



Lightning and surge protection for yachts

Yachts at sea, at anchor and ashore (e.g. in a dry dock) are vulnerable to lightning strikes. The probability of a lightning strike depends on the local ground flash density N_g which specifies how many lightning discharges occur per km^2 and year. The closer the yacht approaches equatorial waters, the higher the risk to be struck by lightning at sea. In general, the ground flash density is frequently higher ashore (at anchor) than at sea.

If lightning strikes the mast of a yacht, lightning currents travel to the deck. Since several cables are routed on the mast, e.g. to navigation lights, the radio antenna or the anemometer, the lightning current enters the inside of the ship through these cables and spreads over the entire cabling of the on-board system supplying the depth sounder and log. This can damage these systems and result in the ingress of water since these devices are located under the water level. While the ingress of water is noticed at sea and can be eliminated, this often remains unnoticed when the yacht is at anchor in winter and the yacht may sink.

To determine potential points of strike, the electro-geometric model (rolling sphere method) is used. It describes the flash (centre of the rolling sphere) which strikes an object after a certain distance (radius). The smaller the radius, the more effectively lightning strikes are intercepted. In the lightning protection standards, different radii r are assigned to classes of LPS I to IV. Class of LPS I provides maximum protection from lightning strikes. In this case, the system safely handles 99 %

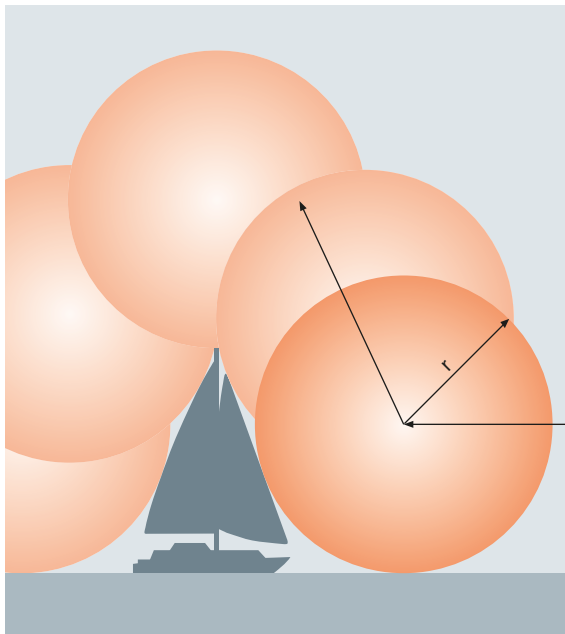


Figure 9.34.1 Determination of the lightning risk for a yacht using the rolling sphere method in case of class of LPS III

of all lightning strikes with impulse currents lower than 200 kA and higher than 3 kA.

Class of LPS III is often used for yachts (see example in **Figure 9.34.1**). This figure allows to assess the risk of a lightning strike to the mast. The information provided below also applies to multi-masted yachts. The points where the rolling sphere touches the yacht are potential points of strike and must be protected.

Lightning protection

To implement lightning protection measures, a distinction must be made between metal and non-metal masts/bodies of the yacht.

Metal yacht

If the yacht has a metal body which is conductively connected to a metal mast, no additional measures for discharging the lightning current must be taken. If lightning strikes the mast of such a yacht, most of the lightning current is discharged via the mast and partial lightning currents are passed through the stays to the body / bottom and to the water (**Figure 9.34.2**).

