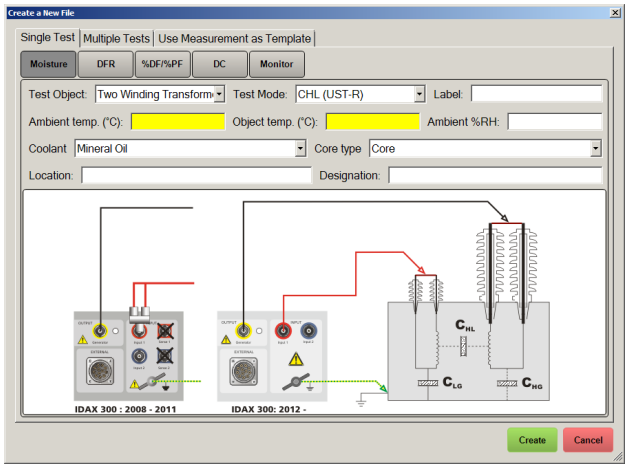
This section provides a step-by-step instruction.

1] Start the IDAX 5.0 SW.
SW will appear similar to picture below.

2] All data will always be saved in a file, therefore, you should press the "New File" button (right-hand side).



3] Then the "Create a New File" window will appear, defaulted to "Moisture". Press the "Monitor" tab. For more information by "Moisture"/"DFR"/"%DF/%PF/"DC" and the tabs "Single Test"/"Multiple Tests/"Use Measurement as Template", see IDAX User's manual.



Important

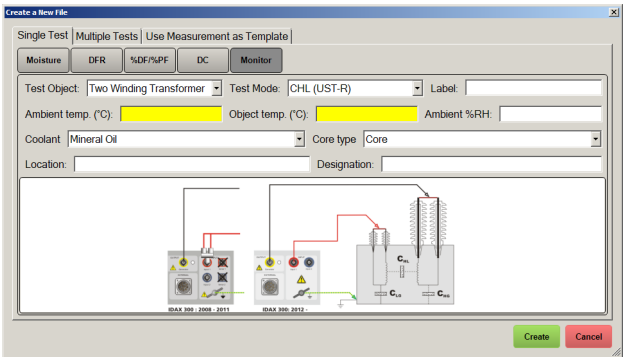
"Monitor" has inherited most of functionality from "Moisture" and therefore "Test Objects" available is limited to those currently available in "Moisture", and only one "Test Mode" per test is allowed. For monitoring, UST configuration is strongly recommended and therefore the "Two Winding Transformer" with "Test Mode" CHL (UST-R) can be used for almost all samples (if a GST measurement is required, select e.g. "Auto Transformer Without Tertiary").

4] Select "Test Object" (normally Two Winding Transformer even if you intend monitoring a current transformer, bushing etc.).

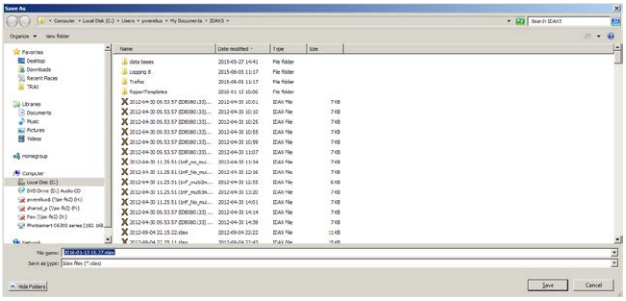
5] Enter temperatures into compulsory fields "Ambient Temperature" and "Object Temperature", e.g. 22C. These two fields are there as inherited from "Moisture", these values will not be used in the Monitoring function.

6] Enter other fields if you need information (or add information to nameplate later).

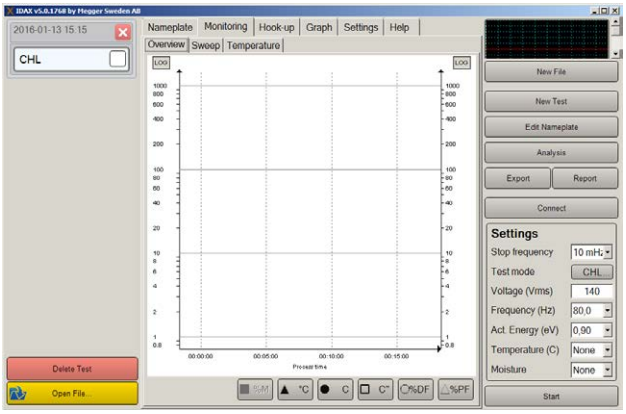
7] Press "Create".



