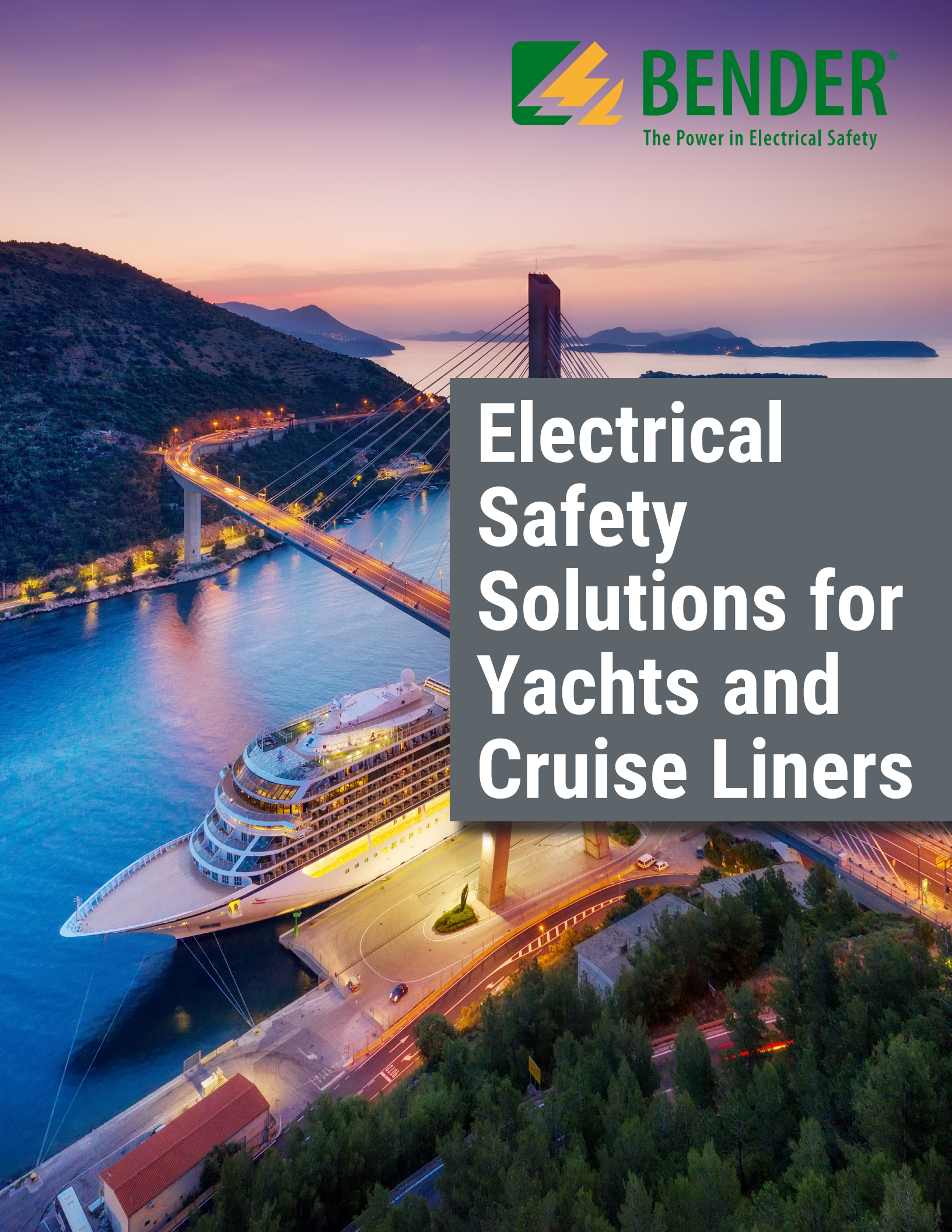
BENDER®
The Power in Electrical Safety



Electrical Safety Solutions for Yachts and Cruise Liners

Luxury should be safe too

During the refit of a megayacht built in Germany, unexpectedly high leakage currents were detected at the central earthing point, the cause of which could not be eliminated. Safety must come first, and technical failure must be ruled out, especially in an environment developed and created for all-round comfort at sea and where numerous technical innovations are designed to create luxury and inspire the guests on board.