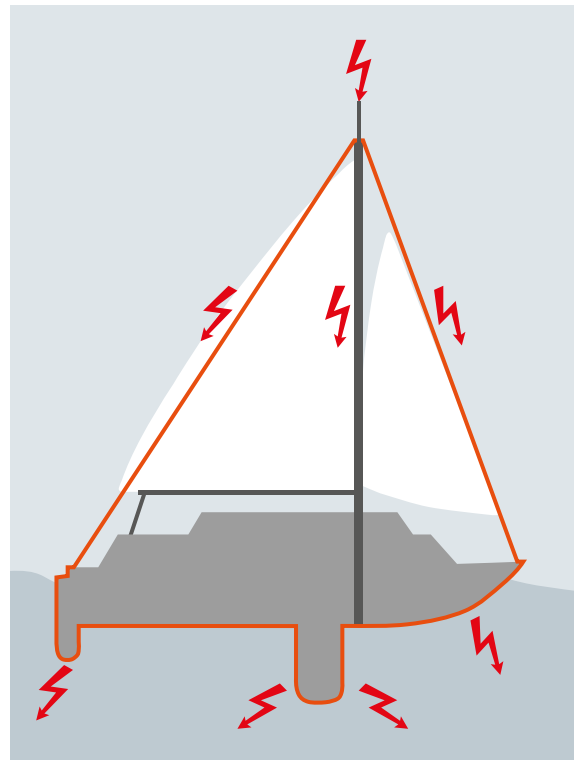


Figure 9.34.2 Lightning current distribution on a yacht following a lightning strike to the mast

Non-metal yacht

Yachts with a wooden or GRP body require additional lightning protection measures.

If the mast is made of e.g. wood, an air-termination rod with a thickness of at least 12 mm must protrude at least 300 mm from the mast. The down conductor routed down the mast can be made of copper and should have a minimum cross-section of 70 mm². It must be routed in the outdoor area of the yacht and connected to the earth plate. The earth plate must have a surface of at least 0.25 m² and must be made of copper or another saltwater-proof material. In case of large yachts, different earth plates may have to be used for the lightning protection and power supply system. In this case, a sufficient distance must be maintained between these earth plates to prevent flashover.

If lightning strikes the air-termination rod on the non-metal mast, the lightning currents must be discharged to the earth plate via the down conductor on the mast and via the shrouds, stays and chain plates. To this end, the mast, shrouds, stays and chain plates must be connected to the earth plate. The copper connecting conductors must have a minimum cross-section of 16 mm². All lightning current carrying connections may only be established by screwing, riveting or welding.

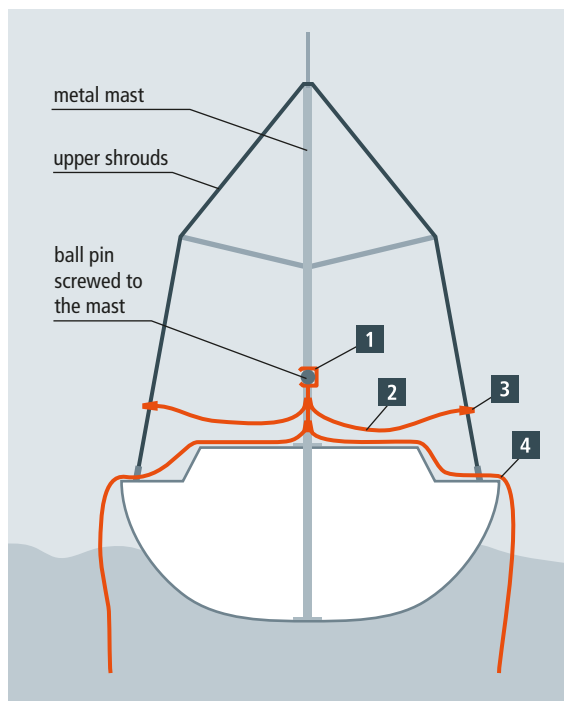
Mobile lightning protection in case of a metal mast

A cost-effective mobile lightning protection system, which is frequently used for occasional charters of a yacht, can be easily implemented. To this end, the lower part of the aluminium mast is fitted with a ball pin, which is used as down conductor. A lightning current carrying terminal, which is connected to two other terminals and two braided copper strips of several metres, is screwed to the ball pin. The terminals are connected to the upper shrouds to use them as down conductor. The free ends of both braided copper strips must be immersed at least 1.5 m in the water (Figure 9.34.3).

All components and the relevant connections must be capable of carrying lightning currents and must be corrosion-proof. This protection measure can be quickly implemented when a thunderstorm approaches and provides a certain protection against lightning strikes. It is not entirely clear to what extent mobile lightning protection systems provide protection for yachts since the normative requirements for equipotential bonding (personal protection), separation distances, etc. are not observed. It can only be assumed that lightning damage such as punctures of the body can be prevented since most of the lightning current flows through the braided copper strips into the water. Therefore, a fixed lightning protection system always has to be preferred.

