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INTERNATIONAL STANDARD

Utility connections in port –
Part 1: High Voltage Shore Connection (HVSC) Systems – General requirements

IEC/ISO/IEEE 80005-1:2012(E)

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Part 1: High Voltage Shore Connection (HVSC) Systems – General requirements

FOREWORD

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International Standard IEC/ISO/IEEE 80005-1 has been prepared by IEC technical committee 18: Electrical installations of ships and of mobile and fixed offshore units, in cooperation with IEC subcommittee 23H: Industrial plugs and socket-outlets, of IEC technical committee 23: Electrical accessories; ISO technical committee 8: Ships and marine technology, subcommittee 3: Piping and machinery; and IEEE IAS Petroleum and Chemical Industry Committee (PCIC) of the Industry Applications Society of the IEEE[1].

This publication is published as an IEC/ISO/IEEE triple logo and prefix standard.

This document cancels and replaces IEC/PAS 60092-510 published in 2009.

A list of all the parts in the IEC 80005 series, published under the general title *Utility connections in port*, can be found on the IEC website.

The text of this standard is based on the following IEC documents:

FDIS	Report on voting
18/1254/FDIS	18/1268/RVD

Full information on the voting for the approvals of this standard can be found in the report on voting indicated in the above table. In ISO, the standard has been approved by 9 members out of 9 having a cast vote.

International standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The IEC Technical Committee, the ISO Technical Committee and IEEE Technical Committee have decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC, ISO and IEEE web site in the data related to the specific publication. At this date, the publication will be

- reconfirmed
- withdrawn
- replaced by a revised edition, or
- amended.

1 A list of IEEE participants can be found at the following URL: http://standards.ieee.org/downloads/80005-1/80005-1-2012/80005-1-2012_wg-participants.pdf

INTRODUCTION

The following standard was developed jointly between IEC technical committee 18: Electrical installations of ships and of mobile and fixed offshore units, ISO technical committee 8: Ships and marine technology, subcommittee 3: Piping and machinery, and IEEE IAS PCIC Marine industry subcommittee.

For a variety of reasons, including environmental considerations, it is becoming an increasingly common requirement for ships to shut down ship generators and to connect to shore power for as long as practicable during stays in port. The scenario of receiving electrical power and other utilities from shore is historically known as “cold ironing”.

The intention of this standard is to define requirements that support, with the application of suitable operating practices, efficiency and safety of connections by compliant ships to compliant high-voltage shore power supplies through a compatible shore to ship connection.

With the support of sufficient planning, cooperation between ship and terminal facilities, and appropriate operating procedures and assessment, compliance with the requirements of this standard is intended to allow different ships to connect to high-voltage shore connections (HVSC) at different berths. This provides the benefits of standard, straightforward connection without the need for adaptation and adjustment at different locations that can satisfy the requirement to connect for as long as practicable during stays in port.

Ships that do not apply this standard may find it impossible to connect to compliant shore supplies.

Where deviations from the requirements and recommendations in this standard may be considered for certain designs, the potential effects on compatibility are highlighted.

Where the requirements and recommendations of this standard are complied with, high-voltage shore supplies arrangements are likely to be compatible for visiting ships for connection.

Clauses 1 to 12 are intended for application to all HVSC systems. They intend to address mainly the safety and effectiveness of HVSC systems with a minimum level of requirements that would standardise on one solution. This standard includes the requirement to complete a detailed compatibility assessment for each combination of ship and shore supply prior to a given ship arriving to connect to a given shore supply for the first time

Annex A includes cabling recommendations that should be used in HVSC systems.

The other annexes in this standard are ship specific annexes that include additional requirements related to agreed standardisation of solutions to achieve compatibility for compliant ships at different compliant berths and to address safety issues that are considered to be particular to that ship type. These annexes use the same numbering as Clauses 1 to 12 with an annex letter prefix. Hence, the numbering is not necessarily continuous. Where no additional requirements are identified, the clause is not shown.

It should be noted that Annex A is considered informative for the purposes of this document. This annex contains performance-based requirements for shore connection cable, and was developed by technical experts from a number of countries. IEC technical committee 18, subcommittee 18A and IEC technical committee 20 were consulted regarding cable requirements. It was determined that existing standards for cable can be used at this time and there is presently no need to develop a separate standard for shore connection cables.

