BENDER®
The Power in Electrical Safety

Electrical Safety Solutions for Harbours and Vessels

Electrical safety ready to sail

The maritime industry everywhere is confronted with high investments in a harsh environment. Safety at sea is therefore part of everyday life and it is necessary to have reliable systems on board.

Solutions for maritime applications

Electrical safety on board of vessels

How was electricity introduced on board of ships?

In 1880, the SS Columbia, a 100 m cargo and passenger steamship, was the first vessel with electrical lighting. Radios, engine order telegraphs and board phones were the next systems to follow. Steam has been replaced by electricity as a secondary power for one century. Currently, the need for secondary power in reefer container vessels or cruise liners is 15 MW or more. Since this power is also needed in ports and emission is becoming more and more relevant, vessels will be fed by means of shore power solutions to shut down their generators – the so-called cold ironing.

By 1880, electrical propulsion was quite common, especially in smaller boats. The first diesel-electric propulsion system was installed in 1903 on a 75 m Russian tanker. Today, these systems have capacities of more than 100 MW. In 2010, the first solar-powered vessel sailed around the world. In recent years, battery and hybrid-powered ferries and tugs are getting more and more common again and other boat types are following. What started 140 years ago with lighting now involves power supply and control everywhere on board and the need for electrical safety for man and machine is undisputed.

What does electrical safety on board mean?

What does electrical safety on board mean?

A set of rules and standards helps engineering electrical systems and safety on vessels. One goal is to decrease electrical shock hazards by reducing and detecting leakage currents. The other is to maximize the availability of electrical systems on board, since no electrical power is a danger too. It is important to detect faults before the system fails to enable planned maintenance instead of spontaneous reaction in the worst case of a storm at sea.

Bender provides electrical safety products that contribute to optimum operational safety and reliability in power and control supplies. The innovative solutions we offer today are based on more than 80 years of experience.

Our products are developed for demanding maritime applications including power distribution, electrical propulsion, control & automation and offline monitoring of safety-relevant loads such as fire pumps.

ISOMETER® – Insulation monitoring device

- Insulation fault location systems (EDS)
- Neutral grounding resistor (NGR) monitoring and fault detection for high-resistance grounded systems (HRG)
- Systems for the electrical safety of medical locations
- Residual current monitors (RCM) for hotel services, galleys and laundries
- Alarm indicator and operator panels
- Communication solutions

What are the different kinds of electrical systems on board of vessels?

The electrical power supply on board of ships is complex. It is divided into different systems to fulfil the respective requirements. This guarantees a high degree of availability and ensures that standard equipment can be used.

- Primary distribution system – directly connected to generators
- Secondary distribution system – powered by transformers
- Emergency power system – powered by emergency generators
- Hotel load
- Electrical propulsion and variable frequency drive (VFD)
- Control system – mostly DC 24 V for automation, sensor and control power supply
- Power supply of onboard hospitals
- 400 Hz system for aircraft, military and radar applications

The complexity of the electrical system and the voltage levels used depend on the total power demand.

The primary system distributes the energy of the generators throughout the vessel and electrical propulsion system if available. The voltage levels depend on the vessel size and typically range from AC 400 V to 690 V in low-voltage systems and from 6.6 to 11 kV in high-voltage systems. Mostly, they are 3-phase systems with 60 Hz but 50 Hz are also common. Currently, low-voltage DC buses are more common, so that generators can run at variable speed to achieve better fuel consumption and emission standards, especially for dynamic positioning in offshore applications.

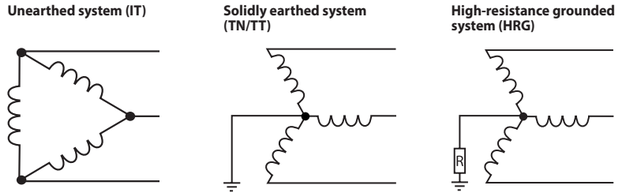
In more complex vessels, e.g. cruise liners, naval, offshore installations and support vessels, it is typical to have at least two independent electrical power supply systems that can cover most of the power requirements. This way, in case of damage, fire or water intrusion in one power supply system, it is possible to return safely to the port while keeping a maximum of the equipment available.
Secondary systems are typically at a low-voltage level between AC 230 V and 690 V and have the same frequency as the primary system. While diesel-electric propulsion systems have a heavy impact on harmonics, secondary systems which are fed by a transformer will provide better voltage and power quality. Therefore, most medium and small loads will be fed on this level. Especially hotel loads with COTS (commercial off-the-shelf) equipment for audio, video, IT and entertainment are very sensitive.

The primary and secondary electrical systems are redundantly supplied with at least two largely independent power sources and one of them additionally with an emergency source. From an electrical point of view, there is one essential detail to distinguish between earth fault protection and star point handling.

Of what importance is the system type of the earthing protection to the installation?

Nowadays, technical installations in shipbuilding and all industries are characterized by ever-increasing complexity and automation. From highly used variable frequency drives to computer based systems the amount of equipment that requires a reliable power supply to function smoothly is steadily growing. Therefore, the foundations for reliability and availability of an installation are already laid by selecting the right power supply system.

During the planning phase of a maritime installation, three system types are available:



Electrical systems on ships and offshore platforms should be designed in such a way that:

- Operating safety and reliability of the electrical systems are guaranteed – fail safety
- Protection for passengers and crew in case of insulation faults is ensured
- Fire protection in case of failure is ensured
- International standards and regulations are complied with

Therefore, the use of unearthed electrical systems (IT systems) with insulation monitoring is crucial in many maritime applications.

For example: IEEE – Recommended Practice for Electric Installations on Shipboard 33.7.6 Electrical installations on tank vessels. Electrical distribution systems of less than 1000 V (line-to-line) should be unearthed.

