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PFISTERER

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Jörg Fries

Editorial

Efficient Without Fail

To operate systems safely and efficiently requires not only knowledge, but also experienced users. Our series of special reports on the basics of contact technology really highlighted this issue. The great response we received to that series motivated us to tackle another topic related to safety, hence the new series of special articles starting in this issue of CONNECT (page 6) explaining the crucial aspects to consider when using voltage detectors. This series makes clear that to protect people and systems efficiently, you must start with user-friendly technology. That's why we develop our products with one eye on eventual operating conditions. Good examples of this type of development are our two new products: the voltage detector for HVDC with innovative test engineering (page 4) and the MV-CONNEX socket for extremely compact yet touchproof transformer terminals (page 18).

We hope you enjoy reading this issue and that it can provide some light bulb moments for you to implement in your projects. And when putting these ideas into practice, of course you can rely on our expertise – without fail!

Sincerely,

Jörg Fries

Chief Sales Officer
of PFISTERER Holding AG

HVDC Under Control. With KP-Test 5.

In today's field of electricity supply, the issue of high voltage direct current transmission has a more important role to play than ever before. Voltage testing on HVDC overhead lines and systems is still as demanding as ever too. So to enable transmission system operators and overhead line installers to perform these tests safely and in a user-friendly way, PFISTERER has developed the KP-Test 5 HVDC voltage detector with innovative test engineering.

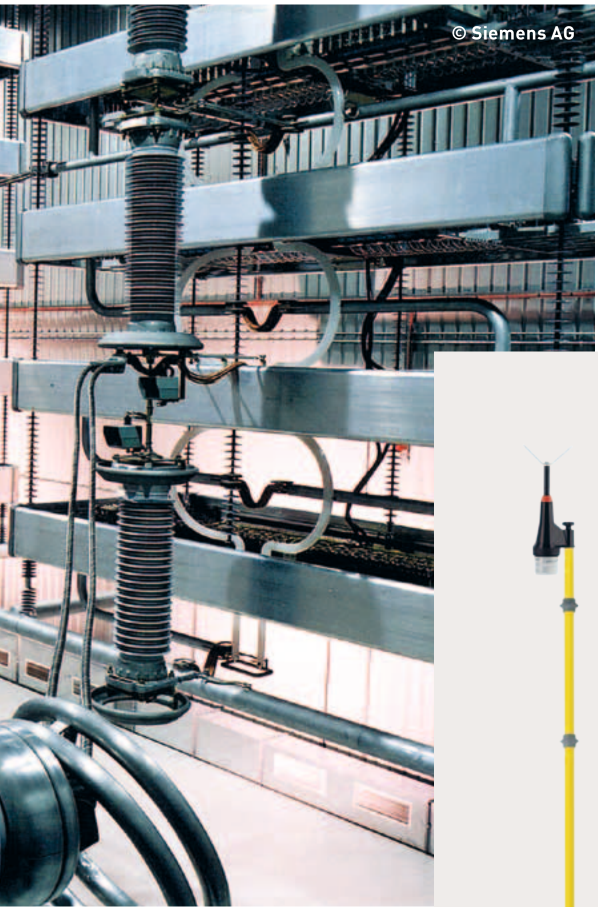
Although since the first attempt was made to transmit direct current long distance from Miesbach to Munich back in 1882 three-phase alternating current technology has won through in many areas of electricity supply, high voltage direct current transmission (HVDCT) remains unbeaten even today in certain applications; for example, if overhead lines need to conduct current over hundreds of kilometers. This is because, at the end of the day, transmission losses on HVDCT routes are lower than with comparable alternating current lines. The longest HVDCT long-distance transmission lines operating in the world include the Inga-Shaba in the Democratic Republic of Congo (1,700 km) and the Southern Hami-Zhengzhou in China (2,210 km), which also achieves the highest transmission capacity to date of 8 GW.

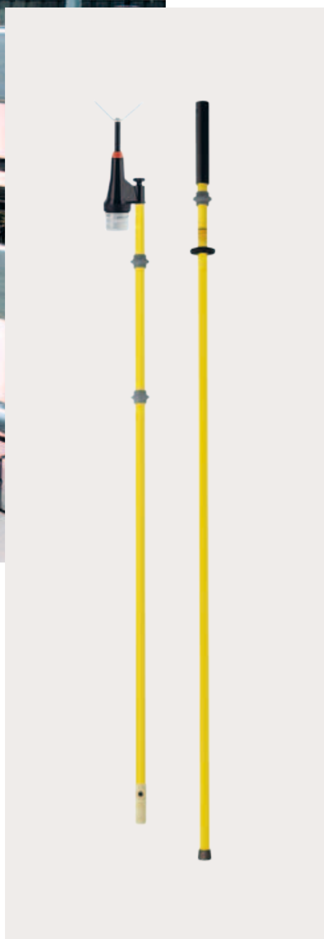
Being relatively small and densely populated, Europe is not home to any HVDCT overhead lines of this magnitude. But attempts are being made to push ahead into new dimensions here too. According to the Grid Development Plan (second draft of 11/04/2014), for instance, at least 3,600 km of new maximum voltage transmission routes will need to be created in Germany by 2024. Over 2,000 km of these routes are assigned to HVDCT corridors alone. At the heart of this planned network expansion are the north-south transmission routes, the longest of which is SuedLink, at over 800 km in total.

The HVDC Challenge

"Not only in the German network, but also in Europe and the world as a whole, a trend toward more and more HVDCT lines is emerging. Just one significant driver of this development is the increased feed-in of power from renewable energies," says Jürgen Finsinger, Product Manager for Safety Equipment at PFISTERER. "The transition to renewable energies in Germany provided a stimulus from several different directions to develop a voltage detector for high voltage direct current systems." But during this process, it became apparent that the voltage test methods in widespread use for HVDC applications encountered problems in practice.

Matthias Pirch, who works in PFISTERER Product Service for Safety Equipment, gives one example: "Even for 400 kV applications, in order to design a safe two-pole resistive voltage detector, one would need to incorporate





Developed for voltage testing on high voltage direct current systems: the user-friendly KP-Test 5 HVDC with an innovative test method.

a bleeder chain capable of being resistant to extremely high voltages. This would make the voltage detector so large and heavy that users would find it very difficult to handle. And that's not the only issue."

"Classic capacitive voltage detectors, on the other hand, are physically unsuitable for use in direct current applications," adds Steffen Jordan, Development Engineer for Safety Equipment at PFISTERER. "That's why we focused our development work on finding a method that would be quite different from standard test methods, which one could use to detect HVDC, and then to produce a device based on that method, which would work flawlessly from a technical point of view and be easy to operate too."