UTILITY CONNECTIONS IN PORT –

Part 1: High Voltage Shore Connection (HVSC) Systems – General requirements

1 Scope

This part of IEC 80005 describes high voltage shore connection (HVSC) systems, on board the ship and on shore, to supply the ship with electrical power from shore.

This standard is applicable to the design, installation and testing of HVSC systems and addresses:

- HV shore distribution systems;
- shore-to-ship connection and interface equipment;
- transformers/reactors;
- semiconductor/rotating convertors;
- ship distribution systems; and
- control, monitoring, interlocking and power management systems.

It does not apply to the electrical power supply during docking periods, e.g. dry docking and other out of service maintenance and repair.

Additional and/or alternative requirements may be imposed by national administrations or the authorities within whose jurisdiction the ship is intended to operate and/or by the owners or authorities responsible for a shore supply or distribution system.

It is expected that HVSC systems will have practicable applications for ships requiring 1 MW or more or ships with HV main supply.

Low-voltage shore connection systems are not covered by this standard.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60034 (all parts), *Rotating electrical machines*

IEC 60076 (all parts), *Power transformers*

IEC 60079 (all parts), *Electrical apparatus for explosive gas atmospheres*

IEC 60092-101:2002, *Electrical installations in ships – Part 101: Definitions and general requirements*

IEC 60092-201:1994, *Electrical installations in ships – Part 201: System design – General*

IEC 60092-301:1995, *Electrical installations in ships – Part 301: Equipment – Generators and motors*

IEC 60092-502:1999, *Electrical installations in ships – Part 502: Tankers – Special features*

IEC 60092-503:2007, *Electrical installations in ships – Part 503: Special features – AC supply systems with voltages in the range of above 1 kV up to and including 15 kV*

IEC 60092-504:2001, *Electrical installations in ships – Part 504: Special features – Control and instrumentation*

IEC 60146-1 (all parts), *Semiconductor convertors – General requirements and line commutated convertors*

IEC 60204-11:2000, *Safety of machinery – Electrical equipment of machines – Part 11: Requirements for HV equipment for voltages above 1 000 V a.c. or 1 500 V d.c. and not exceeding 36 kV*

IEC 60332-1-2:2004, *Tests on electric and optical fibre cables under fire conditions – Part 1-2: Test for vertical flame propagation for a single insulated wire or cable – Procedure for 1 kW pre-mixed flame*

IEC 60502-2:2005, *Power cables with extruded insulation and their accessories for rated voltages from 1kV(U_m=7,2 kV) up to 30 kV(U_m=36 kV) – Part 2: Cables for rated voltages from 6 kV(U_m=7,2 kV) up to 30 kV(U_m=36 kV)*

IEC 60502-4:2005, *Power cables with extruded insulation and their accessories for rated voltages from 1 kV (U_m = 1,2 kV) up to 30 kV (U_m = 36 kV) – Part 4: Test requirements on accessories for cables with rated voltages from 6 kV (U_m = 7,2 kV) up to 30 kV (U_m = 36 kV)*

IEC 60947-5-1:2003, *Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices*

IEC 61363-1, *Electrical installations of ships and mobile and fixed offshore units – Part 1: Procedures for calculating short-circuit currents in three-phase a.c.*

IEC 61936-1:2002, *Power installations exceeding 1 kV a.c. – Part 1: Common rules*

IEC 62271-200:2003, *High-voltage switchgear and controlgear – Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV*

IEC 62613-1:2011, *Plugs, socket-outlets and ship couplers for high-voltage shore connection systems (HVSC systems) – Part 1: General Requirements*

IEC 62613-2:2011, *Plugs, socket-outlets and ship couplers for high-voltage shore connection systems (HVSC-systems) – Part 2: Dimensional compatibility and interchangeability requirements for accessories to be used by various types of ships*

SOLAS 2009, Chapter II-1/D, Regulations 42, 43 and 45

MIL-DTL-38999K, *General specification for connectors, electrical, circular, miniature, high density, quick disconnect (bayonet, threaded, and breech coupling), environment resistant, removable crimp and hermetic solder contacts*

