Cable testing and diagnostics

BAUR
ensuring the flow

To ensure the flow

Cost-optimised maintenance through cable diagnostics

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 mains operators emphasise the importance of cable diagnostics as it provides important information on the hidden faults on the systems and, in particular, on the cable network.

Making target-oriented investments
With cable diagnostics you will solve the problem of providing maximum mains availability whilst ensuring minimum maintenance and repair costs. We provide the appropriate tools with our diagnostics systems that make it possible to realise condition-based and cost-optimised maintenance.

Reducing repair costs
Knowledge and understanding of the cable condition make it possible for you to carry out expensive modification and maintenance measures only where they are really necessary. Preventive measures or exchanging unnecessarily long cable routes are now all in the past.

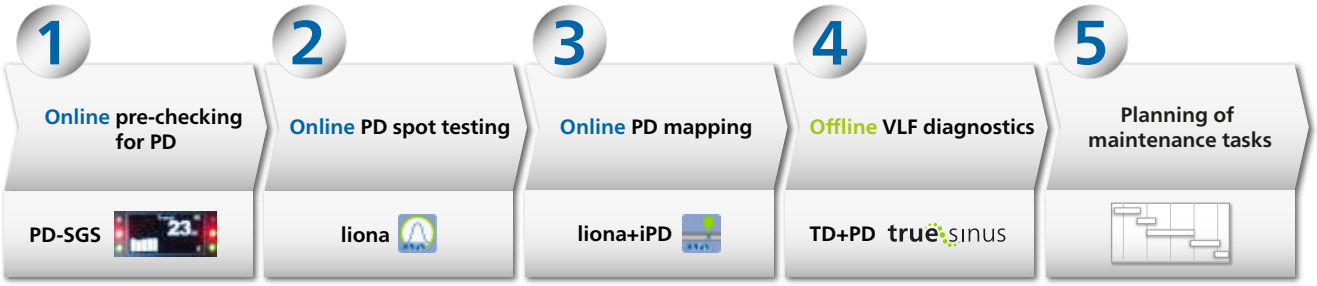
Quality control on new systems
Today, diagnostics procedures are increasingly being used – even on new cable sections – to evaluate the quality of a joint assembly, for example. This can prevent costly complaints or subsequent damage.

↗ The breakdown/fault rate can be decreased and the maintenance costs can be reduced through condition-based maintenance that is based on cable diagnostics.

Wide range of devices for testing and diagnostics

BAUR offers you products that make it possible to quickly and reliably perform cable and cable sheath testing and condition evaluation diagnostics.

From testing devices with AC or DC voltage, from low to high voltage, condition evaluation, online or offline partial discharge detection: BAUR offers you suitable devices and systems for use, in accordance with the applicable standards, on cables, switchgear, isolators, overvoltage arresters, bus bars, transformers and generators.



↗ Example of possible application steps for efficient cable testing and diagnostics based on the combination of various methods and devices

A detailed overview of our product range for testing and diagnostics of mains components can be found on pages 10 and 11.

Meaningful results and standard compliant

Testing and diagnostics in accordance with the standard

Intensive research, international practical experience and an open dialogue with operators and associations have led to the VLF cable testing and diagnostics on medium voltage systems to be recognised by all important bodies, boards and associations. For you, this means that cable and sheath testing as well as diagnostic measurements are effected in a standard compliant manner. 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.

Overview of standards

Testing standards for MV cables	Content	Acceptance tests	Maintenance test
IEC 60502.2-2014 1 kV - 30 kV cables	New IEC standard that describes how to use VLF testing as an acceptance test	VLF testing 3 x U_0, 15 min., 0.1 Hz, TD or PD monitoring recommended	Not covered
Cenelec HD 620 1996, VDE 6 - 30 kV cables	Harmonization document of IEC, VDE European standard for acceptance tests since 1996	VLF testing 3 x U_0, 1 hour, 0.1 Hz	Not covered
IEEE 400-2012 6 - 36 kV cables	Guide for field testing and evaluation of the insulation of shielded power cable systems rated 5 kV and above. Detailed overview on testing and diagnostic methods and technologies	VLF testing: simple withstand test and monitored withstand test	VLF testing: simple withstand test and monitored withstand test
IEEE 400.2-2013	Guide for field testing of shielded power cable systems using very low frequency (VLF). Detailed guide for VLF testing and diagnostics	VLF testing: monitored withstand test, VLF TD diagnostics, VLF PD diagnostics, detailed evaluation criteria	VLF testing: monitored withstand test, VLF TD diagnostics, VLF PD diagnostics, detailed evaluation criteria
IEC 60060-3	Describes the requirements on the characteristics of the VLF wave form	Mandatory, truesinus®	Mandatory, truesinus®
IEC 60270	Describes the measurement of partial discharges	Mandatory	Mandatory
IEC 60229	Cable sheath testing	Recommended for MV cables	Recommended for MV cables
IEEE 433	Recommended practice for insulation testing of AC electric machinery with high voltage at very low frequency	Accepted, VLF testing for rotating machines	Accepted, VLF testing for rotating machines