Imagine that you have chartered a megayacht to do everything you have always dreamed of. The plan: You and your friends start the morning with a dip in the pool, then after a light breakfast in the elegant dining area on the aft deck, you launch the jet skis in the sunshine to play on the waves and later look forward to taking a trip over the gently rolling hills of the island in front of you on the Harleys waiting on board. But then your plan suddenly unravels: When adjusting the counter-current system of the pool on the upper deck, the personal trainer suffers an electric shock, is rescued unconscious from the pool and must be flown by helicopter to the nearest hospital. Cause of accident: Electric shock from a non-tripped residual current device (RCD).

As far as we know, something this bad has never happened before. And so that it never does, the first refit of an over 100 meter megayacht built in Germany focused on residual current monitoring and load monitoring.

Residual current monitoring with the RCMA423 residual current monitor

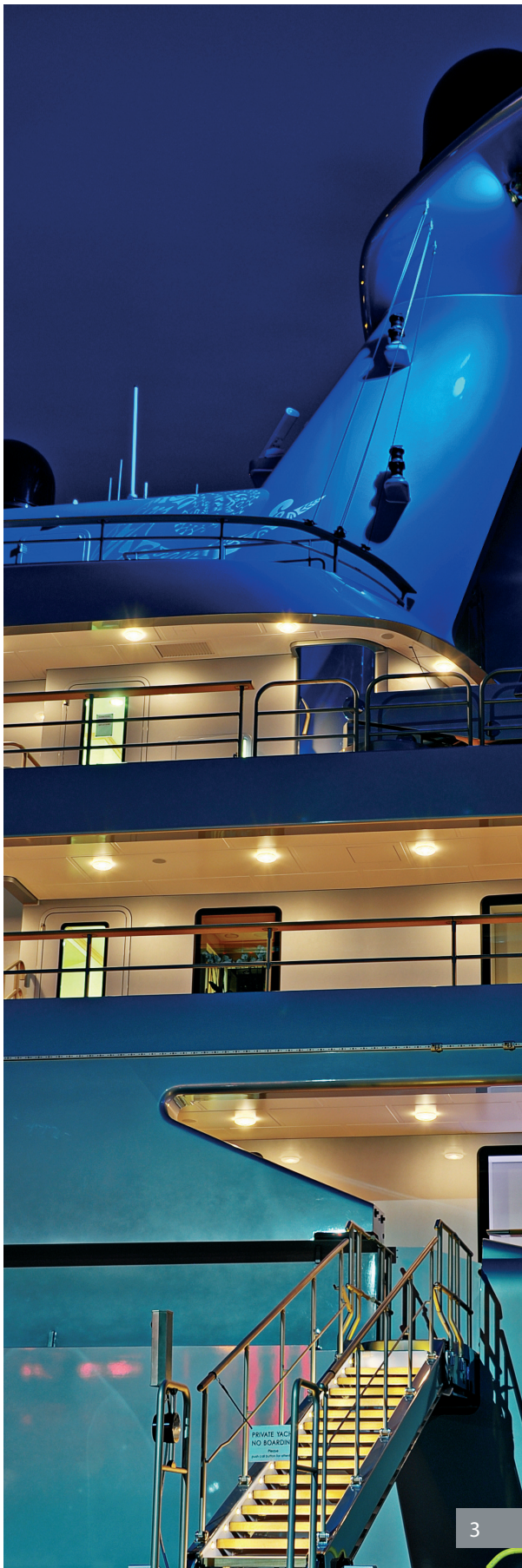
An earthed system at sea needs the right safety concept
An earthed power grid (TN system) was installed on board the traditionally built megayacht. In contrast to this, unearthed systems (IT systems) are usually used on cruise liners, naval and merchant ships. These systems are monitored with Bender insulation monitoring devices ISOMETER® and insulation fault locators (EDS).