Bender system solutions support you in complying with the following standards, for example:

- **IEC 60092-201**
  Electrical installations in ships – Part 201: System design – General
- **IEC 60092-202**
  Electrical installations in ships – Part 202: System design – Protection
- **IEC 60092-502**
  Electrical installations in ships – Part 502: Tankers: Special features
- **IEC 60092-504**
  Electrical installations in ships – Part 504: Special features – Automation, control and instrumentation
- **IEC 60092-507**
  Electrical installations in ships – Part 507: Small vessels
- **IEC 61892-1**
  Mobile and fixed offshore units – Electrical installations – Part 1: General requirements and conditions
- **IEC 61892-2**
  Mobile and fixed offshore units – Electrical installations – Part 2: System design
- **IEC 61892-5**
  Mobile and fixed offshore units – Electrical installations – Part 5: Mobile units
- **IEC 61892-7**
  Mobile and fixed offshore units – Electrical installations – Part 7: Hazardous areas
- **IEC 80005**
  Utility connections in port - Part 1 & 3

Regulations relating to maritime electrical installations: 2001-12, Directorate for fire and electrical safety, Norway and other international standards like: Solas, IMO, Lloyd's, IEE, NEK etc.

Reliable and robust version

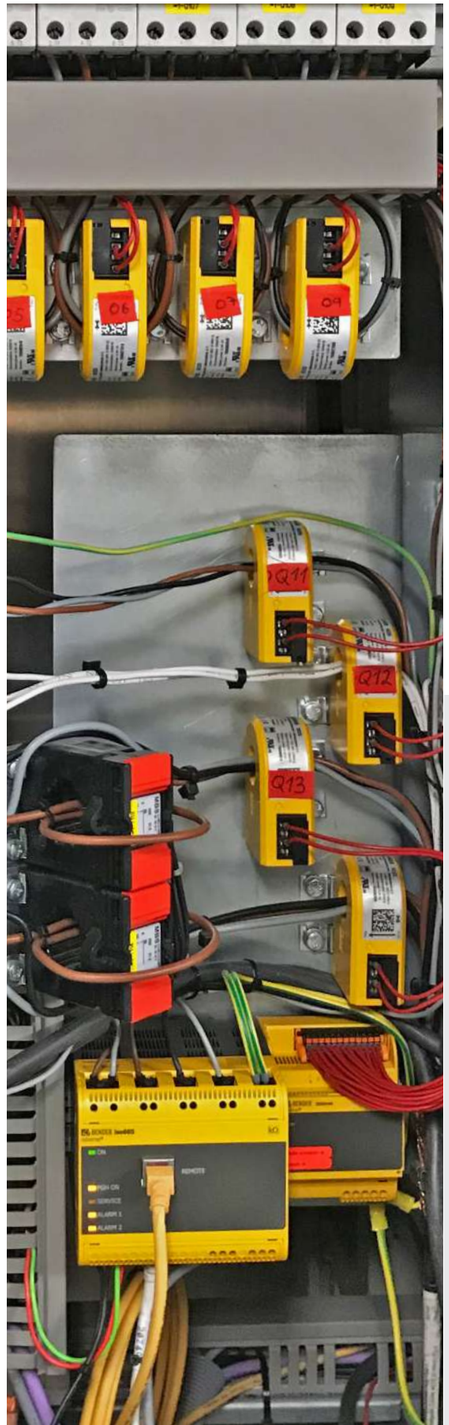
Reliable and robust measuring device – tested and approved

Whether cruise liner, cargo or naval vessel, all types of ships face the same tough requirements at sea. Our measuring technologies meet the most challenging demands on the high seas. Confirmed by classification associations, Bender measurement devices have proven their measurement strength and durability, ability to withstand extreme temperatures and electromagnetic compatibility (EMC), as well as shock and vibration resistance.

All devices with the "W" option are specially hardened to withstand even the most extreme conditions including humidity with possible condensation and formation of ice (3K5), shock up to 25 g and vibration up to 3 g (resistance class 3M7). All iso685 and EDS44x with the "W" option are able to operate in a temperature range of -40 to +70 °C.

Classification society certificates

- **Insulation monitoring:** iso685 series, IR420 series, IRDH series, accessories (FP200, AGHs, …)
- **Insulation fault location:** EDS440/460/490 series, evaluation possibilities
- **Residual current monitoring:** RCM420 series, RCMS460/480 series, accessories (transformers, …)
- **System relays:** VME420 series, VMD420 series
- **Communication:** COM465IP



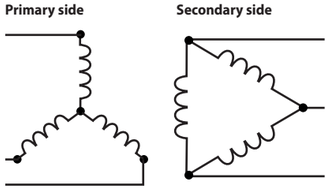
Advantages of an IT system

The unearthed or floating system provides high availability and lowest fault currents. A real insulation value and detection of symmetrical faults are an advantage too. What is interesting for predictive maintenance is that insulation deterioration from several 10 kΩ up to the MΩ range can be detected and monitored, which makes planned maintenance in the electrical system feasible.

Insulation faults will be instantly automatically located – online without switching off any load. Depending on the system configuration and the leakage capacitances up to 100 kΩ, insulation fault location is possible. The traditional way to narrow down the fault was sistematic shutdown of feeding distributions. In practice, it is more difficult because not all systems can be switched off on sea and the fault could disappear because the faulty load is already switched off. In this case, the mobile EDS case is a practical help but it is still manual.

