PFISTERER Customer Magazine
Special Issue **2016**

PFISTERER

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Railway Safety Equipment

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Economically safe for railway systems

Without building, modifying and maintaining the railway system, there would be no rail transportation. Such a simple fact, with such a crucial consequence: cost-effective railway operation requires safe and efficient work materials – such as PFISTERER safety equipment.

For work in the Gotthard Base Tunnel, earthing and short-circuiting devices prove easy to use at a working height of 5.5 m, and extremely resilient (see page 3). KP-Test 5 voltage detectors deliver safety through ease of use for common international railway applications (see page 6). Distance voltage sensors have been specifically developed to assist crane operators during difficult manoeuvres below overhead contact lines (see page 12).

We hope you find this special edition an inspiring read. Via standard and custom solutions, we aim to deliver the optimum for your railway work.

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Legal Notice

Publisher
PFISTERER Holding AG
Rosenstrasse 44
73650 Winterbach
Germany
Tel: +49 7181 7005 0
Fax: +49 7181 7005 565
info@pfisterer.com
www.pfisterer.com

Editorial Team
Jürgen Finsinger, Steffen Jordan,
Peter Kaiser, Lena Kuhnle,
Frank Straßner

Text Editor
Karolina Kos
www.xyzeiler.de

Art Direction
VISCHER & BERNET GmbH
Marketing and Advertising Agency
Stuttgart

For reliable use under hard conditions: PFISTERER supplied time-tested and custom-built safety equipment for the new Gotthard Base Tunnel, which counts as the world's longest railway tunnel to date at 57 km total length. (© AlpTransit Gotthard AG)

Safety Equipment for Record-Breaking Tunnel

As of June 1, 2016, it has officially been "full steam ahead" for the longest rail tunnel in the world – the Gotthard Base Tunnel. Safety equipment from PFISTERER is being used to operate it safely over 57 km. Whether smart, custom solutions or timetested classics, each component also meets the highest requirements: safe handling and reliable function under extreme conditions.

"The greatest challenge in this project was finding a solution for safely and feasibly earthing and short-circuiting the traction current supply lines," reports Jürgen Finsinger, product manager for safety equipment at PFISTERER, "because the usual procedure with standard equipment could not be used in this tunnel."

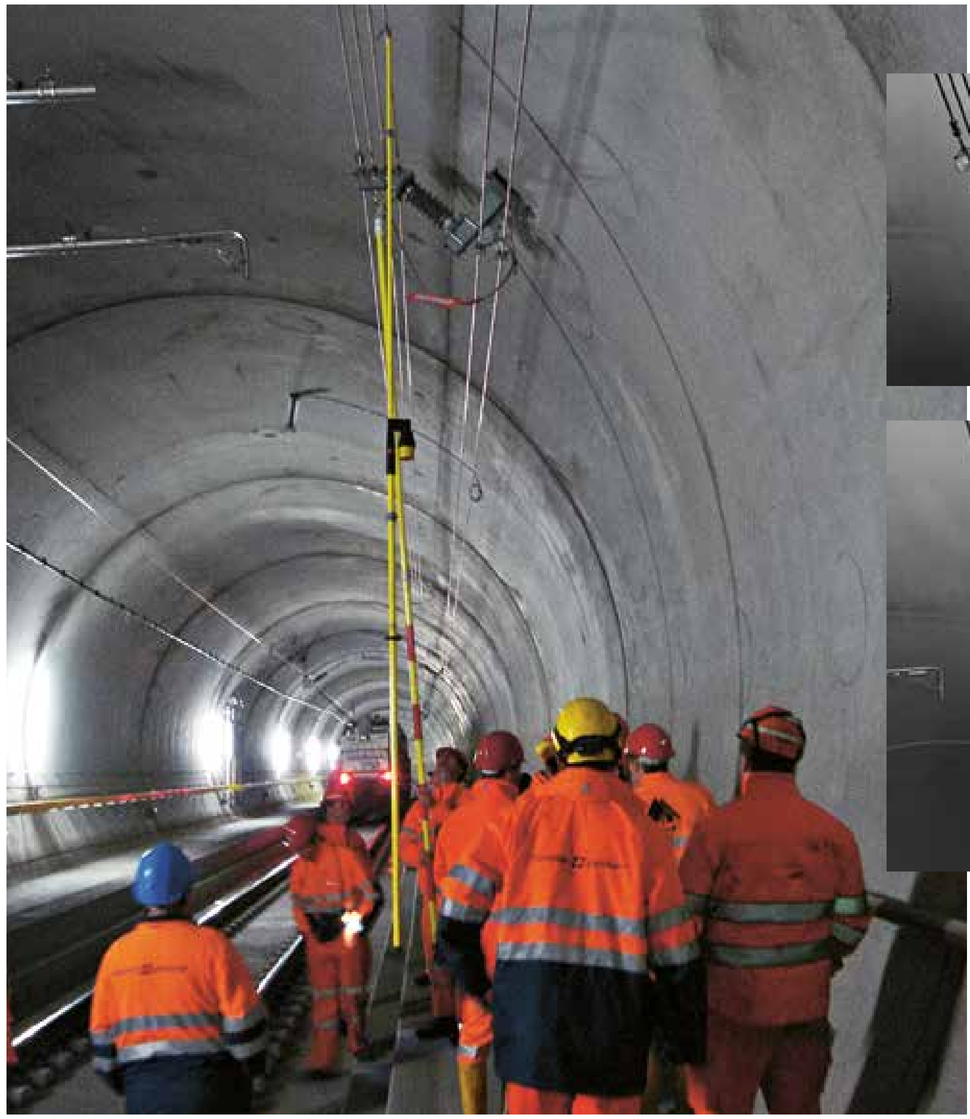
In classic earthing and short-circuiting of open-air railway lines, earthing equipment would be connected so that a train would break it away as it passed. Therefore, in this configuration, the train operation would be regulated according to sections of track. Unlike the stipulations of the Swiss Federal Railways (SBB): In the Gotthard Base Tunnel, the rails must be able to be used for diesel-powered emergency vehicles at all times.

