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Shore power connection with safety devices

TECHNICAL FIELD

10 The present invention relates generally to the technical field of electrical shore power supply for ships, and in particular to a shore power outlet. The term "shore power outlet" refers in particular to an easily connectable and disconnectable connection facility (for example using plug connectors such as a plug socket
15 connector or outlet socket connector) to which a supply line or a supply cable can be connected in an easily disconnectable manner.

INTRODUCTION AND PRIOR ART

There is an increasing demand for ships, when docked at a port, to be connected to a shore power supply, and for the generators of
20 said ships to be shut off, in particular in order to reduce emissions and for environmental protection. The supply of electrical power to ships from the shore (shore power supply) is known under various terms (for example also Alternative Maritime Power (AMP), Onshore Power Supply (OPS) or Shoreside Electricity
25 (SSE)), and is sometimes historically referred to as "cold ironing".

The invention relates generally to the ship-shore connection or ship-shore interface. This must perform several tasks aside from the primary role of supplying power. In particular, it should
30 ensure a high level of reliability and safety in order to reduce risks, for example the risk of an electrical fire or of an explosion and of associated injury to personnel, damage to

material and failure of the power supply.

The standard IEC/IEEE 80005 is intended to allow different ships to be connected at different berths to high voltage shore connections (HVSC) with the least possible adaptation and
5 adjustment to different locations.

The invention is primarily intended for such supply connections in ports, that is to say in particular for high voltage shore connection (HVSC) systems, in accordance with the standard IEC/IEEE 80005, and is intended in particular to be suitable for
10 an HVSC system conforming to IEC/IEEE 80005-1:2019. The invention thus relates in particular but not exclusively to a shore power outlet which is designed and configured for a multi-phase voltage supply at at least 6.6 kV or 7.2 kV, typically at at least 2 MVA (megavolt amperes) connected load.

15 The EMSA shore-side power supply guidelines for port authorities and administrations (European Maritime Safety Agency: Shore-Side Electricity - Guidance to Port Authorities and Administrations, Part 2 - Planning, Operations and Safety, Version 2, August 2022 - see section 9) discusses various safety requirements relating to
20 the shore power supply, including requirements relating to the ship-shore interface and the cable management system (CMS) used therein.

One known and critical problem is the risk of an explosion resulting from an electric arcing fault, hereinafter referred to
25 for short as arc explosion. An arc explosion is a type of electrical explosion which can arise owing to a low-impedance connection through the air to an earthed component or to another voltage phase in an electrical system. The explosion resulting from an electric arcing fault typically gives rise inter alia to
30 the formation of arc gases, molten droplets generated by the extremely hot plasma, pressure waves, and fragments of debris.

According to IEC/IEEE 80005-1:2019, section 7.3.1, the electrical connections must be made in regions from which personnel are protected in the event of an arc resulting from an internal fault,

for example in the plug connectors, by means of barrier and access control measures. These measures must be supported by access control procedures.

Access control alone however does not improve the intrinsic safety
5 of the ship-shore interface or of the CMS with regard to an arc explosion. Personnel can therefore still be exposed to the considerable risks of an arc explosion as a result of human error or non-compliance with safety regulations.

Although the likelihood of an arc explosion is low, this fault
10 scenario poses a very high hazard risk for personnel and equipment, with possibly fatal consequences for personnel. In the present field, there is therefore a need to improve the inherent safety of the ship-shore interface.

In this context, the teaching from WO 20202/16818 A1 is known and
15 is regarded as the closest prior art. Said document proposes a shore power outlet for electrically connecting the on-board power network of a docked ship, for example of a container or cruise ship, as required to a shore-side supply network. Such a shore power outlet typically has an outlet box, which in this case is
20 for example movable and which has box walls which enclose an interior in splash-proof fashion.

An outlet box of the type in question is a major part of the ship-shore interface and serves in particular for providing a plug connection unit, typically a socket outlet, for releasable plug
25 connection to a corresponding plug connector part, typically a plug, of a multi-phase ship supply line. In the interior of the box, the plug connection unit is, in the manner intended for operation, connected fixedly or non-releasably to the individual wires of a feed line of the shore-side supply network, wherein
30 further conductors, for example of a safety circuit or for data transmission, may also be provided.

CN109103783A has proposed a shore power outlet having an outlet box which has additional measures for explosion protection, in particular for use in environments with flammable gases, for

example in the petrochemical or chemical industry. CN109103783A proposes inter alia the provision of a system for detecting flammable gases by means of a sensor which monitors the content of flammable gases in the environment. However, no special protective
5 measures relating specifically to an arc explosion are proposed.

To improve safety in the event of an arc explosion, it has been proposed in W0 2020/216818 A1 that the shore power outlet comprises at least one cover part which is movable relative to the outlet box and which, in a first position, at least partially
10 covers the plug connection unit and a plug connector part which is plug-connectable thereto, and in a second position, uncovers same for the purposes of releasing or making the plug connection. The proposed cover part achieves a certain protective action against uncontrolled propagation of the explosion and associated debris or
15 molten material on the port quay.

The solution according to W0 2020/216818 A1 provides improved protection against the hazards of an arc explosion, but there is still potential for improvement. In particular, the solution according to W0 2020/216818 A1 does not sufficiently reduce the
20 effects of a possible arc ignition on the supply side at the plug connection unit or in the outlet box.

TECHNICAL PROBLEM

A first problem addressed by the invention is therefore that of proposing a shore power outlet of the type in question which has
25 an improved protective action.

According to a first independent aspect of the invention, this is solved by means of the features of independent claim 1.

According to a second independent aspect of the invention, this is solved by means of the features of independent claim 11.

30 According to a third independent aspect of the invention, this is achieved by means of the features of independent claim 20.

Preferred refinements for each of aspects can be found in the respective dependent claims.

GENERAL DESCRIPTION

A shore power outlet of the type in question is suitable for providing a supply to a ship, in particular a container or cruise ship. For this purpose, the shore power outlet is in particular designed and configured as a constituent part of the ship-shore interface, that is to say for electrically connecting the on-board power network of a docked ship as required to a shore-side supply network. The shore power outlet is thus typically designed and configured for a multi-phase voltage supply at least 6600 V and/or for a connected load of at least 2 MVA, that is to say in particular for an HVSC system conforming to IEC/IEEE 80005-1:2019, preferably for a connected load of at least 5 MVA, for example 7.5 MVA, in accordance with IEC 80005-1 Annex D (container ships).

A shore power outlet of the type in question comprises an outlet box having box walls which enclose an interior, in particular in splash-proof fashion, wherein the outlet box has at least one plug connection unit, typically a socket outlet, which allows the electrical connection to be made as required. For this purpose, the plug connection unit is provided on a box wall for releasable plug connection to a corresponding plug connector part of a ship supply line, typically a plug. In the interior of the outlet box, which is typically protected against environmental influences, preferably in accordance with protection class IP66 or IP67, a feed line of the shore-side supply network is fixedly connectable in the operating state, or fixedly connected during operation, to the plug connection unit. In addition to protecting the wiring of the plug connection unit, the outlet box may perform further functions, in particular protective functions.

GENERAL DESCRIPTION OF THE FIRST ASPECT

With regard to the first independent aspect, it is proposed according to the invention that at least one explosion pressure relief device is attached to the outlet box and/or to the cover

part. Preferably, an explosion pressure relief device is provided on the outlet box and an explosion pressure relief device is provided on the cover part. The explosion pressure relief devices on the outlet box and on the cover part may in particular be of substantially structurally identical design.

The explosion pressure relief device (abbreviated to EPRD) is a structural protective measure which primarily prevents explosion pressure in the volume enclosed by the outlet box and/or cover part from exceeding the admissible strength of the surrounding walls, by virtue of pressure being discharged through an opening. The explosion pressure relief device is designed such that it can quickly dissipate pressure that is generated in the event of an arc ignition. The explosion pressure relief device thus prevents the build-up of explosion pressure that could lead to relatively extensive damage, such as an uncontrolled explosion, in particular of the outlet box. The explosion pressure relief device can thus considerably reduce the risks of an actual explosion, or can altogether avoid an explosion in the shore power outlet.

For this purpose, according to the invention, the explosion pressure relief device forms in particular a predefined relief opening having a predetermined orientation, such that the force or effect of the ignition (arc gases, plasma, molten droplets or particles, pressure wave, etc.) can be conducted away in controlled fashion, in particular into a restricted, predetermined external space region outside the shore power outlet. The effect of the arc ignition can thus be conducted away from the port quay, that is to say also away from personnel and port equipment, in order to reduce or minimize resulting risks. Here, the orientation of the relief opening may in particular correspond, or be at least substantially parallel, to the surface normal to the nominally free opening cross section of the relief opening. The relief opening preferably has a fixedly set and invariant orientation relative to the geometry of the outlet box. The predetermined orientation is understood in particular to mean the resulting main flow direction of outflowing explosion gases, for example when

considering the three-dimensional distribution in a vertical plane and in a horizontal plane that intersect the relief opening. The relief opening may be normally closed, or closed during normal operation, and may open only in the presence of a certain
5 pressure, in particular passively as a result of a pressure rise in the event of an explosion.

Owing to the structurally selectable, preferably fixedly predefined orientation of the relief opening, it is - at least substantially - possible for a main outflow direction for gases
10 generated as a result of the arc ignition (referred to here as explosion gases) to be predefined, in particular in a fixedly predefinable direction relative to the geometry of the outlet box or relative to the spatial orientation thereof in the operational setting. In short, the explosion pressure relief device thus
15 serves for the targeted guidance of explosion gases, which are generated in the event of an arc explosion, through the relief opening and into an external space region, in particular a predetermined limited external space region.

The explosion pressure relief device may preferably have at least
20 one guide body, in particular a guide body arrangement. One or more guide bodies can serve as part of the explosion pressure relief device for targetedly guiding explosion gases (gases which are generated abruptly in the event of an arc ignition) through the relief opening and into an external space region, in
25 particular outside the interior of the outlet box. Guide bodies allow more targeted flow guidance, in particular in the interior of the explosion pressure relief device, and/or more pronounced spatial limitation of the space region into which the effect of the arc explosion is intentionally discharged or dissipated in
30 order to avoid uncontrolled propagation of explosion consequences. A guide body or a guide body arrangement can be differently configured, for example by means of the geometry of the outer walls and in particular also by means of inserts or flow-guiding components within the explosion pressure relief device, in
35 particular upstream of the predefined relief opening. The guide

body arrangement is generally a metal device which may comprise a number of lamellae, plates, grilles or pipes, and is arranged in the flow path of the emerging gases.

The explosion pressure relief device makes it easier to implement
5 an explosion-pressure-resistant structural design of the shore power outlet. It contributes to controlling and lessening the effects of an explosion or arc ignition by dissipating the positive pressure safely and in a predefined manner. It may additionally be designed as a type of explosion damper, or may
10 comprise an explosion damper. Aside from the core function of pressure relief and possibly explosion damping, it may optionally also prevent an ingress of outside air that could ignite the combustible gases, and may optionally have means that prevent flame propagation. An explosion damper can be implemented in
15 particular by means of a suitable guide body arrangement. In general, the explosion pressure relief means is constructed such that, in the event of an explosion or arc ignition, it can dissipate the pressure quickly in order to thus prevent the build-up of critical pressure that could lead to more extensive damage
20 and an uncontrolled explosion.