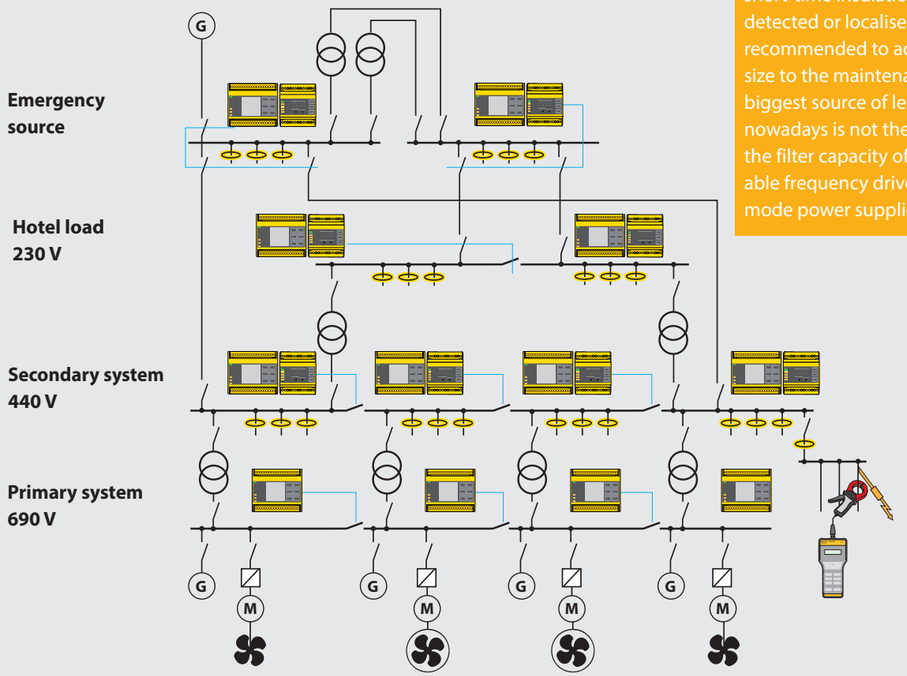
All insulated systems on board require an ISOMETER® by class and acc. to IEC 60092. Since feeding systems will be coupled for load sharing and to reduce running hours of generators, more than one insulation monitoring device (IMD) would be in one galvanic system. In this case, one monitoring device supervises the entire system and the other devices need to be disconnected. Bender IMDs allow decoupling the measuring circuit via a digital input which is controlled by the closed signal of the main circuit breaker or via the ISONET® function. In this case, all ISOMETER®s in one galvanic system will communicate with each other and only one device will measure at a time.

Earth faults in the classical star configuration cause line-to-earth voltage rises. These are dangerous for single-phase commercial off-the-shelf equipment which are typical in hotel areas. This problem can be avoided by connecting the secondary side of the feeding transformer in delta mode.



Recommendation:
Consider the leakage capacitance

The larger the system in terms of leakage capacitance, the longer the measuring time. It is possible that very short-time insulation faults cannot be detected or localised. It is therefore recommended to adjust the system size to the maintenance objectives. The biggest source of leakage capacitances nowadays is not the cable network but the filter capacity of poorly chosen variable frequency drives and switched-mode power supplies.



A frequent choice – but also the best? The TN system

At first impression, a TN or solidly earthed system is the simplest way to build up an electrical system on board. The disadvantages show in the total cost of ownership analysis. In the event of an earth fault, high currents will flow, which means more damage and commonly higher repair costs. If the current is below the tripping value of the circuit breaker, this may cause a fire. Faulty loads will be out of service immediately and this means quite often downtime of the whole vessel if it is an important system.

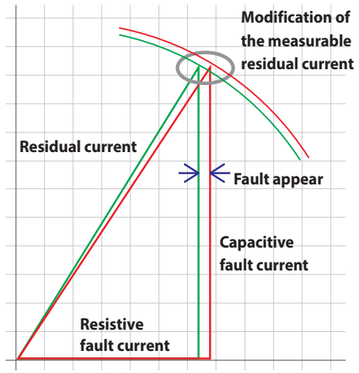
While the insulation level in the unearthed system shows the actual condition of it in solidly earthed systems, ohmic leakage currents are much more difficult to measure. With a Residual Current Monitoring System (RCMS) leakage currents will be detected down to around 1 mA. This represents the vectorial sum of the capacitive leakage charging current and the ohmic leakage current. So changes in the ohmic insulation level are somehow hidden behind the leakage capacitance and detection is a challenging task. However, leakage current detection below 30 mA for personal protection and 300 mA for fire protection limits would allow predictive maintenance before greater damage occurred.

Without an RCMS, faults are simply switched off by an RCD or by overload protection; both operate without any prewarning and with large tolerances, so that predictive maintenance is impossible. Even worse are small additional faults due to which the complete system shuts down and is no longer available.

For example, the sum of different small leakage current deteriorations of switched-mode power supplies of audio, video or computer systems gets too high and all systems will be shut down by the feeding UPS/RCD. Unfortunately, this kind of fault is hard to find while repowering all loads. With an RCMS system, deterioration of one or more loads and additional installation of too many devices are easy to recognise and system failures are avoidable. Instead, RCMS prewarning provides the opportunity to order and install new devices when old equipment reaches the end of its life without any service interruptions.

It is important to know that in solidly earthed systems symmetrical and asymmetrical faults could be detected or measured only to a level of 10-20 kΩ or less.

Since many loads are supplied with switched-mode power supplies or variable frequency drives, DC leakage currents may occur and RCMS type B current transformers are necessary.

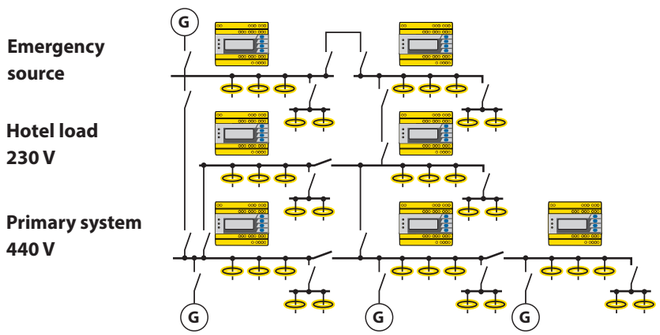


Changes in vectorial sum are small

Water or air heaters in galleys, laundries or HVAC preheaters and reheaters are particularly prone to faults.

Since each generator is solidly earthed in the main switchboard (not locally!), additional earth points are not detectable. This means stray currents can appear without being noticed and disturb all kinds of computer, audio and video systems on board. An additional central earthing point monitoring allows detecting changes due to installation faults and ageing.

