

# Cable testing and diagnostics

Prevent failures,  
reduce investment costs





## Cables – the lifelines of our civilization

In today's world, we face new challenges in the form of globalisation, digitalisation, and climate change. All these factors influence our security of supply. For example, the energy transition has put a greater focus on renewable sources of energy.

As the backbone of distributed power supply, medium-voltage networks are becoming extremely important. For it is indeed here that a growing number of energy producers will be connected in future, along with large wind parks, photovoltaic free-standing systems, and biogas plants.

When expanding and maintaining your network, it is important for you to ensure reliable operation on a continuous basis. But how can you guarantee security of supply? And do it cost-effectively? With BAUR you have an expert partner by your side, enabling you to prevent damage and plan maintenance costs precisely. We are dependent on functioning networks – with BAUR you can ensure that power keeps flowing!

## BAUR – early diagnosis instead of a cable infarction.

It's just like going to the doctor: a detailed and precise examination can identify ailments before something serious happens. The same is true for supply networks: cable diagnostics can detect vulnerabilities in cables before they result in power failure, thereby extending the service life of cables significantly. Using high-end measuring devices and the latest testing and diagnostics software, BAUR prevents damage in networks and makes it easier than ever to plan cost-effective investments in the cable network.



## BAUR enables cost-optimised maintenance

The sheath and cable testing supports you in assessing whether a cable system is safe and ready to operate at the time of testing. More and more network operators emphasise the importance of cable diagnostics, as it provides important information on the hidden faults in systems and, in particular, the cable network.



### Guaranteed security of supply

BAUR measurement technology for cable diagnostics is used before a potential operational failure actually takes place. It allows weak points in power cables to be detected and located immediately. Damaged or incorrectly installed terminations or joints are identified at an early stage, allowing potential problems to be remedied before they even occur.

### Plan investments more effectively

Our precise analyses of the cable condition make it possible for you to carry out expensive modification and maintenance measures only where they are really necessary. The preventive and unnecessary replacement of intact cable routes is a thing of the past.

### Ready for the energy transition

With cable diagnostics, you will solve the problem of providing maximum network availability whilst keeping maintenance and repair costs to a minimum. It is the ultimate way to secure the availability of green electricity.

## home of diagnostics

## Unrivalled measurement and testing expertise under one roof

At BAUR, the “home of diagnostics”, every measurement engineer and asset manager can feel more assured than ever before when it comes to realising the objective of planning repairs in a proactive and cost-optimised way. Several factors come into play here:

### BAUR measurement technology

The BAUR portfolio covers all the important requirements of network operators with regard to testing and diagnostics technology in the medium voltage range.

### Evaluation with BAUR Software 4

The intuitive BAUR Software 4 guides measurement engineers through the process of cable testing and diagnostics, combining the two in an efficient workflow that saves time. Whether using preset standard sequences or customised company-specific processes, operators are in complete control of how the diagnostic measurement is performed.

### Life time estimation with BAUR statex®

The statex® algorithm enables accurate assessment of the cable condition and the remaining life time of cables. This means that existing cables can be used for a longer period of time, reducing investment costs significantly.

### BAUR cable testing and diagnostics – the advantages at a glance:

- Reliable and precise cable diagnostics
- More efficient workflow – tailored to every power supply company
- Reduced maintenance costs
- Optimum balance between network availability and cost efficiency
- Overview of the overall condition of the cable network





# Meaningful results and standard compliant

Based on international research as well as decades of practical experience, **VLF cable testing and diagnostics** on medium-voltage systems is now a recognised method among leading bodies and associations. What this means for you is that cable and sheath testing as well as diagnostic measurements with VLF voltage are performed in compliance with standards. You don't have to concern yourself with **standard-compliant work procedures**

as we've already taken care of that for you. You decide which standard you would like to follow; our devices come with the according procedures. Through the creation of **customised sequences**, the BAUR Software 4 for testing and diagnostics also enables standard-compliant testing and diagnostics with the appropriate flexibility to design **your own diagnostics philosophy** – for optimum integration in your diagnostics sequences.