In a preferred refinement, on the outlet box, in particular as part of the explosion pressure relief device, a pressure relief element is attached to the outlet box. The pressure relief element is suitable for discharging explosion gases from the interior
25 under explosion conditions, in particular in the presence of a predefined response pressure, and for sealingly closing under normal operating conditions. Here, it may be the case that at least or only the explosion pressure relief means attached to the box comprises the pressure relief element. Under explosion
30 conditions, the pressure relief element then opens up the predefined relief opening in order to dissipate explosion gases from the interior of the box through the relief opening, and said pressure relief element sealingly closes the relief opening under normal operating conditions. Such a pressure relief element is not
35 required on the explosion pressure relief device on the cover

part, but is optionally possible in order to standardize the structural design.

The pressure relief element on the outlet box is preferably designed as a splash-proof rupture panel or rupture diaphragm or rupture film, and may for example be installed, as part of the explosion pressure relief device, on the outside at the relief opening, for example in order to facilitate installation, inspection and maintenance. The rupture panel may expediently be designed as a "single-use product" which breaks in the presence of overpressure. As a pressure relief element, use may alternatively also be made of an ejector panel, which is forced out of a holder by the pressure, or of an explosion flap or pressure relief flap, or the like. Advantages of the rupture panel or rupture diaphragm/rupture film are for example that it can be used in any position and requires only little outlay on maintenance. A purely passively triggered rupture panel or rupture diaphragm/rupture film is preferred. The rupture panel or the pressure relief element should be used for optimum protection with the lowest possible static response pressure. It is expedient if the selected static response pressure is for example < 1 bar, in particular ≤ 0.5 bar, particularly preferably ≤ 0.25 bar. Use is preferably made of a rupture panel (or rupture diaphragm or rupture film) consisting of rust-resistant material, for example high-grade steel, in accordance with the preferred structural design of the outlet box consisting of rust-resistant material, in particular high-grade steel, for example a high-grade steel suitable for the maritime sector, for example of type V4A.

GENERAL DESCRIPTION OF THE SECOND ASPECT

With regard to the second independent aspect, it is proposed according to the invention that a first cover part and a second cover part are arranged on the outlet box, which cover parts are, according to the essence of the second aspect, closable to form a volume which is delimited at least on four sides around the outlet components or connection components, such as plug connectors, which are provided on the outside of the outlet box. Explosion

protection can be considerably improved by means of this relatively simple measure alone, because arcs can in particular also ignite at the outer parts of the socket outlet or at the connecting plug of the ship supply line. It is to be assumed that the plugs on the ship-side high-voltage line, which are to be used as far as possible during every docking procedure for connection to the shore power interface or the CMS, constitute one of the greatest sources of risk with regard to hazardous arc ignition.

The two cover parts, possibly together with at least one wall of the outlet box, can serve to limit, preferably substantially or entirely enclose, a volume around the outer outlet components that are at risk of arcing. This is advantageous if an explosion pressure relief device according to the first aspect, which is optional but particularly preferred for the second aspect, is also to be provided in order to achieve effective explosion protection with regard to the outer outlet components.

According to the second independent aspect, to form a delimited or enclosed volume, at least the first cover part may be movable relative to the outlet box, and the two cover parts may be of matching or corresponding or complementary design in order that, in a closed first position, they at least partially cover, in particular enclose, the plug connection unit and a plug connector part which is plug-connectable thereto, and in an opened second position, they uncover said components for the purposes of releasing or making the plug connection. Furthermore, in particular, a locking device is provided by means of which the two cover parts are lockable, in particular are fixedly closed and/or lockable to one another, in the closed first position. In this way, even in the presence of explosion pressure, a substantially closed volume, a type of delimited "plug chamber", is ensured such that, even without an explosion pressure relief device, the effects of an arc explosion can be lessened and/or better channeled, for example toward an open side if the cover parts provide an enclosure at least toward a box wall and on four sides around the outlet components.

The interaction of the two cover parts also makes it possible to implement an access restriction means which prevents an undesired release of the outlet components, for example plug connectors, or makes it possible to implement an additional access monitoring means, for example for connection to a safety circuit.

The cover parts may preferably be designed as corresponding protective flaps, and/or may both be attached to the outlet box. Also conceivable, however, is a separate removable design of the cover parts or protective flaps. Both cover parts are preferably movable, for example portably removable, or particularly preferably supported on the outlet box.

Embodiments of the shore power outlet are particularly preferable which combine the features of the aforementioned first aspect and the features of the second aspect, or implement said features jointly.

GENERAL DESCRIPTION OF THE THIRD ASPECT

With regard to a further independent third aspect, it is proposed according to the invention that

- the at least one cover part, in a first position, secures the plug connection unit and a plug connector part, which is plug-connectable thereto, such that in the first position the plug connection between plug connection unit and plug connector part cannot be released, and the at least one cover part, in a second position, uncovers the plug connection unit and a plug connector part, which is plug-connectable thereto, for the purposes of releasing or making the plug connection,
- a locking device is provided for locking the at least one cover part in the first position, and
- a detector element is operatively connected to the locking device and/or to the at least one cover part, wherein the detector element detects whether the at least one cover part is locked in the first position, and wherein the detector element is connectable or connected, for signal transfer, to a safety circuit, in particular a control current pilot loop of an

interlock safety circuit, of the shore power supply.

The integration of the tamperproof locking of at least one movable cover part for the plug connection(s) makes it possible to achieve a further considerable increase in safety. In particular, in the case of integration into a typical safety circuit, for example into the pilot loop of an interlock circuit conforming to IEC/IEEE 80005-1:2019 (cf. Annex C / Annex D), in particular conforming to Annex D from this standard, it is easily possible to implement an emergency shutoff before the plug connectors can be released. This reduces the risk of arc formation, and avoids the need for other complex measures such as Kirk Key safety systems/interlocks.

Embodiments of the shore power outlet are particularly preferable which combine the features of the aforementioned third aspect and the features of the first and/or second aspect.

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GENERAL DESCRIPTION OF COMMON ASPECTS

The following refining features are applicable in principle to both or all of the aspects of the invention presented here, and can also each be regarded individually as being essential to the invention.

An explosion pressure relief device is preferably provided both on the outlet box and on one of the covers, such that the risks of uncontrolled arc explosion are reduced in both internal volumes. Here, a box-side first explosion pressure relief device having a sealingly closing pressure relief element may be provided on the outlet box, and an open second explosion pressure relief device may be provided on the cover. In principle, it is not of importance whether the cover-side second explosion pressure relief device is provided on the first cover part or on the second cover part, but it is advantageous for both explosion pressure relief devices to be arranged with a directing action toward the same side.

One or each explosion pressure relief device, or the box-side and/or cover-side explosion pressure relief device, may have an explosion damper. This is preferably provided upstream of the relief opening in an outflow direction in order to lessen the effects of an explosion by structural means. The function of the explosion damper can be implemented entirely or in part by means of a guide body arrangement which simultaneously has a flow-directing action.

The at least one explosion pressure relief device preferably has a guide body arrangement which is designed as a cooling and pressure-reducing flow-guiding device, in particular as a gas-cooling and/or pressure-reducing explosion damper or pressure wave damper. A cooling action can possibly also simultaneously have the effect of reducing flame propagation. Aside from a flow-directing action, the guide body arrangement can also serve as a retention device for preventing an escape of debris or molten material.

A suitable guide body arrangement has a multiplicity of mutually parallel cooling elements, preferably planar cooling elements, in particular metal plates in a parallel plate arrangement. The cooling elements may preferably be arranged so as to extend substantially in a desired main outflow direction and/or substantially parallel to the surface normal of the relief opening or of the maximum possible free opening cross section (when closed by a rupture panel, for example).

In principle, the cross sections, in particular the maximum possible free opening cross section, are selected such that a sufficiently fast outflow of explosion gases is ensured. The guide body arrangement may for example also preferably form a flow cross section which remains free and which is larger than or equal to the opening cross section of the relief opening.

Preferably, the or each explosion pressure relief device is of modular structural design and/or can be installed as a preferably prefabricated attachment unit on the outlet box or on a cover part, in particular on a corresponding connecting opening of a box

wall or cover wall.

The explosion pressure relief devices may each be of structurally identical design and may possibly differ only by the use of a rupture panel, which if possibly provided only on the outlet box.

5 In one refinement, the or each explosion pressure relief device is designed as a hood-like attachment unit having outer walls, in which a predefined relief opening having a predetermined orientation is formed, and having an installation flange which surrounds a through-opening and which serves for the installation
10 of the attachment unit, adjacently to the outside, on an opening in the outlet box or in the cover part, wherein the guide body arrangement is provided in the interior of the attachment unit between the through-opening and the relief opening. The installation flange may be fixedly fastened on the wall of the
15 outlet box or cover part.

In a structurally expedient embodiment of the explosion pressure relief device, at least two outer walls of the attachment unit are arranged obliquely, in particular in a trapezoidal or truncated pyramid shape, on the installation flange as a base. The relief
20 opening can thus be provided in an oblique outer wall, the angle of which relative to the installation flange substantially predefines the orientation of the relief flow or a main outflow direction. The orientation of the relief flow can thus be structurally set without the need to modify the outlet box or
25 cover part, that is to say is suitable for any structural designs of the outlet box.

Preferably, the cover parts are designed such that, in the first position, the plug connection between plug connection unit and plug connector part cannot be released, and the locking device has
30 an interlock bolt which is operatively connected to an electrical switching element, wherein the switching element is electrically connectable or connected to a safety circuit of the shore power supply.

The switching element may in particular be connectable or

connected to a safety circuit conforming to IEC/IEEE 80005-1:2019 (cf. Annex C / Annex D).

In principle, the two cover parts are designed to interact, particularly preferably such that, in the first position and
5 together with at least one housing wall of the outlet box, they enclose a plug chamber in substantially closed fashion on all sides, in order to reduce the explosion risks and allow the attachment of an explosion pressure relief device.

For this purpose, one structurally expedient embodiment provides
10 for the cover parts to be dimensioned substantially matchingly with respect to a preferably cuboidal box shape of the outlet box, and to be preferably substantially U-shaped in cross section and preferably substantially L-shaped in longitudinal section. Here, in the first position, the cover parts may each terminate with one
15 end region flush, in particular sealingly, against a housing wall of the outlet box.

The cover parts are particularly preferably designed such that, in the second position, one cover part engages in nested fashion into the other cover part. A design which is mechanically robust with
20 respect to explosion pressure in the interior is thus realized.

Preferably, both cover parts are supported movably on the outlet box. They may in particular be designed as protective flaps and supported on the outlet box such that they can be pivoted open and closed between the first and second positions.

25 Preferably, a mechanism, in particular lever mechanism, couples the movement of the two cover parts relative to the outlet box. Here, the outlet box may preferably form the fixed element of the mechanism. To facilitate operation, at least one gas spring may preferably be coupled to the mechanism so as to provide
30 assistance.

Preferably, each cover part is, at a box-side end region, supported at both sides on the outlet box by means of respective pivot joints.

The lever mechanism for movable support is preferably designed to couple the cover parts and/or limit the maximum pivot angle.