Unrestricted travel in this sense allows unobstructed earthing and short-circuiting while the passage corridor remains accessible. For this, the SBB stipulated that instead of the usual earthing on the rail line, the return line should be bypassed with the feeder line. In the Gotthard Base Tunnel, these lines run parallel on the tunnel floor at 5.5 m height.

Easy handling at a lofty height

The PFISTERER engineers developed a suitable solution for this use case by testing with various models. They ended up with earthing equipment whose reliability and simple handling persuaded the demanding operator consortium. The earthing cable is 1.5 meters long enough for installing the clamps on the lines and also short enough that it does not hang into the passage corridor. As long as the equipment is installed correctly, the earthing rod can be removed.

First test drive through the new Gotthard Base Tunnel: View of the flat, straight railway from the conductor's cab (© AlpTransit Gotthard AG)



Earthing and short-circuiting at a working height of 5.5 m: non-obstructing user-friendly kit developed for the Gotthard Base Tunnel passes field tests with flying colors.

« The greatest challenge in this project was finding a solution for safely and feasibly earthing and short-circuiting the traction current supply lines.»

Jürgen Finsinger
Product manager for safety equipment at PFISTERER

Poor visibility, high ambient noise? No problem for the KP-Test 5R rail voltage detector: its visual and acoustic signals are optimally designed to provide clear measurement results at all times (photo above).

A mounting bracket and torque-controlled mounting head for the earthing rod make the earthing equipment easy to handle. These features work together ideally during installation: First, the return conductor clamp is put on the earthing rod to hoist and suspend the return conductor. To allow the clamps to withstand the enormous dynamic forces if a short circuit occurs, they are screwed down to the line reliably by means of the earthing rod. Once a specific torque is reached, the mounting head releases the return conductor clamp, which is now attached optimally, and only after this happens can the installer remove the earthing rod from the clamp. Thanks to the mounting bracket, installing the subsequent feeder conductor clamps to the feeder conductor is almost child's play. The bracket holds both clamps. When the return conductor clamp is being hoisted, the feeder conductor clamp is also hoisted and remains there in a stable position. It does not disrupt the return conductor clamp installation and, at the same time, is perfectly positioned for the next installation step: Despite the 5.5 m height, it can precisely be mounted with the earthing rod, attached to the neighboring feeder conductor and then also screwed on.