Especially in the case of aluminium hulls, fault currents through the hull are particularly dangerous because they damage it within a very short time causing pitting corrosion. Even larger units with a weight-saving thin steel outer skin have been affected by electrolytic corrosion. This not only affects the hull but also rod bearings, washers, oil and water coolers, and quickly causes major damage.

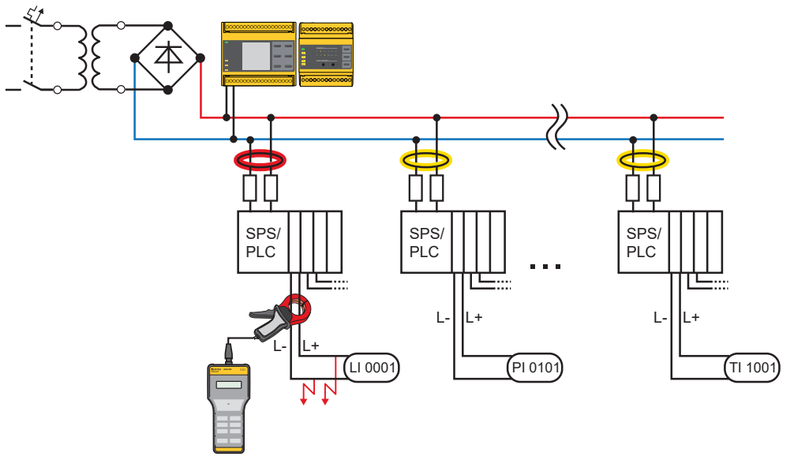


Control systems

The ship automation system and most other systems on board have an internal control voltage of DC 24 V. This is below 50 V; the permissible touch voltage is within a safe level. But for safety reasons the classification societies require for each isolated system (unearthed IT system) an insulation monitoring device (IMD) for continuous monitoring and alarming in the event of abnormally low levels. The advantage of this unearthed system is that if a first fault appears, the system will be fully operable without any malfunction or shutdown because of an RCD trip (TN system). Shutdown can lead to dangerous situations at sea, for example when redistributing the ballast water or fuel if the free surfaces cannot be reduced because the tanks cannot be emptied or filled completely.

The question arises as to the limits of abnormally low levels. Since most analogue sensors for tank levels, pressure etc. are working with 4-20 mA signals, it is a question of resolution. For example, an insulation fault of 24 kΩ at 24 V means a leakage current of 1 mA, which means 6.25 % of the % sensor deviation. Usually even more, because in most cases only part of the sensor range is used.

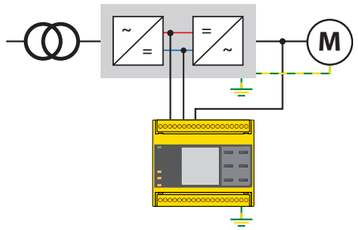
After delivering the ship, the insulation level in the "control system" is very good. However, during operation, the operating state will gradually deteriorate due to ageing and small extensions. This is the challenge because only if the first, apparently small faults are detected and eliminated, there is a chance to keep the insulation value at the same level later on. Bender insulation fault location systems, which are especially adapted to control systems, also help to avoid that the locating current sets any inputs in the "PLCs", energises relays or causes any damage. This way, in the DC 24 V distribution systems, a fault can be narrowed down immediately upon first occurrence and the time-consuming and nerve-racking search for sporadic faults in the entire system as well as the bad feeling that "there is something" are a thing of the past.



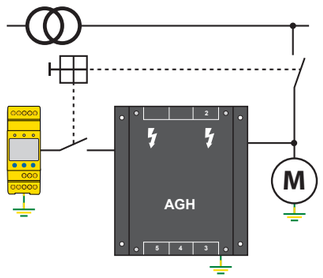
Offline monitoring of the propulsion plant and other important loads

Insulation faults in deenergised loads cannot be measured with the insulation monitoring device of the feeding system. Therefore, the fault is not detected until the load is switched on and usually the circuit breaker switches off the load immediately due to overcurrent protection. This means that the load is practically not available. The insulation monitoring of the windings of the deenergised loads allows detecting insulation faults before the system is switched on and fails. This way, faults that occur in loads which are important in case of emergencies, such as bilges, fire and standby pumps or rescue cranes are immediately detected and reported by means of an offline measurement. This gives the crew the opportunity to eliminate the faults before the systems are actually needed. Furthermore, it enables insulation value deteriorations to be detected long before reaching a critical value and maintenance measures to be planned and scheduled without risking a failure.

More and more large motors, especially in propulsion plants, thrusters, winches and heavy load cranes are controlled by variable-speed drives. Especially at high power it is important to check the insulation resistance of the installation before switching on the voltage, otherwise serious and costly damage will occur. This applies not only to the windings of the drive motor but also to the DC link in the frequency converter. With the ISOgraph integrated in Bender devices, it is possible to detect long-term changes in good time and implement condition-based maintenance.



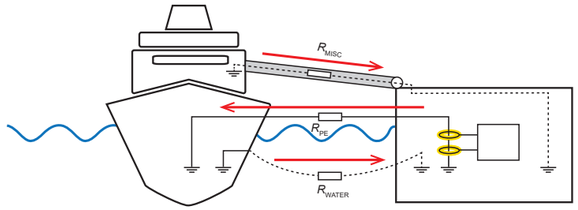
Offline monitoring of VFD and winding



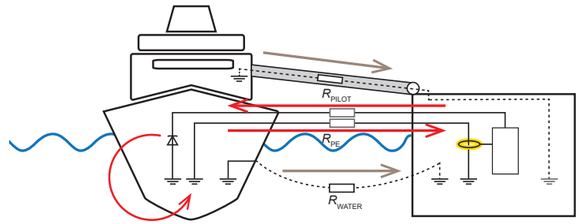
Offline monitoring winding

Shore to ship power

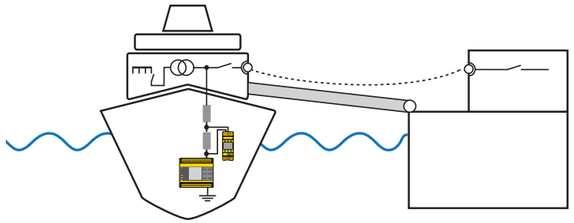
More and more ships are being supplied with onshore power in the ports in order to reduce the pollution of emissions and noise, especially in regions close to cities. This implies not only that the necessary power must be made available but also that it must be brought on board safely. Since the cables and connections are exposed to the weather and movement not only during connection but also during low and high tide and due to the movement of the ship, it is important to monitor these for damage and the resulting leakage currents. IEC 80005-1 regulates the onshore power supply for medium voltage and IEC 80005-3 for low voltage.