An Innovative Solution

The result of this work is the new KP-Test 5 HVDC voltage detector. Its test method, which has a patent pending, is based on the same principle as a charge detector. When the user makes contact with the contact electrode (IEC) on the part of the system under test, a compensating current flows into the voltage detector once, until the detector has taken on the system potential. The voltage detector's evaluation unit assesses this compensating current in terms of time and intensity (integration). If a defined threshold value is exceeded, the voltage detector indicates that operating voltage is present. If this value is not reached, the device signals that there is an absence of voltage.

The voltage detector must be discharged so it is ready to carry out further voltage testing. With the KP-Test 5 HVDC, this is as simple as can be: You make contact with a part of the system connected to earth and press the ON button at the same time. PFISTERER combines strong visual and acoustic signals to ensure the voltage detector indicators can be seen clearly and heard easily even when lighting is poor and in noisy environments. Further details on this, plus other important aspects to bear in mind when selecting a voltage detector, can be found in the first part of our series of special reports on voltage detectors, starting on page 6.

KP-Test 5 HVDC Voltage Detector

Applications, Features, and Benefits

- For voltage testing on HVDC systems: HVDCT overhead lines and converter stations
- Voltages up to U_m = 320 kV (models for higher voltage levels are under development)
- Tested according to IEC 61243-1
- Strong visual and unmistakable acoustic indicator signals
- Available with comprehensive accessories

Testing Voltage Safely.

When work has to be done on electrical systems, voltage detectors should be used to protect people and systems from electric shocks. Whether or not this safety function will be fulfilled is heavily dependent on how safe and easy the voltage detector itself is to operate. This series of reports, focusing on voltage detectors for 1 kV and above, will look at what international standards have to say on this matter and how requirements are put into practice in various markets around the world. This first part will compare the resistive and capacitive measuring principles, plus it will put two fundamental aspects of voltage detectors under the microscope: self-tests and indicator signals.

When working in and on electrical systems, the "Five Safety Rules" call for voltage testing, among other things (Figure 2). Numerous models of voltage detector are available on the market to carry out such tests (Figure 3). Which models are preferred varies around the world. Over the course of the series of reports, examples of preferred models and differences between them will take the situation in German-speaking countries as the starting point, then look further afield toward Europe and other continents.

As far as standards are concerned, the requirements which voltage detectors must meet are laid down in the internationally applicable IEC 61243. The series of reports focuses on the first two parts of this standard: capacitive voltage detectors (Part 1) and resistive voltage detectors (Part 2) for alternating voltages of 1 kV and above, which clearly indicate by means of visual and/or acoustic signals whether the parts of the system under test are still carrying operating voltage or not. Direct voltage detectors will be dealt with too. Since no standard exists for such detectors and combined direct/alternating voltage detectors are often required, in practice Part 2 of IEC 61243 is "borrowed" for DC voltage detectors as well.

Figure 1: Voltage detector in a special case for transporting it safely to the working place.

Figure 2: To prevent electric shocks, many countries have regulations, the essence of which is summarized in the internationally recognized "Five Safety Rules". A translation of the German version from DIN VDE 0105 is depicted on page 7 (text graphic). The majority of the accidents reported in Germany from 2007 to 2011 can be attributed to noncompliance with rules 1 (23.6%), 3 (8.7%), and 5 (11.8%) (source: Berufsgenossenschaft Energie Textil Elektro Medienerzeugnisse (the employers' liability insurance association for the power, textiles, electrical, and media products industries) 2014).

	Class S			Class L
	AC	AC	DC	AC
	Capacitive measuring principle	Resistive measuring principle		Capacitive measuring principle
	Primarily connected design			Primarily separate design
Medium voltage 1 – 36 kV	Substation (inside) Transformer Overhead line Railroad applications	Combination of industrial / railroad applications		Overhead line
High voltage 36 – 765 kV	Substation (outside) Transformer Overhead line	-	-	Overhead line

Figure 3 provides an overview of voltage detectors in common use internationally for 1 kV and above, according to widespread applications.

5 Safety Rules

Before commencing work
- Disconnect the system from the electricity supply
- Secure to prevent unintentional switch-on
- Establish the absence of voltage
- Connect to earth and short-circuit
- Cover or screen off adjacent live parts

Detailed Info 1: Contents of the Series of Reports on Voltage Detectors for 1 kV and Above

Part 1
- Basic assessment of the **resistive and capacitive measuring principles** with conclusions regarding the use of resistive and capacitive voltage detectors from a practical point of view: influences of insulating elements and electric interference fields, advantages and disadvantages
- Normative and practical requirements of **self-test equipment and indicator signals**, plus examples of various types of implementation based on commercially available voltage detectors

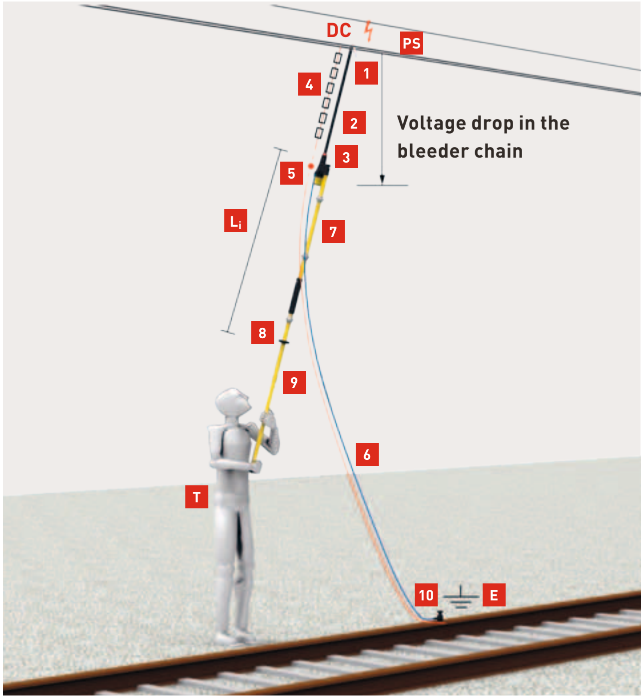
Part 2
- Comparison of **class S and L** voltage detectors: significant design differences and resulting problem areas, as well as regional preferences around the world regarding the use of **substations and / or overhead lines**
- Comparison of voltage detectors with **connected and separate constructions:** potential sources of error when using separate insulating poles, distribution across markets

Part 3
- **Application-specific special features** in
- **Medium voltage:** use of fork electrodes in indoor substations, false indications for applications on coated rails, voltage detectors with multi-range capability
- **High voltage:** distance voltage detectors for overhead lines, solutions for HVDC applications, etc.