Compact and powerful – our truesinus® voltage sources

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 offer an ideally formed, low-frequency sine voltage as well as the DC voltage required for the sheath testing.

Highly accurate tan δ measurement
Thanks to the ideally formed truesinus®, you can rely on highly accurate measurements of the tan δ and meaningful results with partial discharge measurement, as well as on 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 δ measurement that is important for the condition evaluation than other usual voltage shapes or frequencies. The ideal, long-waved sine makes it possible to acquire TD measurement results with the highest resolution. With these results, small rises and detailed properties can be recognised and evaluated. With regard to the dissipation factor measurement, the measurement with truesinus® is more sensitive than a measurement with operating frequency.

The advantages of truesinus®

- Load-independent measurement results
- Highest tan delta accuracy
- Reproducible, precise measurements
- Possible to carry out testing and diagnostic measurement in parallel (MWT)
- Short measuring time
- Compact voltage sources

The dissipation factor measurement (tan delta measurement)

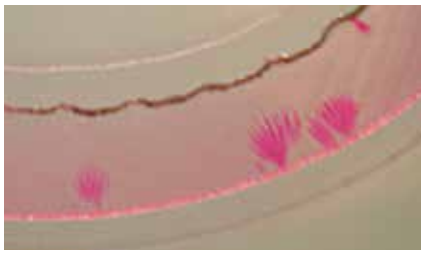
The dissipation factor measurement (tan δ measurement) is a non-destructive and integral procedure that serves to evaluate the condition of an entire cable route. With the dielectric dissipation factor tan δ, the relation of effective power to reactive power of the cable is measured. The measurement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

With the dissipation factor measurement you will discover

- areas in the insulation of XLPE cables that are damaged by water (water trees) which 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 dampness;
- moisture in accessories (joints/terminations) and
- possible partial discharges.

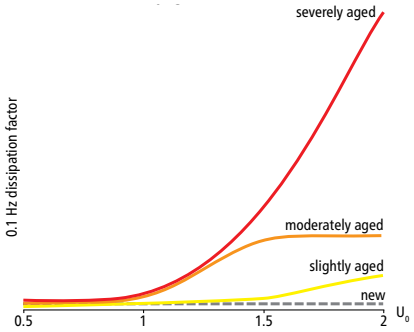
The tangent delta diagnostics process

The tan δ measurement is effected through multiple voltage steps that are provided 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.



↗ Water trees, made visible through colouring

↗ Electrical trees



↗ tan δ trajectory of cables that have aged differently

Evaluation criteria for cables aged through operation according to the IEEE

Condition assessment	VLF-TD time stability (VLF-TDTS) measured by standard deviation at U_0 [10^{-3}]			Differential VLF-TD (VLF-TDT) difference in mean VLF-TD between 0.5 U_0 and 1.5 U_0 [10^{-3}]			Mean VLF-TD at U_0 [10^{-3}]	
	XLPE cables	Paper-insulated mass-impregnated cables		XLPE cables	Paper-insulated mass-impregnated cables		XLPE cables	Paper-insulated mass-impregnated cables
No action required	< 0.1	< 0.1	and	< 5	-35 to 10	and	< 4	< 85
Further study advised	0.1 to 0.5	0.1 to 0.4	or	5 to 80	-35 to -50 or 10 to 100	or	4 to 50	85 to 200
Action required	> 0.5	> 0.4	or	> 80	< -50 or > 100	or	> 50	> 200