In an earthed system there is still a central earthing point (CEP) where the neutral conductor of the system is connected to earth. In the event of a fault, it diverts the sudden high current and causes the circuit breaker to trip. In this case, it is the steel hull of the ship. It is possible to measure at the earthing point how many amperes of leakage flow in total but without being able to make a precise statement about where the current comes from.

For an exact analysis, the individual power distributions with their supplied loads must be deactivated to see how the leakage current at the CEP changes. This is a tedious and time-consuming procedure involving many restrictions and precautions on board.

Revel in splendour and diversity
The ambience of megayachts is equally geared towards elegance as well as functionality. A steel hull with aluminium superstructures and teakwood decks, for example, offers the ideal framework for motor yachts. On board this yacht with over 11,000 HP, a cruising speed of 15 knots and a top speed of over 20 knots, stabilisers are needed, for example, to make the pool usable whilst at sea. Indirect lighting in the luxuriously furnished cabins, lounge and spa areas produces a warm light that showcases the technical gadgets. The bridge deck and the audio and video equipment on board are also state of the art in this price segment. Many different loads in the AC and DC range at the various voltage levels can only be operated 24/7 with a first-class and reliable power supply.

Refit: Achieving the best at speed
When refitting a yacht, it is important to modernise essential aspects of the ship in the shortest possible time and to implement the customer's new technical requirements. Such shipyard stays are organised by the operator of the yacht and are usually conducted out of season – normally during the winter months. In our case, the investigation on the proven leakages of several amperes was one of the points that had to be checked and corrected as part of the refit. In addition, decentralised monitoring needed to be retrofitted for faster and easier detection.



The significance of this measure was immense, because so many of the loads generate exactly the level of comfort that is desired in the luxury segment. If the leakages at CEP were to increase due to electrical faults on board, the crew would not be able to limit this fault by deenergising loads when guests or the owner are on board. This means that in case of an emergency, the crew must decide between: "service as the highest priority" and "safety" in order to locate and eliminate faults as quickly as possible.

The solution: Direct measurement and evaluation

To set up residual current monitoring of the earthed system safely and permanently, the operator has enhanced the central earth fault monitoring system (CEP monitoring) with Bender's residual current monitoring system. He opted for residual current monitoring with the decentralised RCMA423. Other alternatives would be the bus-controlled central 12-channel residual current monitoring system LINETRAXX® RCMS460-D and the decentralised single-channel RCMB300 series.

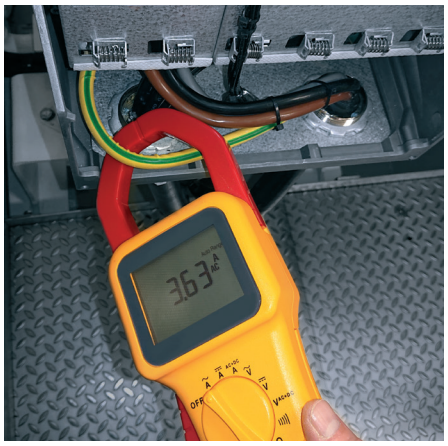
The system uses the corresponding measuring current transformers to measure fault and leakage currents in the earthed power supply and evaluate them directly. This made it possible to quickly determine which sub-distributions were causing the detected residual current of a few amperes without having to limit the functionality of the guest and owner areas.

Sven Steiger, Electrical Technical Officer (ETO) acting as the owner's representative, summarises his experience with this refit project: "We now have an exact overview of all residual currents of the sub-distributions on board, both directly on site and remotely. We can check the loads in the ampere and milliamp range and, if necessary, immediately determine where the fault is. This is very convenient for everyone involved and saves a lot of time and hassle. And almost incidentally, we were even able to identify and correct installation errors on board."

CTUB100 series measuring current transformer in the distribution units

Safety at Sea!