The BAUR truesinus® voltage sources are handy and suitable for all relevant daily tasks – whether cable testing or diagnostics. They ensure highly reliable results and, thanks to the truesinus® technology developed by BAUR, they provide an ideal low-frequency sine voltage as well as the DC voltage required for sheath testing.

**Highly accurate measurements**  
Thanks to the ideally formed truesinus®, you can rely on highly accurate measurements of the  $\tan \delta$  (tan delta or TD) and meaningful results for partial discharge measurement, as well as good reproducibility and comparability of the measured values.

**This following speaks for the truesinus® technology**  
The VLF 0.1 Hz sine voltage is significantly more suitable for the  $\tan \delta$  measurement that is important for the condition evaluation than other usual voltage shapes or frequencies. The ideal sine enables highly accurate TD measurement results. Small changes and detailed properties can be identified and evaluated reliably with these results.

## Excerpt from standards

Test standards for medium-voltage cables	Contents
IEC 60502.2-2014 1 kV to 30 kV cables	New IEC standard, describes VLF testing as an acceptance test
Cenelec HD 620 1996, VDE 6 kV to 30 kV cables	Harmonisation document for IEC, VDE European standard for acceptance tests since 1996
IEEE 400-2012 6 kV to 30 kV cables	Guide for field testing and evaluation of the insulation of shielded power cable systems rated 5 kV and above. Detailed overview of testing and diagnostics methods

Test standards for medium-voltage cables	Contents
IEEE 400.2-2013	Guide for field testing of shielded power cable systems using VLF test voltage. Detailed guide for VLF testing and diagnostics.
IEC 60229	Sheath testing
IEC 60270	Describes partial discharge measurement
IEC 60060-3	Describes the requirements concerning the properties of the VLF voltage shape

## The advantages of truesinus®

- Load-independent measurement results
- Highly accurate tan delta
- Reproducible, precise measurements
- Possible to carry out testing and diagnostic measurement in parallel (Monitored Withstand Test)
- Short measuring time
- Compact voltage sources

↑ Cable diagnostics with BAUR devices and software makes it possible to depict each standard. The BAUR Software 4 enables easy integration in your own diagnostics philosophy.



# Dissipation factor measurement (tan $\delta$ measurement)

The dissipation factor measurement (tan  $\delta$  measurement) is a non-destructive and integral procedure that serves to evaluate the condition of an entire cable route. With the dielectric dissipation factor tan  $\delta$ , the relation of effective power to reactive power of the cable is measured. The measurement provides clear information on the condition of the cable insulation and its ageing.

## Process for tan $\delta$ diagnostics

The tan  $\delta$  measurement is performed over several voltage steps that can be adjusted in our devices. With aged cables, a characteristic increase in dissipation factor can be seen with increasing measurement voltage. A classification of the cables is possible, which proves highly valuable when planning the maintenance measures.

## Detect the following with dissipation factor measurement:

- Areas in the insulation of XLPE cables that are damaged by water (water trees), which later lead to electrical trees and represent the natural cause of a cable fault
- Faults in the insulation of paper-insulated mass-impregnated cables due to drying
- Insufficient insulation of paper-insulated mass-impregnated cables due to moisture
- Moisture in accessories (joints/terminations)
- Possible partial discharges