MIL-STD-1560A, *Interface standard: Insert arrangements for MIL-C-38999 and MIL-C-27599 electrical, circular connectors*

MIL-PRF-29504/5C, *Performance specification sheet. Termini, fiber optic, connector, removable, environment resisting, socket terminus, size 16, rear release, MIL-DTL-38999, SERIES III*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
cable management system
all equipment designed to control, monitor and handle the HV-flexible and control cables and their connection devices

3.2
equipotential bonding
provision of electric connections between conductive parts, intended to achieve equipotentiality

[SOURCE: IEC 60050-195:1998, 195-01-10]

3.3
emergency shutdown-1
ESD-1
shutdown initiated when the ship moves past the warning range of allowable motion forward, aft or outward from the dock, and which initiates an LNG-ESD signal from shore to ship

3.4
emergency shutdown-2
ESD-2
shutdown initiated when the ship moves past the maximum range of allowable motion forward, aft or outward from the dock, and which initiates loading arm disconnection on shore

3.5
high voltage
HV
nominal voltage in range above 1 000 V a.c. and up to and including 15 kV a.c.

3.6
liquefied natural gas-emergency shutdown
LNG-ESD
type of emergency shutdown defined at LNG terminals

3.7
low voltage
LV
nominal voltage up to and including 1 000 V a.c.

3.8
person in charge
PIC
individual responsible for HVSC systems operations

3.9
pilot contact
contact of the plug and socket-outlet which signals correct plug connection and is a safety-related component

3.10
receiving point
connection point of the flexible cable on the ship

3.11
safe
condition in which safety risks are minimized to an acceptable level

3.12
supply point
connection point of the flexible cable on shore

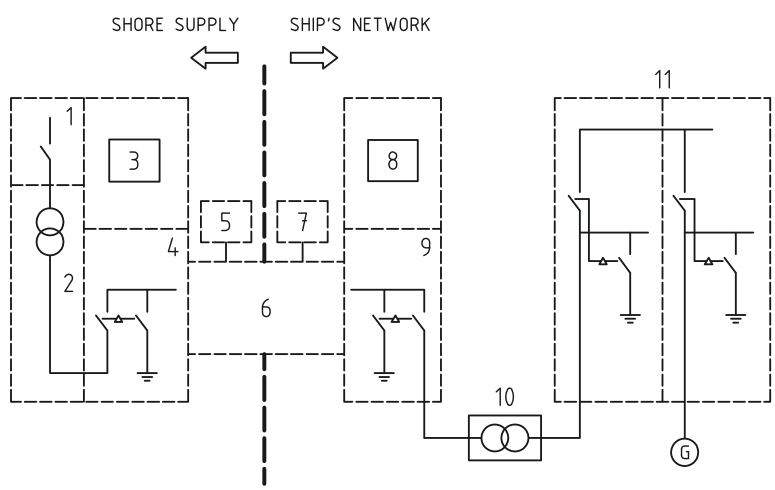
3.13
fail safe
design property of an item which prevents its failures from resulting in critical faults

[SOURCE: IEC 60050-195:1998, 191-15-04]

4 General requirements

4.1 System description

A typical HVSC system described in this standard consists of hardware components as shown in Figure 1.



KEY

1. HV-SHORE SUPPLY SYSTEM
2. SHORE SIDE TRANSFORMER
3. SHORE SIDE PROTECTION RELAYING
4. SHORE SIDE CIRCUIT BREAKER AND EARTH SWITCH
5. CONTROL
6. SHORE-TO-SHIP CONNECTION AND INTERFACE EQUIPMENT
7. CONTROL
8. SHIP PROTECTION RELAYING
9. SHORE CONNECTION SWITCHBOARD
10. ON-BOARD TRANSFORMER (WHERE APPLICABLE)
11. ON-BOARD RECEIVING SWITCHBOARD

Figure 1 – Block diagram of a typical described HVSC system arrangement

4.2 Distribution system

4.2.1 General

Typical distribution systems used on shore are given in IEC 61936-1. Typical ship distribution systems are given in IEC 60092-503.

NOTE IEEE Std 45™ provides additional information on typical ship distribution systems.

4.2.2 Equipotential bonding

An equipotential bonding between the ship's hull and shore earthing electrode shall be established.