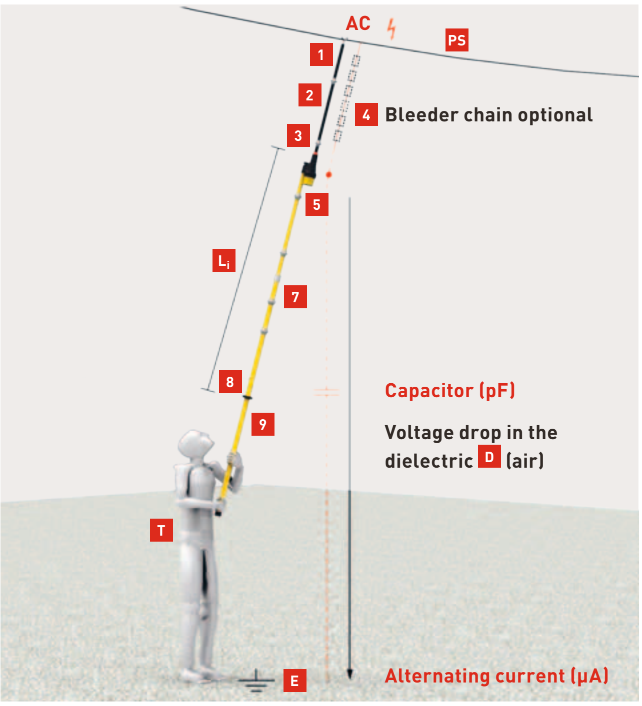
Part 4
Application-specific special features when using voltage detectors in the **railroad sector:** hook electrode, voltage detectors for feeders, third rail as special solution for DC applications, switch-on problems due to interference fields, solutions for mixed systems (railroad stations with DC and AC).

Part 5
Care and maintenance of voltage detectors, plus test methods used for **in-service tests.**

Voltage testing with a
resistive voltage detector for 1 kV and above



Voltage testing with a
capacitive voltage detector for 1 kV and above



Key

- 1 Contact electrode (IEC) (first pole)
- 2 Contact electrode extension (IEC)
- 3 Limiting mark/red ring
- 4 Bleeder chain (resistive element)
- 5 Indicator with evaluation electronics
- 6 Connecting cable
- 7 Insulating pole
- 8 Hand guard
- 9 Handle
- 10 Magnetic contact (second pole)

- PS Part of the system under test
- E Earth connection
- D Dielectric
- L_i Length of the insulating part
- T Tester

Voltage testing with an
LV voltage detector

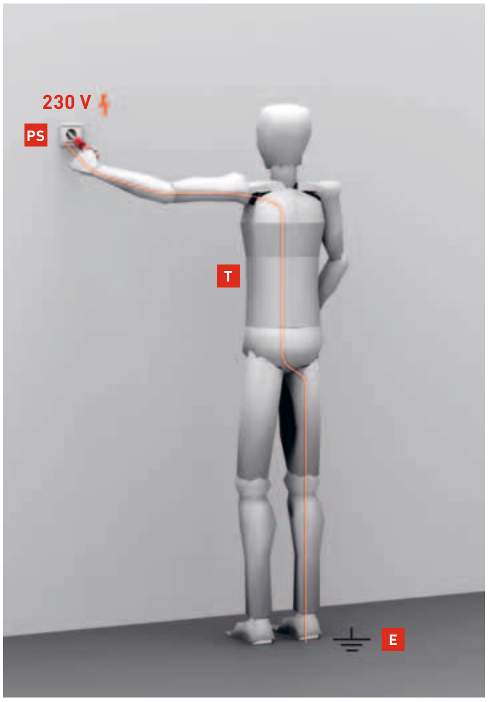


Figure 4: The two graphics on the left, top and bottom, show how the resistive and capacitive measuring principles work, their most significant differences, and the most important elements of resistive and capacitive voltage detectors for voltages of 1 kV and above. In addition, the graphic at the center right depicts how voltages are tested using an LV voltage detector. Details of the graphics are given in the report on page 9 on the right.

The following basic assessment of the capacitive and resistive measuring principles, structured in line with the IEC 61243 standard, provides initial information about the technical features which are crucial in ensuring that voltage detectors are safe and easy to use, and about the resulting possibilities and limitations with regard to their operation.

A. Resistive and Capacitive Measuring Principles

Both the capacitive and resistive measuring principles are based on processes that are incredibly straightforward to specialists trained in electrical engineering: For a voltage detector to be able to assess whether operating voltage or residual voltage is present at the part of the system under test, current must flow through the evaluation electronics in the indicator (page 8, graphics on the left, number [5]). To this end, the voltage detector creates a current path from the part of the system [PS] to the earth connection [E]. The test current must be kept as low as possible in order to protect the user and the device.

With resistive measuring (page 8, graphic at top left), this is achieved via the resistive element [4], a bleeder chain, which is installed in a resistive voltage detector between the contact electrode (IEC) [1] and the indicator [5]. The test current flows from the indicator to the earth connection via a connecting cable [6] and the second pole [10].

The familiar single-pole "phase tester" for domestic sockets (page 8, graphic on right) works resistively too. In this case, the connecting cable is replaced by the tester [T].

With a capacitive voltage detector (page 8, bottom graphic), a bleeder chain may also be incorporated, depending on the model, but here the current path runs not through the user to the earth connection, but through the air. As part of an invisible capacitor, the air forms the dielectric [D] between the indicator [5] and ground potential [E]. Since it is known that a capacitor is able to conduct alternating current, such a current of just a few μA flows from the indicator to the earth connection through the air – hence the name "capacitive" voltage detector.

Irritating Insulation?

This approach to the two measuring principles answers one question that users keep discussing over and over again: Do insulating environmental influences or the use of insulating tools affect the measurement? For voltage detectors used at over 1 kV, the answer is "no". No matter if the user is standing on a wooden pole, wearing insulating gloves, and using insulating mats while performing voltage testing, in both cases the electric circuit will not be completed via the user, but via either the connecting cable (resistive MV voltage detector) or the air (capacitive voltage detector). This means that factors which have an effect on people cannot influence voltage testing.

Interfering Electric Fields?

This depiction of the measuring principles also shows how prone they are to incorrect measurements resulting from interference fields. IEC 61243, Part 1 defines an interference field as an "interfering electric field, which can influence the indicator. It may arise from the parts of the system under test or other, neighboring parts and have any phase position."

With resistive measuring, such interference fields have no significant effect on the test result. The test current which flows through the voltage detector's indicator fluctuates in the mA range, so is relatively large in relation to the potential influences of electric fields from neighboring parts of the system. Conversely, these are too small to affect the evaluation electronics of the voltage detector and, consequently, the measurement result.