Illustration of dissipation factor measurement in the BAUR Software 4: ↓

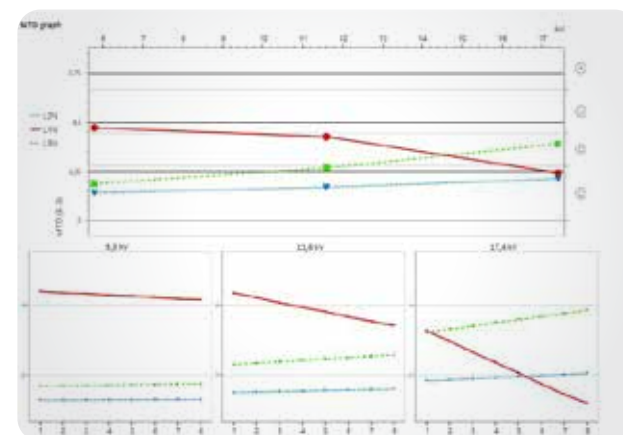
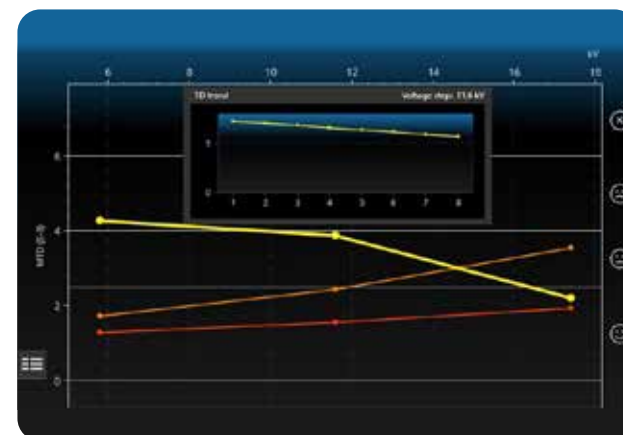


Illustration of dissipation factor measurement in the report ↑

- **Sequencer:** A sequence bundles together the right choice of measurement methods and settings for each application.
- **Programme:** Predefined sequences for the measurement. Uniform and standardised measurements and tests enable comparability across all systems.
- **Evaluation criteria:** The corresponding condition evaluation is automatically calculated based on the cable type and insulation material and is displayed accordingly.
- **Generic methods:** Standardised sequences and measurement methods can be defined globally, irrespective of the cable type and voltage level. They can be used on a general basis and ensure uniform procedures.
- **Data transfer:** The presets as well as the measurements can be quickly and easily transmitted to other measurement systems by means of data transfer. \*

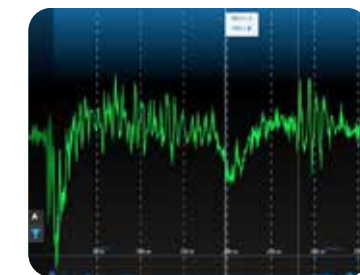
\* Depending on the availability of the software options

# Partial discharge measurement

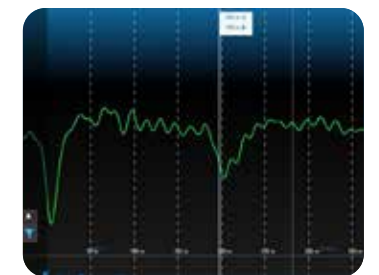
Partial discharges occur at faults in the cable, e.g. at electrical trees, joints and terminations. Partial discharge diagnostics is used to determine possible fault locations in cables and accessories before they lead to failure. This makes it possible to rectify the problem in a timely manner and prevent any subsequent damage resulting from uncontrolled failures. Partial discharge measurement is effected in accordance with standard IEC 60270.

## Partial discharge measurement can detect the following:

- Faults in new and old cable accessories, such as incorrectly fitted joints
- Faults in the insulation of XLPE cables (e.g. electrical trees)
- Insufficient mass-impregnated paper insulation due to drying
- Mechanical damage to the cable sheath



PD signal superimposed with faults ↑



Signal cleaned with filter ↑

## BAUR PD measuring devices can diagnose the following:

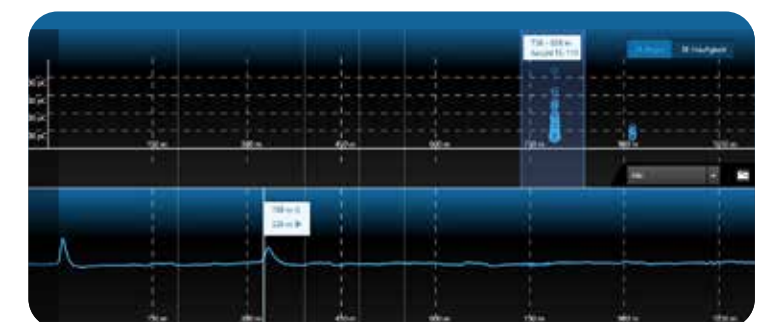
- PD localisation
- PD level
- PD inception voltage / extinction voltage
- PD frequency

