

Operating Manual

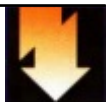
Cable Diagnostic System CDS

Version 2 – EN (128311407)

Operating Manual

Mess- und Ortungstechnik Measuring and Locating Techniques

Elektrizitätsnetze
Power networks



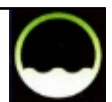
Kommunikationsnetze
Communication networks



Rohrleitungsnetze
Water networks



Abwassernetze
Sewage networks



Leitungsortung
Line Location





Quality System Certificate

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How to contact us?

SebaKMT
Mess- und Ortungstechnik GmbH
Dr.-Herbert-lann-Str. 6
D-96148 Baunach

Telefon: (09544) 680

Telefax: (09544) 2273

E-mail sales@sebakmt.com

Internet www.sebakmt.com

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1 Introduction

The CDS unit is a portable combined dielectric diagnostic instrument which has been developed for integral condition assessment of power cables. This system is able to measure, analyse and interpret the Isothermal Relaxation Current (IRC-analysis) for PE / XLPE insulation and the Return Voltage Measurement (RVM-measurement) for paper insulated cables and transformers.

Applying the forming voltage the charging load current can be measured and the leakage current can be evaluated automatically.

The complete system contains a high voltage and control unit with adjustable DC-forming voltage and charging current analysis. The test procedure is controlled by a laptop. The measurement cycle is simultaneously three-phase and automatically checked by a PC. The test duration for a complete system with the IRC-analysis is 1 h. The test duration for VRM-analysis depends on test procedure and is approximately 1.5 to 2 h.



Figure 1 : CDS unit with control laptop

To guarantee a safe handling of the system the high voltage can only be switched on by a separate push button.

For PE / XLPE cables a software modul with Neuro- Fuzzy-evaluation is used. The intelligent multi-step evaluation software takes into account special construction characteristics of the test object and classifies it, including a residual breakdown strength prediction.

The RVM cable humidity evaluation is realised with a well known standard using characterising factors and threshold values.

The software includes an automating database research for estimation of the residual life expectancy according to DIN VDE 0276 data.

2 Technical description

2.1 Technical data

Output voltage	0 ... 5000 V DC
IRC-Standard	1000 V DC
RVM-Standard	1000 V DC 2000 V DC
Test object capacitance	0,01 μ F – 2 μ F
Measurement range	-130 nA...130 nA
Measurement range	0...5000 V
Dimensions (H x W x D)	470 x 520 x 430 mm
Weight without laptop	app. 26 kg
Power consumption	app. 50 VA
Operating temperature	-10 ... + 40 °C
humidity	non condensing
Power supply	115/230 V AC ∇ 10%; 50/60 Hz
Mains fuses	2 x 1 A SLB (slow blow)

2.2 Components and options

Cable Diagnostic System CDS

IBM Thinkpad Pentium 4 / 1,8 GHz or comparable Notebook (Laptop)

Main memory 256 MB, Harddisk 40 GB, VGA TFT Display 14",

DVD-drive; 56 kModem ; 2 x USB ; Windows XP

Software package CSW CDI-2 preinstalled.

CD ROM with software for automated control of test cycles, memory of test data, evaluation and protocol display of IRC- and RVM-diagnostics. Software module with neuro fuzzy extension for PE / XLPE cables.

VL CDI-2

CDS connecting cable set for diagnosis

EST 35

Discharge rod 35 kV with integrated resistor and hook for direct grounding.

Max. discharge capacitance 6 μ F.

FTS 50

Bag for cable set and discharge rod

Operating manual

3 Safety

The CDS is designed to deliver dangerous voltages > 1 kV why only exclusively qualified personnel should use the described system. Operators should familiarize themselves with the contents of this section before commissioning the system. Safe operation will depend upon strict observance of the information and warnings in this manual.

3.1 Key switch

Due to product safety of instruments which are able to deliver dangerous voltages have to be safe against accidental switching on of non authorised personal. The CDS unit has a key switch for this case which has to be stored by responsible personal in a safe locked place (see page 7, Figure 2).

3.2 General precautions

The instrument should be set up as close to the test object as possible, but keeping a safety distance of 100 cm. All test personnel and assistants should strictly observe all safety precautions against accidental human contact with live components. The power supply cables and connecting cables of the CDS have to be treated carefully and not to be deteriorated. Whenever damage is suspected, switch off the instrument and secure against inadvertent switching back.

Keep children away from the system. Please be careful that there is no possibility for children to play with the system.

The CDS is a sealed unit and does not require any special maintenance. However, the equipment should be checked from time to time for correct functioning and should always be kept away from extremes of temperature, moisture or wet environments and vibrations, if possible. The unit should always be stored in a cool, dry place. The front panel and controls can be cleaned with methylated spirits. A soft and clean cloth should be used for this operation.

The CDS may only be used in normal weather conditions. To remove condensation the instrument should be placed in a warm dry room.

Attention The CDS control laptop should be used only for cable diagnosis. Every change in the system initialisation can lead to a loss of warranty.
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Generally delivered units have a preinstalled software. The initialisation files are stored under standard, measurements can start directly. The database contains additional information of XLPE insulated cable measurements.

3.3 VDE clauses 0104

3.3.1 Mobile (non-stationary) test unit

According to the DIN VDE 0104 standard states the set up of the instrument including the beginning of the cable under test represents a non stationary test installation and is classed as a test site without protection against touching. The same also applies to the end(s) of the cable under test.

3.3.2 Danger area

Test sites without necessary contact protection are classed as danger areas with various zones of danges levels and have to be cordoned off, secured with barriers and marked accordingly.

3.3.3 Emergency off button

Test sites in general have to be equipped with an emergency off button. The CDS unit has a red emergency off button on the front panel plate marked with [1] (page 7, Figure 2). An optional external emergency off button NAG 1 can be connected on the rear panel (page 8, Figure 3). The standard dummy plug is placed in the back, so the device can be switched on.

4 Operating

4.1 Connection and control panel

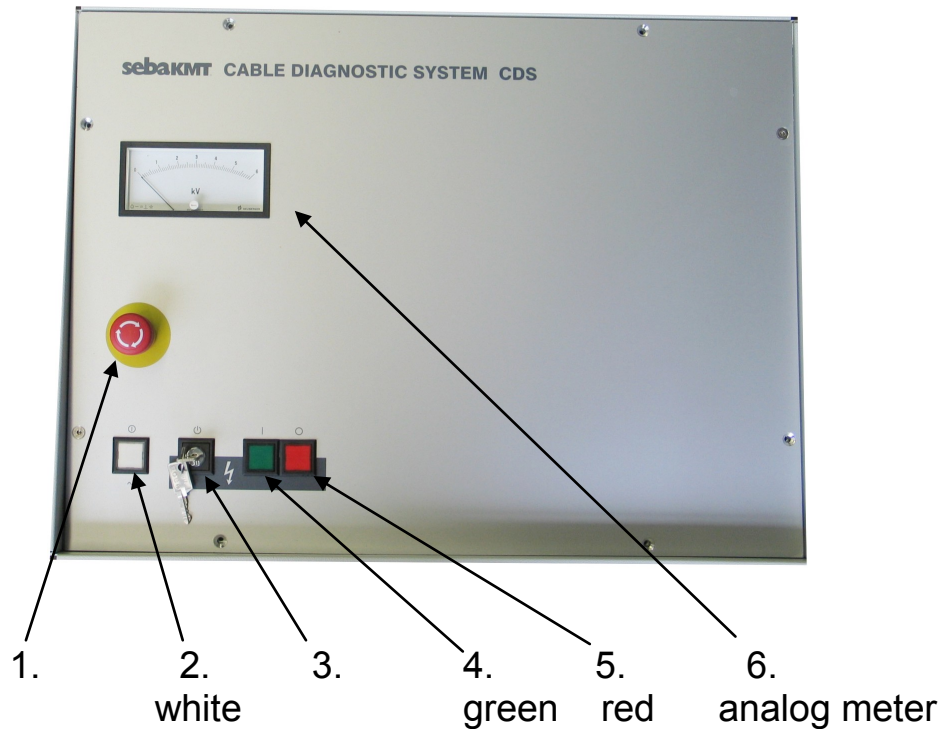


Figure 2 : CDS control panel

1. emergency off button
2. white push-button : on/off power supply
 - ↖ press : switches the unit on
 - ↖ lit : device is switched on
3. key switch
4. **green** push-button : HV on key
 - ↖ lit : stand-by ready for use
 - ↖ press : ready to switch on high voltage (danger!)
5. **red** push-button : HV off key
 - ↖ lit : high voltage is switched on, stand-by
 - ↖ blinking : high voltage active, unit operation
 - ↖ press : switches high voltage off

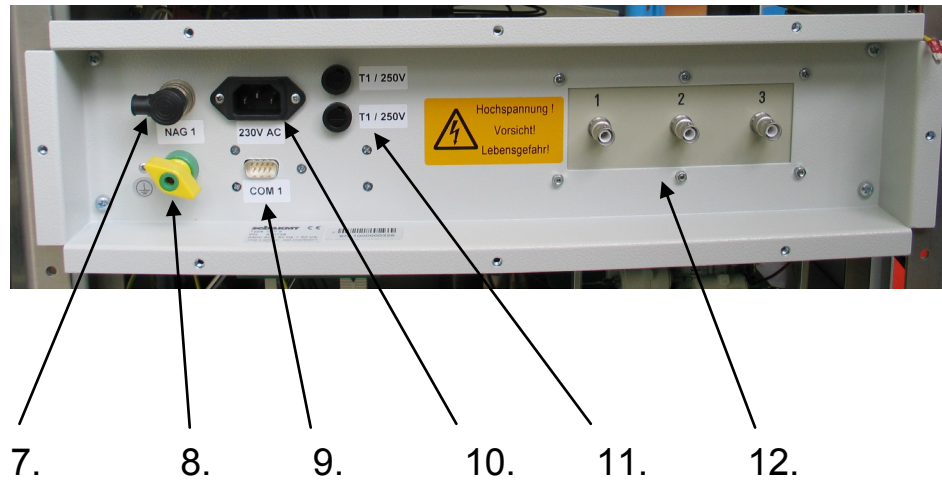


Figure 3 : Connections on the rear panel

7. connection for external emergency off button NAG 1
8. connection protective ground
9. RS232 serial port connection to control PC
10. mains power supply (factory adjusted to 230 V)
11. mains power supply fuse sockets (2 x 1 A SLB)
12. HV cable connections for three phases 1, 2 and 3

4.2 Connecting

Please observe the following procedures for safe operation of the CDS unit:

4.2.1 5 Safety rules

Before connecting the CDS unit to a test object please note the 5 safety rules (additionally check special safety regulations):

1. Turn power off.
2. Secure against reconnecting.
3. Check that no voltage is present.
4. Earthing and shorting.
5. cover neighbouring parts which can carry voltage.