Preferably, each cover part has, at an end region facing away from the outlet box, at least one leadthrough cutout for a ship supply
5 line, wherein a sealing element for lying sealingly against the ship supply line in the first position is preferably provided internally at each leadthrough cutout.

Preferably, an explosion pressure relief device having one or more of the above features, in particular according to the first
10 aspect, is provided on at least one of the cover parts.

The proposed shore power outlet makes it possible to realize a relatively compact but safer structural design, in the case of which the cover parts are preferably attached to the outlet box as captively retained constituent parts.

15 The shore power outlet may be installed in static, that is to say positionally fixed fashion on a port quay. In particular, however, the shore power outlet is designed to be movable (mobile shore power outlet).

Thus, in one refinement, the shore power outlet is installed
20 movably, in particular is installed on a positionable support arm, and/or is installed on a movable carriage or vehicle.

The mobile or static shore power outlet is, in an operational setting, arrangeable or arranged at a quay facility of a port preferably such that explosion gases that arise in the event of an
25 arc explosion are discharged away from the quay facility through the relief opening of the explosion pressure relief device.

The outlet box and/or the outlet components used, in particular the plug connection unit, are preferably of splash-proof design, preferably in accordance with protection class IP66 or IP67 or
30 higher.

The outlet box may preferably have at least two plug connection units which are identical in principle. For example, two plug

connections in particular conforming to DIN EN IEC 62613-2:2016, Annex II and/or IEC/IEEE 80005-1:2019, section 7.3 (in particular Annex D.7.3), are advantageous for the required power for supply to container ships. The plug connection units are however

5 differently coded in order to rule out any mix up. For relatively large container ships (6000-12,000 TEU), the shore power outlet should be configured for a connected load of considerably greater than 2 MVA to 6.5 MVA, for which purpose the phase conductors should be distributed between at least two plugs.

10 For an HVSC system, provision is preferably made for the or each plug connection unit of the outlet box to be designed and configured as a socket outlet for an HVSC system conforming to the requirements of IEC/IEEE 80005-1:2019 and conforming to DIN EN IEC 62613-1:2016 or DIN EN IEC 62613-2:2016, in particular

15 conforming to the requirements of DIN EN IEC 62613-2:2016, Annex II or IEC/IEEE 80005-1:2019, section 7.3.

BRIEF DESCRIPTION OF THE DRAWING

Without limitation of the statements above, further features and advantages will become apparent from the following description of

20 preferred exemplary embodiments of the invention. In the drawing:

FIG.1A-FIG.1B: show schematic perspective views of a first preferred exemplary embodiment of a shore power outlet having an outlet box and having two cover parts which are supported movably on said outlet box and are in the form of protective flaps, in a

25 closed position (first position) in FIG.1A and in an opened position (second position) in FIG.1B;

FIG.2A-FIG.2D: show, as variants in relation to FIG.1A-1B, four further exemplary embodiments of a shore power outlet having cover parts for surrounding the plug connection components in protective

30 and substantially closed fashion;

FIG.3: shows a first usage example of a shore power outlet according to the invention, which is installed on a feeder vehicle which is movable on a port quay;

FIG. 4A-4B: show a second usage example of a shore power outlet according to the invention, which is installed in movable or static fashion on a mast on the port quay, in a perspective view of the arrangement (FIG.4A) and in the opened position of the protective flaps (FIG.4B) for the purposes of making or releasing the plug connection;

FIG. 5A-5D: show a preferred embodiment of a shore power outlet having cover parts in the form of protective flaps which can be pivoted open, according to FIG.1A-1B, in a closed position (first position), respectively in a perspective view from the outside (FIG.5A), in longitudinal section (FIG.5B), in a perspective longitudinal section from slightly below (FIG.5C), and in a perspective cross section through the closed protective flaps (FIG.5D);

FIG. 6A-6C: show the closed position from FIG.5A-5D, in a side view of an intermediate position before the closed position (FIG.6A), in an enlarged view of the closed position (FIG.6B: corresponding to the region indicated by dashed lines in FIG.5B), and in an enlarged view of the leadthrough for the ship-side supply line (FIG.6C: corresponding to the region indicated by dashed lines in FIG.5C);

FIG. 7: shows a block diagram of an HVSC system for container ships in accordance with the standard IEC/IEEE 80005-1:2019 as a preferred use case of the shore power outlet according to the invention;

FIG. 8: shows a schematic diagram with a block diagram of the pilot loops of an interlock safety circuit of an HVSC system for container ships, wherein the locked setting is detected, and unlocking allows triggering of a pilot loop; and

FIG. 9A-9B: are schematic illustrations of the directing action or guiding action of the explosion pressure relief devices according to the invention, in this case as viewed in a vertical plane (FIG.9A) and in a horizontal plane (FIG.9B).

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

Shore power is to be understood here to mean electrical power which is transmitted from a shore-side power supply to a ship, irrespective of the type of ship and the purpose of the supply. In
 5 the context of an HVSC system, a high voltage refers here to a nominal voltage of the system in the range from ≥ 1 kV up to and including 15 kV, or higher. The nominal voltage is typically ≥ 5 kV, and, depending on the ship, is for example 6.6 kV, 7.2 kV or 11 kV. The proposed shore power outlet can be used to
 10 particular advantage in an HVSC system, in particular for container ships, but not exclusively for this purpose.

The construction and functioning of a typical HVSC system for container ships will be discussed merely by way of example with reference to the block diagram in FIG.7. Such a system can be
 15 divided into two subregions. The left-hand subregion in the diagram in FIG.7 (to the left of the dashed line) comprises the shore-side region of the shore power supply system, which receives the shore power and delivers it to the ship (not shown). The right-hand subregion in the diagram in FIG.7 comprises the on-
 20 board distribution network on the deck of the ship. The two subregions are connected via a shore power outlet, which is a constituent part of the shore-ship interface, typically in the form of a CMS (cf. block 6 at the bottom in FIG.7).

FIG.7 shows, at block 1, a shore-side connection to a supply
 25 network, for example of the local power supplier, which provides a supply to the port or the container terminal. Block 2 represents a shore-side shore power transformer and a conversion system which converts the shore power voltage into a desired supply voltage that is to be supplied to the ship, typically for example 6.6 kV
 30 or 11 kV. Block 2 optionally also comprises a frequency converter in order to provide the desired frequency of the AC voltage, for example 50 Hz or 60 Hz. Block 3 denotes a shore-side protective circuit which controls protective devices in a switchgear assembly in block 4. For example, a (shore) circuit breaker and an earthing
 35 switch may be provided in the shore-side switchgear assembly 4.

The protective devices of the switchgear assembly 4 protect inter alia against anomalous currents etc., for example by way of a safety shutoff.

The system components in blocks 5 to 7 in FIG.7 comprise a system
5 for line management or cable management system, hereinafter abbreviated to CMS, which is schematically illustrated by block 6. Here, block 6 with the CMS forms a shore-ship connection or interface apparatus within which the shore power outlet according to the invention is intended to be used in order to connect high-
10 voltage supply cables from the ship to the shore-side supply 1, 2 via the switchgear assembly 4.

Blocks 5 and 7 represent control devices having safety functions of the interface apparatus. These comprise, for example, a controller for the unwinding and winding of the flexible high-
15 voltage supply cable, and a data interface for communication with the protective circuit 3 of the shore-side protective devices 4 and with a ship-side protective circuit 8 for protective devices in block 9 (see below). In the case of a container ship, the supply lines (not shown) which are to be connected to the CMS 6
20 and which are used at the interface 6 are generally carried and provided by the ship. The control devices 5, 7 may implement active control for the unwinding and winding of the supply lines, which also makes adjustments during the loading or unloading of the ship and is for example also intended to compensate for tidal
25 movements.

Block 8 shows the ship-side protective circuit which controls the protective devices in the shore outlet switchgear assembly 9 of the ship. Block 9 denotes said on-board switchgear assembly, which provided as a fixedly installed ship installation in a particular
30 room or in a container or the like in order to enable the apparatus to be exchanged more easily. The apparatuses in blocks 8 and 9 correspond to the assembly parts carried on board the ship for the purposes of connection to the shore outlet of the CMS or of the shore-ship interface apparatus 6. Block 10 denotes a ship-
35 side isolating transformer which is connected to an on-board

receiving installation, which is for example part of the main distribution system 11 on board the ship, which feeds an on-board network 12 of the ship for on-board loads. The on-board generator (not shown) is typically also connected to the main distribution system 11. It is intended that, after connection to and
5 synchronization with the shore power supply, the on-board generator of the ship be deactivated whilst the ship is docked, for example for the transshipment of the containers. The left-hand subregion having the blocks 1 to 4 in FIG.7 is a fixed
10 installation at the port.

The interface region having the blocks 5 to 7, in particular the CMS or the shore-ship interface apparatus 6, is typically installed at the port and may comprise movable system components. The right-hand subregion of the block diagram in FIG.7 having the
15 blocks 8 to 12 is carried on board the ship to which a supply is to be provided, and is thus variable during operation.

A shore power outlet is a necessary main component in the shore-ship interface apparatus 6 of the shore power supply system and constitutes the connection point between the port transformer station, cf. blocks 1-4 in FIG.7, and the on-board power network
20 12 of the ship. A shore power outlet in the present context is sometimes also referred to as a shore power box.

Preferred exemplary embodiments of a shore power box or shore power outlet according to the invention will be described in more
25 detail below with reference to FIG.1-6.

FIG.1A-1B show, as a first exemplary embodiment, a shore power outlet, denoted overall by 20, which is designed and configured for electrically connecting the on-board power network 12 (cf. FIG.7) of a container ship (not shown) as required to a shore-side supply network 1 (cf. FIG.7) in an HVSC system (cf. FIG.7). The
30 shore power outlet 20 is in this case designed and configured, by way of example, for a three-phase voltage supply at 6.6 kV and a connected load of up to 7.5 MVA.

A main component of the shore power outlet 20 is the box-shaped

housing, referred to here as outlet box 21, having the desired electrical connectors 23A, 23B, in particular HVSC socket outlets. The outlet box 21 having the HVSC socket outlets 23A, 23B thus forms a releasable connection means for corresponding plugs 25A, 25B of the flexible supply lines 27A, 27B for the ship. Only a short portion of the supply lines 27A, 27B is schematically shown in FIG.1A-1B. The supply lines 27A, 27B having the plugs 25A, 25B are typically carried on board container ships.

The connectors of the shore outlet 20 thus comprise one or more plug connection units, in this case in the form of HVSC socket outlets 23A, 23B (also referred to as socket outlet connectors), which serve for releasable connection to corresponding ship-side plug connector parts, in this case the HVSC plugs 25A, 25B. The plug connection units provided by the shore outlet 20 are adapted to the electrical requirements of the type of ship to which a supply is to be provided, and generally comprise suitable socket outlets 23A, 23B or socket outlet connectors, which for container ships are designed for a load of typically > 2 MVA, in this case for example of 3.75 MVA each. In the context of the invention, in the case of other types of ship, an arrangement having plug connection units which differs from that shown here may be provided for plug connection purposes.