## Supporting functions

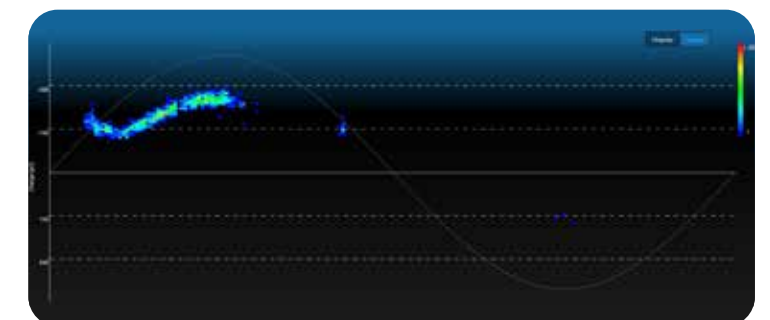
- Phase-resolved PD presentation for every fault location
- PD interference filter function
- Joint localisation

## Phase-resolved PD presentation (PRPD)

The phasing of partial discharges can be determined through state-of-the-art analysis methods. This makes it possible for you to assign the fault to diverse types of fault and to plan subsequent measurements as well as repair measures in a target-oriented and time- and cost-saving manner.



Combined presentation of location and PD assessment ↑



Phase resolving for a PD position ↑

# Diagnostics procedures appropriately combined

Whether dissipation factor or partial discharge measurement - both diagnostics methods have their advantages. However, individually, neither of them can detect all weak points. For this reason, it is worthwhile combining both procedures - whether carried out subsequently or together in one procedure. You will obtain valuable, additional information and increase the certainty in the condition evaluation and in the search for faults.

## Monitored Withstand Test – more information in less time

The time-saving combination of testing and diagnostics is known as the Monitored Withstand Test (MWT). The MWT provides significant information for the condition evaluation and allows for the required test duration to be adapted to the cable condition. The combined procedure is recognised by the IEEE and IEC, and is recommended as an appropriate measurement method for service-aged cable systems.

### Condition evaluation with very low voltage

The procedure programmed in the BAUR devices for the MWT is split into two: The diagnostic measurement takes place in the voltage build-up stage so that you can get an idea of the cable condition; outdated cables are detected and you can take prompt action to ensure that pre-damaged cables are not exposed to the test voltage unnecessarily.

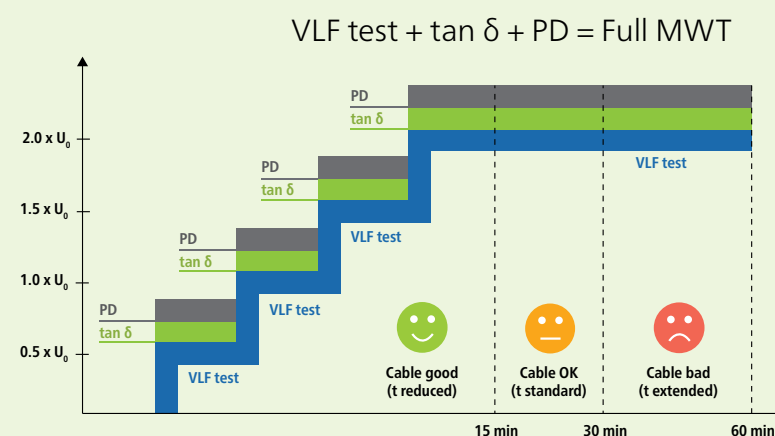
During the MWT stage, in which the diagnostics are carried out in parallel to the cable testing, you will identify the time response of  $\tan \delta$ . During the so-called Full MWT, the partial discharge measurement is also effected and PD faults can be simultaneously presented and precisely localised.