8] Save the "File" at location of your choice



9] Now, you have a “Test” (labeled CHL, upper, left-hand side of window) that can be run (after connected to IDAX and start by press “Start” button in lower right-hand side corner



In lower part of right-hand side, it is a section labeled “Settings” that display part of settings for the test:

Stop frequency	Lowest frequency to be used in DFR sweep of the full sweep defined on settings tab (see section Settings tab). You may change “Stop frequency” in drop down list.
Test mode	By clicking this button you see the basic connection diagram.
Voltage (RMS)	Applied voltage level. You may use any voltage level, however, if you use voltage level below 7 Vrms (10 V peak), you preferable change from 200 V peak amplifier to 10 V peak amplifier on Settings page (may be advisable measuring under Vapor Phase conditions).
Act. Energy	Activation Energy used for ITC temperature correction. Incorrect values scale data slightly incorrect but has limited impact as long as Reference temperature is not too far from actual measurement temperature. Typical values (Cellulose means pressboard, Kraft paper or Crepe paper): ■ Oil-impregnated cellulose, -20-80°C: 0.9 eV ■ Non-impregnated cellulose, >80°C: 1.0 eV
Temperature	Reference temperature for ITC
Moisture	Select a database (Default or other, to be modified in Settings tab), and Moisture is plotted. Note that in case Moisture is selected, Activation energy and (reference) Temperature is fixed to value determined by the selected database

3 Sample connection

This section provides a step-by-step instruction on how to connect the test specimen.

1] Start the IDAX 5.0 SW.

2] All data will always be saved in a file, therefore, you start by press “New File” button.

Oven bushings and high temperature coaxial cables

A common application of IDAX Monitoring is monitor sample during processing in a climate chamber, e.g. oven drying or Vapor Phase drying. In this case, bushings for bringing cables into the chamber are necessary and often also special high-temperature cables, which does not get damaged by high temperatures and kerosene. There are different types of connectors and cables on the market that will work for this application, description below will act as example.

BNC-connectors:

- BNC Adapter, female/female: Rosenberger 51K501-K00N4
- High temperature cable: PRO POWER, RG142 Coaxial Cable, RG142, 50 ohm, order code 2064894
- BNC connector (fit to cable above): Rosenberger 51S107-108N5

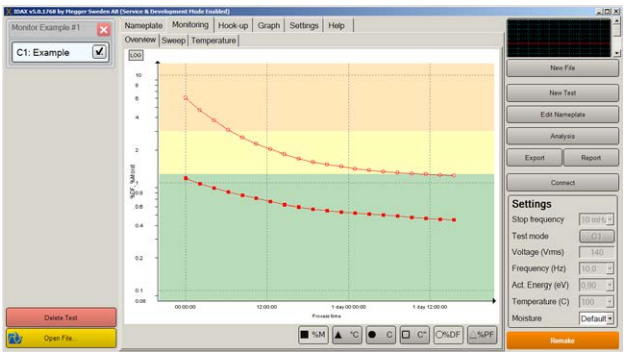
4 Sweep and temperature settings

4.1 Overview

In the Overview tab, the measurement results as function of time are presented.

Note *One or more parameters (e.g. %DF) to be plotted need to be activated; otherwise the graph will be empty.*

The parameters buttons (below the graph) are:	
%M	The moisture content in % based on Moisture assessment table: Left-hand side axis
°C	The temperature in degree Celsius; Left-hand side axis
C	Capacitance in Farad; Right-hand side Y-axis
C”	Complex part of complex capacitance (Impedance Z = 1/(j*2*pi*frequency*(C-jC”))
%DF	Dissipation factor*100 = Loss current*100 / Capacitive current = C”*100/C
%PF	Power factor*100 = Loss current*100/Total current = C”*100/(sqrt(C”^2+C^2))



Based on settings of “Settings” (lower part of right-hand section of window) the frequency sweep data are plotted differently:

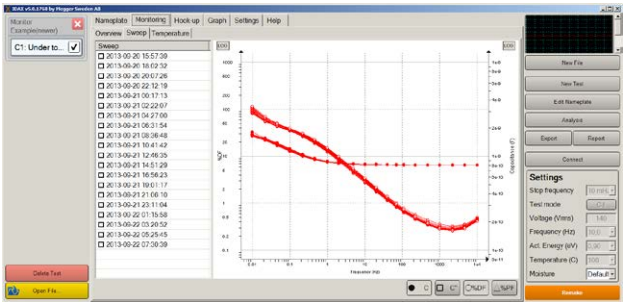
Frequency (Hz)	Frequency for data to be plotted
Act. Energy (eV)	Activation energy if ITC temperature correction is enabled
Temperature (°C)	By select a temperature you activate ITC temperature correction to selected temperature (otherwise, select None)
Moisture	By select a database, you activate Moisture assessment based on table database selected (see Settings page). Inactivate the function by selecting “None”. If a database is selected, Frequency (Hz), Act Energy (eV) and Temperature (°C) are set to fixed values determined by database selected.

4.2 Sweep

In the Sweep tab, the measurement sweeps are presented. At left-hand side the frequency sweeps are listed labeled with Date+Time.

Note *One or more parameters (e.g. C and %DF) to be plotted need to be activated; otherwise the graph will be empty.*

The parameters buttons (below the graph) are:	
C	Capacitance in Farad; Right-hand side Y-axis
C”	Complex part of complex capacitance (Impedance Z = 1/(j*2*pi*frequency*(C-jC”))
%DF	Dissipation factor*100 = Loss current*100 / Capacitive current = C”*100/C
%PF	Power factor*100 = Loss current*100/Total current = C”*100/(sqrt(C”^2+C^2))

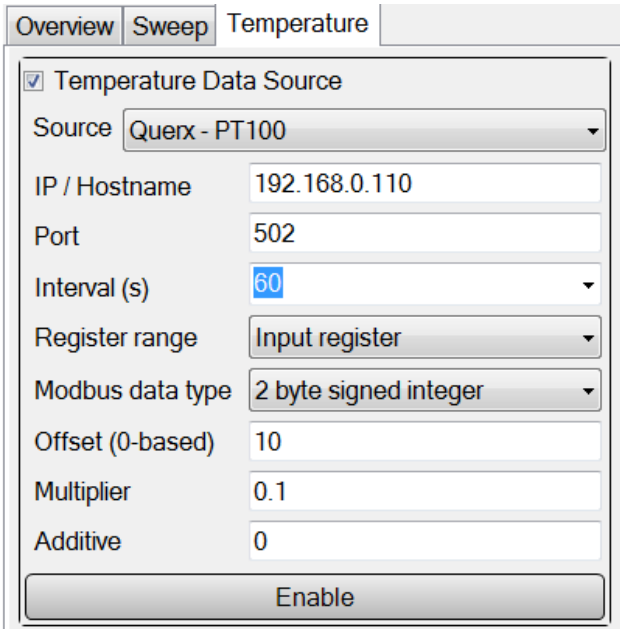


4.3 Temperature

In the temperature tab, the measurement temperatures are presented. At left-hand side the temperature labeled with Date+Time is listed (format according to computer settings) at the right hand the temperature at the specific time.

Automatic entry

Measurement temperatures may be read using either automatic logging device (default) or logfile. Automatic logger use Modbus data interface and is connected via LAN (Ethernet). In order to use it the IP address or hostname must be entered in the field “IP/Hostname”



You may change interval at which data are read and saved. It must be verified with specifications of logging device if other parameters need to be changed in case different logger than Querx-PT100 is used.

Use any compatible temperature logger with Modbus TCP interface.

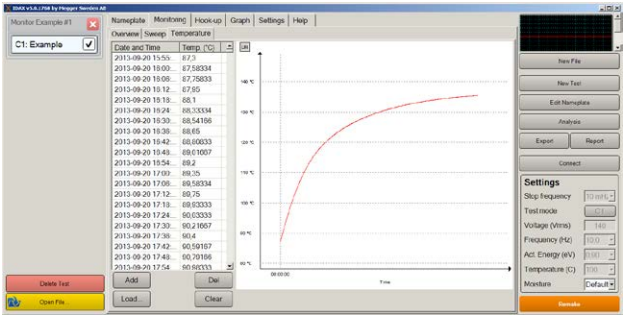
Manual entry

- Press “Add” button to enter temperature manually.
- To delete a temperature data point, press “Del”.
- Delete all data points by pressing “Clear”.
- Load temperature data points by pressing the “Load” button (more information about “Load” see section “Loading a temperature profile” below).
- The “Edit” function is activated by double-clicking on a temperature in the list.