However, this is not the case with capacitive voltage testing, where the test current which flows from the indicator to the earth connection via the air only reaches values in the low μA range, so is much smaller. This means it is much easier for the electric fields of neighboring systems to interfere with the test current. It then becomes difficult for the evaluation electronics to clearly distinguish the test current from the influences of the interference field. But there is a proven solution to this problem: use a contact electrode extension (IEC) (number [2]), which means the voltage detector's indicator will remain outside the interference field during testing (details to follow in the second part of this series of reports, which will compare class S and class L voltage detectors, among other things).

Detailed Info 2: References to Standards and Terminology Used

- References to IEC 61243 relate to the German versions of the standard: EN 61243-1:2005 + A1.2010 for Part 1 and EN 61243-2;1997 + A1:2000 + Corrigendum A2:2002 for Part 2
- Voltages from 1 to 36 kV are referred to as medium voltage (MV), all voltages above that are high voltage (HV)

Alongside this general assessment, there are also other application-specific aspects of the effects of interference fields to consider, such as when a class S voltage detector is appropriate or special factors to take into account regarding railroad applications. These will be looked at in more depth in upcoming reports (see page 7 for a preview).

Figure 5: When voltage testing with a capacitive voltage detector, the user only has to make contact with one part of the system.

Advantages and Disadvantages of the Measuring Principles

If nothing else, an assessment of the measuring principles highlights the basic advantages and disadvantages of using resistive and capacitive voltage detectors. The conclusions are verified by users from numerous countries all over the world.

One Pole or Two?

One advantage of capacitive voltage testing is that it is performed with a single pole (Figure 5). With the voltage detector, the user has to make contact with only one point on the part of the system under test, so can concentrate on just one place. This is different to resistive voltage testing, where two points have to be contacted simultaneously: the part of the system and the ground potential (Figure 6). Depending on the system configuration, it can prove very awkward to make contact with two measuring points at the same time, making it more likely that mistakes will be made in performing the test.

One Cable or None?

If capacitive voltage detectors are handled correctly, it is almost impossible to come into contact with their live parts during voltage testing. These parts are the contact electrode (IEC) and the indicator plus, for class S voltage detectors, the contact electrode extension (IEC) (page 8, graphics on the left, number [2]). The insulating pole keeps the user a safe distance away from all these components, provided that the minimum insulating clearance between the limiting mark and the hand guard, as specified in the relevant standard, is complied with ([L_i] (page 8, graphics on the left); further explanations will follow in the second part of this series of reports).

This is not the case for resistive voltage detectors where, in order to be able to test the voltage, one always needs an earth connection. As has already been explained, with resistive voltage detectors this is achieved via a connecting cable and a second pole. Depending on the position of the part of the system under test and the way in which the voltage detector is used, the connecting cable may come into contact with the user. If the cable insulation is damaged, one could come into contact with voltage. Users are always aware of this, even though the resistive element would restrict the current to a safe value. It's no coincidence that users get an uneasy feeling if the connecting cable breaches the safe distance established by the insulating pole – this is a not insignificant psycho-

Figure 6 shows a standard instance of two-pole resistive voltage testing in the railroad sector. The voltage detector's second pole is secured to the rail in the form of a magnetic contact.

logical moment, which cannot occur when using a capacitive voltage detector. This is another reason why it is relatively rare to encounter resistive voltage detectors in AC applications.

Niches, Limits, & New Ideas
However, there are some good reasons for using resistive voltage detectors. They are well established for DC applications in the medium voltage range, since direct voltages physically cannot be measured according to the capacitive measuring principle (see Detailed Info 3). Typical fields of use are, for example, DC railroads (S-Bahn suburban and U-Bahn underground railroads, older railroads in many European countries) and industrial plants (filters, frequency converters). Models that come recommended for such applications, which realize integrated user safety efficiently, are available all over the world.

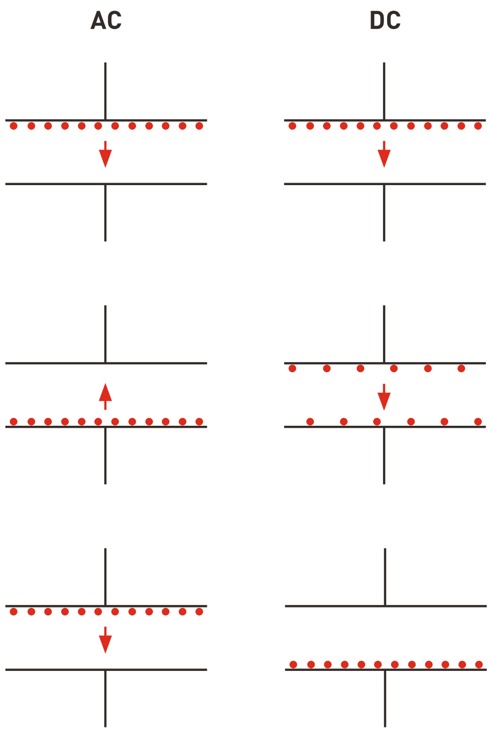
When it comes to other potential fields of application, such as high voltage direct current transmission, the resistive principle comes up against practical limits due to the high voltages involved. A non-resistive single-pole voltage detector for HVDC has been developed as a pioneering alternative (details can be found in the report starting on page 4. Other special features of HV applications will be dealt with in the third part of this series of reports).

B. Self-testing: Does the Voltage Detector Work?
Voltage detectors have to meet certain requirements, regardless of the measuring principle used. To ensure they can be relied upon, Parts 1 and 2 of IEC 61243 call, among other things, for self-test equipment to be provided either as a built-in or an add-on unit, which the user can employ to check the functionality of voltage detectors.

Any restriction in relation to the corresponding standard requirements must be clearly stated in the operating instructions. The various ways in which these standard provisions are implemented can be seen in the following examples of commercially available voltage detectors from different manufacturers.

Detailed Info 3:

In capacitive measuring, a capacitor is alternately charged and discharged thanks to the constantly changing direction of the alternating current. With direct current, on the other hand, charge carriers only flow in one direction; inside a capacitor, this would be from the indicator of the voltage detector (conductor 1) to ground potential (conductor 2). As soon as the capacitor is charged, the flow of current stops. The charging operation takes just microseconds and does not generate an electric signal that would be suitable for evaluation via a capacitive voltage detector.