Power supply system

The IEC 60364-7-709 (HD 60364-7-709) standard (marinas and similar locations) describes the special requirements for



	Component	Type/material	Part No.
1	Universal earthing clamp	UEK 25 HG	774 234
2	Multipole earthing cable	e.g. V6TZ3N8	Can be configured via the DEHN earthing and short-circuiting configurator
3	Earthing tongs	Stainless steel	546 001
4	Braided copper strip	Copper	377 007

Figure 9.34.3 Mobile lightning protection for a yacht with a metal mast

power supply circuits (shoreside power supply system) of water sport vehicles and house boats supplied by public utilities. Water sport vehicles include boats, ships, yachts, motor launches and house boats which are exclusively used for sports and leisure activities.

The information provided only refers to single-phase alternating current power supply systems in a 230 V/50 Hz system (it can be also used for three-phase power supply systems in a modified form). The relevant socket outlets up to 63 A must comply with the IEC 60309-2 (EN 60309-2) standard (CEE design, "blue").

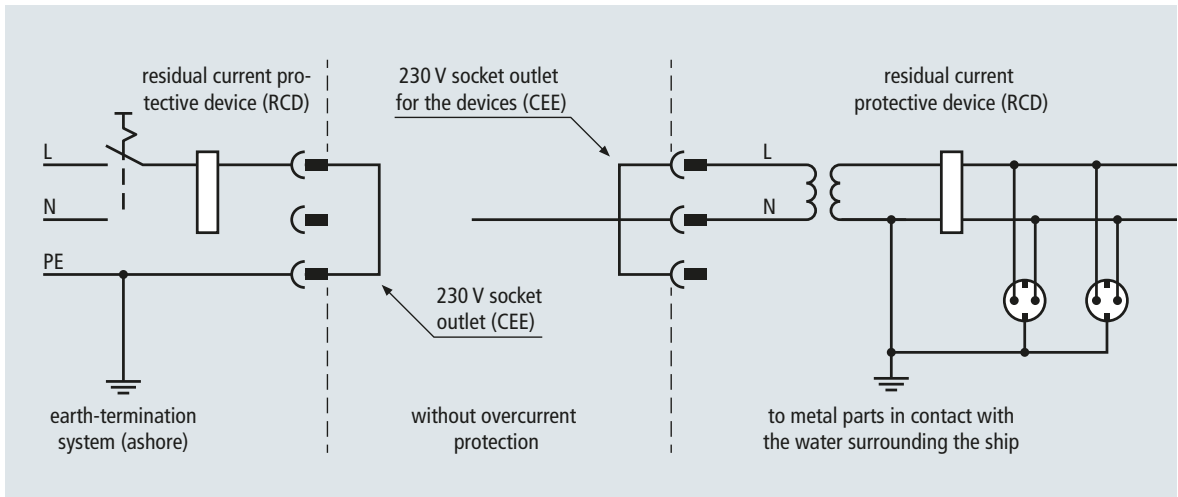


Figure 9.34.4 Use of an isolation transformer to prevent corrosion

For corrosion protection reasons, the protective conductor of the shoreside power supply system must not be connected to the earthed metal parts of the water vehicle. The protective conductor of the shoreside power supply system is not required to protect persons on the yacht against electric shock since an isolation transformer on the yacht ensures protection against electric shock in connection with a residual current protective device (Figure 9.34.4).

