Cable Diagnostic System for three phase IRC and RVM diagnostics

CDS

Benefits:

- **Three phase IRC and RVM as portable instrument**
- **Non-destructive diagnosis**
- **Charging current analysis to detect local weak spots**
- **Easy menus guide through the measurement process**

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Cable Diagnostic System for three phase IRC and RVM diagnostics

Dielectric diagnostic in time domain

The liberalisation of the electricity power markets and new forms of asset management lead to the need for increased life cycles of installed systems and the desire for running them on higher load. Integral diagnostics is a valuable tool for non-destructive analysis of the cable network. It simplifies condition based maintenance and makes the decision ‚repair or replace' for cable or section much easier.

The portable CDS is an universal dielectric diagnostic system for PE / XLPE insulated cables as well as paper insulated cables. It combines the well-known methods of Isothermal Relaxation Current measurement (IRC-Analysis) and Return Voltage Method (RVM-Analysis) for aging and deterioration diagnostics in one portable unit.

The IRC-diagnosis based on the relaxation current measurement is an integral diagnostic method for ageing and the deterioration status of PE / XLPE insulated medium voltage cables. The results of this measurement gives the cable operator essential information about the service reliability of the section under test. This information is very useful in the final decision-making, to repair or replace the cable section in question.

One problem of cables with polyethylen insulation, is the growth of water trees. Under the influence of water, temperature and electrical field strength, these trees deteriorate the insulation. The length of these microscopic structures increases with operation time. The subsequent conversion to an electrical tree can lead to a breakdown and a failure of the cable segment.

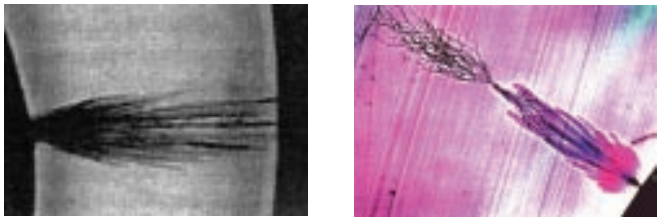

Fig. 1: Water tree bridging the complete insulation left and electrical tree starting from a vented tree on right side

The CDS uses a software-module with a neuro-fuzzy module for the evaluation of the IRC measurements on PE / XLPE cables. The intelligent multi-stage evaluation software takes the construction characteristics of a test object into consideration, categorises the condition of the test object and gives a prognostic maximum residual voltage level.

The software includes a user- and an expert-database with automatic calculation of voltage withstand prognosis values according to data material of the standard DIN VDE 0276 as well as a protocol of the diagnostic results.

The RVM diagnosis is based on the principle of return voltage measurement. After a defined charging cycle and a subsequent short discharge of the capacitance, the voltage curve measured provides characteristic information on the ageing status and moisture content of the paper insulation of the test object.

Due to corrosion of the lead sheath, oil leakage and the decomposition of the cellulose chains based on ageing effects, the moisture content of the insulation increases. This leads to a reduction of the residual breakdown strength until the remaining value is close to the nominal operating voltage and the cable operation is risky. The lifetime of the cables in general strongly depends on the manufacturing quality, the laying- and service conditions.

Fig. 2: Corrosion on the outer sheath and the building of holes in the lead sheath

The RVM cable analysis is based on proven normalisation factors and threshold values.

Since the system output voltage level is limited to about 10% of the nominal service voltage, the danger of initiating cable damage during testing is zero. With the information from RVM diagnosis, the reliability of the network can be accurately judged, which is of vital importance to the operator.

The cruical decision, whether only segments or the total lengths of the cable need to be replaced, is based on sound technical information. Naturally, this results in substantial economic savings.

The dielectric diagnostic system CDS based on the relaxation current / return voltage measurement principle, was developed in close co-operation with the University of Wuppertal. The RVM evaluation coefficients were developed in a scientific co-operation with the University of Siegen.

Measurement principle

By software controlled configuration switches the CDS system is set either for IRC or RVM measurements. The low ohmic IRC current measurement is optimised for the exponentially decaying currents from the polarised PE dielectric. The voltage measurement (RVM-analysis) requires a high ohmic measurement circuit to determine the necessary values.

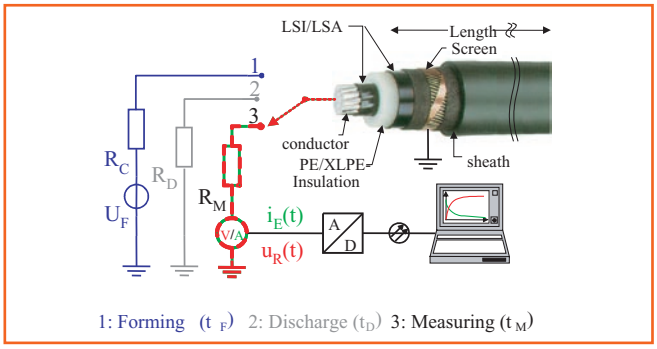

Fig. 3: Measurement principle to determine characteristic ageing values in time domain

CDS

Integral ageing of a polymer changes the morphological properties of the insulation, influencing the dielectric response and can be determined by analysis of the characteristic range of the polarization spectrum.

The charging current is measured and automatically stored during formation simultaneous for each phase, both for the IRC analysis for XLPE and RVM measurement for PILC cables. Thus, the influence of local weak spots like large water trees or wet joints can be detected.