For medium-voltage power supplies, "continuous monitoring of equipotential bonding" must be ensured to prevent life-threatening potential differences when boarding the ship. When supplying cruise ships with one cable each for the 3 phases and PE, different measurement methods are used depending on whether the parallel resistances via gangway, supply hoses and the water have high or low impedance.

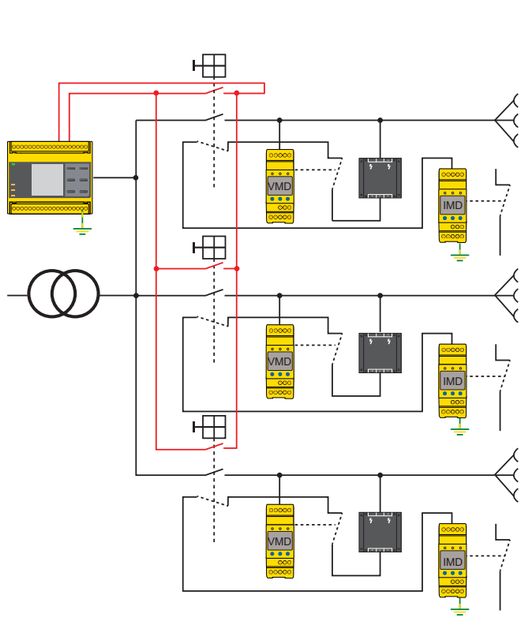


However, there are also constellations in which the ship must not be connected directly to the shore due to electrical corrosion. In this case, the insulation resistance of the feeding medium-voltage side and the cable set including the primary side of the shore connection transformer are monitored on board. A voltage relay interrupts the power supply in the event of rapid voltage shifts due to a cable break.



Low voltage systems

In low-voltage systems, usually several parallel cable sets are required to provide the necessary power. Here, the insulation resistance of the individual cables and the secondary side of the onshore power supply transformer must also be checked before switching on.



Monitoring of safe supply of reefer containers on board and on shore

While at sea, cargo such as fruit, meat, medicine and other types of cargo, needs to be refrigerated in a reefer container. Nowadays, cooling is usually powered by electricity. Electronics and other sensitive cargo must also be transported at a stable temperature. In container ships, the necessary power from the medium-voltage system for two to three cargo bays each is trans-formed to 440 V and the plug distributors are fed into the various tiers in a distributor with 6-8 containers each. To ensure availability, these systems are usually unearthed. However, in the event of a fault, the crew must find the first fault before a second fault current occurs. Otherwise, the fuses of two plug distributors would trip, the connected reefer containers would be disconnected from the mains and the goods would spoil. However, this search is very time-consuming as the distributors of the more than 50 reefer containers have to be taken off the system individually to narrow down the fault. Since not all reefer containers are always in use at the same time, fault location is difficult.

On ferries, the trailers with reefer containers are also supplied with electricity during the crossings. Also in this case, fast localisation of insulation faults is essential to avoid endangering the power supply for an entire deck with several dozen container loads. This solution makes it possible to ensure availability even in the large refrigerated warehouses on shore and detect faulty reefer containers before loading so that they can be repaired or reloaded. If these are powered by an earthed system, RCMS technology is used to detect the fault currents.

Bender insulation fault location systems (EDS) allow the crew to immediately and automatically detect the "distribu-tion" of the reefer container with the first fault as soon as it occurs. Now, all that is left to do is to select the defec-tive container in the "row".

Monitoring of umbilicals

Remotely Operated Vehicles (ROV)

Remotely Operated Vehicles (ROV) and other underwater devices are supplied with electrical power via umbilicals. In order to realise a small cross-section of the supply lines, the voltage levels are set high (several kV). A power failure would usually mean the loss of the device as they navigate on their own and cannot be recovered by pulling the cable. This is why IT systems are also used here, which must be monitored properly in order to detect a change in the insulation level. In this case, the insulation oil in the ROV can be treated or, if necessary, changed.

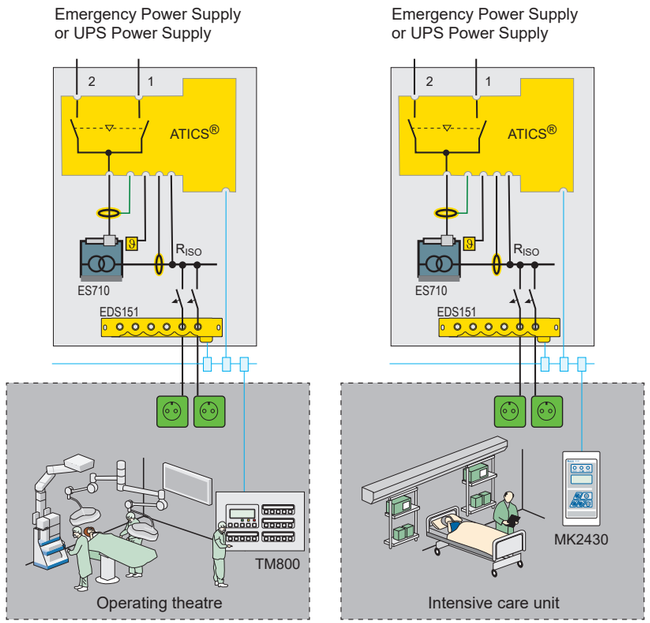
The umbilicals are usually custom-made cables for the individual device and must be manufactured specifically in case of replacement. A long warning time before the failure ensures availability of the expensive underwater device as well as the Offshore Support Vessel (OSV) or the underwater pro-duction device. The new isoHR685 continuously monitors insulation changes even in the giga-ohm range and, with the new synchronous operation, enables the measurement of many parallel cables in the umbilical, which are capacitively coupled due to their length.