### Condition-based test duration

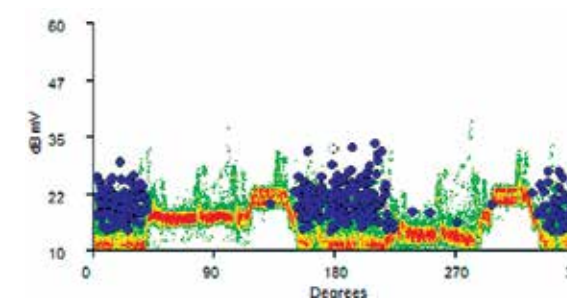
The condition-based test duration is a big advantage for you as the operator. Based on positive diagnostics measured values, cable testing can be shortened to 15 minutes so that the cable is not under load for an unnecessarily long period of time.

## Full Monitored Withstand Test

→ Carrying the cable testing and cable diagnostics out in parallel (with  $\tan \delta$  measurement or partial discharge measurement) in the Monitored Withstand Test saves time and provides valuable information for asset management.



↑ In combination with the iPD transponder, liona accurately and reliably locates PD.

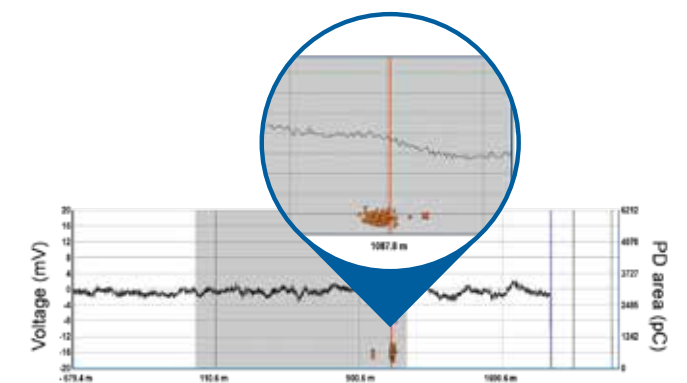


↑ Online PD spot testing result: Partial discharges are shown in blue

# Cable check whilst live

## Online PD testing

With the help of liona, the portable BAUR online PD spot tester, cables can also be quickly and easily tested for partial discharges whilst live (online). The DeCIfer® algorithm supports the detection of partial discharge signals from noise signals. The online PD test helps to detect approximate weak points without switching off the system and, if required, to localise faults.



## liona and iPD – a unique solution

- For PD testing during normal mains operation if cables cannot be taken out of operation
- For inexpensive testing of HV cable routes – even in the case of cross bonding
- For straightforward initial estimation of PD
- For temporary monitoring of a cable route

## Advantages

- Automatic PD detection – despite high noise levels
- PD spot test in 3 minutes: connect – measure – read result
- Unique technology for online PD location using artificial reflection
- Easy-to-install, temporary monitoring system
- Easy testing of MV and HV cables





# BAUR measurement and diagnostics systems

Hardware and software



# Overview of our product portfolio

## 01 / High-voltage test devices

The PGK series comprises compact DC voltage test devices for electrical systems. The proven AC/DC high-voltage test devices in the PGK HB series offer a wider range of functions with continuously adjustable test voltages for DC voltage testing with a selectable polarity up to 260 kV or, for 50 Hz AC voltage testing, up to 190 kVrms.



↑ 01 / PGK HB AC/DC HV test set



↑ 01 / PGK DC HV tester

## 02 / Online diagnostics in medium-voltage networks

liona the measuring device detects partial discharges during normal mains operation in a reliable and cost-saving manner. This initial estimation of the condition of a cable route or switchgear enables the effective planning of additional, precise offline diagnostic measurements.



↑ 02 / liona online PD spot tester



↑ 03 / PHG 80 VLF test system



↑ 03 / Partial discharge inductor tracy

## 03 / Offline testing and diagnostics in medium-voltage networks

Our well-thought-out and cleverly devised testing and diagnostics systems enable fully automatic VLF cable testing and dissipation factor measurement (Full MWT) in a single flow. This saves time and costs, and delivers precise statements.