4.2.2 Earthing of the unit

Before using the CDS the unit has to be grounded. Connect the protective earth connection [7] with the supplied earth lead to a good ground, e.g. substation ground/earth. Note that the grounding cable should only be fixed at clean reliable metallic contacts which is also essential for accurate measurements.

Earthing only via the safety earth of the power supply is not sufficient! The removal of earth connections from either the power cable or the earth connector of the instrument means that the potential of the CDS is floating above earth. This will become extremely dangerous.

4.2.3 Cordoning off open cable ends

As the high voltage applied to the cable under test is hazardous on contact, the cable ends have to be cordoned off in accordance with local safety regulations (e.g. DIN VDE 0104 regulations). The user of the system has to make sure that also the ends of branches are cordoned off and protected. Personal not directly involved should be kept out of the actual test area by barriers or clearly worded warning signs. No one should be allowed to go into the test area until all parts of the high voltage circuit have been visible grounded.

4.2.4 Connecting the CDS to the mains

Now the CDS unit can be connected to the mains. Make sure that the mains voltage is the same as the supply voltage of the CDS (230 V AC or 115 V AC). If the HV power supply is factory adjusted to 115 V AC (adjustable due to internal mains selector switch) the power supply cable has to be marked. Never plug the main power plug into a socket that is not provided with a protective ground contact.

Never open the CDS unit plugged in under voltage, high danger!

5 CDS set up onsite

5.1 IRC measurement principle

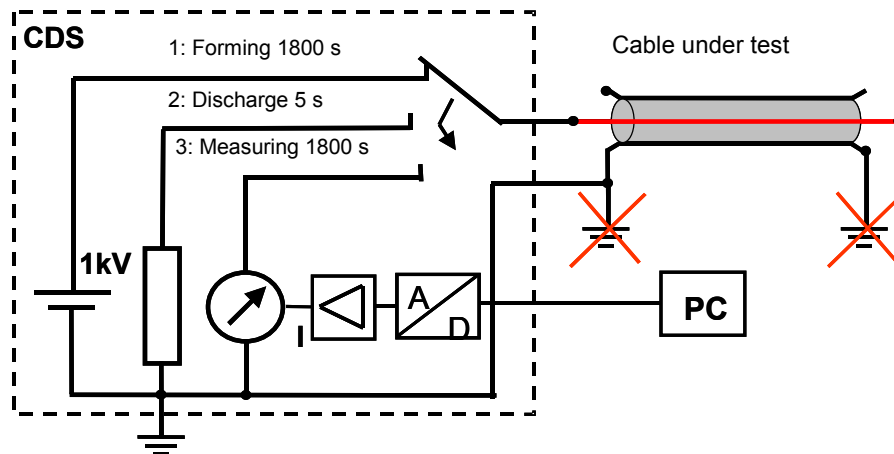


Figure 4 : IRC measurement

For measurements it is necessary to disconnect the cable-conductor and the screen on both sides for better signal quality as shown in figure 4.

The connection CDS to ground in the substation has to be installed. Open the screws and use the discharge rod before and after measuring a polymer-insulated cable. For the power supply of the CDS and the laptop it is common to use the supply voltage available in the substation.

Take notice of the type plate of the system. If you have to use a mobile power supply it is necessary to use a special net filter. It is necessary to ground the cable with the EST 35 before and after every measurement. Don't disturb the measurement if it is working.

In case of recurrence measurements it is necessary to wait at least 30 minutes grounded for a good reproducibility.

5.2 RVM measurement principle

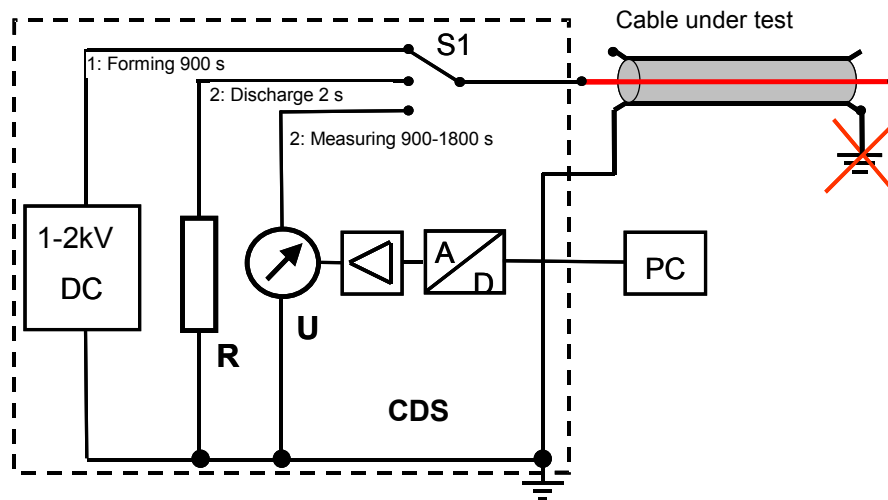


Figure 5 : RVM Measurement

The cable is charged with 1-2 kV by means of a DC for 15 min. Then it is discharged via an internal discharge resistor softly for 2 sec. Afterwards the return voltage increases during 900-1800 s measuring time. The shape of the return voltage curves correlates with the moisture content. This process is repeated two times at different voltages levels.

5.3 Putting into operation

Connecting the mains plug to the CDS unit, the system is designed to charge automatically the internal accumulator. Control and safety circuits are not active the CDS is protected against accidental switching on with the key switch.

Pressing the **white push button [2]** the system will be activated. Control and safety circuits are activated. Turning the key the system automatically switches to stand by ready for use marked with the **green push button [4]**.

Stand by means the high voltage output is low ohmic. The internal high voltage modul has no power supply and is therefore switched off.

5.4 High voltage on

Pushing the green button means high voltage on , the CDS shows a light on the **red push button [5]**. The green light switches off, the high voltage modul is activated, the connected test leads and the output is no longer low ohmic: **Danger !**

The internal microprocessor for control and data handling is switched on via a fiber optic.

Note: Pressing the green push button [4] , without comming up a red light on the red puch button, is defined as the same switching status: **High voltage !**

5.5 Unit under operation

Marked with a red blinking push button high voltage is switched on and the unit is operating. Only the software controls this status, means the high voltage can be activated every time. **High voltage on !**

During the switching status **under operation** the high voltage is always activated. During the measuring the red light is blinking the whole time.

The CDS loads continously the test object up to the value which is limited by the user automatically via fiber optic control. The analog meter shows the charging voltage the software shows the actual on the main screen.

5.6 Switching off the unit

As a standard the unit is switched off automatically leaving the software menu. The red bushbutton switches off, green comes up and the internal microprocessor switches off.

Pressing the red push button manually switches off the CDS power supply only. By pressing the green pushbutton for 5 s the microprocessor is also switched off.

If the switch-off procedure is not performed in the described order, the microprocessor remains active for a further 2 hours (see also chapter 10 Information on the Accumulator).

6 Functions

The CDS unit measures physically based current-voltage values in a time range from seconds to hours. These effects are resulting in relaxation or in charges stored at boundary layers, charges bounded to electrodes, water dipoles or other ions.

6.1 Main menu


Figure 6 shows the software start of the CDS program. By mouse click the user is able to choose the desired dielectric diagnostic method. For the evaluation of a PE/ XLPE-insulation the IRC method is recommended. For PILC segments means paper mass insulations or transformer measurements the RVM method is recommended.

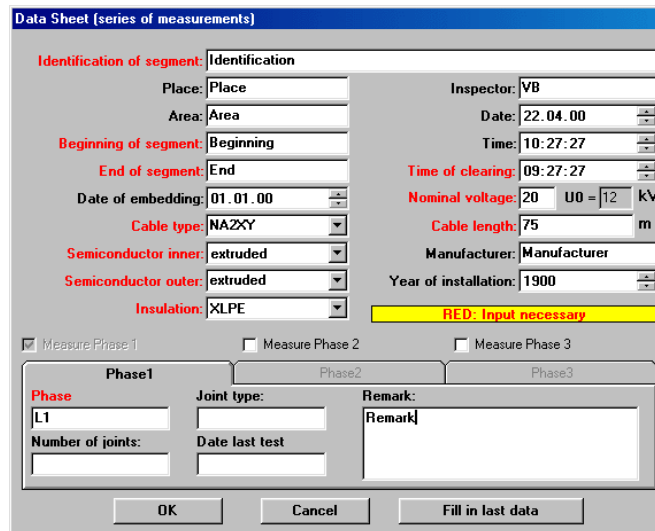


Figure 6 : Software start

If there is any transfer failure of the data (System not ready) it is necessary to switch off the CDS unit and to restart pressing the red button. Additionally all connectors of the system have to be checked again before the restart.

6.2 IRC-measurement start

You can activate the measurement by clicking on the menu button or by clicking on the button .



Data Sheet (series of measurements)

Identification of segment: Identification

Place: Place Inspector: VB

Area: Area Date: 22.04.00

Beginning of segment: Beginning Time: 10:27:27

End of segment: End Time of clearing: 09:27:27

Date of embedding: 01.01.00 Nominal voltage: 20 U0 = 12 kV

Cable type: NA2XY Cable length: 75 m

Semiconductor inner: extruded Manufacturer: Manufacturer

Semiconductor outer: extruded Year of installation: 1900

Insulation: XLPE **RED: Input necessary**

Measure Phase 1 Measure Phase 2 Measure Phase 3

Phase1	Phase2	Phase3
Phase	Joint type:	Remark:
L1		Remark
Number of joints:	Date last test	

OK Cancel Fill in last data

Figure 7 : IRC start screen

In the upper area of the data sheet you can fill in the general data, figure 7. Take care to fill in the red marked fields. They are **strictly necessary** for the program. The program will exclude wrong data and you may be asked to check your input. It is recommended to fill in the other fields as well. Thus you get a better overview in your database.