Safe power supply of onboard hospitals and medical facilities

At sea, the way to the closest hospital is usually very long and often cannot be covered by helicopter. Therefore, treatment rooms are usually set up on board of ships; on larger ships, these correspond to the standard of operating theatres. If there is no doctor on board, remote assistance is used to save lives in case of an emergency.

It is important that the power supply of any medical device in the operation theatres, recovery rooms and intensive care units is not only connected to the emergency power supply but also galvanically isolated from it. An isolating transformer, which is required for every operating theatre in a hospital, limits the leakage capacitance to ensure that any fault currents that occur are very small and that no fault is transferred from one system to another. In this medical IT system, an insulation monitoring device (IMD) indicates immediately when a fault or a transformer overload has occurred so that it can be eliminated right away after medical treatment to avoid system failure. Insulation fault locators help to detect the fault precisely so that the defective device can be quickly identified and the fault can be eliminated.

IEC60364-7-710 as well as local directives describe the requirements. On this subject, see…



Visualisation and gateways

Due to the complexity of the electrical system, a large number of devices must be monitored. Gateways allow easy access to all information of the ISOMETER®s and EDS devices as well as parameterisation of the devices for commissioning. Wherever the integration of all channels into the ship automation system is too expensive, the BCOM interface offers an elegant possibility to call up all messages at a central point and access the information and insulation processes.

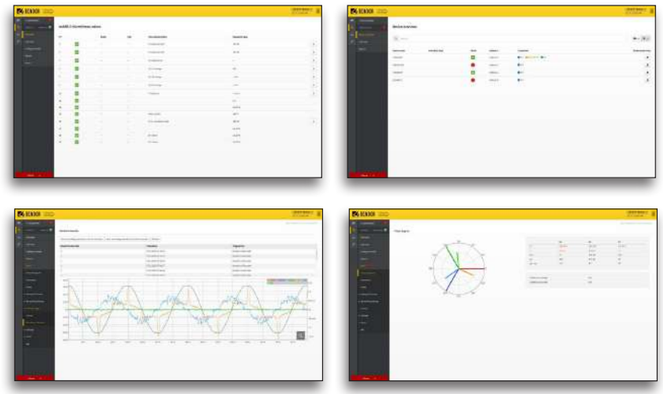
By connecting it to the Wi-Fi, the ETO can also work on-site to further narrow down insulation faults and eliminate faults without additional support.

Interconnection and visualisation made easy

The COMTRAXX® monitoring systems are used in a wide range of applications. However, what they have in common is that the user can obtain relevant information in a fast and easy way. In the event of an alarm, the system informs actively via e-mail, switching contacts or by forwarding information to higher-level control systems. To carry out an analysis or create a report, the user accesses data points that were captured previously. The Bender system control centre allows both in one system. Data is collected from all connected measuring devices, evaluated and processed according to the respective application. In doing so, the browser-based concept offers many advantages:

- Remote access to the current measured values, status/alarm messages and parameters via LAN/WAN Internet
- All users work live in a browser-based system
- 10/100 MBit Ethernet gateway for Modbus TCP, Modbus RTU and Profibus DP and support for third-party devices
- Central management
- The system is safe and geared toward the future with expansions

From the entire system overview with an integrated visualisation tool to detailed power quality evaluations, the Bender system control centre accompanies the user with intuitive operation and guided support during fault analysis.



Display of device data on the web user interface (COM465IP)

Maintenance

Data basis for maintenance

Maintenance is one of the focal points in maritime operations due to the high investments and autonomy at sea. This encompasses electrical maintenance on board in engine rooms, light and power supply in exterior and hotel areas but also control & automation, navigation & communication as well as audio & video entertainment. Bender monitoring devices provide assistance in the monitoring of the electrical power supply. They continuously furnish data about the condition of the installations and are therefore indispensable for preventive and predictive maintenance.

Good to know:
Stationary solutions for insulation fault location can also be retrofitted. Portable and stationary solutions from Bender comply with IEC 61557-9

The aim: reduce costs – increase availability

The aim of every plant operator should be to detect malfunctions at an early stage and eliminate the causes economically to achieve optimal system and operational safety and ultimately reduce costs significantly. Only those who are aware of the condition of their system can fulfil the prescribed targets concerning personal, system and fire protection. With Bender monitoring devices, installation operators stay on top of things.

Identifying the trend of the insulation resistance level & recognising faults before they have negative effects

When you analyse the progress of the insulation resistance, you can see that many deteriorations develop gradually and can therefore be predicted. This makes maintenance measures plannable instead of just reacting to the ISO alarm. The trend of the insulation value thus becomes the starting point for proactive maintenance. The correlation of leakage capacitances, measurement times and measurement interferences enables even better analysis.