Strength in all positions

The earthing equipment has proven its unique durability at an external testing institute: The clamps held onto the conductors, without shifting, at a stipulated, maximum short-circuit current of 40 kA/0.1 s. The SBB personnel can reliably check that the power is cut off before earthing and short-circuiting according to five safety rules – using the KP-Test 5R voltage detector. Even in unfavorable environmental conditions, these worldwide, time-tested devices clearly relay the test results due to the optimally harmonized acoustic and visual signals. When the equipment is switched on, a self-test checks the functionality of the voltage detector, including the contact electrode extension.

All safety devices must be effortless to use. Therefore, voltage detector, such as the earting equipment, should not only be at hand in the Gotthard Base Tunnel at a distance of no more than 1000 m, they should also be protected from the rough conditions in the tunnel: Temperatures of –20° C to +40° C, more than 70 % humidity, heavy contamination, and strong pressure and suction forces when a train passes. PFISTERER also makes custom solutions for that: Custombuilt storage cabinets – rustfree, dust-proof and pressureresistant.

The Overhead Buzz

Precisely matched to globally wide-spread railway applications, yet flexibly adaptable for country-specific and custom requirements: the KP-Test 5 voltage detector product family ticks both boxes. And more besides. Voltage detecting on railway systems is often carried out under challenging conditions. The tests need to be reliable all the time, everywhere – to protect human life and property.

A voltage detector can show two possible outcomes: "voltage not present" or "voltage present". Whatever the result, it is critical information for implementing the Five Safety Rules. Safety standards for working in or on electrical systems are there to prevent a serious danger – namely an electrical accident that poses a threat to life and health, a risk to system integrity, and could bring urgent work and normal operation to a stop.

"For prevention to succeed, voltage detectors need to do far more than accurately assess voltage states," says Jürgen Finsinger, product manager for safety equipment at PFISTERER. And he knows why: "Voltage detectors are often used when maximum efficiency is required, for example for work on railway systems or in emergencies. One of the most important considerations for the efficiency of voltage detectors is how easy they are to use."

Unpredictable environment. Crystal clear indicator.
A key factor here is the design of the signals that indicate the voltage state. "The test engineer needs to be able to see the voltage state clearly and easily. Anything else holds things up and is risky because of the possibility of mistakes," explains Steffen Jordan, development engineer at PFISTERER. "So when designing the signals it's important to take all possible environmental factors into account, as these can make it dramatically more difficult to see or hear the signals correctly."

When you're standing next to railway tracks, and when engineering work is going on, it's very noisy. Tailwinds can carry an audible signal away. When long insulating rods are used, the distance between the user and the display unit increases. The further it moves away, the fainter audible and especially visual signals become. When parts of the system are poorly accessible, an awkward viewing angle is all it takes to make the display hard to see. The same is true in bright daylight or dense fog.

Fig. 1: For railways worldwide: The KP-Test 5R shown in use here is one standard model among many PFISTERER voltage detectors. They are adaptable to fit requirements and enable efficient, safe voltage detecting not only on contact wires but also on third rails, switchgear and power lines.

Fig. 2: Adverse environmental conditions: Noise from engineering work or normal railway operations, bright sunlight and other environmental factors can make it difficult to see or hear voltage detector signals. This makes good signal design all the more important.

Experience feeds into development: PFISTERER was one of the first manufacturers in the world to combine visual and audible signals (see fig. 3). Since then, it has been optimising their interaction. With strong signals arranged intelligently, all of today's KP-Test 5 voltage detectors overcome potential obstacles to sight and hearing – with scope for national or custom adaptations. The KP-Test 5R, for example, is one of many models that PFISTERER developed specifically for railway applications.

"We modified our standard signal output on the KP-Test 5R for a large Swiss railway company," Steffen Jordan explains. As a result, when no voltage is present, a green light flashes, accompanied by an intermittent tone. If voltage is present in the system component, a continuous tone sounds along with a red continuous light. PFISTERER can offer a total of five different signal modes off-the-shelf (see overview 1). Many other country and customer-specific versions are also available. With good reason.

Global diversity. Targeted benefit.
"So that safety equipment can be used efficiently internationally, existing differences have to be taken into account," says Jürgen Finsinger. "That requires a variety of different models." Even the number of different railway power supply systems in use is immense (see overview 2). They differ not only between but also within many countries. With its KP-Test 5 voltage detectors for railway applications, PFISTERER covers the main alternating-current (AC) and direct-current (DC) systems (see overview 3). Others can be added at any time on request.