For container ships, an arrangement is preferred which has two HVSC socket outlets 23A, 23B of 3.75 MVA each, designed in accordance with the requirements of IEC/IEEE 80005-1:2019 (cf. Annex C), section 7.3, and DIN EN IEC 62613-1:2016 or DIN EN IEC 62613-2:2016, in particular Annex II. In the example shown here, exactly two HVSC socket connectors 23A, 23B are provided for exactly two HVSC plugs 25A, 25B. For other types of ship, a different number of HVSC socket connectors 23A, 23B may be provided, wherein the shore power outlet 20 is then dimensioned accordingly, or it is also possible for two corresponding outlet boxes 21 each having two HVSC socket connectors 23A, 23B to be provided. For a RoRo ship (cf. IEC/IEEE 80005-1:2019, Annex B), only one plug is required, with a connected load of 6.5 MVA at

11 kV rated voltage, and for cruise ships, 4 plugs are required for a connected load of 16 MVA.

In the example shown, the HVSC socket outlets 23A, 23B, the HVSC plugs 25A, 25B and the supply lines 27A, 27B are designed for
 5 three-phase shore power at a high voltage, typically for example 6.6 kV, 7.2 kV or 11 kV depending on the ship, and for nominal currents corresponding to a nominal supply power of several MVA, which depending on the type of ship is typically > 2 MVA up to 6.5 MVA or higher. As preferred HVSC socket outlets 23A, 23B, FIG.4A
 10 shows examples conforming to protection class IP67, having covers and push-pull levers, preferably for 3 phase conductors and a neutral conductor, each for a nominal current of at least 200 A, and having at least 2 pilot contacts. The HVSC socket outlets 23A, 23B have a corrosion-protected housing, consisting for example of
 15 aluminum alloy.

In general, the shore power outlet 20 is designed and configured for an HVSC system, that is to say for electrically connecting the on-board power network (cf. 12 in FIG.7) of a docked ship, in this case for example of a container ship, as required to the shore-
 20 side supply network for shore power (cf. 1 in FIG.7).

The outlet box 21 serves here as a connection point or interface (cf. 6 in FIG.7) and as a housing, in particular for protecting the internal fixed cabling of the connection terminals (cf. FIG.5C) of the HVSC socket outlets 23A, 23B with the shore power
 25 feed line from the shore-side switchgear assembly 4 (FIG.7). The outlet box 21 is correspondingly weather-resistant and robust and protects electrical components against environmental influences and protects personnel against the high voltage. The outlet box 21 is of closed design at least in accordance with protection class
 30 IP66, preferably protection class IP67, and is intended to be suitable for use on a port quay 32 (cf. FIG.4A). In the interior of the outlet box 21, the HVSC socket outlets 23A, 23B are fixedly connected to a feed line (not shown) of the shore-side supply network (cf. block 1 in FIG.7).

The outlet box 21 is preferably designed substantially as a welded metal housing consisting of high-grade steel, preferably of V4A or CrNiMo steel, for high saltwater resistance and for rust prevention in a maritime environment. In the example according to FIG.1A-2D, said outlet box has a flat cuboidal shape having six substantially rectangular box walls which enclose an interior. The outlet box 21 is of relatively compact construction, and may in particular be designed as a self-supporting chassis. The outlet box 21 can thus serve as a mechanical fixed element, and may for example be fastened by a fastening end and installed in cantilevered fashion.

As shown in FIG.1A-1B, in the preferred exemplary embodiment, the outlet box 21 has, at an end opposite the fastening end, an upper first cover part 22A and a lower second cover part 22B. The cover parts 22A, 22B are attached at an end to the outlet box 21 and movably supported thereon. In FIG.1A-1B, the two cover parts 22A, 22B serve as protective flaps 22A, 22B.

As can be seen from a comparison of FIG.1A and FIG.1B, the protective flaps 22A, 22B are movable between a first, closed position (FIG.1A) and an opened second position (FIG.1B), preferably can be pivoted open and pivoted closed. For this purpose, in FIG.1A-1B, each protective flap 22A, 22B is supported by means of a suitable articulated connection, so as to be pivotable about an axis A, on the outlet box 21, which correspondingly serves as a fixed element. In FIG.1A-1B, the axis A is situated at the long sides of the box wall of the outlet box 21 having the HVSC plugs 25A, 25B, and runs substantially parallel to the local short-side edges of the outlet box 21, typically horizontally.

FIG.1A shows the closed operating position. In FIG.1A, the cover parts or protective flaps 22A, 22B surround both the HVSC socket outlets 23A, 23B and the HVSC plugs 25A, 25B in substantially closed fashion, or enclose same. In a preferred embodiment, the protective flaps 22A, 22B surround the plug connectors 23A, 23B and 25A, 25B on all five sides in a substantially enclosing manner. The sixth

side is closed by the end-side box wall, which bears the socket outlets 23A, 23B, of the outlet box 21. Thus, all plug connectors 23A, 23B and 25A, 25B are both additionally protected against weather influences and made inaccessible during operation, that is to say such that no plug connection can be undesirably released.

FIG.1B shows the second, opened position. In FIG.1B, the opened cover parts or protective flaps 22A, 22B uncover all HVSC plug connectors, that is to say the HVSC socket outlets 23A, 23B and the HVSC plugs 25A, 25B, such that these can be released or connected by operating personnel.

In FIG.1A-1B, the two cover parts 22A, 22B are designed as protective flaps or protective covers which are of corresponding or complementary design in the manner of packaging-box-like cover parts in order that, in the closed position (FIG.1A), they surround a type of plug chamber having the HVSC socket outlets 23A, 23B and HVSC plugs 25A, 25B in as far as possible closed fashion. The two cover parts 22A, 22B are thus designed to interact in order that, in the closed first position (FIG.1A) and together with a box wall of the outlet box 21, they substantially enclose such a plug chamber on all sides. Here, in the closed position (FIG.1A), the two cover parts 22A, 22B form a type of closed extension or closable/openable continuation of the supporting outlet box 21 at the box wall having the HVSC socket outlets 23A, 23B. The plug chamber surrounded by the protective flaps 22A, 22B may surround an internal volume which is similar in size to the outlet box 21 (+/-33%).

The closable cover parts 22A, 22B together with the outlet box 21 simultaneously make considerably improved explosion protection possible, as will be discussed in more detail further below with reference to FIG.5A-5D. According to a core concept, it is sufficient for this purpose if two cover parts 22A, 22B correspondingly interact in order that, in a closed position (cf. the first position in FIG.1A, FIG.3 and FIG.5A-5D), they substantially enclose the HVSC socket outlets 23A, 23B, and the HVSC plugs 25A, 25B which are connected thereto during operation, as intended in a delimited space (plug chamber). As shown by FIG.2A-

2D, it may suffice if only one of the two cover parts 22A, 22B is movable relative to the outlet box 21.

FIG.2A shows an exemplary embodiment of a shore power outlet 20A in which the upper cover part 22A is loosely removable and the
5 lower cover part 22B is fixedly installed as intended on the outlet box 21.

FIG.2B shows a further exemplary embodiment of a shore power outlet 20B, in which both cover parts 22A, 22B are releasably fastenable to the outlet box 21 and are removable from the outlet
10 box 21. In the closed position, similarly to FIG.1A, the cover parts 22A, 22B are fastened fixedly but releasably to the outlet box 21, for example by a suspension device, locking means or some other suitable releasable fastening.

FIG.2C shows a further exemplary embodiment of a shore power
15 outlet 20C, in which, correspondingly to FIG.1A-1B, two cover parts 22A, 22B in the form of protective flaps are supported pivotably on the outlet box 21, with the axis A in FIG.2C also being situated horizontally but extending substantially in the direction of the plug connection direction or of an imaginary
20 longitudinal direction of the shore power outlet 20C, that is to say perpendicularly to the pivot axis A in FIG.1A-1B.

As a further variant in relation to FIG.1A-1B, FIG.2D shows a shore power outlet 20D in which the two cover parts 22A, 22B as protective flaps are supported on the outlet box 21 in multiply
25 pivotable, for example in each case doubly pivotable fashion. The upper cover part 22A is supported on the lower cover part 22B pivotably about a horizontal pivot axis A or parallel to a long side. The lower cover part 22B is supported, at a short side, on the outlet box 21 about a further horizontal axis B or
30 approximately parallel to the short side of the box wall having the HVSC socket outlets 23A, 23B. Thus, the upper cover part 22A can be pivoted open similarly to the situation in FIG.2C, and can then be pivoted away laterally together with the lower cover part 22B in order to uncover the plug connectors 23A, 23B; 25A, 25B.

As shown by the examples in FIG.1A-1B and FIG.2A-2D, the two cover parts or protective flaps 22A, 22B are dimensioned substantially matchingly with respect to a cuboidal structural shape or geometry of the supporting outlet box 21. The two cover parts 22A, 22B can
5 be referred to as protective flaps if both are pivotably supported. The cover parts 22A, 22B may for example be designed as packaging-box-like cover parts which are open on one side and which consist of substantially four walls, cf. FIG.1A-2D, of which a pair of long side walls is approximately congruent, said side
10 walls being perpendicular to a main wall, with a short side wall which forms a closure perpendicular to the other side walls and perpendicular to the main wall. The cover parts 22A, 22B may be preferably substantially U-shaped in cross section and preferably substantially L-shaped in longitudinal section, see also FIG.2A-
15 2D. In the closed first position, the two cover parts 22A, 22B terminate flush, preferably sealingly, with the open end region, in particular in the region of the box wall having the HVSC socket outlets 23A, 23B.

FIG.1A-1B and FIG.2A-2D show a further aspect of the invention
20 merely in schematic form, namely a first explosion pressure relief device 41 on the outlet box 21 and a second explosion pressure relief device 42 on at least one of the two cover parts 21A, 21B, in this case on the upper cover part 21A. A dedicated explosion pressure relief device 41, 42 (hereinafter abbreviated to
25 "EPRD") is preferably provided for each of the enclosed cavities, that is to say for the interior of the outlet box 21 and for the so-called plug chamber within the closed cover parts 21A, 21B.

The first explosion pressure relief device (EPRD) 41 is provided for the interior in the outlet box 21, said interior being
30 permanently enclosed during operation. The second explosion pressure relief device (EPRD) 42 is provided for the plug chamber, which, during operation, when the protective flaps or cover parts 22A, 22B are in the closed position (FIG.1A), is substantially enclosed by said protective flaps or cover parts. The first EPRD
35 41 and the second EPRD 42 may differ in parts in terms of their

structural design. The EPRDs 41, 42 are however preferably of substantially modular or identical design in order to minimize the number of different components.

Each of the two EPRDs 41, 42 is designed and configured to form in
5 each case one predefined relief opening 43, 45 (FIG.1A) with a predetermined orientation C, D. The EPRDs 41, 42 are furthermore each designed and configured for the targeted and controlled discharge of explosion gases from the interior, through the relief opening 43, 45, to the outside into a designated chosen external
10 space region 49 (cf. FIG.4A). The term "explosion gases" refers here to gases that form in the interior of the shore power outlet 20, 20A..., 20D in the event of an arc explosion or arc ignition. The external space region 49 (cf. FIG.4A) into which the explosion gases are intended to be discharged is in this case determined in
15 particular by the predetermined orientation C, D of the relief opening 43, 45. The external space region 49 into which the explosion gases are discharged is however also determined in part by the structurally predefined guiding action or directing action of the EPRDs 41, 42. The EPRDs 41, 42 preferably also limit the
20 associated external space region 49. The guiding action or directing action of the EPRDs 41, 42 is such that, as seen in plan view, the explosion effect is discharged only to one side, and the other three sides remain protected as far as possible against explosions.