↗ Classification of XLPE cables aged through operation and paper-insulated mass-impregnated cables by means of tan δ, selection from IEEE 400.2-2013

Partial discharge measurement

Partial discharge measurement is effected in accordance with standard IEC 60270. Partial discharges (PD) occur at faults in the cable, e.g. at electrical trees, joints and terminations. Amongst other things, the following can be detected through partial discharge measurement:

- Defects in new and old fittings, for example, defective joints or even fittings
- Defects affecting the insulation effect in the insulation of plastic-insulated cables, such as electrical trees
- Insufficient insulation of paper-insulated mass-impregnated cables due to dried-up insulation
- Mechanical damage to the cable sheath

The following properties can be diagnosed with BAUR PD measuring devices:

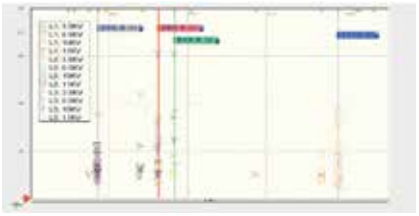
- PD localisation
- PD level
- PD inception voltage / extinction voltage
- PD in cable termination, joints und cables (also mixed cables)

Supporting functions:

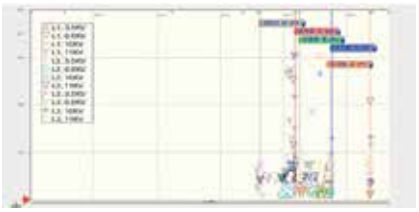
- Phase-resolved display per fault
- PD interference filter function
- Joint localisation

Phase-resolved display (PRPD)

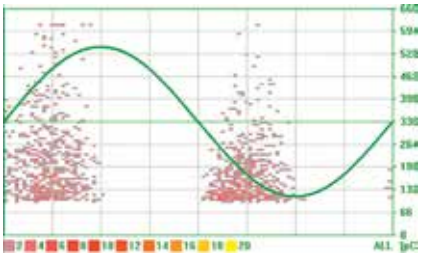
The phasing of partial discharges can be determined through state-of-the-art analysis methods. This makes it possible for you to assign the fault to diverse types of fault and to plan subsequent measurements as well as repair measures in a target-oriented and time- and cost-saving manner.



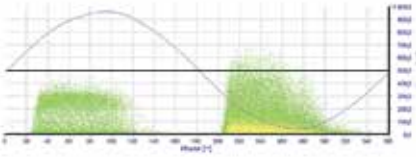
↗ Result of a partial discharge measurement on an XLPE cable



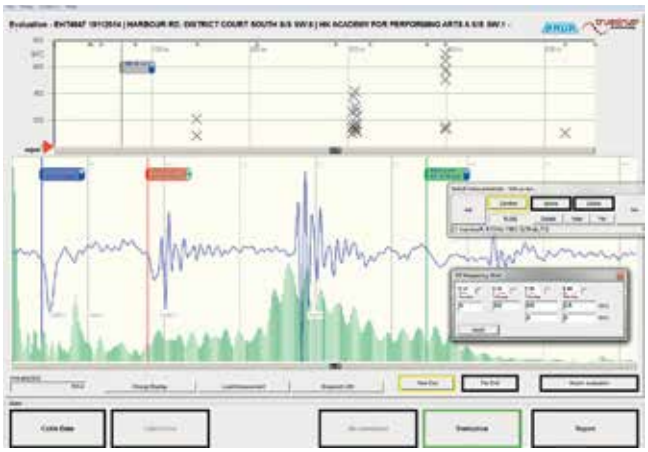
↗ Result of a partial discharge measurement on a mixed cable



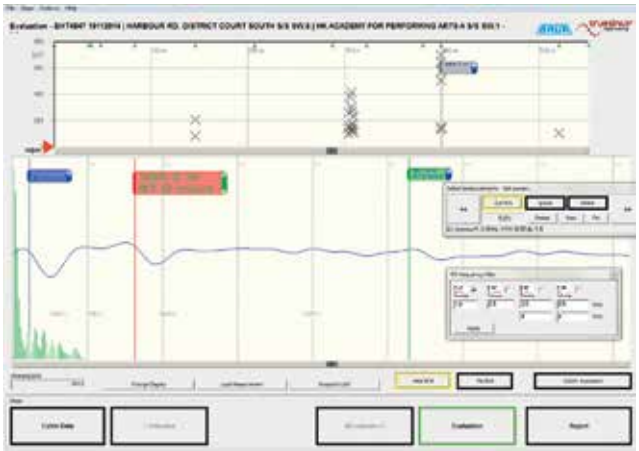
↗ Phase-resolved display of a partial discharge at 0.1 Hz