Passive Voltage Detectors Without a Self-test

One of the oldest solutions available has neither an ON button nor a battery, so it does not have integrated self-test equipment either. If operating voltage is present, a lamp on the voltage detector simply lights up. The only power for this visual indicator comes from that drawn from the part of the system under test. This causes two problems for users: If the lamp does not light up, uncertainty remains. Why has no signal appeared? Because the system really is at zero potential? Or because the voltage detector is faulty? Self-test equipment would be helpful here. But on these models it cannot be built into the voltage detector; without a battery it is lacking the necessary power source.

PRACTICAL TIP:

In order to ensure battery-operated voltage detectors for 1 kV and above can be relied upon to be in standby (ready for operation), the use of lithium batteries (1.5 V) is recommended. They do not run out and continue to work reliably even at low temperatures, thanks to their low level of self-discharge and high capacity. Their long service life means that, with normal use, there is no need to replace the battery between in-service tests, which are scheduled every six years. Conventional alkaline batteries (type AA, LR6) can be used too, but their service life is usually shorter, which may mean the battery has to be replaced more frequently.

In such circumstances, a reference measurement must be taken (see IEC 61243-1, Annex B). To this end, a reference voltage is required from another part of the system where it is known operating voltage is present. But even aside from these factors, this procedure no longer reflects the state of the art: The brightness of the lamps is usually very low on such voltage detectors, making them difficult for the user to see. The previously understandable argument that devices with batteries would not be reliably ready for use has been confounded by technological progress. Batteries nowadays have really long lives. Those which are recommended for use in voltage detectors are described in the Practical Tip at the bottom left of this page.

External Test Devices With a Piezo Element

One may come across external test devices used as tools in certain markets. These generate a test voltage via a piezo element, which is then brought to the contact electrode (IEC) of a voltage detector. But this too is bound up with uncertainty: How does one generate a defined test current with two single-pole devices? Even if one can answer this particular question, this laborious method does not seem reliable. The test signal emitted by the piezo element has a high frequency and the voltage detector responds completely differently to this than to the line frequency for which it has been designed.

Standby Voltage Detectors With a Self-test

Standby models with an automatic ON function and integrated self-test are associated with similar problems to passive voltage detectors without a self-test: If operating voltage is present, the voltage detector switches on automatically and indicates an operating voltage. But what if the device stays switched off? Once again, safety-related questions must be answered. Is there really no operating voltage present? Or is the device not working? At least with this type of voltage detector the integrated self-test saves the hassle of taking a laborious reference measurement. However, the user is not completely safe: The absence of a mandatory sequence to follow when operating the voltage detector can put him in danger. If the user relies on the automatic ON function, so does not perform a self-test by pressing the ON button after identifying an "absence of voltage", any fault with the voltage detector or an empty battery will not be detected.

Voltage Detectors to Be Switched On With an Active Self-test

None of these uncertainties come into play when using voltage detectors with integrated active self-test equipment. These can only be switched on by the user pressing a button. Such devices also perform a self-test automatically (Figure 7). If the result is negative, the voltage detector does not enter standby (become ready for operation). So, the device "forces" the self-test before voltage

Figure 7: The self-test equipment of a voltage detector for 1 kV and above tests the function of the evaluation unit, the battery status, and the electrical connection via the contact electrode extension (IEC) to the contact electrode (IEC) and back. If one of the elements is faulty or the connection is interrupted, the voltage detector will not enter standby.

testing can be performed (Figure 8), thus helping to prevent accidents.

Optimum Test Scope?

The scope of the self-test differs according to model and manufacturer. The maximum scope covers all electric circuits, including the contact electrode extension (IEC) for class S voltage detectors. In this case, the voltage detector's electronics send a test signal as far as the contact electrode (IEC); from there, the signal takes the same path as the voltage to be measured during voltage testing. If the signal reaches the evaluation unit in the indicator correctly, the voltage detector is reported as being ready for operation (in standby). If the returning signal is not detected or is found to be faulty, the voltage detector does not enter standby. This also explains why voltage detectors with an integrated self-test cost more on average than those without: Because the test voltage not only runs from the contact electrode (IEC) to the indicator, but first has to reach there from the battery, a double bleeder chain is required.

As is always the case when extra costs are involved, it is only fair to ask whether a full self-test is really necessary. It definitely makes sense when dealing with medium voltage, as if the bleeder chain in the voltage detector is interrupted because a resistor fails or the wire between two resistors breaks to create a clearance of just millimeters, the voltage may be too low to be able to bridge the gap. It's different with high voltages, where such an interruption would have hardly any impact. It is not

Figure 8: The latest voltage detectors with a built-in active self-test function offer the safest and most user-friendly way of performing a self-test. This image shows a KP-Test 5 model signaling via a lit green LED that a self-test has returned a positive result: the voltage detector is working and ready for operation.

usually possible for gaps larger than a few millimeters to arise, since the inside of the contact electrode (IEC) is filled with compound, so the resistors are embedded in plastic. However, one need only look at the rough service conditions often experienced in practice to see that fine wire breaks can occur. For example, if a toolbox is chucked into a van with some force, a voltage detector in the box can sustain quite an impact.

To ensure that daily use does not adversely affect function in this or any other way, every voltage detector must prove its durability by means of a type test. Type tests performed according to Parts 1 and 2 of IEC 61243 comprise mechanical tests, including those relating to vibration stability, resistance when dropped, and impact resistance.

C. Visual and Acoustic Signals
The design of the indicator signals is crucially important to the functional reliability and user safety of voltage detectors too, irrespective of the measuring principle used. According to IEC 61243-1 and IEC 61243-2, a voltage detector must indicate the test result "clearly." To this end, the status indicators "voltage present," "voltage not present," and "standby" can be combined in different ways. They can be shown via visual and/or acoustic signals, which can be "discerned with absolute certainty" "in the operating position" and under "standard" conditions in terms of visibility and noise.

But real-life circumstances present challenges for the devices time and again, as can be seen in practice around the world. Voltage detectors for high voltage applications, for example, need large insulating clearances, which are created with the help of long insulating poles (details to follow in the second part of this series of reports). But this increases the distance between the user and the indicator too. Not only can this weaken the impact of visual signals, if the user is standing on the mast during voltage testing, an unfavorable tail wind can also "carry off" the acoustic signal. So one comes across known obstacles regarding sight and sound in practically every working place one can think of (Figure 9): On building sites, railroads, and industrial plants, it is often noisy, while if the parts of the system under test are difficult to access, a poor angle of view toward the indicator can impair perception. Even bright daylight can be a problem if it's blinding.

It's not for nothing that the signals of voltage detectors are being constantly optimized. Today, voltage detectors with a strong visual indicator are widespread, whereby the number, intensity, layout, and construction of the lamps are used as leverage to achieve the best possible visual effect. Unmistakable acoustic signals have now become the state of the art too. To ensure that users are equipped for various application situations, it is recommended to combine visual and acoustic signals in one device (Figure 10), taking the potential interference factors into account.