25 Further details relating to the preferred structural design of protective flaps or cover parts 22A, 22B according to the invention and relating to the preferred structural design of explosion pressure relief devices or EPRDs 41, 42 according to the invention will be discussed below with reference to FIG.5A-5D.

30 FIG.3 and FIG.4A-4B firstly show two exemplary, movable variants of a shore power outlet 20E, 20F, each conforming to the principle from FIG.1A-2D, having two protective flaps 22A, 22B and having a first EPRD 41 on a side wall of the outlet box 21 and a second EPRD 42 on the main wall of the first protective flap 22A. The
35 shore power outlet 20E, 20F is preferably mobile, in particular

movable along the port quay 32, and can thus be moved to a suitable position along the length of the ship (not shown) to which a supply is to be provided.

In the example from FIG.3, the shore power outlet 20E is for this purpose mounted for example on a motorized feeder vehicle 30, or on some other freely movable vehicle. The shore power outlet 20 can thus be moved with the feeder vehicle 30, inter alia in a longitudinal direction L, to the desired position along the port quay 32 (cf. FIG.4A), and placed into a remote parked position when not in use. The feeder vehicle 30 supports the outlet box 21 at one end in a cantilevered arrangement. The protective flaps 22A, 22B, which can be pivoted open and closed, are accessible at the other end of said outlet box for operation purposes. Not shown in FIG.3 is a storage device, assigned to the feeder vehicle 30, for laying the feeder lines from the fixed supply installation (cf. blocks 1-4 in FIG.7) to the shore power outlet 20. For example, a suitable drum device or a reel device according to DE 20 2014 105 940 U1 may be used for this purpose, wherein the lines are preferably laid in an energy guiding chain.

FIG.3 also shows, as a possible design variant, a directing action of the two EPRDs 41, 42 of the shore power outlet 20E which differs from that in FIG.1A-2D. The predetermined orientation C, D of the relief openings 43, 45 of the two EPRDs 41, 42 is parallel and, in FIG.3, is in a lateral direction with respect to the shore power outlet 20E, in a direction substantially in a plane perpendicular to the longitudinal direction L. In FIG.3, the predetermined orientation C, D of the two EPRDs 41, 42 likewise points toward the sea or away from the port, but is directed obliquely upward from the quay surface.

Thus, in FIG.3, the orientation C, D is, purely by way of example, perpendicular to the longitudinal extent of the shore power outlet 20E or to the pivot plane of the protective flaps 22A, 22B. The orientation C, D can be easily set by virtue of the EPRDs 41, 42 being correspondingly designed and oriented, in this case for example by virtue of the EPRDs 41, 42 being fastened to the outlet

box 21 or the protective flaps 22A having been rotated through 90° relative to the vertical in relation to FIG.1A-2D. For selective orientation, the EPRDs 41, 42 preferably have a square basic shape and are fastened by means of a corresponding installation flange,
5 cf. FIG.5A-5D.

As shown most clearly by FIG.4A, the EPRDs 41, 42 generally allow a predetermined orientation C, D such that - in the event of an arc explosion within the outlet box 21 and/or within the closed protective flaps 22A, 22B - explosion gases are conducted in
10 controlled fashion through the relief openings 43, 45 into a non-critical external space region 49, specifically away from the port quay 32 (cf. FIG.4A), that is to say toward the sea or water. The discharge takes place here in accordance with the orientation C, D and preferably into a limited space region 49 away from the port
15 quay. The space region 49 may be limited in terms of an angle, and preferably lies within a solid angle of $<180^\circ$, preferably $<120^\circ$, in the vertical plane and within a solid angle of $<180^\circ$, preferably $<120^\circ$, in the horizontal plane. The solid angle may be measured in each case proceeding from the particular EPRD 41, 42,
20 for example in polar coordinates with the particular EPRD 41, 42 as coordinate origin and with the orientation C, D as angle bisector, cf. for example FIG.4A.

Such a spatial limitation of the explosion effect of an arc explosion by means of the EPRDs 41, 42 in combination with the
25 enclosing housing provided by the outlet box 21 and the cover parts 22A, 22B is preferably provided for all exemplary embodiments of the invention and serves for effectively protecting personnel and equipment in the port or at the port quay 32.

FIG.4A-4B show a variant of the shore power outlet 20F in relation
30 to FIG.3, in which the predetermined orientation C, D of the two EPRDs 41, 42 is likewise oriented toward the sea or away from the port, but obliquely downward toward the sea or toward the water. The orientation C, D can be regarded as a vector and, in the case of the shore power outlet 20F in FIG.4A-4B, lies in a vertical
35 plane and is oriented obliquely downward, for example at an angle

of approximately 30°-60°, preferably approximately 40°-50°, with respect to the horizontal. Here, the EPRDs 41, 42 with their relief openings 43, 45 are designed such that an explosive blast from the in this case upper EPRD 41 is conducted substantially
 5 past the other, in this case lower EPRD 42, even in a horizontal orientation (FIG.5B). As shown in FIG.4A, the orientation C, D and guiding action of the EPRDs 41, 42 is, for each of the exemplary embodiments, selected such that the effect of an arc explosion within the outlet box 21, on the one hand, and within cover parts
 10 22A, 22B, can be conducted through the associated EPRDs 41, 42 and away from the port quay 32, preferably into a restricted space region 49 in a half-space defined by a vertical plane at the shore power outlet 20, 20A... 20F.

A special feature of the variant of FIG.4A-4B is a support arm 44
 15 on a carriage 46 which is movable in a front-side guide (not shown) along the quay wall of the port quay 42 in order to position the shore power outlet 20F along the ship. The orientation C, D remains unchanged during this movement.

FIG.4A-4B shows further generally preferred features of the shore
 20 power outlet 20F, namely a locking device 47A, 47B on the protective flaps 22A, 22B. The locking device 47A, 47B serves to lock the protective flaps 22A, 22B in the closed first position (FIG.4A) and, when unlocked, allows said protective flaps to open. FIG.4B shows the fully opened second position, in which the
 25 protective flaps 22A, 22B uncover the plug connectors. For the plug connection, use is made here of HVSC socket outlets 23A, 23B having push-pull levers 24 for facilitating the plug connection, and of the HVSC plugs 25A, 25B of the supply lines.

To facilitate the opening and closing of the protective flaps 22A,
 30 22B, a lever mechanism 50 is provided, which will be discussed in more detail with reference to FIG.5A and FIG.6A. The lever mechanism 50 and the pivotable support of the protective flaps 22A, 22B about the pivot axes A are such that each protective flap 22A, 22B can be pivoted open through approximately 90°. As shown
 35 in FIG.4B, in the opened position, the HVSC socket outlets 23A,

23B are easily accessible, and the push-pull levers 24 thereof can be easily operated. FIG.4B also shows a seal 48 on the lower protective flap 22B, into which seal the upper protective flap 22A engages in the closed position (cf. FIG.6B).

- 5 FIG.3 and FIG.4A-4B illustrate, as an advantage of the load-bearing structural design of the outlet box 21, the versatile or variable usability of the shore power outlet 20, 20A... 20F.

A particularly preferred structural design of the shore power outlet 20, and further functions or effects and advantages, will
10 be discussed with reference to FIG.5A-5D.

The structural design of the explosion pressure relief devices, abbreviated to EPRDs, 41, 42 can be seen most clearly from FIG.5A-5C. Identical components of the two EPRDs 41, 42 are denoted by identical reference signs. Each of the two EPRDs 41, 42 is
15 designed as a hood-like attachment unit and comprises a hood 401 which consists of sheet metal, in particular of V4A high-grade steel, and which is fastened, for example welded, to an installation flange 402. The installation flange 402 is designed as a substantially square metal frame which consists of sheet
20 metal, in particular of V4A high-grade steel, and which forms or surrounds a through-opening 403 to the interior of the EPRD 41, 42. Owing to its rotationally symmetrical, in this case square basic shape, the installation flange 402 can thus be selectively rotated in each case through $\pm 90^\circ$ (see also FIG.3) with the
25 through-opening 403 on a corresponding connecting opening in the upper box wall of the outlet box 21 or in the main wall of the protective flap 22A. By means of the installation flange 402, the hood 401 is fixedly screwed externally onto the edge of the associated connecting opening, as can be seen most clearly from
30 FIG.5C. In order to provide sealing against an ingress of water, a seal 404 may be provided between the installation flange 402 of the first EPRD 41 and the outlet box 21, said seal however not being required in the case of the second EPRD on the protective flap 22A. The through-opening 403 on the underside of the EPRD 41,
35 42 leads openly through the connecting opening into the interior

of the outlet box 21 or into the plug chamber of the cover parts or protective flaps 22A, 22B, as can be seen from FIG.5B-5C.

As shown in FIG.5B, the hood 401 is designed in each case such that its outer walls form, in cross section (vertically), the shape of an isosceles trapezium, wherein the long base site is open and is bordered by the installation flange 402 (FIG.5A/FIG.5C).

The hoods 401 each form, in a, in particular in exactly one, side wall 405, at least one predefined relief opening 43, 45 having a predetermined orientation C, D. The orientation C, D is determined structurally by the geometry of the hood 401, that is to say in this case in particular by the internal angle between the oblique side wall 405 and the base surface or the plane of the installation flange 402. This angle, as angle of inclination α , is illustrated in FIG.5B. The orientation C, D can thus be structurally set by way of the corresponding angle of inclination α of the side wall 405.

A difference between the first EPRD 41 and the second EPRD 42 consists in that the relief opening 43 of the first EPRD 41, in the new state or in the normally operational state, is closed in watertight fashion by means of a rupture panel 411 as a pressure relief element, with a peripheral seal preferably being provided between the rupture panel 411 and the edge of the side wall 405 surrounding the through-opening 45. The rupture panel 411 is preferably produced from thin high-grade sheet steel, and is designed to have a low static response pressure, in particular of ≤ 0.5 bar, particularly preferably ≤ 0.25 bar. Alternatively, some other pressure relief element may be used, for example a rupture diaphragm or a rupture film consisting of plastics material. The rupture panel 411 is installed on the outside of the hood on the side wall 405 and is thus easily accessible for inspection and exchange. To mechanically protect the rupture panel 411 against undesired damage, a protective grille 413 is also attached to the hood 401 of the first EPRD 41.

By contrast, in the case of the second EPRD 42, the through-opening 45 does not need to be closed in watertight or splash-proof fashion, because the plug connectors, that is to say in this case HVSC socket outlets 23A, 23B and HVSC plugs 25A, 25B, are
5 already of splash-proof design in accordance with a suitable protection class, for example IP67. Therefore, in the case of the second EPRD 42 - by contrast to the sealed rupture panel 411 of the first EPRD 41 - merely an open grille, for example in the form of a perforated plate 412, or the like is provided in order to
10 provide a certain degree of mechanical protection and possibly pressure damping.

Both the rupture panel 411 of the EPRD 41 and optionally the perforated plate 412 of the EPRD 42 can act as a pressure relief element. The rupture panel 411 of the EPRD 41 however opens up the
15 relief opening 43 in the presence of explosion conditions in the interior of the outlet box 21. By contrast, the perforated plate 412 serves primarily to provide mechanical protection against an ingress of undesired foreign bodies.