Fig. 3: A clear result: Working efficiently and safely with a voltage detector requires clear results. So PFISTERER combines strong visual and audible signals on all KP-Test 5 models. The signal mode can be adapted if required (for details, see overview 1). Here you can see the standard signal output. If 'no voltage is present', the KP-Test 5 model shown displays a green continuous light without a signal tone. If 'voltage is present', six red LEDs flash and an intermittent signal tone sounds.

Overview 1:

Signal Mode	Zero potential		Potential present	
	Green LED	Tone	Red LED	Tone
COII (standard)	Steady light	No tone	Interval	Interval
CCIO	Steady light	Steady tone	Interval	No tone
IOCC	Interval	No tone	Steady light	Steady tone
IICO	Interval	Interval	Steady light	No tone
IICC	Interval	Interval	Steady light	Steady tone

Adaptable to requirements. Visual and audible signal outputs are partly a question of user preference. PFISTERER's customers can therefore choose between four other signal modes in addition to the standard "COII" mode. For a Swiss rail operator, for example, the 'IICC' mode was implemented on the KP-Test 5R for AC overhead contact lines.

"Our range of voltage detectors has continued to grow with the requirements of different markets," says Jürgen Finsinger. "This multi-layered perspective sharpens your appreciation of the design concepts that have what it takes to generate a universal advantage." The KP-Test 5R is a good example of this, too.

Make contact with overhead contact lines. Using a hook.
This model is specially designed for AC catenary wires (see fig. 4), as can be seen from the contact electrode, a key component of the voltage detector. To test for voltage, there needs to be an electrical connection between the voltage detector and the component being tested. The user makes and maintains contact during the voltage test by touching the contact electrode onto the system component. Although the voltage test doesn't take long, making the contact is challenging, in view of the way that overhead lines are constructed and how they are typically tested.

Overview 2:

The main railway power supply systems in the world
and countries where they are widely established or used in places, e.g. for important links, high-speed lines, in metropolitan areas and particular regions (excerpt):

- **25 kV AC single-phase / 50 Hz**
  Australia, Belarus, Belgium, Bosnia-Herzegovina, Bulgaria, China, Croatia, Czech Republic, Denmark, Finland, France, Greece, Hungary, India, Iran, Italy, Japan, Kazakhstan, Lithuania, Luxembourg, Macedonia, Montenegro, Netherlands, New Zealand, Portugal, Romania, Russia, Serbia, Slovakia, South Africa, Spain, Tunisia, Turkey, Ukraine, United Kingdom, Uzbekistan
- **25 kV AC single-phase / 60 Hz**
  Canada, Japan, South Korea, Taiwan, United States
- **15 kV AC single-phase / 16.7 Hz or 16 2 / 3 Hz**
  Austria, Germany, Liechtenstein, Norway, Sweden, Switzerland
- **3 000 V DC**
  Armenia, Belgium, Brazil, Chile, Czech Republic, Estonia, Italy, Latvia, Morocco, Poland, Russia, Slovakia, Slovenia, South Africa, Spain, Ukraine
- **1500 V DC**
  Australia, Brazil, Columbia, Denmark, Dominican Republic, Egypt, France, Ireland, Italy, Japan, Netherlands, New Zealand, Saudi Arabia, Spain, Sweden, Switzerland, United States

Many other railway power supply systems are used around the world in addition to those listed above. Especially for tramways, for example, 500 V DC, 600 V DC and 750 V DC are widespread. There are also other single-phase AC systems and various three-phase systems.

Overview 3:

Flexibly equipped for the world's most common railway power supply systems
PFISTERER railway voltage detectors are currently available for the following voltage systems:

- 15 kV AC at 16,7 Hz
- 25 kV AC at 50 Hz
- 1500 V DC
- 3 000 V DC
- Tramway power supply systems
- Power supply systems for interurban railways with a live third rail

PFISTERER can supply model variants for other voltages on request. Depending on the model, KP-Test 5 voltage detectors are suitable for use on catenary wires and railway power lines, as well as on switchgear.