The data points are automatically sorted by date/time and extrapolated before after covered times (using

two last data points if more than one data point).
If you need two constant temperatures, e.g. 100°C and 120°C use 4 data points (two at 100°C and 2 at 120°C).

Note *If no temperature is entered "Ambient Temperature" from Nameplate is used.*



Loading a temperature profile

It is also possible to load a complete temperature profile. The file should be semicolon separated *.csv with the following format:

YYYY-MM-DD HH:MM;Temperature

Example

YYYY-MM-DD HH:MM;Temperature
can be:
2013-09-19 09:42;21,5

The first row means 19th (19) September (09) 2013, at 09:42 (24h syntax). Temperature in degree Celsius is shown after the semicolon.

1] **By pressing "Load" button, an Open dialog window will appear showing all files with extension ".csv".**
The "Load" function accepts both point and comma as decimal separator.

Note *By changing view to show all files "*.*" it is possible to show files created e.g. as *.txt*

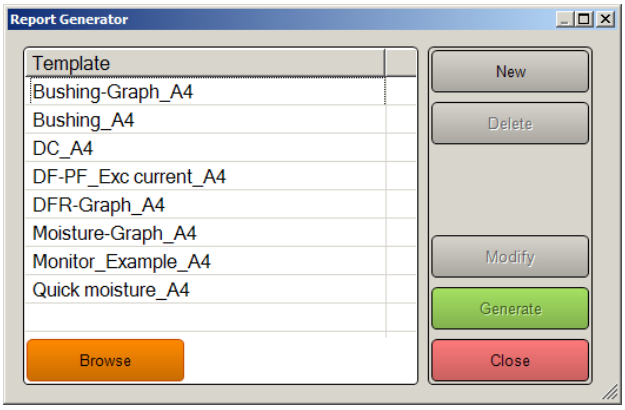
5 Export and Report

5.1 Export and report

1] Press the “Export” button to export all measurement data into a *.txt-file

2] Pressing the “Report” button connects data to Microsoft Word and opens a report dialog where pre-defined report templates are available.

3] Select “Monitor_Example_A4” and press “Generate”.



Note *All graphs/pictures will be in report as in SW, if you have enabled only %DF in Overview graph, only %DF will be present in Overview graph in report.*

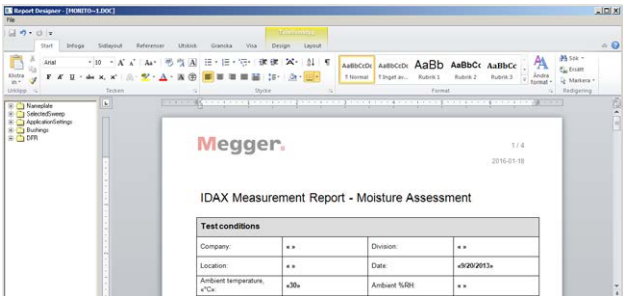
Design a personalized report

The most simple way of designing a personalized report template is to select an existing template and then modify it.

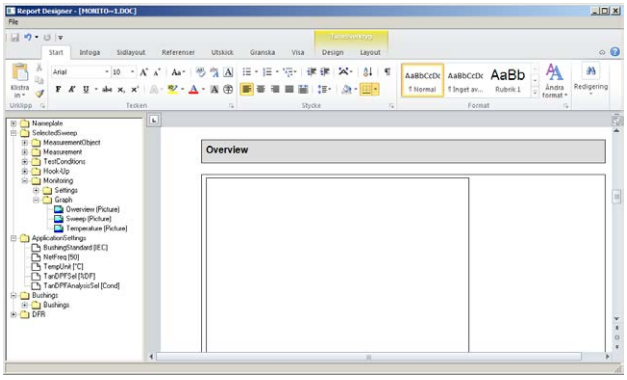
Example

1] Select “Monitor_Example_A4”.

2] Press “Modify”.
The “Monitor_Example_A4” report can now be modified under “File”.
You may design the report using normal Word functionality and “drag-and-drop” data from the legend on left-hand side of report generator.



3] Below you see the data “Overview (picture)” that earlier was placed under the Overview name. By delete the square (the overview picture from template) and then drag-and-drop e.g. Sweep (Picture) to same location, you have changed the template.