Verification of the equipotential bonding shall be a part of the safety circuit (see 7.2.5). Loss of equipotential bonding shall result in the shutdown of the HVSC system, and the ship shall go into ship power restoration mode (see 8.6).

NOTE The terms earth(ing) and ground(ing) are used interchangeably throughout this standard and have the same meaning (see IEC 60050-195:1998,195-01-08).

4.3 Compatibility assessment before connection

Compatibility assessment shall be performed to verify the possibility to connect the ship to shore HV supply. Compatibility assessment shall be performed prior to the first arrival at a terminal.

Assessment of compatibility shall be performed to determine the following:

a) compliance with the requirements of this standard and any deviations from the recommendations;
b) minimum and maximum prospective short-circuit current (see 4.7 and 4.8);
c) nominal ratings of the shore supply, ship to shore connection and ship connection (see 5.1);
d) any de-rating for cable coiling or other factors (see 7.2.1);
e) acceptable voltage variations at ship switchboards between no-load and nominal rating (see 5.2);
f) steady state and transient ship load demands when connected to a HV shore supply, HV shore supply response to step changes in load (see 5.2);
g) system study and calculations (see 4.8);
h) verification of ship equipment impulse withstand voltage;
i) compatibility of shore and ship side control voltages, where applicable;
j) compatibility of communication link;
k) distribution system compatibility assessment (shore power transformer neutral earthing);
l) functioning of ship earth fault protection, monitoring and alarms when connected to a HVSC supply (see 8.2.2);
m) sufficient cable length;
n) compatibility of safety circuits, in accordance with 9.1;
o) total harmonic distortion (THD) (see 5.2);
p) consideration of hazardous areas, where applicable (see 4.6.4);
q) when a HV supply system is connected, consideration shall be given to provide means to reduce current in-rush and/or inhibit the starting of large loads that would result in failure, overloading or activation of automatic load reduction measures;
r) consideration of electrochemical corrosion due to equipotential bonding;

s) utility interconnection requirements for load transfer parallel connection; and

t) equipotential bond monitoring.

4.4 HVSC system design and operation

4.4.1 System design

The design and construction shall be integrated and coordinated among the parties responsible for shore and ship HVSC systems.

System integration of shore and ship HVSC systems shall be managed by a single designated party and shall be performed in accordance with a defined procedure identifying the roles, responsibilities and requirements of all parties involved.

4.4.2 System operation

During the operation of HVSC systems, PIC(s) shall be identified at the shore facility and on board the ship for the purposes of communication.

The PIC(s) shall be provided with sufficient information, instructions, tools and other resources for safety and efficiency of these activities.

4.5 Personnel safety

Construction of the HV equipment and operating safety procedures shall provide for the safety of personnel during the establishment of the connection of the ship supply, during all normal operations, in the event of a failure, during disconnection and when not in use.

The use of the term “safe” is not intended to suggest or guarantee that absolute safety can be achieved in any situation and/or by compliance with the recommended practices set forth herein. The use of terms such as “safe,” “intrinsically safe,” “electrically safe work practices,” “safe work condition,” “safe work environment,” “safe design,” “safe distance,” “safe work method,” “safe work area,” “safe use,” etc. describe practices, conditions, etc. in which safety risks are minimized but not eliminated absolutely, such that safety is not guaranteed.

4.6 Design requirements

4.6.1 General

Protection and safety systems shall be designed based on the fail safe principle.

Suitable warning notices shall be provided at locations along connection equipment routes including connection locations.

4.6.2 Protection against moisture and condensation

Effective means shall be provided to prevent accumulation of moisture and condensation, even if equipment is idle for appreciable periods.

4.6.3 Location and construction

HVSC equipment shall be installed in access controlled spaces.

Equipment shall be suitable for the environment conditions in the space(s) where it is expected to operate. Ship equipment shall comply with the applicable requirements of IEC 60092-101 and IEC 60092-503.

Equipment location is critical to the safety and efficiency of operation of the ship's cargo and mooring systems. When determining the location of the HVSC system, the full range of cargo, bunkering and other utility operations shall be considered, including:

a) the cargo handling and mooring equipment in use on the ship and shore, and the areas that must be clear for their operation, along with any movement of the ship along the pier required to accommodate these operations;
b) traffic management considerations such that the use of an HVSC system does not interfere with other ships' operations (including mooring) or prevent necessary traffic flow on the pier and to maintain open fire lanes where required; and
c) personnel safety measures, such as physical barriers to prevent unauthorized personnel access to HVSC equipment or the cable management equipment.