Electrical safety for both man and machine is extremely important on board a ship. Ideally, all the different aspects of safety should be included in the planning stage of a new construction. Where it isn't possible to plan, optimal residual current monitoring can also be installed on board at a later date. The following summarises the elements that should be considered in planning.



Stray currents detected

Earthed or unearthed system?
The most significant difference between an unearthed (IT) and an earthed system can be seen in the impact of a failure. The IT system essentially differentiates itself from the earthed TN system by a conductive connection between the star point of the generator or transformer supplying the system and earth. This connection is present in the earthed system, but not in the unearthed system.

Usually, if someone touches a live conductive enclosure in a faulty unearthed system, nothing happens. Although there is a current, it is dependent on leakage capacitances and is therefore very low. An earthed system, on the other hand, would produce a closed fault current circuit and faults can – depending on severity – have serious consequences:

- With a low-resistance fault, high currents flow through the fault location and cause local damage, which leads to an increased need for repairs or even to a system failure – even if the fuse is rapidly tripped.
- If the fault is at the level of the load current, the latter will not be interrupted. This can lead to local increases in temperature, which, above 60 W (e.g. 300 mA at 230 V), could cause a fire at the fault location.
- If a High-resistance fault occurs in an earthed system whilst a person is touching the live enclosure, a residual current will flow through the person despite the High-resistance connection to the supply transformer. This is measured and should be switched off by the residual current device within 30 ms. It is necessary to check the required protective technology at regular intervals in order to ensure it will work at a given moment.

Risks in earthed systems
In earthed systems, earth – at sea, this is the ship's hull – is connected to the neutral conductor at the central earthing point (CEP). It is commonly accepted that this potential bonding means that earth and neutral conductors are the same. In consequence, earth on various loads is often directly connected to the N conductor in the sub-distributions. This produces yet more – but no longer central – earthing points.

In the traditional systems of older ships, these additional earthing points would have had little effect. In modern ship installations, however, various connections with good conductivity have been added. The data cables, whose shields are made from copper braiding or aluminium foil, conduct the current but have a low current carrying capacity. This means, for instance, leakage currents with double-digit amperage have been measured over parallel data cables in data centres – a fire-hazardous situation in the truest sense of the word. In addition to the effect on data quality and bandwidth and the unplanned system crashes (blue screen), leakage currents can lead to charred cables and even fires.

DC residual current in an AC system?

Until today, energy on board is mainly provided as an AC power supply system. However, modern loads, such as LEDs, power supplies etc., operate with direct current. Usually, high-value components have integrated power supplies and can be used with the traditional AC power supply. However, if a fault occurs in the loads downstream the power supply unit, it becomes a DC fault. It is also essential to recognise and differentiate these faults. Indeed, a DC fault of this kind can disable an upstream type A (pulse current sensitive) residual current device (RCD) through magnetic saturation. This is called "blinding" in technical jargon. In this way, DC residual currents of 6 mA can stop RCDs from tripping even in the event of residual currents exceeding AC 30 mA, which leads to serious incidents.

Standard: Central earthing point

Consequently, DIN EN 50174-2, VDE 0800-174-2:2018-10 and IEC 60364-1 "Information technology – Cabling installation" prescribe exactly one central earthing point as standard. The result is convincing: No stray currents can flow in accordance with Kirchhoff's Voltage Law. Additional earthing points need to be identified and removed as quickly as possible. Thanks to the residual current measurements taken at the CEP, the distribution systems and the loads, sudden changes due to another earthing point can be identified quickly and restricted, as, in this scenario, any currents will split in a demonstrably different way.