Note: actual time and the time of clearing will be identical. This is due to the fact that the program is not allowed to take a guess on the time of clearing, so you **must** change it manually in order to continue.

In the lower part of the data sheet the phase description will be made. Note that by marking the options "Measure Phase 2" and/or "Measure Phase 3" you decide how many measurement you will make: one, two or three. Once you made the phase description, by pressing the OK- button you will be led to the measurement module.

Hint: If you made any measurement at all, your inputs have been saved and by pressing the button "Fill in last data" the program automatically fills in the last data.

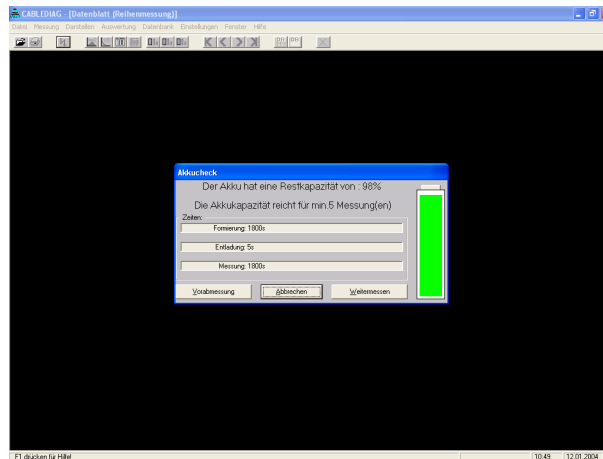


Figure 8 : Accucheck

The accucheck shown in the figure 8 works automatically. The remaining capacity of the accumulator and the number of the approximately possible measurements is pointed out above.

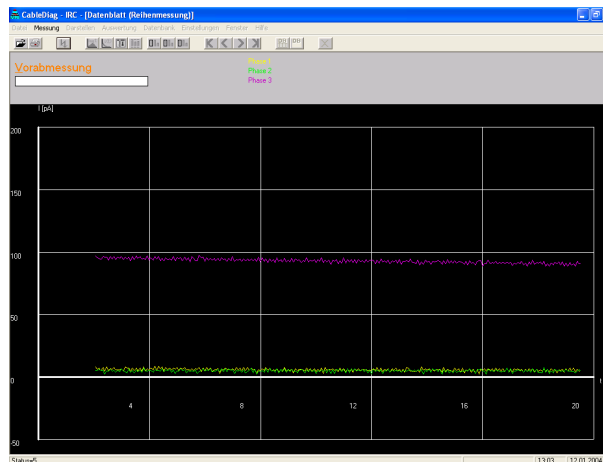


Figure 9 : Preliminary IRC measurement

The user should carry out a preliminary measuring of every phase under test. The figure above shows in detail the selection for three phases. During the preliminary measuring, the noise level of the cable under test is evaluated (figure 9).

After the preliminary measuring an overview about the noise level occurs for all measured phases. If these values are out of the tolerance band e.g. phase two, which is still acceptable, a check of the system set up is recommended. All criteria for on site measurements should be controlled carefully to increase the signal quality. The preliminary measurement should be repeated as long as the measured values are inside the acceptable range. A measurement can also be started if the values remain outside the noise levels. Please notice: A bad signal quality always leads to a reduction of the reliability of the measurement result and it can happen that no complete evaluation is possible.

With “yes” the measurement can be started. During the charging period the monitor gives the user the information to pay attention: the capacitor of the CDS 1 is under high voltage. Never touch a cable under test voltage. Never make a connection to a cable under voltage. At first discharge the cable and ground it with the EST 35. It is necessary to ensure that the cable is dead before connecting or touching the test object!

Figure 10 shows the results of a three phase simultaneous load current measurement. Correlating the shape of the curves and the amplitude of the load current for all phases, L1 (yellow) shows the highest values based on humidity in terminations or maybe insulation bridging water trees. The green marked phase L2 and the violett L3 are close to the zero-line.

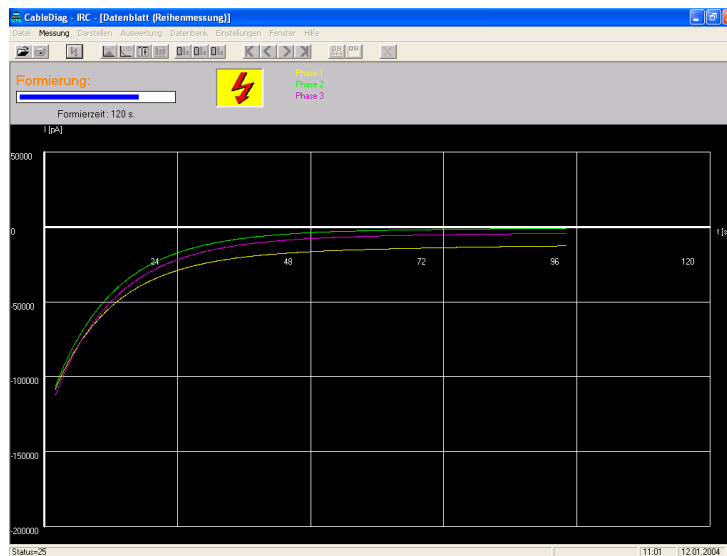


Figure 10 : IRC load current measurement

Attention: A high load or leakage current is not directly combined or comparable with a strong ageing behaviour of the cable insulation. Especially an untypical high leakage current can be often based on defects in joints and terminations.

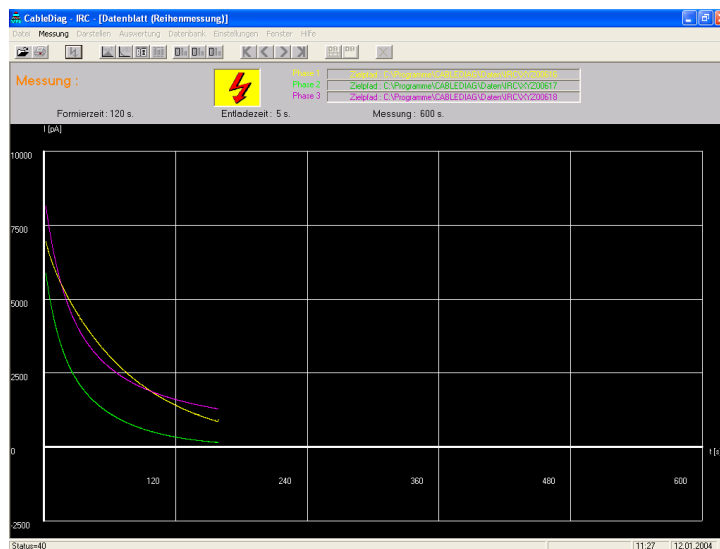


Figure 11 : Linear plot shown during a measurement

The auto scaling function of the measured current shows the graphical result of the measurement. During the measurement the system shows the amplitude of the current versus the time t in a linear plot, see figure 11. Using a three phase measurement all measurements proceed analog. Storing data on the hard disc and automatically noise reduction takes place.


The measurement data are stored under the specified subfolder with an automatic file generator. Additionally the number increases with every measurement controlled automatically by the software.

If the user mode is used, the data files will be opened automatically and shown in an overall evaluation. Under expert mode, you have to open the files manually. In the $I^*t - \log(t)$ – plot the ageing behaviour can be recognized with special amplitudes in the time range above 100 seconds. The characteristic increase of the I^*t signal in the range of more than 100 seconds up to 1000 seconds describes the integral ageing process of a polymer insulated cable.

Especially with the data view as in the figure above it is possible for the system user to make use of the graphical ageing evaluation with references. Significant amplitudes in a time range above 100 seconds describe an increase of the ageing status of a cable insulation. Attention: the shape of the curve is more difficult to interpret with the increase of the cable length. For an expert diagnosis it is possible to take the following features into consideration:

If there is one absolute maximum in the shape of the curve in the $I^*t - \lg[t]$ - plot in the time range lower than 100 seconds the cable should work without problems. This behaviour is characteristically for perfect cables.

If there are two absolute maximum in the shape of the curve in the $I^*t - \lg[t]$ - plot, one of them in the time range above than 100 seconds, the cable is aged but ready for service. If there is one absolute maximum in the shape of the curve in the $I^*t - \lg[t]$ - plot in the time range above than 100 seconds the cable is strong aged. The behaviour is characteristically for a cable, which is critical in service.

Print out possibility is available over the main menu or  the hardcopy button.

To become a better view of the data to change the type of the plot or it is possible to zoom in the time axis. You can do that holding the left mouse back right double click on the graphic (figure 12).

Even in this presentation form you are able to see the ageing status of a cable. The blue curve shows a nearly constant current over a longer period of time (>100 s) due to the depolarisation process. This is an indication of a critical cable.

Furthermore this presentation form is useful to recognise an over steering of the measurement system. This is recognisable by a horizontal line of the measurement shape at the beginning. Additionally too small signal amplitude is detectable ($I_{max} < 80\text{pA}$). In both cases the automatic evaluation often works, but the results are questionable respectively you should ask an expert for advice in such cases.