D. Conclusion and Outlook
Just these initial assessments of the measuring principles and basic functional elements of voltage detectors for medium and high voltage show us that even though standards and the application in question determine which voltage detector should be used in many respects, there remains a certain room for maneuver when it comes to selecting a model. Safety and ease of use are fundamental reference points in making this choice. The more risks that typically arise during operation which a voltage detector's concept can exclude, the more reliable it is in protecting people and systems. Which special considerations must be taken into account when choosing between class S or L voltage detectors and between a connected or separate construction, will be explained in the second part of this series of reports.

Figure 9: When performing voltage testing on overhead lines, atmospheric turbulence can "carry off" acoustic indicator signals. Very bright sunlight can blind users equally whether they are in an elevated position or on the ground. These and other unfavorable environmental influences are not uncommon during voltage testing, which explains the crucial importance of signal design with regard to voltage detectors.

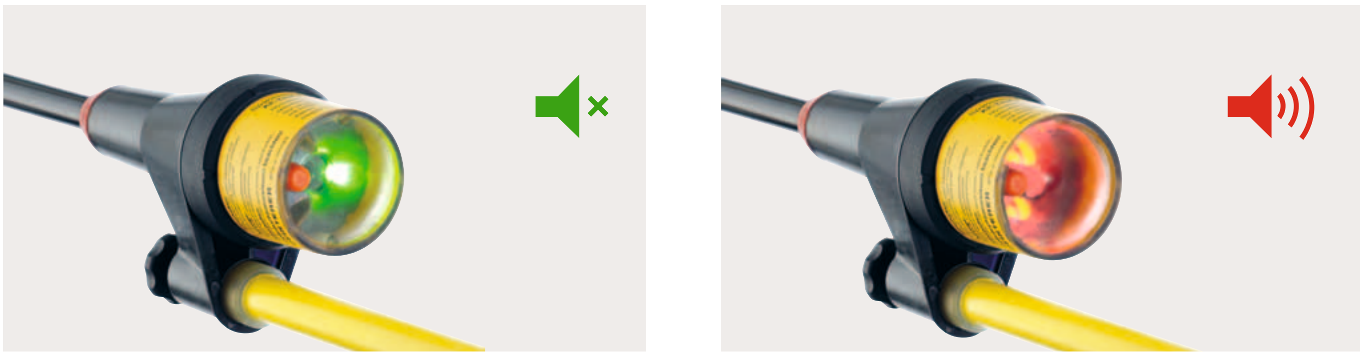


Figure 10: A clear status indicator is a basic requirement for using voltage detectors safely. Their design varies from manufacturer to manufacturer, since the applicable standard specifications leave room for interpretation when it comes to implementing them. Depicted here is a solution which combines visual and acoustic indicator signals as follows: If there is "no operating voltage present," the KP-Test 5 model shown emits a continuous green light with no beep tone when contact is made with the conductor. However, if there is an "operating voltage present," six red LEDs flash and an intermittent beep tone sounds.

Breaking New Ground in Railroad Earth Connections

New earthing and short-circuit devices for railroads are setting new standards for short-circuit withstand currents. The new products, which have been successfully tested, complement PFISTERER's varied and proven range of safety equipment for all users who have particularly high demands on safety.

The new earthing and short-circuit devices stand out from the crowd thanks to their high short-circuit withstand current: They can reliably withstand a short-circuit current of 40 kA/100 ms with a peak of 100 kA in the initial phase. This was verified in the summer of 2014 by an independent test lab.

A special solution was needed to ensure that the earthing and short-circuit devices remain securely seated even at these peak values. In Switzerland, screw-on earthing and short-circuit devices are used on feeders, although not for railway catenaries. "Every national railroad system has its own requirements," says Reto Aeschbach, Head of Sales at PFISTERER SEFAG AG. "So our engineers designed a contact wire hook, which can be flexibly attached when making conventional earth and short-circuit connections."

Safe in the Event of a Short-circuit. Strong on the Contact Wire.

The hook is easy to attach and does not require any additional fastenings. The special shape of the hook ensures that it holds and makes contact reliably. No matter how the railway catenary moves in response to the short-circuit current, the hook cannot fall off or lose contact with the catenary.

The first widespread use of the new earthing and short-circuit devices in the field began in Switzerland. The Swiss Federal Railways (SBB) put out an invitation for bids for a seven-year general contract according to the criteria of the General Agreement on Tariffs and Trade (GATT) concerning the supply of safety equipment. Alongside the new earthing and short-circuit devices, PFISTERER also offered classic earthing and short-circuit sets for feeders, as well as voltage detectors from the KP-Test 5R series, which have already proven how user-friendly and reliable they are over many years of use in the field. The complete bid package was accepted in 2015. "This contract not only confirms just how practical our products are," says Aeschbach in summary. "It is also a clear signal of how strong we are when tested against global competition."

«This contract not only confirms just how practical our products are. It is also a clear signal of how strong we are when tested against global competition.»

Reto Aeschbach
Head of Sales at PFISTERER SEFAG AG

Versatile Safety Equipment From One Supplier

From 2015, SBB will purchase the following annual guideline volumes from a single supplier: PFISTERER.

Earthing and Short-circuit Devices

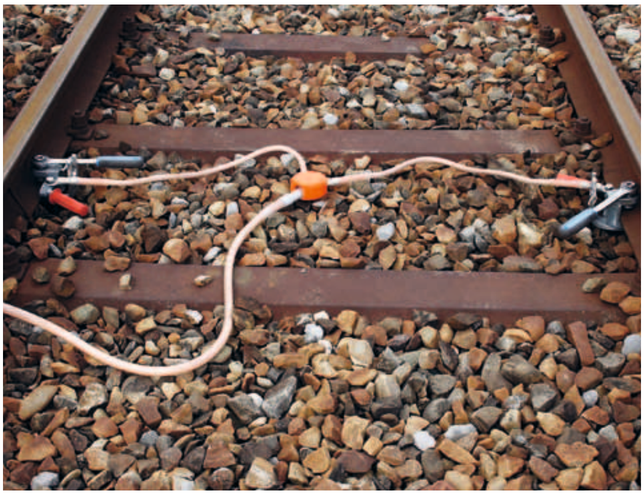
- 160 units with special contact wire hooks, 2-part for on-site provision in insertion boxes
- 80 units with special contact wire hooks, 3-part for variable working places
- 50 units for feeders, 1-part, telescopic

Voltage Detectors

- 60 units KP-Test 5R 15 kV/16.7 Hz, 2-part
- 20 units KP-Test 5R 15 kV/16.7 Hz, 5-part
- 5 units KP-Test 5R 25 kV/50 Hz, 2-part

Load-bearing rail earthing clamps ensure that the earthing and short-circuit set is held securely on the track.