↗ Phase-resolved display of a partial discharge at 50 Hz



↗ Partial discharge measurement unfiltered



↗ Partial discharge measurement with interference filter function

Combine diagnostics procedures meaningfully

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

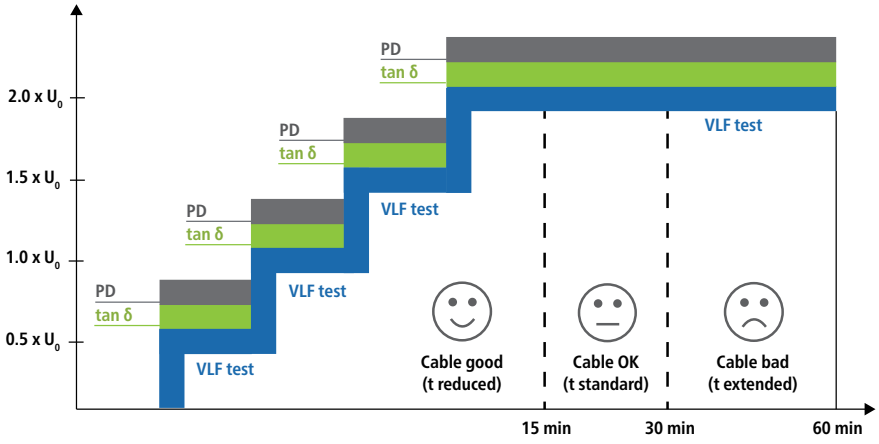
The time-saving combination of testing and diagnostics is known as the Monitored Withstand Test (MWT). The MWT provides significant information for the condition evaluation and allows for the required test duration to be adapted to the cable condition. The combined procedure is approved by the IEEE and recommended as a meaningful measurement method for cable systems aged in operation.

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 build-up stage so that you can get an idea of the condition of the cable; overaged cables are detected and you are able to react in a timely manner to ensure that pre-damaged cables are not unnecessarily exposed to the test voltage.

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 δ. 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 measurement values, the cable testing can be reduced to 15 minutes.

VLF Test + tan δ + PD = Full MWT

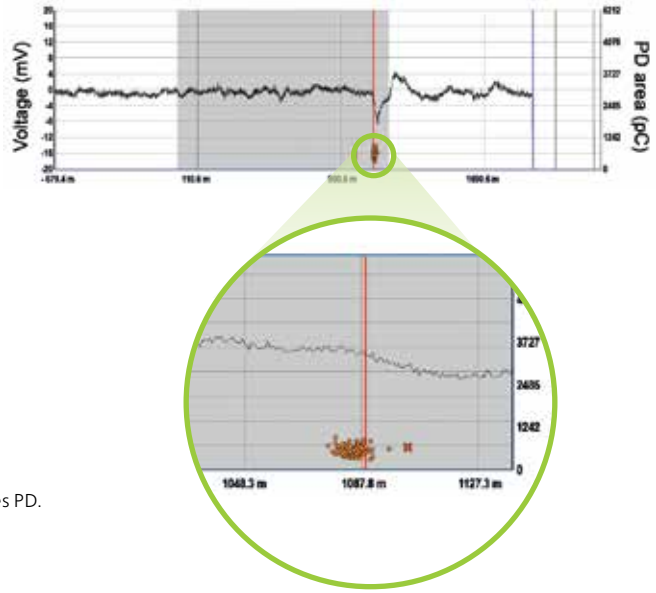


smart✓testing

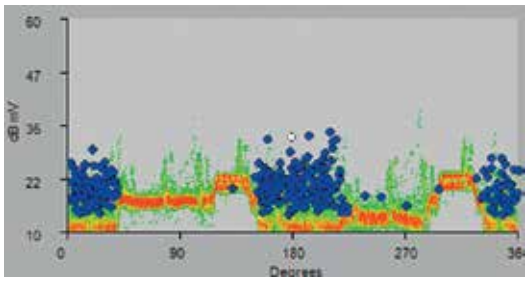
↗ Carrying the cable testing and cable diagnostics out in parallel (with tan δ measurement or partial discharge measurement) in the Monitored Withstand Test saves time and provides valuable information for asset management.