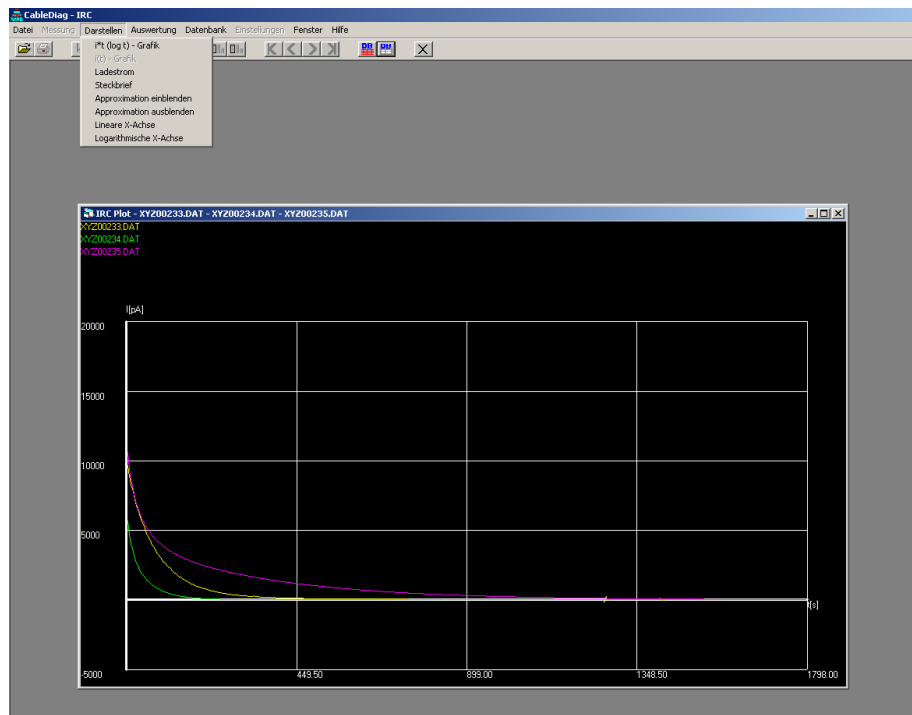
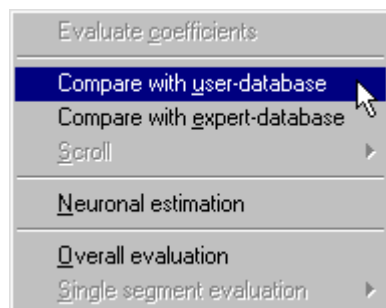


Figure 12 : Selection menu for the IRC measurement plot

6.3 Comparison with user database

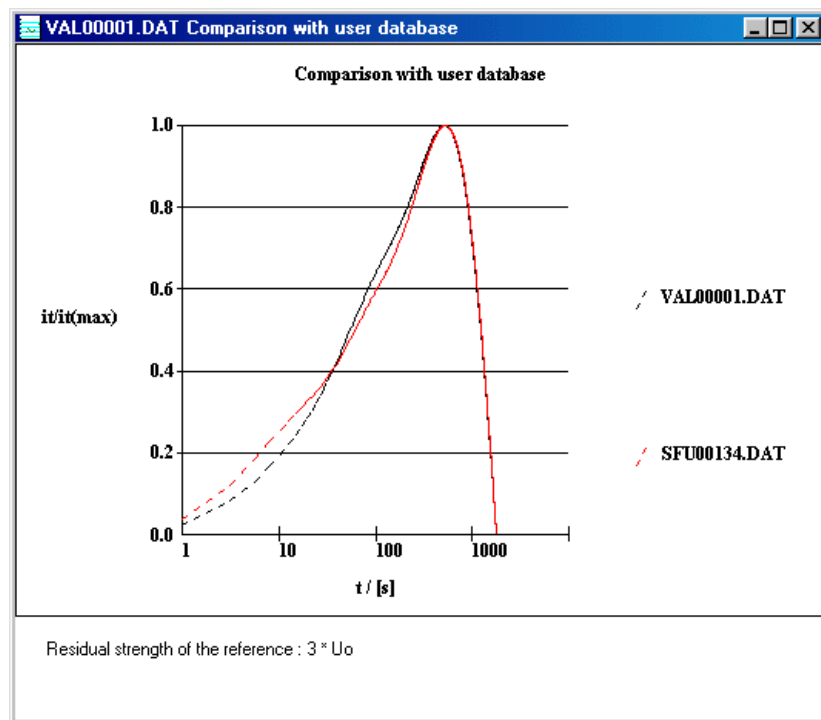
Only available in expert mode!

The evaluation of the ageing status of the investigated cable leads to an expected value of $m \cdot U_0$ in correlation to the German FGH step test. The basic information stored in the data header of the cable identification list is important. Especially the information about the semi conducting layers and the cable length has an influence on the expected residual strength.



The operator has the possibility to determine the residual strength by means of comparison with the user database, which belongs to the software package. This database can be increased with own measurements, fact which leads to a better prognosis.

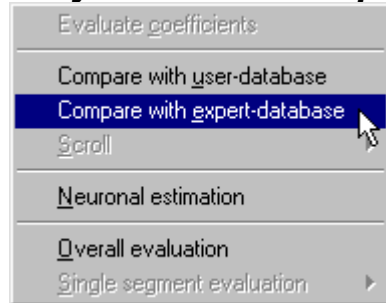
The next figure shows a comparison between an actual measurement and one from the user database (red). The result of the step test of the reference is $3 U_0$ corresponding to 36 kV and estimates additionally the actual measurement. This information is to be rated high if the cable referenced to comes from the same producer, is the same type and has been produced in the same year.



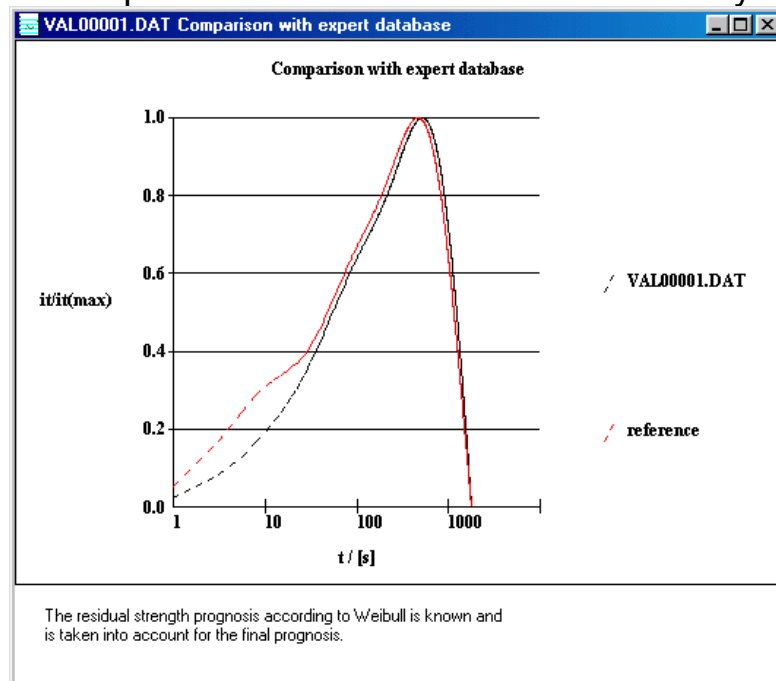
Should there be more similar references, one gets the option to move from one to another **K < > K**.

6.4 Comparison with expert database

Only available in expert mode!

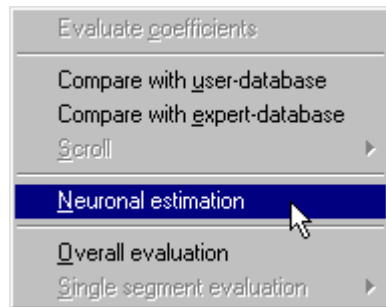


The expert database consists of scientifically aged cables.



6.5 Neuronal evaluation

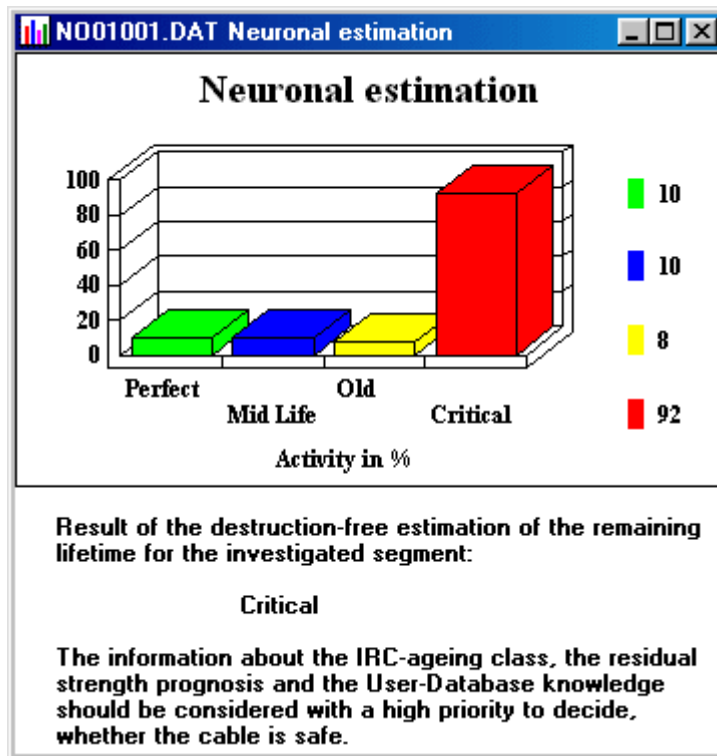
Only available in expert mode!



With the help of the neural prognosis the examined cable segment can be classified into a IRC-ageing class. The result is gained without the necessity of reference measurements. This neural lifetime prognosis gives the operator directly the information about the ageing classification in one of four ageing groups:

perfect
mid life
old
critical



Every class has a typical residual strength, which has been determined by a lot of measurements.



Always ground the cable segment after a measurement.

6.6 Data sheet

Only available in expert mode!

By  or  the menu shows the data sheet of one or more files. The arrow buttons move from one file to the next (if more than one loaded). With the data sheet one can identify exactly the actual measurement data.

Besides the identification data, one can also see the measured current, as well as the coefficients from the *file.kof* (in the middle of the figure 13).