Once the earthing and short-circuit set has been installed, an orange flag on the earthing pole (IEC) indicates that maintenance work is being carried out and signals the prohibited area.



Earthing and short-circuit set once attached to the rail.

The trend toward ever more compact substations calls for new solutions. To achieve space-saving, touchproof cable terminations on power transformers (IEC), PFISTERER has developed the transformer terminal clamp for 52 kV with a vertical outgoing feeder for four cables. This latest addition to the proven MV-CONNEX system not only brings brand new benefits with it, but also offers all the features for which its predecessors have been so prized for several decades.

"The need for compact cable terminations is springing up wherever the little floor space available for systems is limited, such as in offshore stations and substations incorporated into buildings," says Christian Späth, CONNEX Product Manager at PFISTERER. "If these systems are located on several levels, the MV cables to be connected to the transformer can protrude from the top. The new CONNEX socket is perfect for complex system configurations of this type. It enables the cables to be introduced vertically, four of which can be inserted in a compact fashion, at the same time."

This application is becoming more and more common and to find out why, one needs only look at current developments on global energy markets. Today, more people live in towns and cities than in rural areas. By 2020, it is predicted the world will be home to 27 megacities with over ten million inhabitants each. Thanks to this process of urbanization, substations are advancing into densely populated areas. The share of power created from offshore wind energy is on the rise too: In December 2013, the global front-runner was Great Britain, with a generating capacity of around 3,700 MW. China wants to increase its capacity to 30 GW by 2020. Japan's first floating megawatt-class wind turbine started operating in 2013 off the Nagasaki coast. In the USA, numerous ministries are supporting the development of offshore wind parks off the US coast by releasing areas and providing millions of dollars in investment.

Efficient Once Installed

"In demanding environments such as these, compact, fully insulated solutions have clear advantages over outdoor systems. They save valuable installation space, protect people, and are resistant to environmental influences, which helps to ensure trouble-free and safe operation," says Peter Müller, Sales Project Manager at PFISTERER. "In developing the new straight transformer bushing we also took other application-specific factors into account,

Compact Transformer. With New MV-CONNEX Connection.

«The need for compact cable terminations is springing up wherever the floor space available for systems is limited, such as in offshore stations and substations incorporated into buildings.»

Christian Späth
CONNEX Product Manager at PFISTERER

Proving its worth in operation: Like all MV-CONNEX components, the MV-CONNEX elbow bushing for connecting up to four MV cables to transformers horizontally (on the left in the photo) is touchproof and resistant to environmental influences.

A forward-looking newcomer: In substations with several levels where space is at a premium, the new straight MV-CONNEX transformer bushing enables up to four cables to be connected vertically in a way that saves space and is touchproof. The first customer project using the new bushing has already been realized in Switzerland.

which are very important when it comes to safeguarding efficient operation once the socket is installed."

Carmen Mertens, a member of the CONNEX Product Management team, describes two examples: "The length of cable screens is restricted. If the cable outlet is axially to the bushing, the classic earthing connection directly on the transformer cover plate is difficult. To enable fitters to establish the earth connection easily and flexibly regardless of this circumstance, all four sides of the straight CONNEX bushing feature three transition points. What's more, a voltage tap has been integrated into the bushing in order to test for absence of voltage."

MV-CONNEX Cable Termination System

Applications

- Connection of transformers and substations via cables
- Nominal current up to I_n = 1,250 A
- Maximum operating voltage U_m = 52 kV
- Cu or Al cable of 25 to 1,000 mm^2

Features & Benefits

- Touchproof, as fully insulated
- No partial discharges or risk of leaks thanks to solid insulation
- Metal housing for high mechanical integrity
- Maintenance-free for indoor and outdoor applications
- Suitable for offshore use, as saltwater-proof and submersible
- Compatible with EN 50180/EN 50181
- Dry plug-in type with no laborious gas or oil work
- Quick and simple to install
- Pre-tested in the factory
- Type-tested in accordance with DIN VDE 0278-629-1
- Integrated voltage tap
- Comprehensive accessories: surge arrester, test adapter, etc.

Pioneer for Pioneers

Just like the MV-CONNEX system as a whole, this new product is characterized by its reliability and relevance for practical applications. All components feature solid insulation, so there is no chance of leaks, partial discharges are nothing to worry about, and there is no need for maintenance. "Overall, the straight transformer bushing provides a high level of efficiency and operational reliability, which you can really trust," says Karl McFadden, Applications Specialist for Cable Systems at PFISTERER." Because even though it is a new product, it is based on a system that is tried and tested, and has helped to shape standards."

The MV-CONNEX system was patented and launched on the market in the 1970s. At the time, it was the first dry plug-in type system that enabled cables to be connected to transformers and substations directly and in a touch-proof manner without the need for an additional cable terminal box. MV-CONNEX quickly established itself in German-speaking countries as the pioneering alternative to uninsulated connection variants. The direct predecessor to this new straight socket has been in use for 30 years: with its elbow design, it allows multiple cables to be connected horizontally. In 2010, CONNEX became the first system of its kind to receive official certification of its suitability for offshore use, issued by Germanischer Lloyd (now known as DNV GL), one of the world's leading classification societies for the maritime industry.

"The history of cable terminations can be traced through the continuous further development of the CONNEX system," continues McFadden. "Its benefits continue to impress plant operators to this day. And when consulting with such operators, we can fall back on the experience we have gained in hundreds of different projects. It's not for nothing that pioneering projects both onshore and offshore are realized with CONNEX components."

This detailed image of the MV-CONNEX elbow bushing shows just how little space is needed to install up to four MV cables with one connection to transformers – without a terminal box and fully insulated.

Three transfer points are integrated on all four sides of the new straight MV-CONNEX transformer bushing to enable cables connected vertically to be connected to earth flexibly and easily. Shown here is an earth connection variant linking one cable and three dummy plugs.