Cable check whilst energised

With the help of the portable BAUR online PD spot tester liona, cables can also be quickly tested, in an uncomplicated manner, 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.



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



↗ Online PD spot testing result: partial discharges are shown in blue

Locate partial discharges with a handheld device

With the PD-SGS, BAUR offers a handheld device for the quick initial detection of partial discharges in switchgear and cable accessories. The device has two safe procedures for detecting partial discharges that can be applied whilst live and without attaching sensors to the cable. Instead, it uses capacitive couplers to detect PD activities occurring along the metal exterior of the switchgear. The second method works acoustically and makes it possible to observe Corona discharges or discharges along insulator surfaces.

↗ PD-SGS for acoustic and capacitive location of partial discharge in switchgear

Overview of our product portfolio

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 cost, and delivers precise statements. This is where the BAUR smart testing best demonstrates its strengths.

↗ VLF tester and diagnostics devices frida/frida TD and viola/viola TD

↗ VLF test generators

↗ Portable PD diagnostics system PD-TaD 60

↗ Partial discharge inductor tracy

Online diagnostics in medium-voltage networks

The liona and PD-SGS measuring devices detect existing partial discharges during normal mains operation in a reliable and cost-saving manner. This initial estimation on the condition of a cable route or switchgear makes effective planning of additional precise offline diagnostic measurements possible.

↗ Online PD spot testers liona

↗ Handheld online PD detector PD-SGS

High-voltage test devices

The PGK series comprises compact DC voltage test devices for electric systems. The tried and tested AC/DC high-voltage test devices in the PGK HB series offer a broader functional scope with continuously adjustable test voltages for DC voltage testing with a selectable polarity up to 260 kV or for AC voltage testing up to 190 kV_{rms}.

↗ DC HV tester

↗ AC/DC HV test set

Technical information and data sheets for each of our products is available at www.baur.eu/testing-diagnostics

Product function matrix

Try our product advisor on our website at:
www.baur.eu/product-advisor

		Application / measurement methods										
		Offline									Online	
	Products	Operating equipment test with AC	Operating equipment test with DC	Cable testing VLF 0.1 Hz sine in acc. 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/mapping, cable length measurement	Handheld online PD detector for switchgear
Testing	DC HV tester PGK 25		■		■							
	DC HV tester PGK 50-80		■		■							
	AC/DC HV test set PGK HB (70-260)	■	■		■							
	VLF testing and diagnostics device frida		■	■	■							
	VLF testing and diagnostics device viola		■	■	■							
	VLF test generator PHG 70/80		■	■	■							
Diagnostics	VLF testing and diagnostics device frida TD		■	■	■	■	■		■*			
	VLF testing and diagnostics device viola TD		■	■	■	■	■		■*			
	VLF test and diagnostics systems PHG 70/80 TD		■	■	■	■						
	VLF test and diagnostics systems PHG 70/80 TD/PD		■	■	■	■		■				
	Portable PD diagnostics system PD-TaD 60					■*	■*	■**				
	Partial discharge inductor tracy									■		
	Online PD Spot Tester liona + iPD transponder										■	
	Handheld online PD detector PD-SGS											■

* ... in combination with frida TD + PD-TaD 60 or viola TD + PD-TaD 60 ** ... in combination with each VLF source
Abbreviations used: MWT ... Monitored Withstand Test, PD ... partial discharge, TD ... tan δ

Professional consultation and service worldwide

We offer reliable service by competent experts and a comprehensive range of services. We are happy to offer assistance in the following areas:

- Technical support for questions on devices, software or applications
- Maintenance and repair of devices
- Calibration and measurement
- Training
- Creation of a diagnostics philosophy

For further information or competent advice, please contact us at: www.baur.eu/services

ensuring the flow

Other BAUR brochures

BAUR company brochure

BAUR product overview

Cable fault location

Cable test vans and systems

Insulating oil testing

Our brochures and manuals are also available online at: www.baur.eu/brochures

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Item No. 821-045 02/16
Subject to modifications.