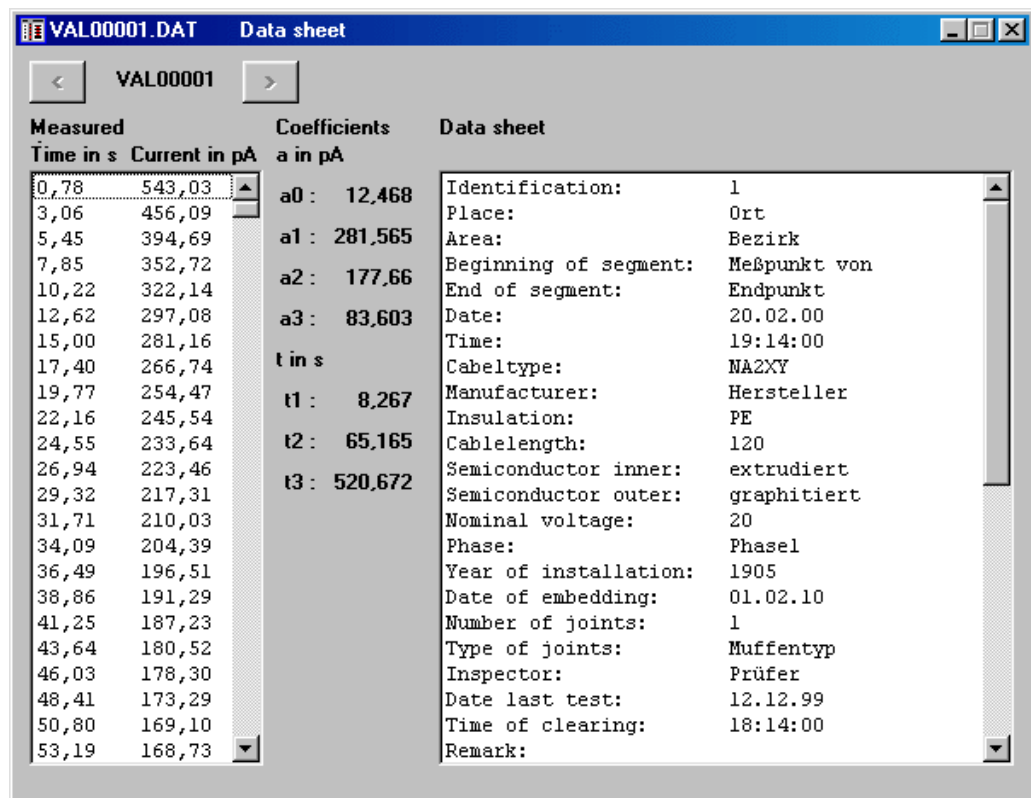
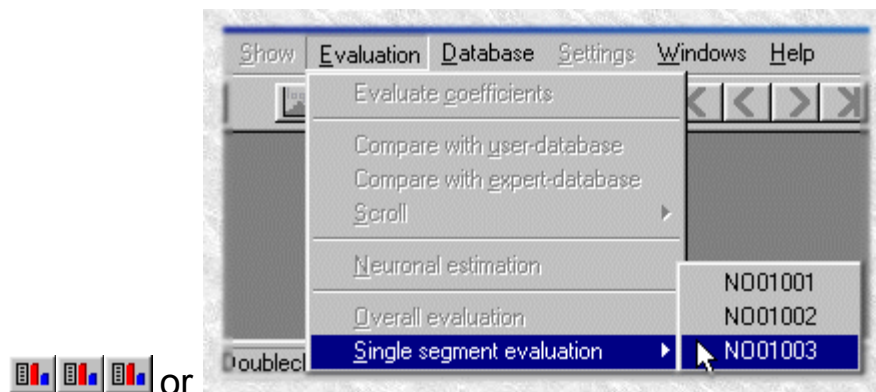


Figure 13 : Data sheet of a CDS IRC measurement

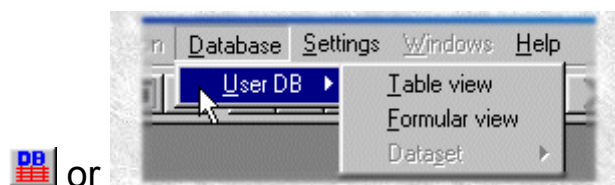
Below the coefficients the insulation resistance becomes visible calculated from the measured leakage current (only possible if leakage current measurement was activated during forming phase).

6.7 Single phase evaluation



The strength prognosis and the data sheet comes up.

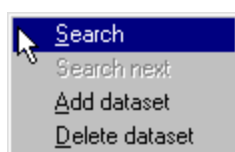
6.8 Table view



The user database contains results from field measurements. Evaluating an actual new measurement these results are used automatically to analyse data most accurate.

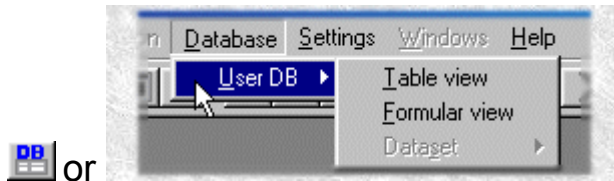
Identification	Cabeltype	Nominal voltage	Cablelength	Place
EP0510	NA2XSZY	20	15	bekannt
EP0602	NA2XSZY	20	15	bekannt
EP0623	NA2XSZY	20	15	bekannt
EP0701	NA2XSZY	20	15	bekannt
EP0707	NA2XSZY	20	15	bekannt
EP0717	NA2XSZY	20	15	bekannt
EP0811	NA2XSZY	20	15	bekannt
EP0914	NA2XSZY	20	15	bekannt

You can search for a special dataset, add a dataset to the database or delete one (only expert mode).



TIP: right click on the table pops up the menu shown above.

6.9 Formular view



This is a more comfortable view of the user database shown in figure 14.

The screenshot shows a window titled 'User database - Formular view'. It contains several input fields organized into sections:

- Identification:** 2
- Place:** Ort
- Area:** Bezirk
- Beginning of segment:** Meßpunkt von
- End of segment:** Endpunkt
- Date of embedding:** 01.02.10
- Cabletype:** NA2XY
- Semiconductor inner:** extrudiert
- Semiconductor outer:** extrudiert
- Insulation:** PE
- Filename:** VAL00001.dat
- Inspector:** Prüfer
- Date:** 20.02.00
- Time:** 19:14:00
- Time of clearing:** 18:14:00
- Nominal voltage:** 12 U0 = 6 kV
- Cablelength:** 120 m
- Manufacturer:** Hersteller
- Year of installation:** 1905
- Stepstestresult:** 14 U0
- Phase:** Phase1
- Number of joints:** 1
- Date last test:** 12.12.99
- Type of joints:** Muffentyp
- Remark:** Phase1 Bemerkung1, Phase1 Bemerkung2
- 7 coefficients:**
 - a0: 12,468
 - a1: 281,565
 - a2: 177,66
 - a3: 83,603
 - t1: 8,267
 - t2: 65,165
 - t3: 520,672
 - IRCA: 3,641

At the bottom, there are buttons for 'Add dataset', 'Delete dataset', and 'Search'. A status bar at the very bottom shows navigation icons and the text '4/79'.


Figure 14 : User database

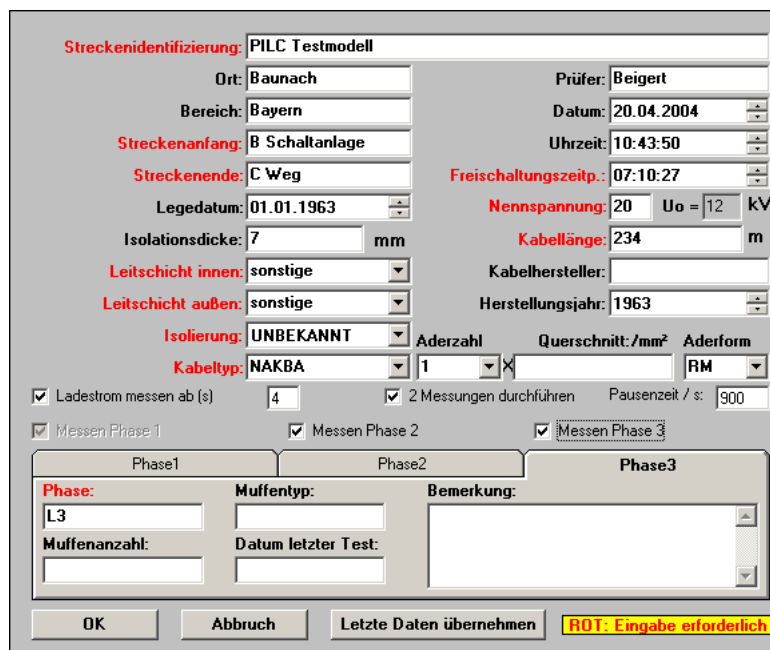
There are given the same possibilities as in the table view to search, add and delete a dataset. Moreover, in expert mode, you can change most data. Nevertheless, you are not allowed to change the nominal voltage, cable length, cable type, semiconductor and insulation.

Note: If you added a dataset with a new semiconductor type to the database and you would like to change the step test result, the program will call your attention to the fact that this dataset will not be taken into account for the final diagnosis. Once you have added more than 5 datasets of the same semiconductor type, you can let the program generate the necessary factors for the diagnosis.

7 RVM measurement start

The cable is charged by means of a DC for 15 or 30 min. Then it is discharged via an internal discharge resistor softly for 2 sec. Afterwards the return voltage increases. The shape of the return voltage curves correlates with the moisture content. This process is repeated two times at different voltages levels. The data of the measured curves contain the information about the status of the cable insulation.

You can activate the measurement by clicking on the menu button or by clicking on the button .



The screenshot shows a software interface for RVM measurement start. The form is divided into several sections:

- Streckenidentifizierung:** PILC Testmodell
- Ort:** Baunach
- Bereich:** Bayern
- Streckenanzang:** B Schaltanlage
- Streckenende:** C Weg
- Legedatum:** 01.01.1963
- Isolationsdicke:** 7 mm
- Leitschicht innen:** sonstige
- Leitschicht außen:** sonstige
- Isolierung:** UNBEKANNT
- Kabeltyp:** NAKBA
- Prüfer:** Beigert
- Datum:** 20.04.2004
- Uhrzeit:** 10:43:50
- Freischaltungszeitp.:** 07:10:27
- Nennspannung:** 20 U₀ = 12 kV
- Kabellänge:** 234 m
- Kabelhersteller:**
- Herstellungsjahr:** 1963
- Aderzahl:** 1
- Querschnitt/mm²:**
- Aderform:** RM
- Ladestrom messen ab (s): 4
- 2 Messungen durchführen
- Pausenzeit / s:** 900
- Messen Phase 1
- Messen Phase 2
- Messen Phase 3

At the bottom, there are buttons: OK, Abbruch, Letzte Daten übernehmen, and a red button: ROT: Eingabe erforderlich.

Figure 15 : RVM start menu

In the upper area of the data sheet you can fill in the general data, figure 15. Take care to fill in the red marked fields. They are **strictly necessary** for the program. The program will exclude wrong data and you may be asked to check your input. It is recommended to fill in the other fields as well. Thus you get a better overview in your database. Breaktime and the standard cycle with two measurements is activated.