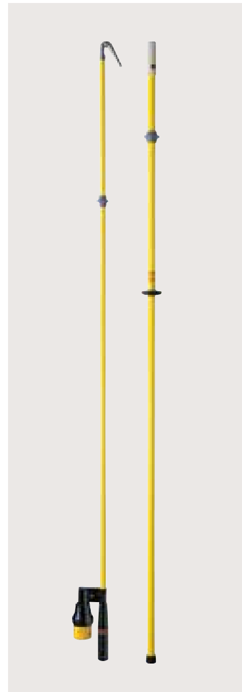


Fig. 4: KP-Test 5R for AC overhead lines: The hook-shaped electrode makes easier contact with catenary wires (for details see fig. 5). Reaching them is no problem: the two-part version of the 5R (shown here) has a total length of 4795 mm. The five-part version, with an overall length of 4785 mm, is recommended for use at changing locations. It dismantles down to 1100 mm in length for practical transportation.

« Our voltage detectors have been tried and tested in many railway countries. That's why our development activities are also shaped by individual requirements. »

Jürgen Finsinger
Product manager for safety equipment at PFISTERER

Fig. 5: Making contact the smart way: To make easy and reliable contact, PFISTERER voltage detectors for AC or DC overhead lines have a robust hook electrode. This hooks onto the catenary wire. For optimal contacting, its contact pin (circled in red) penetrates into the catenary wire. Because it is suspended from the wire, the voltage detector's own weight maintains constant contact pressure.

Fig. 6: KP-Test 5R DC for DC overhead lines: With this model, another benefit in addition to the hook electrode is that the earth pole is fixed to a magnet. This makes it easier to properly connect both poles – without unnecessary effort. PFISTERER can supply an insulating rod of suitable length on request (not shown here).

A comparison with voltage tests on switchgear makes it clear: switchgear is usually installed on the ground, and its busbars provide space. Good contact can usually be made with a contact electrode in the shape of a test tip. Catenary wires, on the other hand, are not only significantly thinner but also suspended overhead. They are generally located at a height that can be reached using standard voltage detectors. So contact is very frequently made from the ground. However, particular care, skill and also strength are required when using a long device with a small contact electrode. It is not always possible to tell with certainty, from a distance, whether the test tip is cleanly touching the catenary throughout the voltage test.

The KP-Test 5R is a significant improvement. Its electrode takes the form of a sturdy aluminium hook, with a metal contact pin on the inside angle (see fig. 5). Jordan explains the advantages: "Thanks to the hook shape, this special electrode simply hooks onto the catenary wire. Its contact pin penetrates through any oxide layers into the surface of the overhead contact line, ensuring a clean electrical contact. Hooking onto the wire has other positive effects: the voltage detector's own weight ensures constant contact pressure. After the voltage test, the device can be left in place, e.g. to monitor the absence of voltage until an earthing and short-circuiting kit has been fitted, or as an additional signal that safety-relevant work can be carried out on this section of track."

Flexible for DC voltage

The same hook electrode combined with another practical design feature makes the KP-Test 5R DC simply ideal for easy use on DC catenary wires (see fig. 6).

Because testing for DC voltage requires an galvanic connection between conductor and earth, DC voltage detectors have two contact elements, also known as poles. On conventional models these are attached to two rods. This type of design means that to make contacts, the user simultaneously has to hold one rod on the rail and the other on the catenary wire. It's a method that can quickly turn into a balancing act. And cost valuable time.

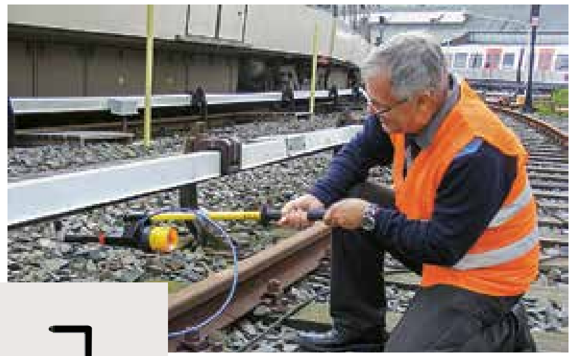
Things are different with the KP-Test 5R DC. Its earthing negative pole is attached to a magnet, enabling quick and secure attachment to the rail. The user can then use both hands to guide the rod with the hook-shaped positive pole up to the catenary wire and hook it in place.

The voltage state of live third rails on DC railways can be tested in the same uncomplicated way – using a model variant of the KP-Test 5 DC. Its negative pole attaches to the rail in the same way, by magnet. The positive pole is matched to the design of third rails in railway systems. Since they are laid on the ground and electrical contact can be made across their whole surface, a test tip is sufficient for making contact with the rail. At the same time, the top face of third rails is usually covered for safety reasons. To enable easy contact from underneath, the test tip extends at a right-angle (see fig. 7).