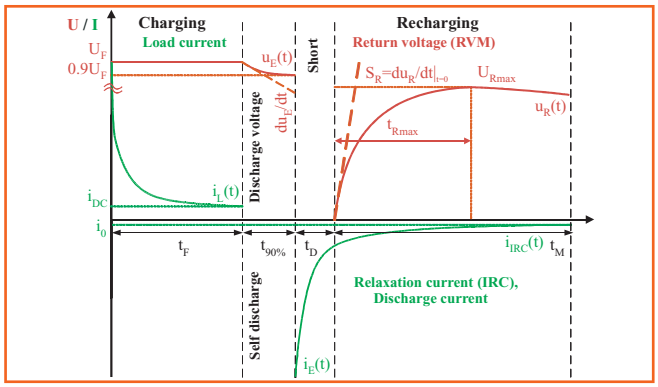

Fig. 4: Dielectric response in time base

IRC analysis

Based on a high number of field measurements on service aged cable segments and accelerated aged cables, a data-base was created, which includes all important information of various test objects. So cable diagnosis is possible without any prior reference measurements of the cable under test.

The NN-software uses the classification of the IRC plot in one of four ageing classes. Each ageing class has a statistical correlation to the step test behavior of a lot of cables. This correlation is described as a typical residual strength.

The result is an excellent base for decision making about the further operation, renovation or replacement of the specific cable (or segment).

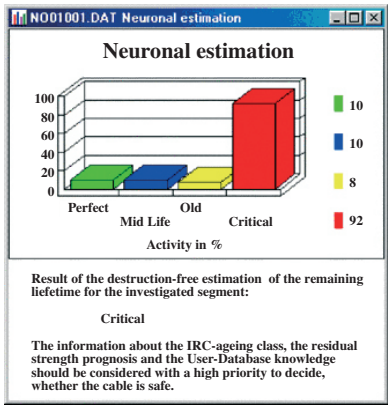

Fig. 5: Determination of the IRC ageing classification

RVM analysis

The RVM evaluation depends on threshold values. The non-linear behavior of the return voltage versus the increase of the charging voltage and the shape of the measurement curve are analysed.

The factor Qa is used, to determine the non-linearity, the initial slope of the return voltage. It is measured at two charging voltages, that are in a 2:1 ratio (typical 1 kV and 2 kV). The ratio of the initial slopes is 2.0 for an absolutely dry cable and gets closer to 1.5, the higher the moisture content of the insulation is.

The empirical evaluation of the Quotient Qa is:

2.00 … 1.87	dry
1.86 … 1.65	moist
< 1.65	wet

Another factor for judging the moisture content of the PILC insulation, which is also directly related to the de-composition of the cellulose, is the so called ‚p-factor'. Depending on a lot of field tests, it correlates well with ageing / moisture.

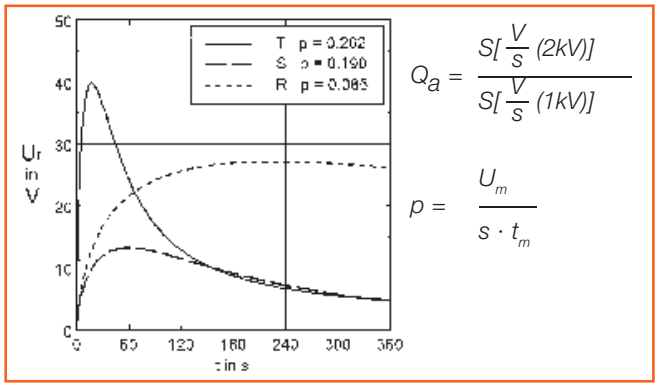

Fig. 6: Return voltage of three paper insulated cable segments and evaluating p-factors

The definition of the p-factor is based on the shape of the return voltage curve, namely the maximum value of the voltage Um [V], the time till the maximum voltage tm [s] and the initial slope s [V/s]. If the cable insulation is wet, the factor p is above 0,2.

We are happy to provide you with information!

Field - and laboratory measurements

The CDS is a portable unit, the setup on site of the instrument and the test lead connection to a cable segment is easy to handle because of the low charging voltage levels. If possible, the cable screen and the cable conductor should be disconnected on the far end from the substation to increase the signal quality.

Even short cable segments of about 10 m length, typical for lab tests, can be measured easily.

The CDS can perform single phase tests or simultaneous three phase measurements.

Fig. 7: CDS setup during a field measurement

Fig. 8: CDS measurement in a high voltage laboratory

Scope of Delivery

- Measurement and control unit
- Laptop computer with software preinstalled
- Set of connecting cables
- Operating manual

Features

- Absolutely non-destructive condition evaluation of PE / XLPE or paper-oil insulated cable systems
- Simple operation and automatic measurement procedures
- Three-phase parallel measurement for current- and voltage duration of a complete measurement 1 hour
- Extended dynamic range for IRC-measurement for long cable segments
- Measurement of the charging current during formation
- Improved filters
- Higher capacity of internal rechargeable battery for serial measurements
- Extended formation voltage up to 5 kV - suitable for diagnosis on HV cables

Technical Data

Current measuring range	- 130 nA … 130 nA
Voltage measuring range	0 … 5000 V
Max. output voltage	5 kV
Resistance measurement	up to TΩ
Power supply	115 / 230 V; 50 / 60 Hz
DC-charging current	3 mA
Power consumption	50 Watt (without Laptop)
Dimensions (H x W x D)	490 x 550 x 415 mm
Weight	26 kg (without Laptop and cables)

Our range of products: Equipment and systems to locate faults in power and communications networks, as well as for leak location on pipe networks · line location equipment · seminars · service · contracting.

Technical data subject to change without notice.

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