↑ 03 / viola/frida TD and VLF testers and diagnostics devices



↑ 03 / PD-TaD 80 and PD-TaD 62 portable PD diagnostics systems

## 04 / Software

The BAUR Software 4 enables the comprehensive evaluation of cable networks as well as the fast and reliable determination of the cable condition based on your own diagnostics philosophy. Using statex®, the innovative software solution from BAUR, you can determine the remaining life time of cables and plan investments in the cable network with a high degree of accuracy.



↑ 04 / BAUR Software 4




↑ 04 / statex® software

# Function matrix for our products

Technical information and data sheets for each of our products is available at [baur.eu/t-and-d](http://baur.eu/t-and-d)

# Function matrix for our products



Technical information and data sheets for each of our products is available at [baur.eu/t-and-d](https://baur.eu/t-and-d)

			Application / measurement methods										
			Offline									Online	
			Operating equipment test with AC	Operating equipment test with DC	Cable testing VLF 0.1 Hz sine in accordance with IEC, CENELEC, IEEE	Cable sheath testing	Dissipation factor measurement TD	TD MWT	PD measurement	Combination of TD and PD test, Full MWT	Confirmation of the PD position	Online PD spot testing, cable length measurement, PD mapping	Handheld online PD detector for switchgear
Testing	Cat.	Products											
	01	PGK 25 DC HV tester		■		■							
	01	PGK 50 E and PGK 80 E DC HV tester		■		■							
	01	PGK HB (70-260) AC/DC HV test set	■	■		■							
	01	frida VLF tester		■	■	■							
	01	viola VLF tester		■	■	■							
Diagnostics	01	PHG 70/80 VLF test system		■	■	■							
	02	frida TD VLF tester and diagnostics device		■	■	■	■	■		■*			
	02	viola TD VLF tester and diagnostics device		■	■	■	■	■		■*			
	02	PHG 80 portable VLF test system		■	■	■	■			■*			
	02	PHG 80 TD VLF test and diagnostics system		■	■	■	■			■*			
	02	PHG 80 TD PD VLF testing and diagnostics system		■	■	■	■		■				
	02	PD-TaD 62 and PD-TaD 80 (portable) PD diagnostics systems					■*	■*	■**				
	03	tracy partial discharge inductor									■		
	03	liona online PD spot tester + iPD transponder										■	
	03	PD-SGS handheld online PD detector											■

\* ...in the following combination: frida TD/viola TD + PD-TaD 62 or PHG 80 TD + PD-TaD 80  
\*\* ...in combination with any VLF source

Abbreviations used: MWT = Monitored Withstand Test, PD = partial discharge, TD = tan δ



For further information or competent consultation, contact us at: [baur.eu/service](http://baur.eu/service)







## BAUR Software 4 – easy and comprehensive evaluation of cable networks

The new BAUR Software 4 allows you to quickly detect and evaluate the cable condition in accordance with your own diagnostics philosophy. The intuitive operational concept supports asset managers and measurement engineers working on site, firstly with the extremely efficient measurement process and secondly through precise condition monitoring of cable networks. In short: the BAUR Software 4 elevates application and evaluation to a new level – thereby enabling further optimisation of the condition-based maintenance of cable networks.

### The measurement methods

The BAUR Software 4 is used together with BAUR test and diagnostics systems for cable testing (VLF truesinus®, VLF square wave, and DC voltage), cable sheath testing, and diagnostics with dissipation factor measurement or partial discharge testing.

#### Cable testing

- Cable testing (VLF truesinus®, VLF square wave, DC voltage)