The first EPRD 41 and second EPRD 42 are in turn structurally
20 identical with regard to a guide body action and guide body arrangement 420, which is provided in the interior of the attachment unit or of the hood 401 between the through-opening 403 and the relief opening 43 or 45 respectively. In each EPRD 41, EPRD 42, a guide body arrangement 420 is provided which comprises
25 a primarily gas-cooling and pressure-reducing explosion damper 422 comprising a multiplicity of mutually parallel cooling elements, in this case in the form of a parallel plate arrangement as an explosion damper 422 having a multiplicity of parallel thin-walled metal plates 424 or metal sheets which are held in parallel by
30 means of transverse struts 426 and interposed spacer disks as spacer elements, as can be seen from FIG.5B-5C. The geometry of the hood 401 with its side walls also contributes to the guiding action of the guide body arrangement 420. By means of the transverse struts 426, the explosion dampers 422 are, for example
35 at the ends, fastened by fastening elements to the installation

flange 402, such that each EPRD 41, 42 can be installed as a prefabricated attachment unit onto the output box 21 or onto a protective flap 22A, 22B and exchanged if necessary.

The explosion damper 422 of each EPRD 41, 42 is designed such that
5 the metal plates 424 act as cooling elements in order to absorb thermal energy from explosion gases and lower the temperature of the explosion gases. The metal plates 424 are preferably arranged so as to extend substantially in the main outflow direction C, D or in the cross-sectional planes of FIG.5B, that is to say
10 substantially parallel to the surface normal of the relief opening 43, 45. Through the selection of the spacer elements, the flow cross section that remains free between the metal plates 424 is preferably larger than or equal to the opening cross section of the relief opening 43 or 45, so as not to cause any back-pressure.
15 By means of the parallel metal plates 424, the explosion damper 422 can influence the flow of the gas flowing through it, in this case explosion gas in the event of an arc explosion, and under certain conditions can generate an at least partially laminar flow. Furthermore, owing to the parallel metal plates 424, the
20 explosion damper 422 has a flow-guiding action such that the propagation of the explosion gas in the direction perpendicular to the plane of FIG.5B before and in particular also after said explosion gas exits through the relief opening 43 or 45 is reduced. Owing to the parallel metal plates 424, the explosion
25 damper 422 also causes a pressure drop over the flow path from the through-opening 403 to the particular relief opening 43 or 45, that is to say in the interior of the particular hood 401 and thus within the EPRD 41 or EPRD 42. This pressure drop occurs primarily owing to thermal energy absorption from or cooling of the
30 explosion gas in the explosion damper 422, such that plates having high thermal conductivity, for example metal plates 424, are advantageous. The pressure drop may also be intensified by way of flow effects, and is dependent on factors such as the gap width between the metal plates 424, the internal volume of the hoods
35 401, and the cross sections both of the relief openings 43 and 45 and of the passage opening 403. The pressure drop or pressure

relief can thus be structurally influenced.

By means of the EPRDs 41 and 42, in particular the explosion dampers 422, damaging explosion effects can be significantly reduced by virtue of the spatial impact outside the shore power outlet 20 being limited, and significant pressure relief being achieved within the EPRDs 41, 42, in particular by gas cooling. The explosion dampers 422 are preferably provided in structurally identical form in both EPRDs 41, 42. Owing to the preferred arrangement within the hoods 401, the explosion dampers 422 are mechanically protected against damage.

The relief openings 43, 45, as mouth openings of the EPRDs 41, 42, also have an influence on the gas flow for the escape of gas to the outside. For spatial limitation of the external space region 49 into which explosion gases and the explosion pressure wave are discharged from the EPRDs 41, 42, in particular in a direction perpendicular to the longitudinal section of the outlet box 41 or perpendicular to the plane of FIG.5B, it is advantageous if the geometry of the relief openings 43, 45 in the side walls 405 is of substantially rectangular, oval or rounded oblong or similar shape, and is selected to have a side ratio of length:width (or ratio of long axis to short axis) of $\geq 2:1$. The width may for example be between 100 mm and 300 mm, and the length may accordingly be 200 to 600 mm, depending on the structural size of the outlet box 21. To achieve the most uniform possible flow conditions or guiding action, it is advantageous if the internal volume of the outlet box 21 and that of the closed protective flaps 22A, 22B differ only insignificantly from one another, for example by less than $\leq 20\%$, cf. FIG.5A-5D. The relief openings 43, 45 should have an opening cross section of at least 10% of the smallest cross section of the internal volume (perpendicularly to the plane in FIG.5B) of the plug chamber within protective flaps 22A, 22B or interior of the outlet box 21, in order to achieve fast pressure dissipation in the event of arc explosions. The free cross section of the through-opening 403, which is preferably defined by the installation flange 402, from the interior or plug chamber to the interior of the EPRD 41, 42 should preferably be

significantly larger than the opening cross section of the relief openings 43, 45, as can be seen from FIG.5B-5C.

Practical tests have shown that an arc ignition event in the plug chamber within protective flaps 22A, 22B typically propagates into the interior of the outlet box 21 and vice versa, and it is therefore particularly advantageous to provide in each case one EPRD 41, 42 both on the outlet box 21 and on one of the protective flaps 22A, 22B, as can be seen for example in FIG.5B. A design variant would however also be conceivable which has only one EPRD 41, 42 and has a passage, which opens in the presence of explosion pressure, between the plug chamber and the interior, said passage being closed for example by means of a suitably dimensioned rupture panel (not shown) in order to allow a release of pressure into the other space in an ignition event.

Further details of a preferred support configuration of the cover parts or protective flaps 22A, 22B on the outlet box 21 will be discussed on the basis of FIG.5A-5D. The cover parts or protective flaps 22A, 22B are each supported on one side in cantilevered fashion on the outlet box 21, in this case by means of a hinge-like pivot support which defines the pivot axes A of the protective flaps. For this purpose, for each of the protective flaps 22A, 22B, two hinge elements 501 are provided on the outlet box 21 symmetrically on both sides, said hinge elements supporting and holding a common hinge axle 502. On the upper hinge axle 502, in each case one hinge arm 503A for the first protective flap 22A is provided symmetrically on each side, by means of which hinge arms the protective flap 22A is supported pivotably about the axis A on the outlet box 21. Similarly, on the lower hinge axle 502, in each case one hinge arm 503B for the second protective flap 22B is provided symmetrically on each side, by means of which hinge arms the protective flap 22B is supported pivotably about the axis A on the outlet box 21. The arrangement is such that the protective flaps 22A, 22B are pivotable, for example in each case through approximately 90°, upward and downward respectively (cf. also the position in FIG.4B), wherein the pivot angle can be set by means

of the dimensioning of the components, for example hinge arms 503A, 503B. In the preferred embodiment, the cover parts form protective flaps 22A, 22B which, by means of the hinge axles 502, are each supported on the outlet box 21 such that they can be
5 pivoted open between a first, closed position (FIG.5A-5B) and a second position (cf. FIG.4B), and pivoted closed. The protective flaps 22A, 22B are supported, and held in cantilevered fashion or supported on one side, on the outlet box by means of the respective pivot joints consisting of two hinge elements 501, a
10 hinge axle 502 and two hinge arms 503A and 503B.

Owing to the intrinsic weight of the protective flaps 22A, 22B together with the attachment parts such as EPRDs 41, 42 etc., and for ease of handling, a lever mechanism 50 is provided which mechanically couples together the pivoting movements of the
15 protective flaps 22A, 22B. For this purpose, the hinge arms 503A, 503B each have projections, which are designed as lever arms 505A, 505B and which are kinematically coupled together via a coupling rod 506 such that, when for example the upper protective flap 22A pivots, the lower protective flap 22B is correspondingly
20 automatically pivoted concomitantly. For ease of operation and for a holding action in the opened second position, the lever mechanism 50 on each side comprises a spring, for example a damping gas spring 507, which is coupled to the coupling rod 506. Inter alia, the gas spring 507 prevents the protective flap 22A or
25 22B from slamming shut. The outlet box 21, which is of cantilevered construction, forms the fixed element for the lever mechanism 50 that couples the movement of the two cover parts. The parameters of the lever mechanism and, inter alia, the maximum pivot angle can be set by means of the lever lengths of the lever
30 arms 505A, 505B at the hinge arms 503A, 503B, such that it is for example also possible to set different angles by means of a transmission ratio.

As can be seen most clearly from FIG.5D and FIG.6A, a locking device 510 is also provided, by means of which the two cover parts
35 or protective flaps 22A and 22B can be locked in the closed first

position. For this purpose, at the free end of the protective flaps 22A and 22B opposite the hinge axles 502, a lock axle 512A and 512B respectively is provided so as to extend transversely through each protective flap 22A and 22B. In each case one locking lever 514 is arranged rotationally conjointly, at the outside on both sides, on the upper lock axle 512A of the protective flap 22A, such that said locking levers are supported robustly and pivotably on the protective flap 22A by means of the lock axle 512A. An actuating lever 513 is provided on at least one of the locking levers 514. Each locking lever 514 forms, at an end, a locking hook 515 which in the closed position (FIG.5D) engages behind the other lock axle 512B of the other protective flap 22B. In the engaged position, the two lateral locking hooks 515 thus engage on the other lock axle 512B, which is fixedly connected to the protective flap 22B. In this position, the protective flaps 22A, 22B cannot be opened, and are closed in explosion-resistant fashion. For additional safety, a locking bolt 520 (also referred to as interlock bolt) is provided which can be opened and closed only in the locked setting (FIG.5D), by releasable engagement into a lock opening in the protective flap 22B (cf. FIG.5D). An electrical switching element 522 is operatively connected to the one interlock bolt or locking bolt 520, said switching element being electrically connectable or connected to a safety circuit of the shore power supply.

As can be seen from FIG.5A-5D, the cover parts or protective flaps 22A, 22B are designed such that, in the closed first position, the plug connection between plug connection unit, that is to say in this case HVSC socket outlet 23A, 23B, and the plug connector parts, that is to say in this case the HVSC plugs 25A, 25B, cannot be released. Additional safety is achieved by means of the locking, thus also ensuring explosion-resistant closure of the protective flaps 22A, 22B. An interlock function can additionally be realized by means of the switching element 522 if the switching element 522 is connectable or connected to the pilot loop of the safety circuit of the HVSC system from FIG.7. It is thus possible, for example, to avoid conventional Kirk Key interlocks. The pilot

loop monitors for the correct connection of plug connections in the high-voltage electrical circuit, with the aim of preventing electrical hazards from arising as a result of inadvertent or improper separation, or separation for any other reason, of an HV plug connection in an active HV installation. To achieve this, the locking means 510 having the locking bolt 520 and the electrical switching element 502 may be integrated, for signal transfer, into the so-called pilot loop or safety loop.

FIG.5A-5D also each show a peripheral seal 48 on the open edges of the protective flaps 22A, 22B, which seals will be discussed in more detail on the basis of FIG.6B. The seal 48 is provided on the open edge of each of the protective flaps 22A, 22B. Here, the peripheral edge 532A of the upper protective flap 22A is bent or deformed outward, and the peripheral edge 532B of the lower protective flap 22B is bent outward. During the closing process (cf. FIG.6A), the upper protective flap 22A engages into the lower protective flap 22B. Sealing closure is thus made possible by virtue of the seals 48 coming into contact, or one protective flap 22A or 22B bearing against the seal of the other protective flap 22A or 22B, in the closed position. Furthermore, in the event of an explosion in the plug chamber within the closed protective flaps 22A and 22B, the inwardly deformed edge 532A of the protective flap 22A is pushed outward against the other protective flap 22B, in order to intensify the sealing action and contain the explosion.