Specialists & all-rounders

"Our voltage detectors have been tried and tested in many railway countries. That creates trust," Finsinger adds. "And it's why our development activities are also shaped by individual requirements." This is how the KP-Test 5 for railway power lines was developed (see fig. 8): with a thinner hook electrode, extended contact electrode and shorter insulating rod, it is perfectly adapted to railway power lines, which are suspended even higher than catenary systems and are therefore tested from the tower or a lifting platform. For a Spanish railway operator, PFISTERER engineers customised the KP-Test 5R DC specifically for use on DC catenary wires that run parallel to an AC line. The special model clearly distinguishes between the presence of DC voltage and induced AC voltage. As a result, the risk of incorrectly showing "voltage present" on a de-energised DC line is eliminated.

Some more specialised devices for railway systems have been developed from general-purpose devices in the KP-Test 5 family: a modified KP-Test 5H with fork electrode is designed for use on power supply lines for single-phase railway networks (see fig. 9). Along with the standard version of the KP-Test 5 DC, PFISTERER offers a shorter model as a handy option for use on switchgear for DC railways. Regardless of their variations, there is one more feature that all models share in addition to the combined LED and sound signals: the self-test, which automatically checks that the device is ready for operation before each voltage test. "The KP-Test family is a tried-and-tested modular system that combines stringency with variability," Jordan sums up. "Consequently, it can grow to meet varying international requirements, while maintaining consistently high safety and ease of use."



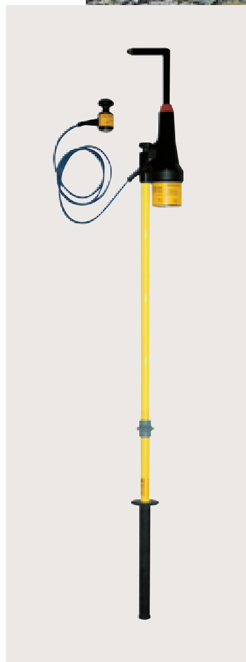


Fig. 7: KP-Test 5 DC for third rail: The test tip extends at 90 degrees on this model variant, so it is easy to make contact with covered power rails on DC railways once the negative pole has been securely attached to the track.

Fig. 8: KP-Test 5 for railway power lines: This model shows again how the type of system and working practices can be taken into account in the voltage detector design: its slim design with a narrower hook electrode is optimal for voltage testing on railway power lines performed from the tower or from a lifting platform.

Fig. 9: KP-Test 5H for railway networks: This model is identical in design to the KP-Test 5H for high-voltage applications. It was designed specifically for voltage detection on power supply lines for single-phase railway systems, and has a fork electrode as well as a two-part insulating rod.

Fine-Tuning for Railway Giants

Positioning bulky heavy loads safely and precisely – Kirow railway cranes are proven all-rounders in this field. For more than 130 years, the world market leader has been building agile heavy goods equipment for demanding applications on rail networks. And offering fine-tuning to customer requirements. As is the case with the PFISTERER distance voltage sensor: this assistance system was specifically developed for crane operators carrying out sensitive work near overhead contact lines.

It is important to keep a safe distance away from overhead lines. For railway crane operators, this is an everyday challenge. They balance, change, and position tracks and points. They rerail railway vehicles, and clear debris in an emergency. With the greatest precision, usually under time pressure, always looking out for construction workers, emergency responders, incident commanders. And frequently surrounded by obstacles such as platforms, masts, signalling equipment and indeed overhead contact lines. PFISTERER distance voltage sensors offer more safety for delicate manoeuvring. The assistance system detects the voltage state of overhead lines. If they are energised, the crane must not get too close to them under any circumstances. Otherwise, high-voltage electricity will take an uncontrolled path.

No contact. But still deadly.
Even critical proximity to an overhead contact line can cause a flashover, accompanied by an arc. Their destructive power can damage hearing, give a fatal electric shock, ignite combustible material, or cause an explosion. If direct contact is made, high currents will flow straight through the crane into the ground. The crane operator should be all right, as the metal cab shields the operator like a Faraday cage. But everyone and everything in the vicinity of the crane is in immense danger: persons of bodily injury or death, property of damage or destruction.