Note: actual time and the time of clearing will be identical. This is due to the fact that the program is not allowed to take a guess on the time of clearing, so you **must** change it manually in order to continue.

In the lower part of the data sheet the phase description will be made. Note that by marking the options "Measure Phase 2" and/or "Measure Phase 3" you decide how many measurement you will make: one, two or three. Once you made the phase description, by pressing the OK- button you will be led to the measurement module.

Tip: If you made any measurement at all, your inputs have been saved and by pressing the button "*Fill in last data*" the program automatically fills in the last data.

With the o.k. button the RVM measurement modul is started.

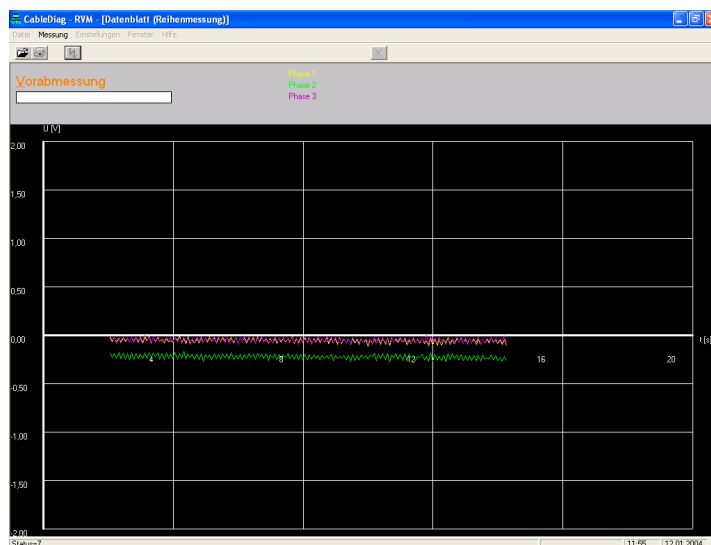


Figure 16 : Preliminary RVM measurement

If the preliminary voltage measurement shows a significant increase of the in the volt- range it is recommended to shorten the cable conductor again for several minutes.

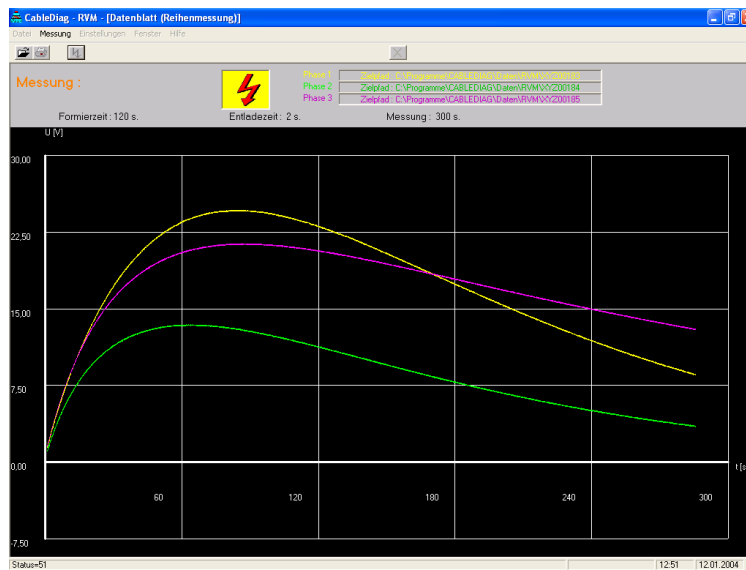


Figure 17 : RVM measurement

After the selection of the two cycle measurement in the start menu the second measurement with 2 kV starts automatically after the first measurement with 1 kv forming voltage without the necessity of an additional confirmation. Figure 18 shows the RVM results on all three phases of a cable line measured with 1 kV and 2 kV. The shape of the return voltage curves are similar for all three phases, measured with 1 kV and 2 kV.

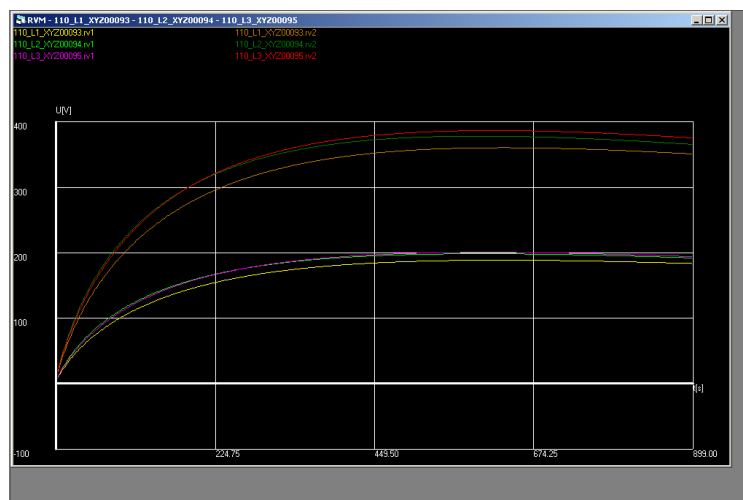


Figure 18 : RVM measurement three phase simultaneously for two charging voltages (typically 2 kV and 1 kV)

Water has a non linear current voltage correlation, therefore the initial slope of the measured voltage change with the voltage level dependant from the degree of humidity.

The parameters of the measured curves and their relation at different charging voltages contain information about the cable condition. The test is conducted fully automatically (PC) and follows a standardized sequence.

The RVM evaluation of paper insulated cables is based on the well known status with the characteristic factor Q_a (Quotient of the initial slopes) and defined threshold values in The empirical evaluation limits for Q_a are:

Dry:	2,0 ... 1,87
Moist:	1,86 ... 1,65
Wet:	< 1,6

$$Q_a = \frac{S\left[\frac{V}{s}(2kV)\right]}{S\left[\frac{V}{s}(1kV)\right]}$$

The initial slope changes dependently on the water content nonlinearly to the charging voltage. To find out the non-linearity the initial slope of the return voltage is measured at two charging voltages that are in a 2:1 relation. The relation of the initial slopes is 2.0 for the ideal dry cable and becomes the closer to 1.5 the higher the humidity is.

For more investigation of the temperature influence measurements were made in the climate chamber. A 16 m long lead shielded cable was used. The test showed that the maximum return voltage and the start slope changed strongly with the temperature whereas the quotient Q_a remained almost independent of the temperature. A climate chamber was used to study the effects of temperature on the shape of the return voltage curves.

The real age can be very different from the nominal age of a cable segment. Maintenance or replacement decisions should be accurate using the results correlating with the real

age. Cable segments with very low Q_A should be replaced partly independant from the year of installation. This evaluation of a paper mass insulation can be correlated partly also for transformers. Field measurements show that the results may depend sometimes on the construction but the tendency is similar to cables.

With an additionally new integral diagnostic method developed from the University of Siegen based on the analysis of the voltage shape it is possible to evaluate the actual cable status also non destructive. The physical evaluation criterion is the direct correlation of the moisture content with the shape of the RVM plot of the PILC insulation measurement which is also additionally directly connected with the decomposition of the cellulose.

The definition of p depends not on specific parameters, the influence of the measuring resistance can be neglected and the factor increases with the ageing of the cable insulation.

$$p = \frac{U_m}{s \cdot t_m}$$

- Um: Maximum value of return voltage
- S: Initial slope of the voltage increase
- Tm: Time of the maximum

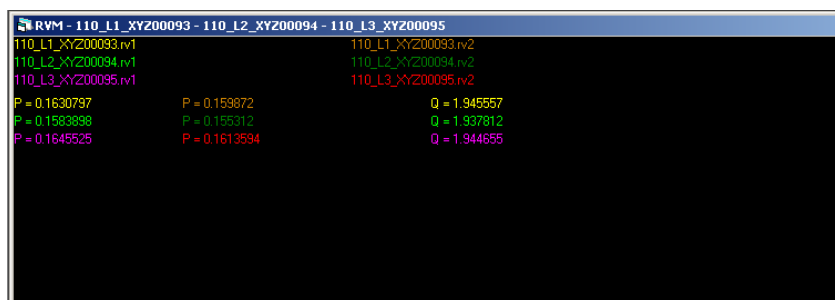


Figure 19 : Evaluation of the RVM-results

Figure 20 shows partly the protocol with the calculated p -factors and Q_a -quotient to describe humidity in paper cable segments.

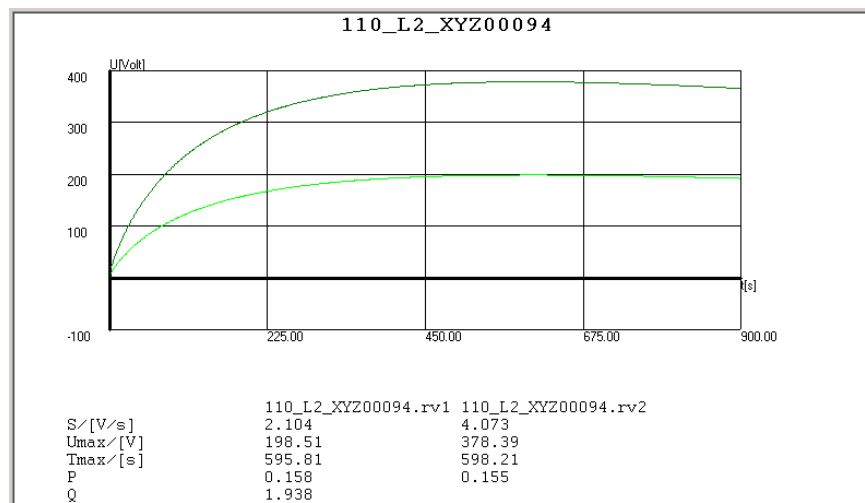



Figure 20 : RVM measurement and evaluation parameters

The measured p-factor of this cable phase L2 is in a range below 0,2. This result shows, that the cable is dry and in good condition.

Cable segments with increased failure rates are laying above this value due to laboratory and field experiences.

Print out possibility is available over the main menu or  the hardcopy button.

8 Settings

8.1 Data storage

The measured data are stored directly using CDS standard software installation in the folders

C:\Program Files\CABLEDIAG\Daten\IRC

C:\Program Files\CABLEDIAG\Daten\RVM

which are marked below.