Equipotential bonding

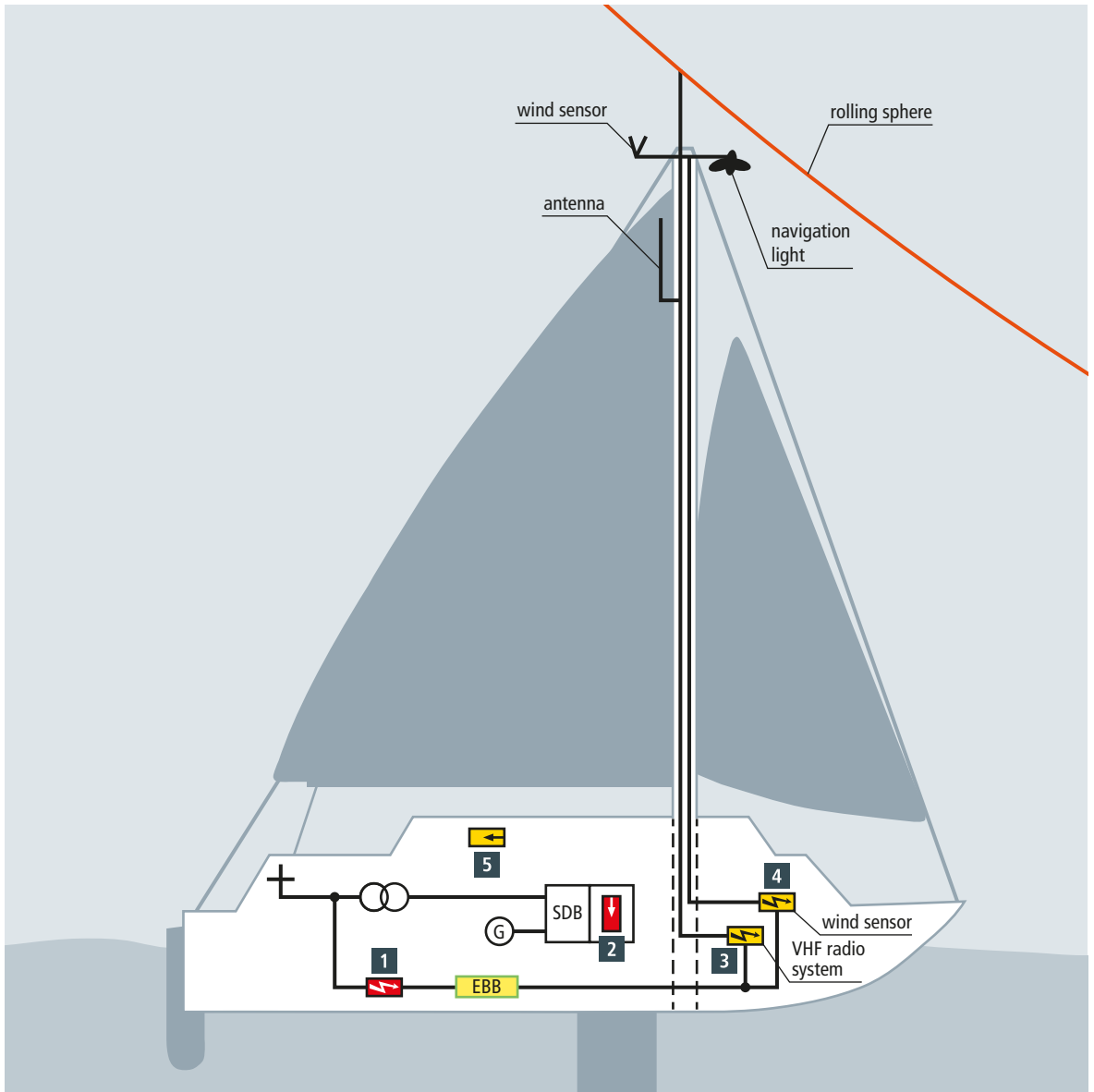
In general, all protective conductors of the board electronics and all metal parts of yachts must be connected to the common equipotential bonding/earth-termination system of the power supply system. This measure prevents dangerous touch voltage/sparking. The copper protective bonding conductors, which do not carry lightning currents, must have a minimum cross-section of 6 mm². For this purpose, stranded, solid or flexible conductors must be used. Flexible conductors should be preferred due to vibrations. In this context, it must be observed that the conductors can be damaged by the corrosive environment (saline, moist) and the capillary effect. Therefore, the cable lug at the ends of the flexible conductors must be sheathed with a heat shrinkable sleeve.

Internal lightning protection/surge protection

A combined arrester, which is directly installed in the power supply system, is one of the most important protection measures (Figure 9.34.5). The necessity of such an arrester is shown based on the following two scenarios.