To prevent this, there are regulations for working in or on electrical systems. Nevertheless, electrical accidents involving overhead lines do still happen. While the Five Safety Rules are considered to be an international standard, they are not always applied everywhere. Human error can undermine any safety precautions. Kirow takes these facts into account.

Unclear circumstances. Clear boundaries.
"Crane manufacturers know the potential application-specific hazards. What they cannot know are the specific operating conditions. Cranes move around, and every site is different. Take overhead lines for example. You don't find them everywhere. Where they are present, the question is whether they are live. Or rather, are they de-energised when they are supposed to be," says Arnfried Wagner, control technology specialist at Kirow in Leipzig. "It follows that a practical railway crane is

one that can be used flexibly and safely. Our multi-tasker cranes meet these criteria in multiple respects. They are fundamentally suitable for working below overhead contact lines, whether those are switched off or live."

One way this is achieved is through a control mechanism for the crane arm, which is essentially the tool that the crane operator works with. On multi-tasker cranes, its working height is preset at the factory. It provides enough room for manoeuvre for common tasks such as track works. At the same time, the crane arm cannot be extended beyond a defined maximum height. As long as the crane operates with this basic setting, the crane arm automatically keeps a safe distance from overhead contact lines.

Working height changes to suit the application
"For many common applications, this makes the job easier for crane operators," Wagner notes. "Rail networks need to be modernised or modified. Overhead contact line systems power most electrified railways. So there's a high likelihood that a railway crane will be operating below overhead contact lines. In our experience, it's really the rule for track works." Multi-tasker cranes are practically flexible for other types of applications, including deviations from normal operation.

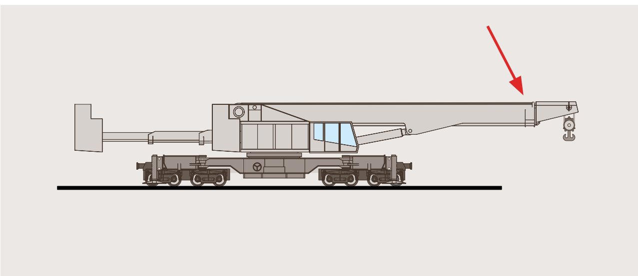
"Railway cranes place locomotives and carriages onto tracks, and recover them if they derail. Just to get a rail car under the crane hook, you sometimes need to be able to extend the crane arm higher than usual. And it's the same with other applications," explains the control technology expert. "That's why the crane operator can switch off the working height limiter if needed."

For efficient working: Kirow multi-tasker railway cranes automatically keep a safe distance from overhead contact lines – thanks to a factory-set working height limiter on the crane arm. It can be switched off at any time if more room for manoeuvre is required.

Voltage sensor
Adaptability is a requirement that stems not only from the wide variety of applications, but also from railway operators' safety standards. These vary from country to country. And they change based on experience. So custom adaptations are part of the routine for Kirow. Sometimes they break new technological ground, as was the case in 2011.

"A customer in China wanted an additional feature. They wanted the crane operator to be able to check for themselves whether an overhead wire was live or not," Wagner relates. "Detecting high voltage is not a core competence for crane manufacturers, but at Kirow we are used to exploring new possibilities. So we sought the help of an experienced specialist. And that's what we got from PFISTERER."

Their contribution to the custom solution was a distance voltage sensor for use below 25 kV/50 Hz overhead contact lines. Fitted to the top of the crane arm, it detects the voltage state of the overhead line from a defined distance, and sends signals accordingly. These signals are clearly displayed for the crane operator on a monitor. Green indicates "no voltage present", red warns "voltage is present".



For safety below overhead contact lines: the PFISTERER distance voltage sensor is fitted to the top of the crane arm so it can detect whether voltage is present in overhead contact lines. This means that crane operators can always verify the voltage state of lines for themselves, with certainty.