Fig. 1: Electrical spot corrosion at sea water cooled chiller condenser

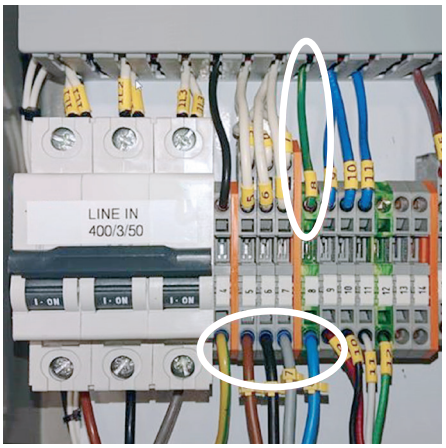
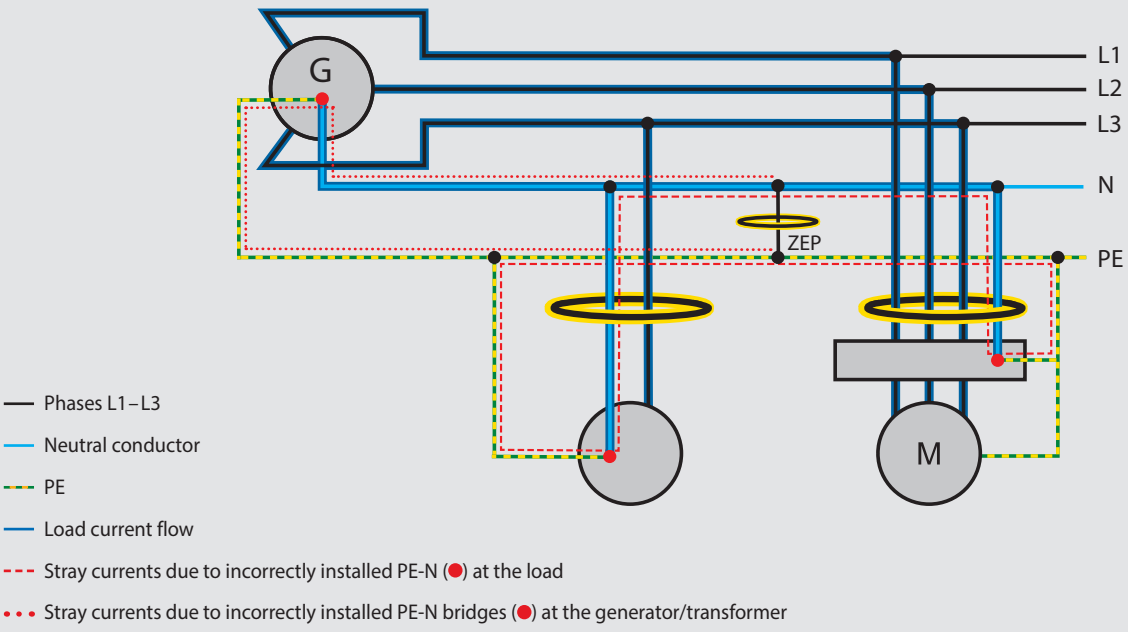


Fig. 2: Faulty installation encountered: extra earthing point of the neutral conductor at terminal 8

How stray currents flow



Peter Eckert, Market Segment Manager Critical Infrastructure at Bender, explains: "Thanks to residual current monitoring, ship operators can immediately identify incorrectly installed PEN bridges (see figure 2 on page 6) on loads and direct the service personnel to remedy them promptly as part of maintenance. This avoids any further impact on the whole system and prevents dangerous currents from flowing through the data cable shields. Stray currents (see figure 1 on page 6) are particularly dangerous at sea as currents flow through the path with lowest electrical resistance, which could be the shield of a data cable or the copper core of an N conductor."

RCMB132 AC/DC

Monitoring all outgoing circuits individually: also possible for refitting

The RCMB132 AC/DC-sensitive residual current monitoring module product range enables the complete, continuous monitoring of each individual outgoing circuit. It has been tested in data centres and is also ideal for continual use in final circuits on board. This module can be refitted and local cabling laid on board during operation. It is installed on the circuit breakers in the sub-distribution and monitors the individual outgoing circuits. Evaluation takes place digitally via Modbus protocol, either to the next automatic sub-distribution or to a local operating panel. In addition to digital recording, LEDs are available to show the crew where a fault has occurred. Thanks to the comprehensive residual current monitoring on board, stray currents and incidents that endanger human life and installations can be avoided, even in complex systems.