Interpreting short-time insulation fault messages correctly

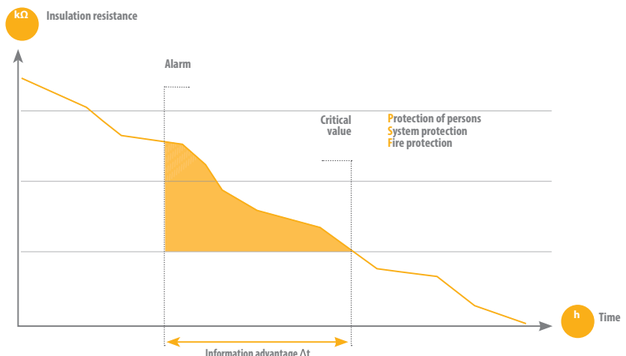
Short-time insulation faults are difficult to interpret. If, for example, the insulation value falls below the alarm notification threshold value for only ten minutes and then rises again to a normal level, the electrician on board often does not stand a chance in finding the cause of the fault. Maintenance must then be terminated without fault elimination, and the faulty insulation remains a hazard for the system.

Avoiding additional harbour or yard days

Insulation faults at sea can lead to unplanned berthing times and thus to schedule delays as well as losses in charter rates. Traditionally, many insulations faults were located manually, which made it necessary to switch off the system supplies. Many systems can only be switched off when the ship is moored in port and so time usually runs against the crew. However, if the insulation faults are ignored, critical and dangerous conditions may arise at sea due to a second fault. Bender technology detects slowly decreasing of insulation values and uses communication interfaces to enable predictive maintenance and analysis.

Fault location in electrical installations made easy

In order to rapidly find insulation faults also in the case of systems with exten¬sive routes and distribution systems, the implementation of stationary insulation fault location systems is preferred. They are able to allocate insulation faults to individual route sections on different levels in the distribution system. A further advantage is: Bender fault location systems find insulation faults during ongoing operations, without system or load disconnection.



Proactive instead of reactive: predictive maintenance

Determination of the ideal time for maintenance

Reducing risks of failure

Whether it is gradually developing insulation faults, stray currents, or malfunctions due to material fatigue of the electrical systems, often accelerated by humidity, temperature differences and vibrations but also dust and salty atmosphere: The impact of these problems, which can be detected at an early stage, is often underestimated and range from triggering protective devices and the sudden appearance of arcs to fire damage, loss of system capabilities or even personal injuries. Those who only react once a fault has occurred are forced to accept regular downtimes with all the associated financial and image-damaging consequences.

Many installation operators test their systems at regular intervals and renew technical components as a precautionary measure. This simple model of preventive maintenance may impede many avoidable downtimes but is personnel and cost-intensive due to manual inspections and wasted residual quality of the components. Furthermore, intermittent assessments of the condition are very unreliable.

What if downtimes could be predicted and therefore prevented?
What if maintenance could be cost-optimised?

This can be achieved with Bender monitoring systems as they enable monitoring that provides analysis capabilities and can thus determine the ideal time for maintenance. This predictive maintenance saves valuable resources: Maintenance measures can be planned, and devices and components can be used until the end of their service life. Moreover, the targeted and fast localisation of problem areas is achieved by Bender insulation fault location systems. Predictive maintenance allows you to achieve maximum cost effectiveness.

Only forward-looking planning enables foresighted maintenance

Electrical devices are subject to normal wear and may be susceptible to faults during their service life. The portable insulation fault location systems from Bender can be a valuable tool in the search for insulation faults as they allow easy determination of the fault location.

Maintenance strategies

Corrective

Downtime-oriented

- Reaction after direct damaging event
- Unscheduled downtime

Preventive

Time-dependent

- Established deadlines
- Frequent exchange of intact components

Condition-oriented

- Reaction to warning thresholds concerning the system condition, still prior to downtime
- Optimum use of service life (wear margin)

Predictive

Analysis-supported monitoring

- Prediction of the ideal time for maintenance
- Maintenance measures that can be planned

Predictive maintenance allows you to achieve maximum cost effectiveness. Bender monitoring systems help you to

- improve the management of your assets (CAPEX)
- optimise maintenance efficiency (OPEX)

Retrofit

Is your system still state of the art?

Even the most modern electrical systems cannot escape the marks of time. Whether diminishing operational reliability, changed legal stipulations or increasing energy costs: Upgrading to the respective current state of the art is indispensable. Products for monitoring energy quality and fault search are typically retrofitted.

Risk assessment according to operating safety regulations: Does your presently installed monitoring equipment recognise symmetrical and asymmetrical insulation faults?

Symmetrical and asymmetrical insulation faults present a high risk potential. Bender insulation monitoring devices continuously monitor your systems,
insulation faults are captured and reported. Bender insulation monitoring devices comply with IEC 61557-8.

We will check your electrical installations and provide you with recommendations on how to proceed further.

Bender delivers flexible solutions for retrofit projects

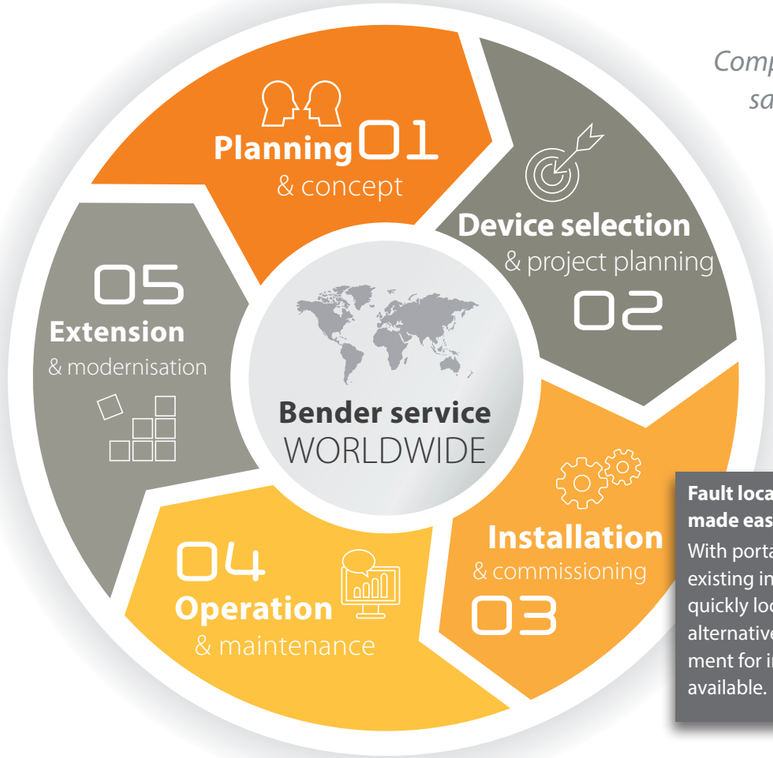
Modern monitoring methods can be integrated in older installations as well – also during ongoing operation. Retrofitting is possible via devices such as divisible transformers, whereby the transformers do not even have to be shut down nor must cable installations be disconnected.