FIG.6C finally shows, in each case at the free front side of the edge 532A or 532B of each protective flap 22A and for each plug connection, a leadthrough cutout 530 for the leadthrough of each ship supply line 27A, 27B (not shown in FIG.6C) of the two HVSC plugs 25A, 25B (cf. for example FIG.2D). Here, on the upper protective flap 22A, an additional sealing element 533 for lying sealingly against the ship supply line 27A, 27B is provided internally at the leadthrough cutout, said additional sealing element being adaptable to the desired line diameter by means of an adjusting plate 534. On the other protective flap 22B, a half-

shell-like counterbearing 535 is provided such that, in the closed position, the ship supply lines 27A, 27B can be clamped or abut sealingly between the protective flaps 22A, 22B.

As can be seen from FIG.2A-2D and from FIG.5A-5D and FIG.6C, the
5 leadthrough cutouts 530 are aligned with the axis of the HVSC
socket outlets 23A, 23B, and the protective flaps 22A and 22B are
designed such that the joining plane or interface is approximately
aligned with the axis of the HVSC socket outlets 23A, 23B, making
it easier for operating personnel to handle the heavy ship supply
10 lines 27A, 27B. The plug connections can also thus be relieved of
transverse forces.

FIG.8 schematically illustrates an electrical schematic diagram
based on figure D.2 from IEC/IEEE 80005-1:2019, Annex D - wherein,
of the pilot loops of the interlock safety circuit which is known
15 to a person skilled in the art, only those parts which are
essential here are shown.

The pilot loop 80 (of the interlock safety circuit, cf. figure D.2
from IEC/IEEE 80005-1:2019, Annex D) has a shore-side control
current pilot loop 81 and a ship-side control current pilot loop
20 82. The shore-side control current pilot loop 81 can be
interrupted in the event of safety-relevant activation by a first
circuit breaker unit 83 (shore side), which is intended to trigger
a shutoff of the HVSC supply. The control current pilot loop 82 on
the ship side also has a circuit breaker unit 84 for triggering
25 the shutoff. In addition to the various typical triggering signals
or activation means, a third aspect of the invention provides for
a suitable sensor or a suitable detector element 85 to be provided
on the shore power outlet 20, more specifically on one of the two
protective flaps 22A, 22B and/or on the locking device thereof.
30 The detector element 85 determines whether the cover part(s) 22A,
22B are locked in the first position. If the cover parts 22A, 22B
or protective flaps are not locked, the detector element 85
activates the circuit breaker unit 84, in this case for example
that of the ship-side control current pilot loop 82. In principle,
35 use may be made of any type of detector element, for example an

inductive or capacitive sensor, a position switch etc. For example, the circuit according to FIG.8 may, as a detector element 85, use a switching element 552 and the structure according to FIG.5A-5D. Other implementations also fall within the scope of the invention. The mode of operation of an interlock safety circuit may correspond for example to IEC/IEEE 80005-1:2019. The pilot loops 81, 82 function as a communication path and provide the real-time status of the connection and of the system conditions.

The interlock safety circuit (not shown) utilizes the signals of the pilot loops in order to ensure safety.

FIG.9A-9B schematically illustrate how the EPRDs 41, 42 are designed and configured so as to each have a predefined relief opening 43, 45 (FIG.1A) which has a predetermined guiding action for the targeted and controlled discharge of explosion gases from the interior of the outlet box 21 and/or of the closed and locked protective flaps 22A, 22B. In the event of an explosion, pressure and gases are discharged through the relief opening 43, 45 into a designated chosen external space region, as shown here by way of example in FIG.9A in a side view (vertical plane) and FIG.9B in a plan view (horizontal plane).

The geometry and design of the EPRDs 41, 42 are such that the external space region into which the explosion gases are intentionally discharged is predetermined and confined, in particular to a half-plane, preferably a quadrant, of a vertical plane (FIG.9A). It is intended here that the spatial region also be restricted in this half-plane to a certain first solid angle α (in this case in the vertical plane), preferably a solid angle of $\alpha \leq 90^\circ$. It is also intended that, as viewed in the horizontal plane, the propagation be controlled and limited to a second solid angle β (FIG.9B), preferably a solid angle of $\beta \leq 180^\circ$, preferably $\beta \leq 160^\circ$, particularly preferably $\beta \leq 120^\circ$. By means of a structurally predefined guiding action or directing action of the EPRDs 41, 42, the external space region 49 into which the explosion gases are discharged can be set to a limited spatial region which is restricted to two adjacent geometrical octants

(so-called halves of a half-space), as illustrated here by way of example in FIG.9A-9B on the basis of the YZ planes (side view/horizontal planes) and the XY planes (plan view/horizontal planes), which the adjacent octants limit as a space region into
5 which the explosion gases are discharged (shown schematically by "lightning bolts").

The coordinate system may for example be selected here such that the XY and YZ planes correspond to the orientation of side walls of the outlet box.

- 10 It is self-evident that the direction of the predefined guiding action or directing action of the EPRDs 41, 42 depends on the application-dependent spatial orientation of the EPRDs 41, 42 on the shore power outlet 20, and on the orientation thereof in space.
- 15 It is finally stated in summary that the proposed shore power outlet improves safety, in particular the protection of personnel, in several aspects. Safety should be of primary importance in the context of shore power systems, in particular HVSC systems.

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Applicant:**igus GmbH****51147 Cologne**

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Shore power connection with safety devices**List of reference signs**

10

FIG.1A-1B, FIG.2A-2D; FIG.3-4

20 Shore power outlet

20A, 20B, 20C, 20D, 20E, 20F Shore power outlet (variants)

21 Outlet box

15 22A, 22B Cover part or protective flap

23A, 23B HVSC socket outlet

24 Push-pull lever

25A, 25B HVSC plug

27A, 27B Supply line

20 30 Feeder vehicle

32 Port quay

41, 42 Explosion pressure relief device (abbreviation: EPRD)

43, 45 Relief opening

44 Support arm

25 46 Carriage (movable on the port quay)

47A, 47B Locking device

48 Seal

49 External, limited space region

50 Lever mechanism

30 A, B Pivot axes (of the protective flaps)

C, D Direction of orientation (of the EPRD)

L Longitudinal direction/direction of travel

FIG.5A-5D, FIG.6A-6C

35 20 Shore power outlet

- 21 Outlet box
- 22A, 22B Protective flap
- 23A, 23B HVSC socket outlet
- 41, 42 Explosion pressure relief device (abbreviation: EPRD)
- 5 43, 45 Relief opening
- 48 Seal
- 50 Lever mechanism
- 401 Hood
- 402 Installation flange
- 10 403 Through-opening
- 404 Seal
- 405 Oblique side wall (with through-opening)
- 411 Rupture panel
- 412 Perforated plate
- 15 413 Protective grille
- 420 Guide body arrangement
- 422 Explosion damper
- 424 Metal plates
- 426 Transverse struts
- 20
- 501 Hinge elements
- 502 Hinge axle
- 503A, 503B Hinge arm
- 505A, 505B Lever arm
- 25 506 Coupling rod
- 507 Gas spring
- 510 Locking device
- 512A, 512B Lock axle
- 30 513 Actuating lever
- 514 Locking lever
- 515 Locking hook
- 520 Locking bolt
- 522 Switching element
- 35
- 530 Leadthrough cutout
- 532A, 532B Peripheral edge

- 533 Sealing element
- 534 Adjusting plate
- 535 Counterbearing

5 **FIG.7 (typical HVSC system)**

- 1 Connection to the supply network
- 2 Shore-side transformer, possibly with frequency converter
- 3 Shore-side protective circuit
- 4 Shore-side switchgear assembly (circuit breaker, earthing switch
- 10 etc.)
- 5 Controller
- 6 Shore-ship interface apparatus / CMS
- 7 Controller
- 8 Protective circuit for the ship
- 15 9 Shore outlet switchgear assembly
- 10 On-board isolating transformer
- 11 On-board receiving circuit
- 12 On-board power network on the container ship

20 **FIG.8 (Safety circuit)**

- 20 Shore power outlet; 21 Outlet box; 22A, 22B Protective flap
- 80 Pilot loop (of the interlock safety circuit)
- 81 Control current pilot loop, shore side
- 82 Control current pilot loop, ship side
- 25 83 Circuit breaker unit (shore side)
- 84 Circuit breaker unit (ship side)
- 85 Detector element (sensor / on the shore outlet)

FIG.9A-9B

- 30 20 Shore power outlet; 21 Outlet box; 22A, 22B Protective flap
- 41, 42 Explosion pressure relief device (abbreviation: EPRD)
- X, Y, Z: Axes of a Cartesian coordinate system
- α , β Limited solid angle (of the predetermined space region)

Claims

1. A shore power outlet for providing a supply to a ship, wherein the shore power outlet is designed and configured for electrically connecting the on-board power network of a docked ship, in particular of a container or cruise ship, as required to a shore-side supply network, in particular is designed and configured for a multi-phase voltage supply at at least 6.6 kV or 7.2 kV and/or at at least 2 MVA connected load, wherein
- the shore power outlet comprises an outlet box having box walls which enclose an interior, wherein the outlet box comprises at least one plug connection unit, in particular a socket outlet, which is provided on a box wall for releasable plug connection to a corresponding plug connector part, in particular a plug, of a ship supply line, and which in the interior of the outlet box is fixedly connectable to a feed line of the shore-side supply network, and
 - the shore power outlet comprises at least one cover part which is movable relative to the outlet box and which, in a first position, at least partially covers the plug connection unit and a plug connector part which is plug-connectable thereto, and in a second position, uncovers same for the purposes of releasing or making the plug connection,
- characterized in that**
- at least one explosion pressure relief device is attached to the outlet box and/or to the cover part, preferably both to the outlet box and to the cover part, and in that
 - the explosion pressure relief device forms a predefined relief opening with a predetermined orientation, and
 - the explosion pressure relief device preferably has at least one guide body, in particular a guide body arrangement, for guiding explosion gases that form in the event of an arc explosion through the relief opening and into an external space region.
2. The shore power outlet as claimed in claim 1, characterized in that

a pressure relief element is attached to the outlet box, said pressure relief element being designed to discharge explosion gases from the interior under explosion conditions, in particular in the presence of a predefined response pressure, and to sealingly close under normal operating conditions.

3. The shore power outlet as claimed in claim 2, characterized in that

at least one explosion pressure relief device comprises the pressure relief element and at a box side is attached to the outlet box, wherein the pressure relief element opens up the predefined relief opening under explosion conditions in order to discharge explosion gases from the interior through the relief opening, and sealingly closes the relief opening under normal operating conditions, and/or

the pressure relief element is designed to be splash-proof, preferably as a rupture panel or rupture diaphragm.