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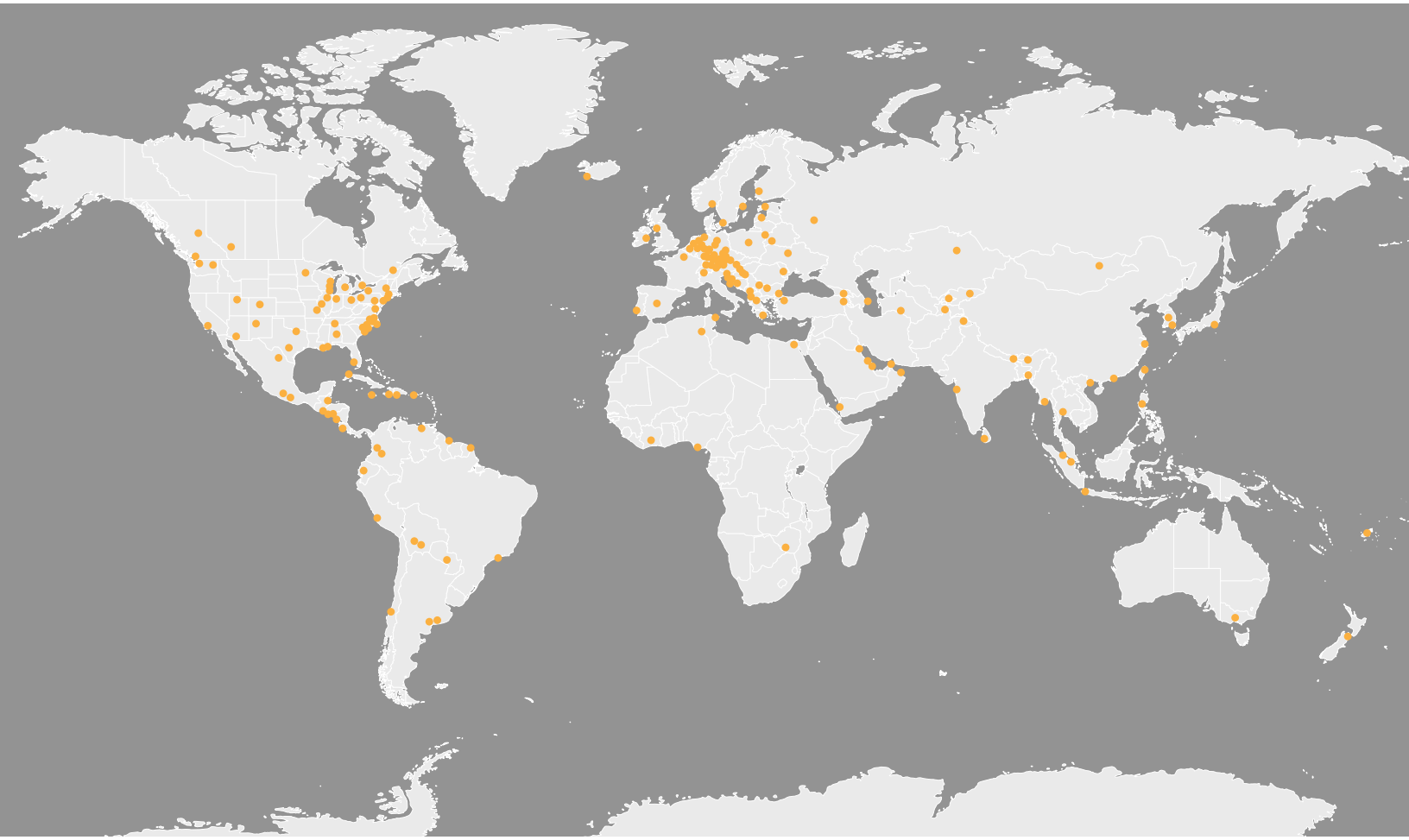
Bender is located in over 70 countries around the world



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