4] Save it under a new name that will appear under Template next time you press “Report” button.

5.2 Settings

The Settings Tab looks similar to standard IDAX SW, described in IDAX User's manual.
In bottom, middle, part of the window a section labeled Monitoring is added with the following functions:

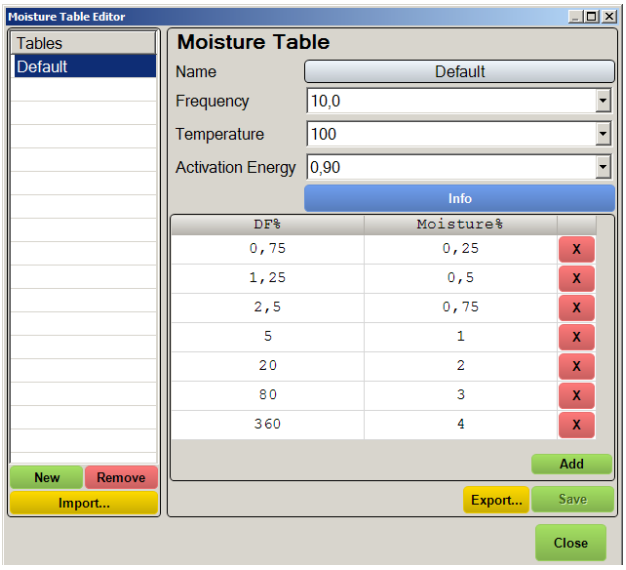
Sleep Time: (Default 15 minutes)

After a measurement is completed, the system waits (sleep) for the selected time before next measurement is started. If a frequency sweep takes about 5 minutes to perform (1 kHz to 10 mHz, single frequency measurements) and sleep time is 15 minutes you will get a new sweep every 20 minutes. Selectable alternatives are none, 5, 10, 15, 20, 30, 60 or 120 minutes.

Time Format: (Default "Process Time")

Each DFR sweep has a Date+Time stamp (when it starts) and each temperature also has a date+Time stamp. You can select if data should be plotted with X-axis set as Date+Time (Computer time) or if time = 0 is set at start of first measurement sweep (Process time).

Edit Ranges (screen shot below)

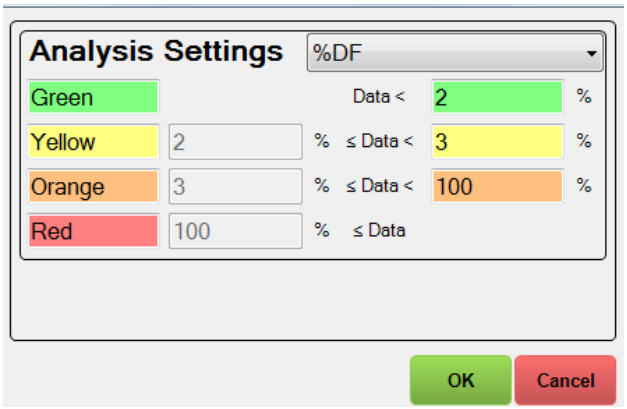


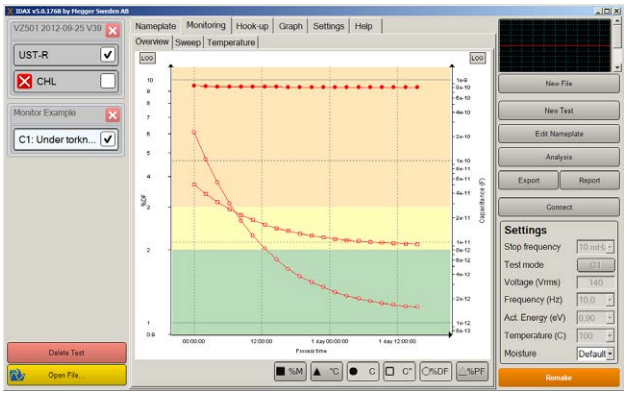
A moisture table may be selected which maps an ITC corrected dissipation factor at a certain frequency to a moisture content.