« Voltage sensors can offer added safety in many other applications, for example work near overhead power lines. PFISTERER is already experienced in developing individual custom solutions. »

Jürgen Finsinger
Product manager for safety equipment at PFISTERER

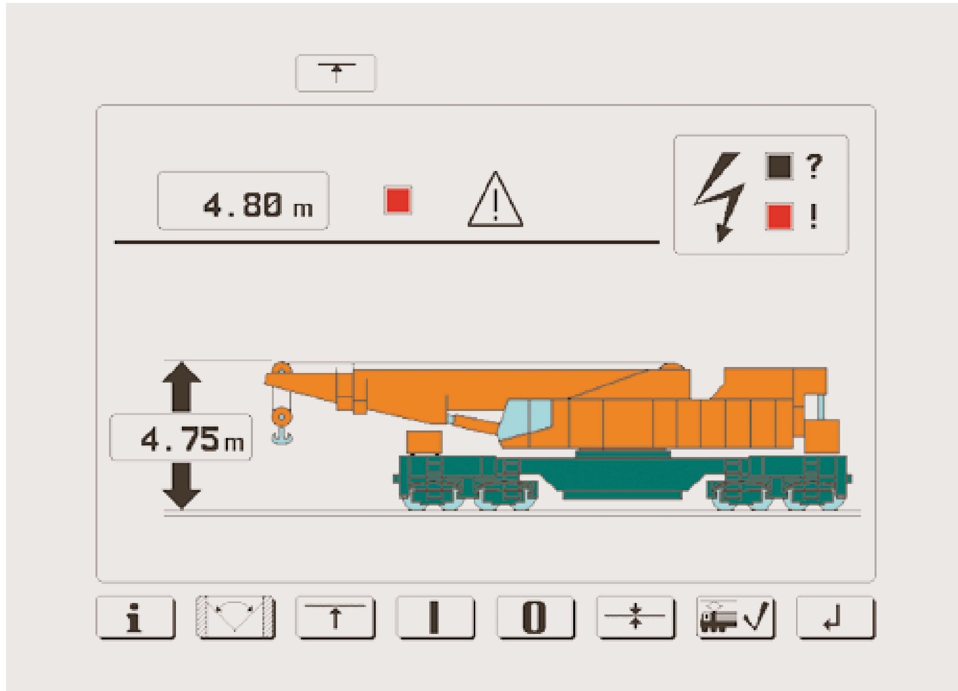
Result from the Far East
"Our solution has been in use in China for four years with no problems," Wagner reports. The voltage sensor has a built-in self-test for reliability. As soon as the crane operator activates the sensor, its operational readiness is tested automatically in a matter of seconds.

The PFISTERER assistance system is making a valuable contribution to workplace safety in many applications. Wagner explains why: "Whatever safety measures are put in place for work on or near overhead lines, there are many factors that influence their effectiveness. Even with established processes and trained, experienced personnel, misunderstandings are still possible – increasingly so as more people are involved. This is where our solution is beneficial. It means that crane operators can always clearly verify the voltage state of an overhead line for themselves."

Sensor with signal effect: Kirow cranes fitted with PFISTERER voltage sensors demonstrate that assistance systems for voltage detection can provide added safety wherever heavy mobile equipment encounters electrical conductors, including overhead power lines.

Launch in Switzerland. Potential for more.
It's an advantage that recently attracted the attention of a Swiss track construction company. For the imminent market launch in this forward-looking railway country, the distance voltage sensor is being modified to meet various operator requirements, including use below 15 kV/16.7 Hz overhead contact lines. "We took this development step with PFISTERER too," says Wagner. "Our collaboration so far and its results have been highly successful." Jürgen Product manager for safety equipment at PFISTERER, sees further application potential: "Cranes and excavators of all kinds are constantly running into dangerous sources of electricity. Voltage sensors can therefore offer added safety in many other applications, for example work near overhead power lines. PFISTERER is already experienced in developing individual custom solutions."

Tried-and-tested in China, ready to launch in Switzerland: PFISTERER voltage sensors (circled in red) fitted to crane arms on Kirow multi-tasker cranes. On the left you can see the sensor model for use below 25 kV/50 Hz overhead contact lines. On the right is the sensor version for 15 kV/16.7 Hz railway power supply systems.



Working by eye: Kirow helps crane operators during manoeuvring with a user-friendly display on a monitor. This screen shows that the crane arm is currently at a working height of 4.75 m, and that its automatic height limiter is set to 4.80 m. Switching off the height limiter is out of the question in this case. The red square to the right tells the crane operator what the PFISTERER distance voltage sensor (also active) has detected: the overhead contact line above is live.

PFISTERER

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Easy. Safe.

Voltage detectors plus earthing and short-circuiting kits from experts.