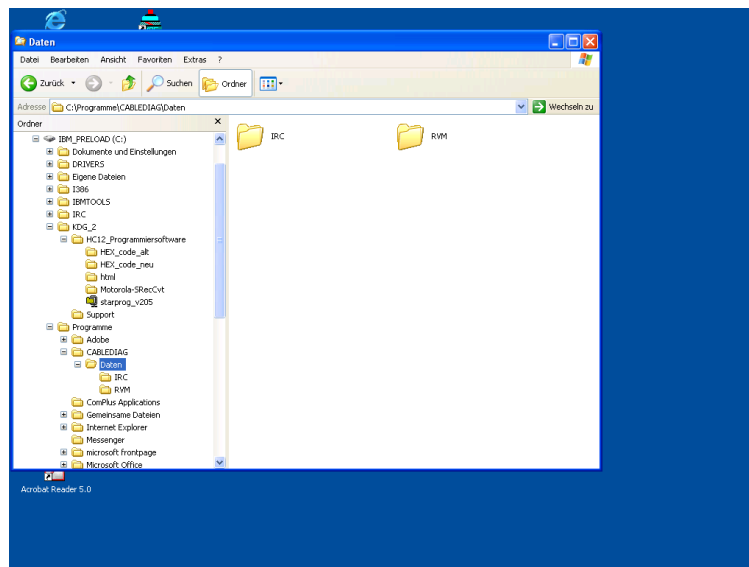
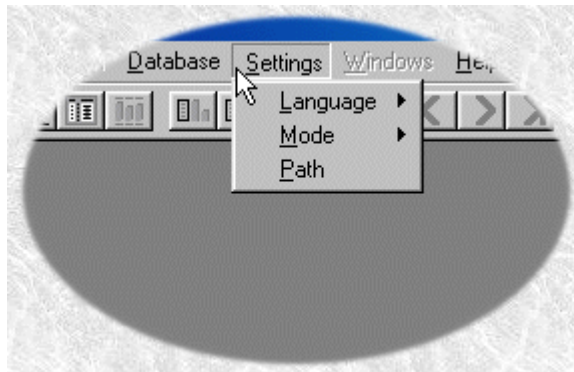
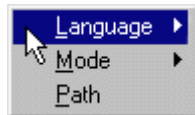


Figure 21 : Software directories data storage

8.2 Set up language

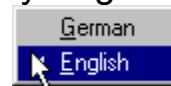


This menu is available only on the main page, i.e. no other windows should be opened.

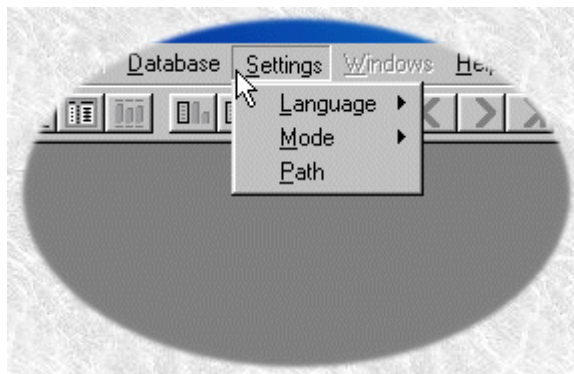


At the time being there are only English and

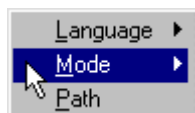
German as program languages available



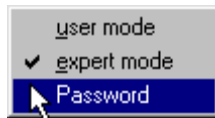
8.3 Set up mode



This menu is available only on the main page, i.e. no other windows should be opened.



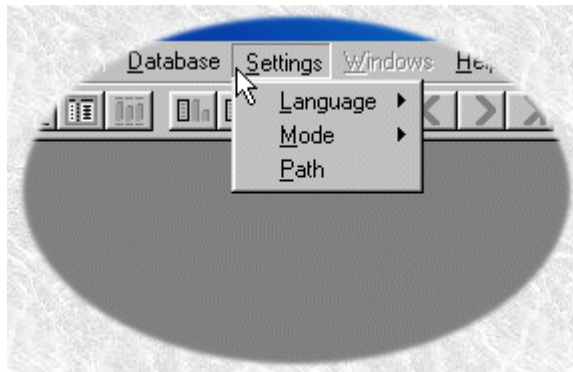
There are two different modes:



The user mode disposes of all the necessary functions to evaluate a measurement the right way and is meant to be the standard mode. The expert mode (you can only set up this mode using the **Expert** password - you can change the password later) possesses more functions, which can help you solve more difficult cases.

In the measuring menu for special measuring cases the system initialisation of the CDS software can be changed with the password MSG-Options. Measuring times or the ID number of the datafiles can be varied. Generally all preinstalled values should not be changed to avoid misinterpretation of the data.

8.4 Set up path information



This menu is available only on the main page, i.e. no other windows should be opened.

The program Cablediag needs a couple of information to work properly. This information is being saved in the initialisation file corresponding to the program.

The initialisation file delivered with the installation pack contains standard settings of your system. In case the file system of your computer is changed manually, it can happen that the program doesn't find necessary files. Then you will be asked to fill in the correct files.

9 Scientific support

You can get scientific support regarding your measuring data from [Seba Dynatronic](#) and cost effective help from the Laboratory of High Voltage Engineering Bergische University of Wuppertal under the following address:

Prof. Dr.-Ing. H.-G. Kranz
Fuhlrottstraße 10
42097 Wuppertal
Tel. 0202/439-3027
Fax. 0202/439-3026
Email kranz@uni-wuppertal.de

It is recommended to make always a copy of your original measuring data for example with an USB Memory Stick.

The CDS-unit uses the IRC-method to analyse the ageing status non destructive and evaluates integral the remaining residual strength and the safety of a cable segment. The included RVM-method is used to check and evaluate the humidity status of an insulation.

Planing investments the data derived through this measurements lead to economic savings.

10 Information on the Accumulator

After completion of the measurement, it is recommended to exit the software properly before the CDS is switched off. In this way, it is ensured that the microprocessor of the CDS switches off (low but audible click in the device).

Otherwise, the microprocessor will remain active for a further 2 hours and is powered by the internal accumulator during this time. Depending on the age and condition of the accumulator this may - at worst - result in "deep discharge" of the accumulator. In such a case, the charging circuit incorrectly identifies the accumulator as "fully charged" and stops charging shortly afterwards. Measurements are aborted after a short time.

In order to recover an accumulator which has been over-discharged, it needs to be charged 3 to 5 times for about 10 minutes. Between individual charges, the CDS must be disconnected from the mains for about 30 seconds. Afterwards, the charging circuit should be able to correctly identify the fully discharged state and to fully charge the accumulator (about 4 hours) again.

To avoid deep discharge while the CDS remains in storage for an extended period, the accumulator needs to be recharged every two months.

11 Literature

- [1] G. Hoff, H.-G. Kranz, Isothermal Relaxation Current Analysis: A New Non-destructive Diagnostic Tool for Polymeric Power Distribution Cables, April 1999 IEEE / PES Panel on Diagnostic Measurement Techniques for Power Cables, New Orleans, USA
- [2] G. Schmidt, H.-G. Kranz, Grundsätzliche Abgrenzungen und Wechselwirkungen zwischen Alterungs- und Schädigungsdiagnose polymerisolierter Kabel, März 2004, ETG Fachtagung Köln, Germany
- [3] M. Beigert, R. Madarasz: Predictive Maintenance and Proof tests on MV-cables, DISEE, Slovak Republic, 2000.
- [4] Hvidsten, S.; Faremo, H.; Benjaminsen, J.-T.; Ildstad, E.; Condition assessment of water tree aged XLPE cables by dielectric response measurements, Cigre Session, Paris, 2000.
- [5] Hvidsten, S; J. T. Benjaminsen; Sintef Energy Research TR A5180, Condition assessment of water tree aged XLPE cables, comparison of four commercial methods, Trondheim, Norway 2000.
- [6] Patsch, R.; Kouzmine, O.; P-factor, A meaningful Parameter for the evaluation of return voltage measurements, CEIDP Cancun, Mexico 2002.
- [7] Patsch, R.; Kouzmine, O.; Analyse und Auswahl von Mess- und Diagnoseparametern bei Rückkehrspannungsmessungen an Mittelspannungskabeln mit unterschiedlichen Isolierungen, März 2004, ETG Fachtagung Köln, Germany
- [8] Hoff, G.; Optimierung und Grenzen der technischen Diagnostik am Beispiel der Alterungsbestimmung polymerisolierter Mittelspannungskabel, Dissertation, BUGH Wuppertal, 2003.

12 Service

The CDS is a sealed unit and maintenance free if the specified environmental conditions are adhered to. If the system has not been used for a long time it is recommended that the system should be tested on correct function.

In case of any malfunctioning during use of the system please contact Seba Dynatronic or your CDS supplier.

The equipment should be returned for repair to our factory or a qualified and authorised service department. Non authorised opening of the CDS unit may lead to a loss of warranty.

When changing a blown fuse, it should be ensured that the replacement is of correct current rating and specified type.

Never make a short circuit in a fuse holder.

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Warranty

Seba Dynatronic® warrants its equipment to be free from defects in workmanship and material under normal and proper use and service for one year from date of purchase by original user. Seba Dynatronic® assumes no obligation to repair or replace equipment which has been altered or repaired by other than a Seba Dynatronic® - approved procedure, been subject to misuse, misapplication, improper maintenance, negligence or accident; has had its serial number or any part thereof altered, defaced or removed; or been used with parts other than those approved by Seba Dynatronic®. Warranty does not include batteries. Expendable items such as fuses and lamps are excluded.

Any product proved defective under this warranty will be repaired or replaced free of charge at the Seba Dynatronic® factory or approved Seba Dynatronic® repair station. The equipment should be returned to our factory by prepaid transportation after requesting and receiving return authorisation from our Service Department. Seba Dynatronic®'s obligations are limited to repair or replacement of broken or defective parts, which have not been abused, misused, altered or accidentally damaged, or at the option of Seba Dynatronic®, to refund of the purchase price. Seba Dynatronic® assumes no liability for removal or installation costs, consequential damages or contingent expenses of any other nature.