- At left hand side you have available tables.
  The "Default" table comes with installation.
- At left hand-side, bottom section, you may add a new table "New", delete an exciting table "Remove" or "Import" a table into the SW (e.g. created by another SW installation).
  Export is available from bottom part of table (right-hand side).
- "Moisture Table" is the actual table selected
  - Name is simply the name.
  - Frequency affects the relation between dissipation factor and moisture, therefore the frequency for the table need to be stated.
  - Temperature affects the relation between dissipation factor and moisture, therefore the frequency for the table need to be stated.
  - Activation energy for the material assessed affects the ITC correction and therefore it need to be stated (estimated).
  - The table is the relation between %DF (dissipation factor/100) and moisture content. Values between points are interpolated using Log(%DF) and Log(Moisture%) and extrapolated from two last points outside covered range.
    Delete data pair by pressing the red "X"
    Add new data pair by pressing the green "Add" button.
    Press "Save" to save the data table.
    Press"Export" of table, to be stored or imported by other used.

Edit assessment limits

Assessment limits for %DF, %PF and Moisture can be adjusted to suit particular requirements. These limits are applicable only to measurements during monitoring process.





5 Appendix A

Individual Temperature Correction (ITC)

An important property on most insulation materials is the possibility makes a master curve from a set of DFR data obtained at different insulation temperatures [1].

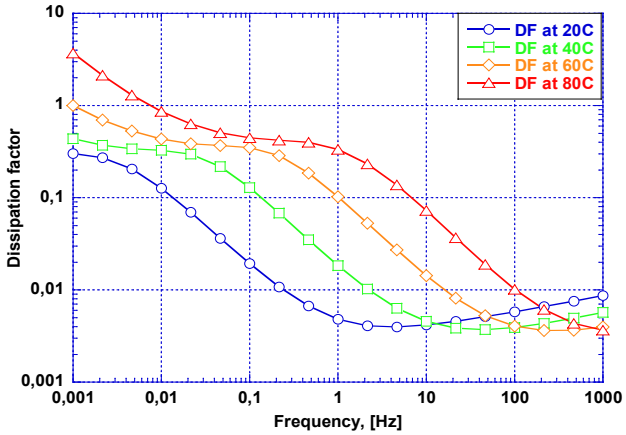


Figure 1. DFR of dry mass-impregnated Kraft paper at different temperatures.

To create a master curve, you prepare the insulation sample and measure the sample at different temperatures while making sure that other entities such as moisture content is kept constant. See Figure 1. The temperatures in Figure 1 are 20°C (blue, lowest dissipation factor at 1 Hz), 40°C (green), 60°C (orange) and 80°C (red, highest dissipation factor at 1 Hz).

The curves are then shifted in frequency by using Arrhenius equation with activation energy as a single parameter and temperature as variable. Figure 2 show the master curve created from measurement data in Figure 1. The activation energy is 0.9 eV.

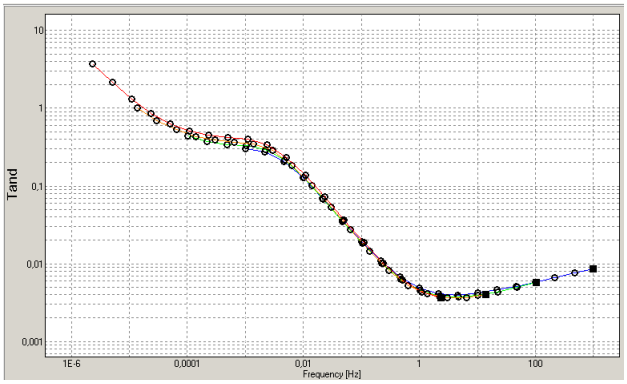


Figure 2. Master curve at 20°C, dry Kraft paper

Since the master curve now describe the relation between frequency and temperature, dielectric parameters such as the dissipation factor (DF) at 50 Hz can now be plotted as function of temperature [2]. See Figure 3.

This technique is used to establish individual temperature correction factors (ITC) [3] to correct measurements performed at a higher, or lower, than a reference temperature of e.g. 20°C.

For example if measure the DF at 50 Hz of the insulation material in Figure 1-3 at 40°C, the DF is about 0,004 or 0,4%, see figure 1 (or Figure 3). By measure a frequency sweep and plot it as function of temperature, the estimated dissipation factor at 20°C is about 0,005 (0,5%).