Successor devices from Bender can conveniently replace older installations. Long-term availability is thus guaranteed.

Support during all stages

Comprehensive service for your installation: remote, by phone, on site

Competent service for maximum safety and high availability of your installation



Fault location – made easy

With portable fault location systems, existing insulation faults can be quickly located. They are the best alternative if no stationary equipment for insulation fault location is available.

From planning to modernisation – Our extensive know-how is at your disposal during all project phases.

Furthermore, with our first-class service we guarantee maximum safety for your electrical installations.
We offer services ranging from support over telephone to repairs and on-site service – with modern measuring devices and competent employees.

Secure yourself:

- High availability of your installation thanks to fast reaction to fault messages
- Increased profitability of your capital expenditure (CapEx) via optimised maintenance processes
- Targeted operating expenditure (OpEx) due to less downtimes and shorter service visits
- Support for your prospective system monitoring and regular tests of your system/power quality/monitoring devices
- Automatic control, analysis, correction, new settings/updates
- Competent assistance with setting changes and updates

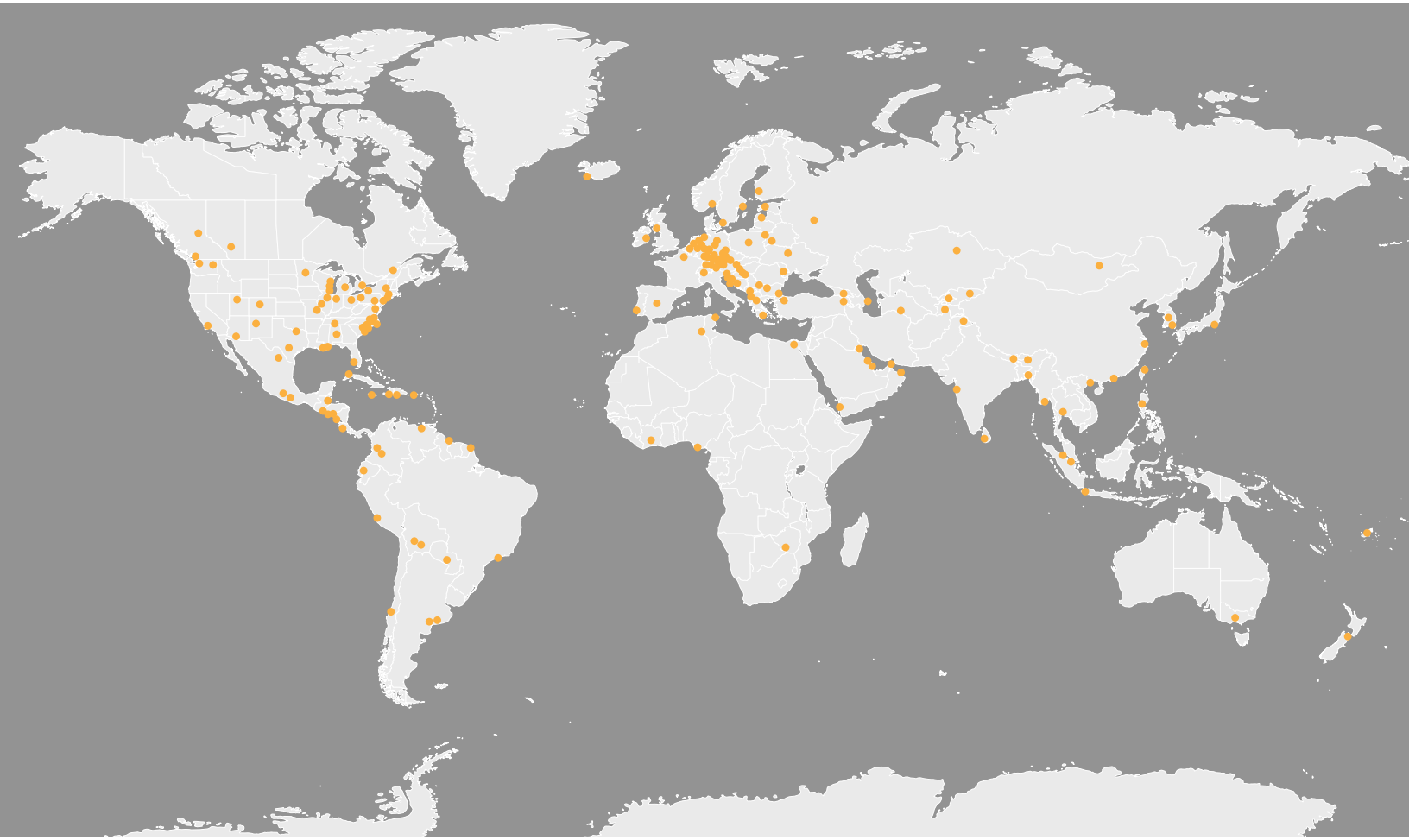
Bender Remote Assist
Bender Remote Assist offers you support via remote access, high-quality service and advice for your challenging task consisting in ensuring consistent high safety in your systems.

Many service visits, fault clearance but also analyses and controls can be carried out remotely – without the expenses of time and money that an on-site visit of a technician implies.

This fast, efficient help and advice by our expert network allows the highest possible availability of your system.

BENDER®
The Power in Electrical Safety

Bender is located in over 70 countries around the world



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