#### TD

- Dissipation factor measurement

#### PD

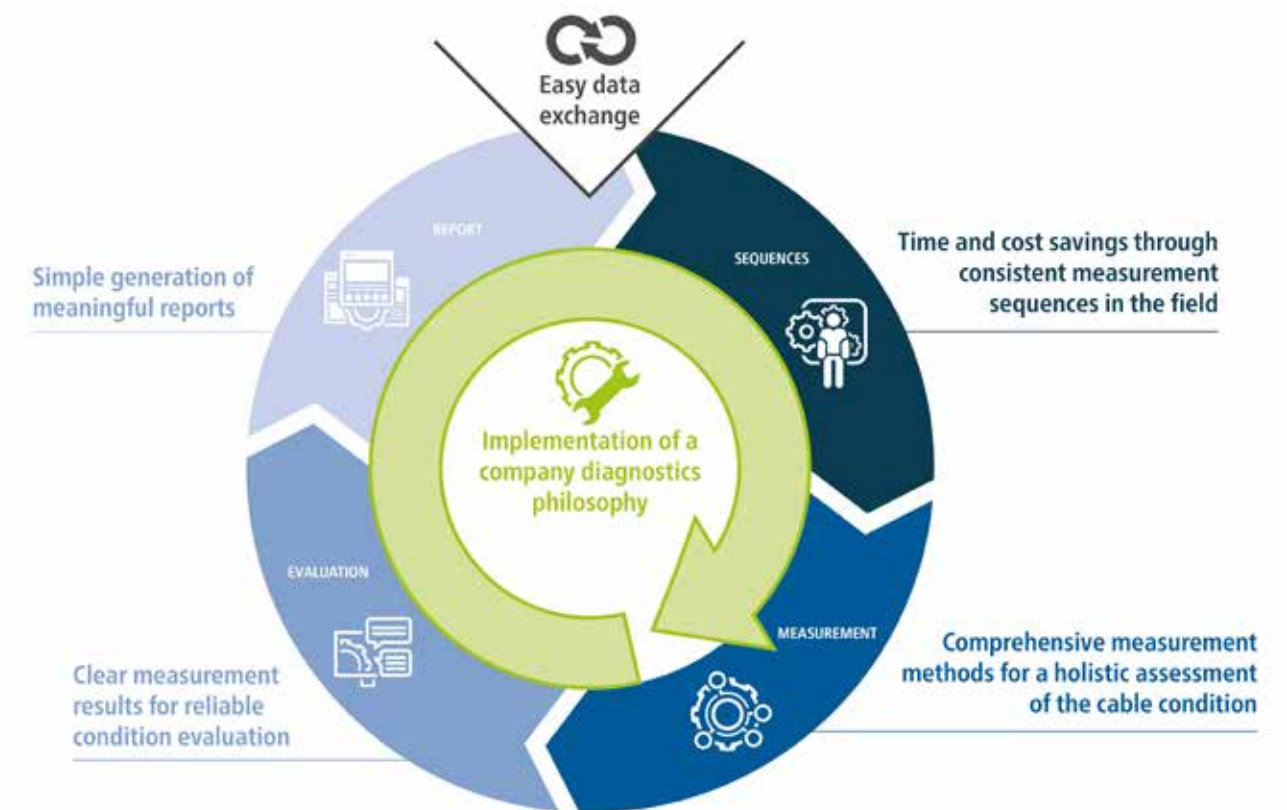
- Partial discharge testing

#### TD & PD

- Parallel dissipation factor and partial discharge measurement

### Our software – your benefits:

- Better decisions based on comprehensive condition evaluation of the cable network
- Saves time on site thanks to automated sequences and report generation
- Easy operation thanks to the intuitive operational concept



### Your own diagnostics philosophy as the basis

Operators can either use standardised diagnostics sequences or create their own company-specific diagnostics sequences. To do this, in-house specifications for various cables or various phases in the network life cycle, such as commissioning or maintenance, are simply created within the diagnostics sequences. The criteria, ranging from current standards and guidelines through to company-specific specifications, are thus stored at the start of every measurement and the engineer starts the measurement procedure with just a few clicks.

### Comparable results – better basis for decision-making

The sequences can be exported directly to all BAUR measurement systems used and can be adapted at any time as required. These standardised measurement cycles provide asset managers with reproducible and comparable measurement results that show not only the condition but also the ageing of a cable route over time – the ideal

basis for making informed decisions concerning network planning and investment in maintenance.

### Evaluation made easy

All measurements and tests (including all condition data for every cable route) are stored in the central cable database. The results are represented graphically during the process, even while evaluating the measurement. At the end of measurement, the overall condition of the cable route is displayed along with the results of the individual measurements.

### All information at a glance:

The BAUR Software 4 automatically generates reports on the measurements that have been performed. The reports contain all the information about the tested cables and can be exported as a PDF file. The diagnostics results and condition evaluation can also be easily presented in graph and table format.