4. The shore power outlet as claimed in claim 1, 2 or 3, characterized in that

the shore power outlet comprises the first cover part, which is movable relative to the outlet box, and a second cover part, wherein the cover parts are of corresponding or complementary design and interact, preferably in lockable fashion, in order that, in the first position, they enclose the plug connection unit and a plug connector part, which is plug-connectable thereto, at least on four sides, and a locking device is provided by means of which the two cover parts are lockable, in particular are lockable to one another, in the first position.

5. The shore power outlet as claimed in any one of the preceding claims, in particular as claimed in claim 4, characterized in that

a box-side first explosion pressure relief device having a sealingly closing pressure relief element is provided on the outlet box, and an open second explosion pressure relief device is provided on the cover side, wherein the cover-side

second explosion pressure relief device is provided on the first cover part or on the second cover part.

6. The shore power outlet as claimed in any one of the preceding claims, characterized in that
5 the box-side and/or cover-side explosion pressure relief device has an explosion damper which is provided upstream of the relief opening in an outflow direction.
7. The shore power outlet as claimed in claim 6, wherein the
10 guide body arrangement comprises a gas-cooling and/or pressure-reducing explosion damper.
8. The shore power outlet as claimed in any one of claims 1 to 7, in particular as claimed in claim 7, characterized in that the guide body arrangement comprises a multiplicity of mutually parallel cooling elements, preferably planar cooling
15 elements, in particular metal plates in a parallel plate arrangement,
 - which are preferably arranged so as to extend substantially in a main outflow direction and/or substantially parallel to the surface normal of the relief opening, and/or
 - 20 - which preferably form a flow cross section which remains free and which is larger than or equal to the opening cross section of the relief opening.
9. The shore power outlet as claimed in any one of the preceding claims, characterized in that
25 the or each explosion pressure relief device is designed as a hood-like attachment unit having outer walls, in which a predefined relief opening having a predetermined orientation is formed, and having an installation flange which surrounds a through-opening and which serves for the installation of the
30 attachment unit, adjacently to the outside, on an opening in the outlet box or in the cover part, wherein the guide body arrangement is provided in the interior of the attachment unit between the through-opening and the relief opening.
10. The shore power outlet as claimed in claim 9, characterized in

that,

in the explosion pressure relief device, at least two outer walls of the attachment unit are arranged obliquely, in particular in a trapezoidal or truncated pyramid shape, on the installation flange as a base, and the relief opening is provided in an oblique outer wall, the angle of which relative to the installation flange substantially predefines the orientation of the relief flow or a main outflow direction.

11. A **shore power outlet** for providing a supply to a ship, wherein the shore power outlet is designed and configured for electrically connecting the on-board power network of a docked ship, in particular of a container or cruise ship, as required to a shore-side supply network, in particular is designed and configured for a multi-phase voltage supply at at least 6.6 kV or 7.2 kV and/or at at least 2 MVA connected load, wherein
 - the shore power outlet comprises an outlet box having box walls which enclose an interior, in particular in splash-proof fashion,
 - the outlet box comprises at least one plug connection unit, in particular a socket outlet, which is provided on a box wall for releasable plug connection to a corresponding plug connector part of a ship supply line, and which in the interior of the outlet box is fixedly connectable to a feed line of the shore-side supply network,**characterized**
 - in that a first cover part and a second cover part are provided, wherein at least the first cover part is movable relative to the outlet box, and wherein the cover parts are of corresponding or complementary design in order that, in a first position, they at least partially cover the plug connection unit and a plug connector part which is plug-connectable thereto, in particular enclose same at least on four sides, and in a second position, they uncover same for the purposes of releasing or making the plug connection, and
 - in that a locking device is provided by means of which the two cover parts are lockable, in particular are lockable to

one another, in the first position.

12. The shore power outlet as claimed in claim 11, characterized in that
the cover parts are designed such that, in the first position,
5 the plug connection between plug connection unit and plug connector part cannot be released, and/or
the locking device has an interlock bolt which is operatively connected to an electrical switching element, wherein the switching element is electrically connectable or connected to
10 a safety circuit of the shore power supply.
13. The shore power outlet as claimed in claim 4 **or** as claimed in either one of claims 11 and 12, characterized in that
the cover parts are designed to interact in order that, in the first position and together with at least one wall of the
15 outlet box, they enclose a plug chamber in substantially closed fashion on all sides.
14. The shore power outlet as claimed in claim 4 **or** as claimed in any one of claims 11 to 13, characterized in that
- the cover parts are dimensioned substantially matchingly
20 with respect to the preferably cuboidal box shape of the outlet box, and are preferably substantially U-shaped in cross section and preferably substantially L-shaped in longitudinal section in order that, in the first position, they terminate with one end region flush, in particular sealingly, against a
25 housing wall of the outlet box, and/or,
- in the second position, one cover part engages in nested fashion into the other cover part.
15. The shore power outlet as claimed in claim 4 **or** as claimed in any one of claims 11 to 14, characterized in that
30 both cover parts are supported movably on the outlet box, in particular are designed as protective flaps and are supported on the outlet box such that they can be pivoted open and closed between the first and second positions, and/or
a mechanism, in particular lever mechanism, couples the

movement of the two cover parts relative to the outlet box,
and wherein the outlet box preferably forms the fixed element
of the mechanism, and/or wherein at least one gas spring is
preferably coupled to the mechanism so as to provide
5 assistance.

16. The shore power outlet as claimed in claim 15, characterized
in that
each cover part is, at a box-side end region, supported at
both sides on the outlet box by means of respective pivot
10 joints.
17. The shore power outlet as claimed in claim 4 **or** as claimed in
any one of claims 11 to 16, characterized in that
each cover part has, at an end region facing away from the
outlet box, at least one leadthrough cutout for a ship supply
15 line, wherein a sealing element for lying sealingly against
the ship supply line in the first position is preferably
provided internally at each leadthrough cutout.
18. The shore power outlet as claimed in claim 4 **or** as claimed in
any one of claims 11 to 16, characterized in that
20 each cover part has, at an end region facing away from the
outlet box, at least one leadthrough cutout for a ship supply
line, wherein a sealing element for lying sealingly against
the ship supply line in the first position is preferably
provided internally at each leadthrough cutout.
- 25 19. The shore power outlet as claimed in any one of claims 11 to
18, characterized in that at least one explosion pressure
relief device, in particular as claimed in at least one of
claims 1 to 4 or 6 to 9, is provided on the first cover part
or on the second cover part.
- 30 20. A **shore power outlet** for providing a supply to a ship, wherein
the shore power outlet is designed and configured for
electrically connecting the on-board power network of a docked
ship, in particular of a container or cruise ship, as required
to a shore-side supply network, in particular is designed and

configured for a multi-phase voltage supply at at least 6.6 kV or 7.2 kV and/or at at least 2 MVA connected load, wherein

- the shore power outlet comprises an outlet box having box walls which enclose an interior, in particular in splash-proof fashion,

- the outlet box comprises at least one plug connection unit, in particular a socket outlet, which is provided on a box wall for releasable plug connection to a corresponding plug connector part of a ship supply line, and which in the interior of the outlet box is fixedly connectable to a feed line of the shore-side supply network,

- at least one cover part is provided which is movable relative to the outlet box,

characterized

- in that the at least one cover part, in a first position, secures the plug connection unit and a plug connector part, which is plug-connectable thereto, such that in the first position the plug connection between plug connection unit and plug connector part cannot be released, and the at least one cover part, in a second position, uncovers the plug connection unit and a plug connector part, which is plug-connectable thereto, for the purposes of releasing or making the plug connection,

- in that a locking device is provided for locking the at least one cover part in the first position, and

- in that a detector element is operatively connected to the locking device and/or to the at least one cover part, wherein the detector element detects whether the at least one cover part is locked in the first position, and wherein the detector element is connectable or connected, for signal transfer, to a safety circuit, in particular a control current pilot loop of an interlock safety circuit, of the shore power supply.

21. The shore power outlet as claimed in claim 20, characterized in that

the locking device has an interlock bolt which is operatively connected to an electrical switching element as detector

element, wherein the switching element is electrically connectable or connected to a safety circuit of the shore power supply.

22. The shore power outlet as claimed in claim 20 or 21,
5 characterized in that a first cover part and a second cover part are provided, and the cover parts are designed to interact
- in order that, in the first position and together with at least one wall of the outlet box, they enclose a plug chamber
 - 10 in substantially closed fashion on all sides, and/or
 - such that, in the first position, the plug connection between plug connection unit and plug connector part cannot be released.
23. The shore power outlet as claimed in any one of claims 20 to
15 22, characterized in that
- the cover parts are dimensioned substantially matchingly with respect to the preferably cuboidal box shape of the outlet box, and are preferably substantially U-shaped in cross section and preferably substantially L-shaped in longitudinal
 - 20 section in order that, in the first position, they terminate with one end region flush, in particular sealingly, against a housing wall of the outlet box, and/or,
 - in the second position, one cover part engages in nested fashion into the other cover part.
24. The shore power outlet as claimed in any one of claims 20 to
25 23, characterized in that
- both cover parts are supported movably on the outlet box, in particular are designed as protective flaps and are supported on the outlet box such that they can be pivoted open and
- 30 closed between the first and second positions, and/or a mechanism, in particular lever mechanism, couples the movement of the two cover parts relative to the outlet box, and wherein the outlet box preferably forms the fixed element of the mechanism, and/or wherein at least one gas spring is
- 35 preferably coupled to the mechanism so as to provide

assistance.

25. The shore power outlet as claimed in claim 24, characterized in that
each cover part is, at a box-side end region, supported at
5 both sides on the outlet box by means of respective pivot joints.
26. The shore power outlet as claimed in any one of claims 20 to 25, characterized in that
each cover part has, at an end region facing away from the
10 outlet box, at least one leadthrough cutout for a ship supply line, wherein a sealing element for lying sealingly against the ship supply line in the first position is preferably provided internally at each leadthrough cutout.
27. The shore power outlet as claimed in any one of claims 20 to 26, characterized in that
15 each cover part has, at an end region facing away from the outlet box, at least one leadthrough cutout for a ship supply line, wherein a sealing element for lying sealingly against the ship supply line in the first position is preferably
20 provided internally at each leadthrough cutout.
28. The shore power outlet as claimed in any one of the preceding claims,
characterized in that the shore power outlet
- is installed movably, in particular is installed on a
25 positionable support arm, and/or is installed on a movable carriage or a vehicle; and/or,
- in an operational setting, is arrangeable or arranged at a quay facility of a port such that explosion gases that arise in the event of an arc explosion are discharged away from the
30 quay facility through the relief opening of the explosion pressure relief device.
29. The shore power outlet as claimed in any one of the preceding claims, characterized in that the outlet box and/or the plug connection unit are/is of splash-proof design, preferably in

accordance with protection class IP67 or higher.

30. The shore power outlet as claimed in any one of the preceding claims, characterized in that
the outlet box has at least two structurally identical plug
5 connection units, and/or
the or each plug connection unit of the outlet box is designed
and configured as a socket outlet for an HVSC system IEC/IEEE
80005-1:2019, in particular in accordance with the
requirements of DIN EN IEC 62613-1 and DIN EN IEC 62613-2.
- 10 31. A shore-ship interface apparatus, in particular for an HVSC
system of a container terminal, comprising a shore power outlet
as claimed at least one of the preceding claims 1 to 19 or one
of claims 20 to 30.