Straight MV-CONNEX Transformer Bushing

Applications

- Connection of up to four cables, dummy plugs, and/or surge arresters to transformers
- Nominal current up to I_n = 3,150 A
- Maximum operating voltage U_m = 52 kV
- Cu or Al cable of 25 to 1,000 mm²

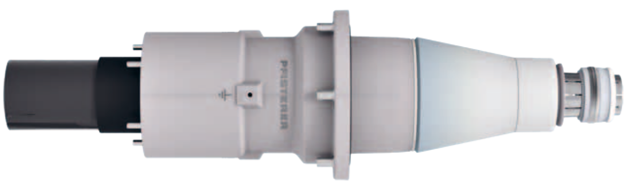
Features & Benefits

- Axial cable outlet for feeding in cables from above in compact indoor systems (onshore and offshore)
- Transition points on all four sides of the socket for flexible cable screen earth connection
- Integrated voltage tap
- Quick and simple to install with fastening bolts
- Type-tested in accordance with IEC 60137
- Compatible with MV-CONNEX sizes 3 and 3-S
- Voltage testing possible via continuous voltage indicator system (DSA)
- For other benefits, see the overview of the MV-CONNEX cable termination system on page 19

News

New EHV-CONNEX Components for Extra High Voltage

The forward-looking PFISTERER range of extra high voltage cable accessories (DIN/VDE) continues to grow: The new EHV-CONNEX components for maximum operating voltages of 300 kV (size 7) and 362 kV (size 7-S) complete the existing EHV-CONNEX portfolio of products for up to 550 kV. Among the new additions are dry plug-in type separable connectors and sockets, as well as comprehensive test equipment including SF_6 gas-insulated connection joints and silicone rubber dummy plugs, all of which have been successfully type-tested. Really impressive is the extremely compact design of the cable termination components: Depending on the application in question, the sockets can turn out up to 63 % smaller than prescribed in the relevant standards. After the bell flange, the separable connectors are only about 95 mm longer than the size 6-S separable connectors for operating voltages of up to 245 kV. Corresponding adapter elements are available for adjusting the products to standard dimensions.



Scan this QR code
for more information.

New EHV-CONNEX Connections for Transformers and GIS

Applications

- Connection of transformers and substations
- Nominal current up to I_n = 4,000 A
- Max. operating voltage U_m = 300 kV (size 7) or 362 kV (size 7-S)
- Cu or Al cable up to 3,000 mm²

Features & Benefits

- Touchproof, submersible, and maintenance-free
- Suitable for offshore use, as saltwater-proof
- No gas or oil work during installation
- More compact than conventional systems in accordance with EN 50299/IEC 62271-209
- Pre-tested in the factory
- Type-tested in accordance with IEC 62067
- With test equipment: SF_6 gas-insulated connection joints, silicone rubber dummy plugs, gas blind covers, current test plugs

News

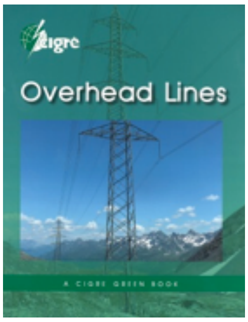
Prize for Tower Design With PFISTERER Insulator Strings

Compact and aesthetically pleasing – the "Eagle Pylon" design for overhead line towers by Bystrup Architecture has been awarded the "Good Practice of The Year" prize by the European Renewable Grid Initiative (RGI). The approximately 30% shorter tower design was made possible thanks to the use of forward-looking composite insulator strings from PFISTERER. One line featuring the newly designed towers has already been put into operation in Denmark: The 400 kV overhead line run by the Energinet operator plays a crucial role in supplying the country with power. In order to increase the level of acceptance of the towers among the population, Energinet placed great importance on making them aesthetically pleasing. The corresponding Bystrup designs and Energinet's functional demands resulted in complex requirements for the insulator strings to meet, which excluded the use of conventional insulators. The solution came from PFISTERER: Thanks to its in-house ACIM (Automatic Continuous Injection Molding) method, the company was able to produce, among other things, four-meter silicone-rubber long-rod insulators for the V-shaped suspension insulator strings of the angle towers. These long-rod insulators are able to withstand tension and compression, plus they provide the required insulation lengths – while at the same time having the aesthetically pleasing appearance which was desired and boasting a relatively lightweight construction.

V-shaped suspension insulator strings by PFISTERER for a compact and aesthetically pleasing tower design.

Source: Bystrup

Around 30% shorter than conventional lattice towers: Compact overhead line towers with composite insulator strings by PFISTERER.



For engineers, decision-makers, and university graduates: The comprehensive CIGRE Green Book on Overhead Lines is available in English under ISBN 978- 2-85873-284-5.

Expert Knowledge of Overhead Lines

Overhead lines form the backbone of electrical power networks all over the world. To ensure that supply reliability can be further optimized in light of the innovations made over recent years and the many-faceted field experience built up over decades, the CIGRE B2 Study Committee for Overhead Lines published a new Green Book in 2014. This covers important topics concerning overhead lines, such as planning and management concepts, electrical and mechanical requirements, environmental factors, and many more. Thanks to this scope, it can quite rightly be viewed as THE current standard reference for the field.

Dr. Konstantin Papailiou, a former CEO of PFISTERER Holding AG, put forward the idea of a CIGRE series of books at a CIGRE conference held in 2011. As the person in overall charge of the publication of the CIGRE Green Book on Overhead Lines, he coordinated over 50 internationally renowned experts as contributing writers, including Dr. Frank Schmuck, coauthor of a specialist book on silicone composite insulators published in 2012 and head of the Insulators technology division at PFISTERER. Dr. Schmuck wrote the chapter on insulators which appears in the CIGRE Green Book. This deals, among other things, with questions of design, standard requirements, test philosophies, practical examples, and the various fault mechanisms of conventional and silicone rubber insulators.

A very important aspect of this Green Book is its objectivity, as well as the way it reflects international experience: The chapters have been written from CIGRE's scientific perspective and illustrate the state of knowledge published over recent years. It is an indicator of the book's success that the second reprint has already sold out and further reprints are in the pipeline for 2015.

Scan this QR code for more information.

PFISTERER in the Lexicon of Global Market Leaders

PFISTERER has been included in the "Lexikon der deutschen Weltmarktführer" (the "Lexicon of German Global Market Leaders"). This publication provides an informative overview of German companies which, thanks to their innovative and high-quality products, are among the top three suppliers worldwide within their sectors. The new edition was launched in January 2015 and PFISTERER, as the world's largest independent producer of high voltage cable accessories, is represented therein. The company's pioneering role has been safeguarded by a number of innovations: The CONNEX modular, dry plug-in type connection system for medium and high voltage networks, for example, allows extremely compact, reliably insulated, and maintenance-free system connections to be made for substations incorporated into buildings. And PFISTERER's forward-looking composite insulator strings enable a much more compact, and around 30% shorter, overhead line tower design to be realized.

The "Lexikon der deutschen Weltmarktführer" is available as a German new edition from the Deutsche Standards business publishing house under ISBN 978-3-86936-656-2.

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