# BAUR's innovative statex® software – determine the remaining life time of cable routes



## Advantages of statex®

- Significant potential savings through maximum utilisation of medium-voltage cables
- More accurate planning of investments year on year
- Targeted measurements – better overview of the condition of the overall cable network ... and all while significantly improving security of supply

All asset managers aim to keep medium-voltage cables in service for as long as possible without jeopardising security of supply. BAUR has the ideal solution. The new statex® analysis software evaluates the data from the dissipation factor measurement (tan  $\delta$  measurement) and uses a patented algorithm to calculate the statistical remaining life time of cables – more accurately and more clearly than ever before.

The software is based on a stored data pool and also takes into account the new TD-Skirt parameter, resulting in improved evaluations and estimations. The algorithm that is used was developed jointly by the Korea Electric Power Corporation (KEPCO) and the University of Mokpo (Korea) and has already proved successful, drawing upon results from 45,000 cable routes for statistical analysis.

Error rate of diagnosed cables is actually lower than that of new cables.

## Evaluation options and results in the software:

- Ageing index R
- Speed of ageing VR
- Statistical remaining life time
- Reminder function for subsequent measurements
- 3D status graph
- TD-Skirt graph

## More accurate estimations – significant savings with example analyses by KEPCO

An evaluation of the TD measurement data of 15,000 cable routes according to IEEE 400.2 determined that approx. 255 km of the cables fell into the "Action required" category.

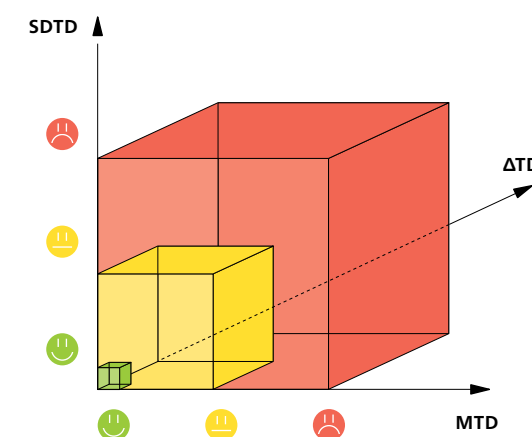
The evaluation of the same measurement data with statex® determined that only approx. 55 km of the cables in operation had a statistical life time of <2 years. This means that it was not yet necessary to replace approx. 200 km of cable.

**Result:** On average, more accurate estimations with statex® increase the statistical life time by

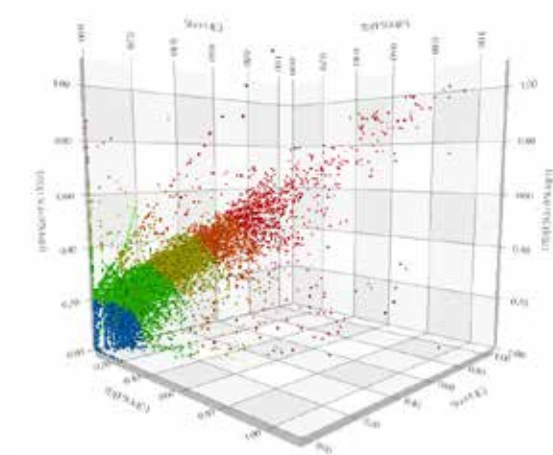
# 11 years.



## Evaluation according to IEEE 400.2\*



## Evaluation with statex®



statex® calculates a 3D ageing index R, which also takes into account the new evaluation parameter TD-Skirt in addition to the evaluation of MTD,  $\Delta$ TD. This enables precise recommendations to be made as to when a subsequent measurement should be performed or when work is required on the cable route. When repeat measurements are performed on the same cable, statex® incorporates the earlier measurements to produce an even more precise estimation.



## Other BAUR Brochures



Cable fault location



Insulating oil testing



Cable test vans and systems



Product overview



Company brochures



Further product information  
is available at:  
[baur.eu/brochures](https://baur.eu/brochures)