If lightning strikes the air-termination rod or the metal mast of the yacht at anchor which is supplied with electricity, the potential of this yacht is raised above the connection of the shoreside power supply system. A part of the lightning current is passed to the water and flashover to the power cable of the shoreside power supply system will occur depending on the conductivity of the water. This flashover can damage the cables/equipment on the yacht and cause fire. However, it is even more likely that a yacht at anchor, which is supplied with electricity, is threatened by a shoreside lightning strike. In this case, the lightning current flows in the direction of the yacht and causes the damage described above.

If a type 1 combine arrester is installed, it must be ensured that the connection of the earth-termination/equipotential bonding system of the yacht to the protective conductor of the shoreside power supply system does not cause corrosion. The surge protective devices shown in Figure 9.34.6 consider that the polarity (L, N) is changed, which is typical of earthed socket outlets (not standard-compliant, but may be the case). In this case, the phase conductor (L) and the neutral conductor (N) are twisted until they reach the L and N connections of the on-board supply system. The increased voltage protection level is sufficient for the electric strength of the primary winding. Irrespective of whether a yacht is made of metal or non-metal material, there is the risk that lightning hits, for example, marine radio antennas or wind sensors installed on the mast, which can damage these pieces of equipment and downstream radio or evaluation devices. Since these pieces of equipment are located in the protected volume (air-termination tip on the



	Surge protective device	Protection for	Part No.
1	DEHNventil DV MTN 255 DEHNgap DGP M 255	Power supply system	951 200 961 101
2	DEHNguard DG M TT 2P 275	Sub-distribution board	952 110
3	DEHNgate DGA AG N	VHF radio system	929 045
4	BLITZDUCTOR BXT ML4 BE 24 + BXT BAS base part	Wind sensor for the navigation system	920 324 + 920 300
5	BLITZDUCTOR BXT ML4 BE 36 + BXT BAS base part	Power supply system of the navigation system	920 336 + 920 300

Figure 9.34.5 Basic surge protection for a yacht (observe the technical data of the manufacturer of the surge protective devices)

mast), it is not to be expected that lightning strikes them. Adequate surge protective devices are shown in **Figure 9.34.5**. The effects of induced surges and switching overvoltages caused by board generators and UPS systems must also be observed. In this case, it is advisable to use type 2 surge arresters in the distribution board (**Figure 9.34.6**).

Personal protection

The equipotential bonding measures for all connections listed in the above "Equipotential bonding" chapter reduce the risk for persons on the yacht. In the event of a thunderstorm, persons should therefore

- ➔ Not stay on deck since potential differences, which present a risk in conjunction with wet skin, can occur due to wet surfaces
- ➔ Not touch shrouds, rods or other metal objects
- ➔ Check the lightning protection system at regular intervals and do not wait until thunderstorm occurs. In this context, it is important to check whether the equipotential bonding system, namely the connection of all conductive metal devices on board to the lightning protection system, is in good order and condition.

More detailed information can be found in the "Blitzschutz für Yachten" [Lightning protection for yachts] book by Michael Hermann, Palstek Verlag, Hamburg, 2011 (German).

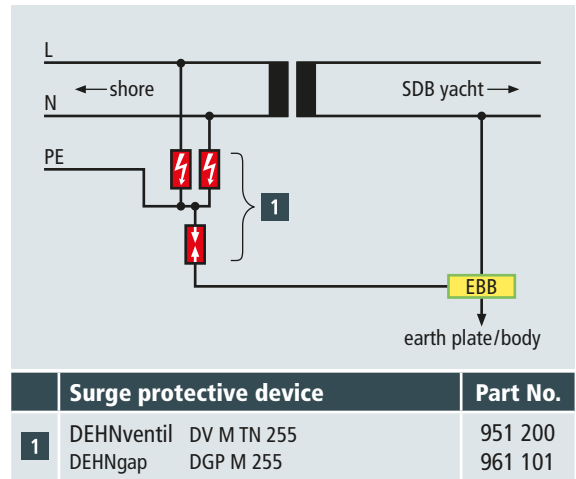


Figure 9.34.6 Detailed view of the shoreside power supply system with a lightning current carrying type 1 combined arrester