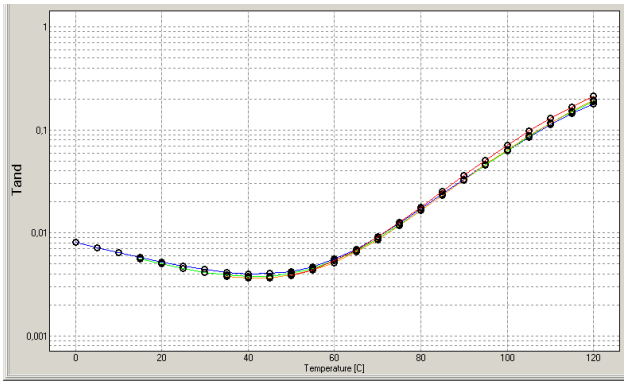


Figure 3. DF at 50 Hz as function of temperature (°C)

A similar application is to estimate the DF at a high operating temperature based on a measurement at ambient temperature. In Figure 4, the DF as function of frequency is measured on an about 100 m oil-filled 400 kV cable at about 20°C; the cable connects a Generator Step-Up transformer to the substation.

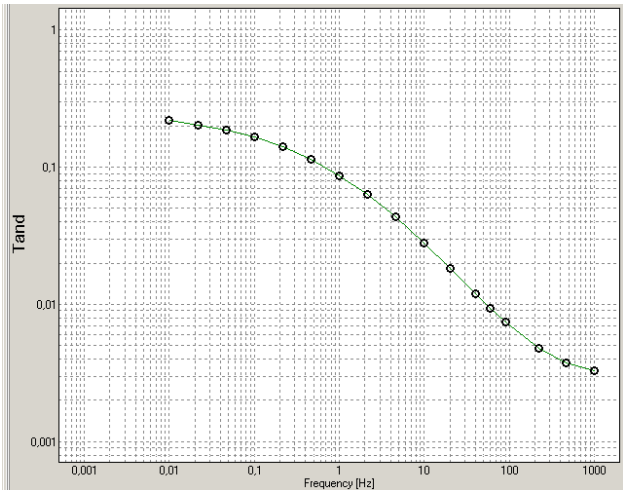


Figure 4. DF as function of frequency for an oil-filled 400 kV cable

The DF is high, about 0,01 (1%) at 50 Hz but is it critical or not? By looking at the 50 Hz DF as function of temperature, see Figure 5, heat dissipation calculations showed that the if DF at 60-80°C is above about 10%, there is a large risk of a thermal runaway breakdown. The cable was replaced prior any failure.

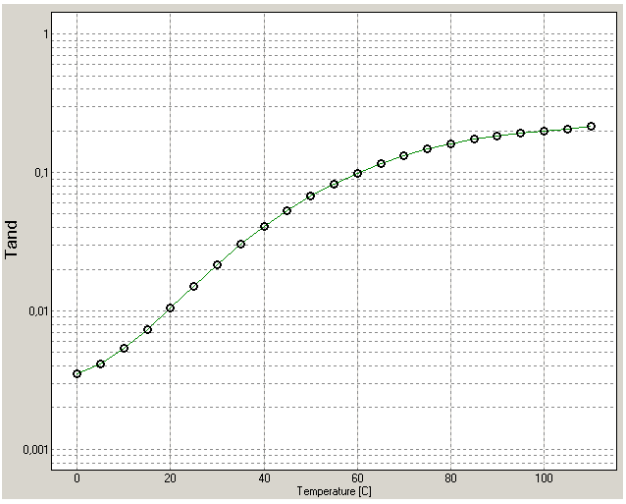


Figure 5. DF at 50 Hz as function of temperature. Data from figure 4.

Other examples are when evaluating new of modified insulation materials. A manufacturer of Kraft papers for bushings was evaluating different modifications in order to lower the DF. The new material had significantly lower DF at 20 °C, however, DFR measurement showed increase loss at lower frequencies and consequently, the 50 Hz DF was higher at 90°C compared to the original bushing paper.

REFERENCES

[1] U Gafvert, "Condition Assessment of Insulation Systems, Analysis of Dielectric Response Methods, NORD-IS 1996

[2] ITC patent. US2010/0106435 A1

[3] M Ohlen et al, Dielectric frequency response and temperature dependence of dissipation factor, TechCon Asia Pacific, Australia, 2009

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- Line Testing Equipment
- Low Resistance Ohmmeters
- Motor & Phase Rotation Test Equipment
- Multimeters
- Oil Test Equipment
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- Power Quality Instruments
- Recloser Test Equipment
- Relay Test Equipment
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