The system fulfils the following requirements :



EMV - demand:
Low voltage demand:

89/336/EWG
73/23/EWG [EEC]

[EEC]



Tento symbol indikuje, že výrobek nesoucí takovéto označení nelze likvidovat společně s běžným domovním odpadem. Jelikož se jedná o produkt obchodovaný mezi podnikatelskými subjekty (B2B), nelze jej likvidovat ani ve veřejných sběrných dvorech. Pokud se potřebujete tohoto výrobku zbavit, obraťte se na organizaci specializující se na likvidaci starých elektrických spotřebičů v blízkosti svého působiště.



Dit symbool duidt aan dat het product met dit symbool niet verwijderd mag worden als gewoon huishoudelijk afval. Dit is een product voor industrieel gebruik, wat betekent dat het ook niet afgeleverd mag worden aan afvalcentra voor huishoudelijk afval. Als u dit product wilt verwijderen, gelieve dit op de juiste manier te doen en het naar een nabij gelegen organisatie te brengen gespecialiseerd in de verwijdering van oud elektrisch materiaal.



This symbol indicates that the product which is marked in this way should not be disposed of as normal household waste. As it is a B2B product, it may also not be disposed of at civic disposal centres. If you wish to dispose of this product, please do so properly by taking it to an organisation specialising in the disposal of old electrical equipment near you.



Този знак означава, че продуктът, обозначен по този начин, не трябва да се изхвърля като битов отпадък. Тъй като е B2B продукт, не бива да се изхвърля и в градски пунктове за отпадъци. Ако желаете да изхвърлите продукта, го занесете в пункт, специализиран в изхвърлянето на старо електрическо оборудване.



Dette symbol viser, at det produkt, der er markeret på denne måde, ikke må kasseres som almindeligt husholdningsaffald. Eftersom det er et B2B produkt, må det heller ikke bortskaffes på offentlige genbrugsstationer. Skal dette produkt kasseres, skal det gøres ordentligt ved at bringe det til en nærliggende organisation, der er specialiseret i at bortskaffe gammelt el-udstyr.



Sellise sümboliga tähistatud toodet ei tohi käidelda tavalise olmejäätmena. Kuna tegemist on B2B-klassi kuuluva tootega, siis ei tohi seda viia kohaliku jäätmekäitluspunkti. Kui soovite selle toote ära visata, siis viige see lähimasse vanade elektriseadmete käitlemisele spetsialiseerunud ettevõttesse.



Tällä merkinnällä ilmoitetaan, että kyseisellä merkinnällä varustettua tuotetta ei saa hävittää tavallisen kotitalousjätteen seassa. Koska kyseessä on yritysten välisen kaupan tuote, sitä ei saa myöskään viedä kuluttajien käyttöön tarkoitettuihin keräyspisteisiin. Jos haluatte hävittää tämän tuotteen, ottakaa yhteys lähimpään vanhojen sähkölaitteiden hävittämiseen erikoistuneeseen organisaatioon.



Ce symbole indique que le produit sur lequel il figure ne peut pas être éliminé comme un déchet ménager ordinaire. Comme il s'agit d'un produit B2B, il ne peut pas non plus être déposé dans une déchetterie municipale. Pour éliminer ce produit, amenez-le à l'organisation spécialisée dans l'élimination d'anciens équipements électriques la plus proche de chez vous.



Cuireann an siombail seo in iúl nár cheart an táirgeadh atá marcáilte sa tsíle seo a dhíúscairt sa chóras fuíoll teaghlaigh. Os rud é gur táirgeadh ghnó le gnó (B2B) é, ní féidir é a dhíúscairt ach oiread in ionaid dhíúscairthe phobail. Más mian leat an táirgeadh seo a dhíúscairt, déan é a thógáil ag eagraíocht gar duit a sainfheidhmiú in ndíúscairt sean-fhearas leictrigh.



Dieses Symbol zeigt an, dass das damit gekennzeichnete Produkt nicht als normaler Haushaltsabfall entsorgt werden soll. Da es sich um ein B2B-Gerät handelt, darf es auch nicht bei kommunalen Wertstoffhöfen abgegeben werden. Wenn Sie dieses Gerät entsorgen möchten, bringen Sie es bitte sachgemäß zu einem Entsorger für Elektrogeräte in Ihrer Nähe.



Αυτό το σύμβολο υποδεικνύει ότι το προϊόν που φέρει τη σήμανση αυτή δεν πρέπει να απορρίπτεται μαζί με τα οικιακά απορρίματα. Καθώς πρόκειται για προϊόν B2B, δεν πρέπει να απορρίπτεται σε δημοτικά σημεία απόρριψης. Εάν θέλετε να απορρίψετε το προϊόν αυτό, παρακαλούμε όπως να το παραδώσετε σε μία υπηρεσία συλλογής ηλεκτρικού εξοπλισμού της περιοχής σας.



Ez a jelzés azt jelenti, hogy az ilyen jelzéssel ellátott terméket tilos a háztartási hulladékokkal együtt kidobni. Mivel ez vállalati felhasználású termék, tilos a lakosság számára fenntartott hulladékgyűjtőbe dobni. Ha a terméket ki szeretné dobni, akkor vigye azt el a lakóhelyéhez közel működő, elhasznált elektromos berendezések begyűjtésével foglalkozó hulladékkezelő központhoz.



Questo simbolo indica che il prodotto non deve essere smaltito come un normale rifiuto domestico. In quanto prodotto B2B, può anche non essere smaltito in centri di smaltimento cittadino. Se si desidera smaltire il prodotto, consegnarlo a un organismo specializzato in smaltimento di apparecchiature elettriche vecchie.



Št zíme noráda, ka izstrādājumu, uz kura tā atrodas, nedrīkst izmest kopā ar parastiem mājsaimniecības atkritumiem. Tā kā tas ir izstrādājums, ko cits citam pārdod un lieto tikai uzņēmumi, tad to nedrīkst arī izmest atkritumos tādās izgāztuvēs un atkritumu savāktuvēs, kas paredzētas vietējiem iedzīvotājiem. Ja būs vajadzīgs šo izstrādājumu izmest atkritumos, tad rīkojieties pēc noteikumiem un nogādājiet to tuvākajā vietā, kur īpaši nodarbojas ar vecu elektrisku ierīču savākšanu.



Šis simbols rodo, kad juo paženklinto gaminio negalima išmesti kaip paprastų buitinių atliekų. Kadangi tai B2B (verslas verslui) produktas, jo negalima atiduoti ir buitinių atliekų tvarkymo įmonėms. Jei norite išmesti šį gaminį, atlikite tai tinkamai, atiduodami jį arti jūsų esančiai specializuotai senos elektrinės įrangos utilizavimo organizacijai.



Dan is-simbolu jindika li l-prodott li huwa mmarkat b'dan il-mod m'ghandux jintrema b'hal skart normali tad-djar. Minhabba li huwa prodott B2B , ma jistax jintrema wkoll f'centri civici ghar-rimi ta' l-iskart. Jekk tkun tixtieq tarmi dan il-prodott, jekk jogh'gok ghmel dan kif suppost billi tiehdu ghand organizzazzjoni fil-qrib li tispeccjalizza fir-rimi ta' taghmir qadim ta' l-elettriku.



Dette symbolet indikerer at produktet som er merket på denne måten ikke skal kastes som vanlig husholdningsavfall. Siden dette er et bedriftsprodukt, kan det heller ikke kastes ved en vanlig miljøstasjon. Hvis du ønsker å kaste dette produktet, er den riktige måten å gi det til en organisasjon i nærheten som spesialiserer seg på kassering av gammelt elektrisk utstyr.



Ten symbol oznacza, że produktu nim opatrzonego nie należy usuwać z typowymi odpadami z gospodarstwa domowego. Jest to produkt typu B2B, nie należy go więc przekazywać na komunalne składowiska odpadów. Aby we właściwy sposób usunąć ten produkt, należy przekazać go do najbliższej placówki specjalizującej się w usuwaniu starych urządzeń elektrycznych.



Este símbolo indica que o produto com esta marcação não deve ser deixado fora juntamente com o lixo doméstico normal. Como se trata de um produto B2B, também não pode ser deixado fora em centros cívicos de recolha de lixo. Se quiser desfazer-se deste produto, faça-o correctamente entregando-o a uma organização especializada na eliminação de equipamento eléctrico antigo, próxima de si.



Acest simbol indică faptul că produsul marcat în acest fel nu trebuie aruncat ca și un gunoi menajer obișnuit. Deoarece acesta este un produs B2B, el nu trebuie aruncat nici la centrele de colectare urbane. Dacă vreți să aruncați acest produs, vă rugăm să-o faceți într-un mod adecvat, ducând-ul la cea mai apropiată firmă specializată în colectarea echipamentelor electrice uzate.



Tento symbol znamená, že takto označený výrobek sa nesmie likvidovať ako bežný komunálny odpad. Keďže sa jedná o výrobok triedy B2B, nesmie sa likvidovať ani na mestských skládkach odpadu. Ak chcete tento výrobok likvidovať, odneste ho do najbližšej organizácie, ktorá sa špecializuje na likvidáciu starých elektrických zariadení.



Ta simbol pomeni, da izdelka, ki je z njim označen, ne smete zavreči kot običajne gospodinjске odpadke. Ker je to izdelek, namenjen za druge proizvajalce, ga ni dovoljeno odlagati v centrih za civilno odlaganje odpadkov. Če želite izdelek zavreči, prosimo, da to storite v skladi s predpisi, tako da ga odpeljete v bližnjo organizacijo, ki je specializirana za odlaganje stare električne opreme.



Este símbolo indica que el producto así señalado no debe desecharse como los residuos domésticos normales. Dado que es un producto de consumo profesional, tampoco debe llevarse a centros de recogida selectiva municipales. Si desea desear este producto, hágalo debidamente acudiendo a una organización de su zona que esté especializada en el tratamiento de residuos de aparatos eléctricos usados.



Den här symbolen indikerer att produkten inte får blandas med normalt hushållsavfall då den är förbrukad. Eftersom produkten är en så kallad B2B-produkt är den inte avsedd för privata konsumenter, den får således inte avfallshanteras på allmänna miljö- eller återvinningsstationer då den är förbrukad. Om ni vill avfallshandla den här produkten på rätt sätt, ska ni lämna den till myndighet eller företag, specialiserad på avfallshandtering av förbrukad elektrisk utrustning i ert närområde.