When determining the connection point of the HVSC system, all tidal conditions and ship operations affecting ship's free board shall be considered.

4.6.4 Electrical equipment in areas where flammable gas or vapour and/or combustible dust may be present

HVSC equipment shall be located outside the hazardous areas of the ship and shore facilities under normal operating conditions, except where it is shown to be necessarily located in these areas for safety reasons.

HVSC equipment that may fall within one of the hazardous areas of the terminal under emergency conditions (inadvertent movement of ship from berth) shall be:

a) certified in accordance with IEC 60079 as suitable for the flammable gas or vapour and/or combustible dust encountered; or
b) automatically isolated and discharged before entering the potentially hazardous area.

Control equipment located within hazardous areas shall not present an ignition hazard.

HVSC systems should as far as possible not be installed in areas which may become hazardous areas upon failure of required air changes per hours during loading and offloading cargo or during normal operation.

When a tanker is at a berth, it is possible that an area in the tanker that is regarded as safe according to IEC 60092-502 may falls within one of the hazardous zones of the terminal. If such a situation should arise and, if the area in question contains electrical equipment that is not of a safe-type, certified or approved by a competent authority for the gases encountered, then such equipment may have to be isolated whilst the tanker is at the berth. IEC 60079 should be considered during the compatibility assessment.

4.7 Electrical requirements

For all HVSC system components type and routine tests shall be performed according to relevant standards.

NOTE See IEEE Std C37.100.1™ for additional recommendations.

To allow standardisation of the HV shore supply and link nominal voltage (6,6 kV a.c. or 11 kV a.c.) in different ports, any equipment requiring conversion to nominal voltage shall be installed on board.

The prospective short-circuit contribution level from the HV shore distribution system shall be limited by the shore side system to 16 kA rms, unless otherwise specified in the ship specific annexes.

The prospective short-circuit contribution level from the on board running induction motors and the generators in operation shall be limited to a short circuit current of 16 kA rms, unless otherwise specified in the ship type's specific annexes.

Electrical system/equipment, including short-circuit protective device rating, shall be suitable for the prospective maximum short-circuit fault current. Equipment shall be rated for minimum of 16 kA rms for 1 s, and 40 kA peak, unless otherwise specified in the ship specific annexes.

4.8 System study and calculations

The shore-connected electrical system shall be evaluated. The system study and calculations shall determine:

a) the electrical load during shore connection;
b) the short-circuit current calculations (see IEC 61363-1) shall be performed that take into account the prospective contribution of the shore supply and the ship installations. The following ratings shall be defined and used in these calculations:
    1) for shore supply installations, a maximum and minimum prospective short circuit current for visiting ships;
    2) for ships, a maximum and minimum prospective short circuit current for visited shore supply installations.
c) the calculations may take into account any arrangements that:
    1) prevent parallel connection of HV shore supplies with ship sources of electrical power; and/or
    2) restrict the number of ship generators operating during parallel connection to transfer load;
    3) restrict load to be connected.
d) system charging (capacitive) current for shore and ship;
e) this system charging current calculation shall consider the shore power system and the expected ship power including the on line generator(s);
f) shore power transformer neutral earthing resistor analysis (see 6.2.3); and
g) transient overvoltage protection analysis (see 5.2).

These calculated values shall be used to select suitably rated shore connection equipment and to allow the selection and setting of protective devices so that successful discriminatory fault clearance is achieved for the largest on-board load while connected.

The system study shall be made available to all involved parties.

For ships with low voltage main distribution the connection between LV-side of the on-board transformer and main switchboard shall be evaluated and overload protection shall be provided between the on-board transformer and the receiving switchboard.

Documented alternative proposals that take into account measures to limit the parallel connection to short times may be considered where permitted by the relevant authorities. Documentation should be made available to relevant ship and shore personnel.

4.9 Emergency shutdown including emergency stop facilities

Emergency shutdown facilities shall be provided. When activated, they will instantaneously open shore connection circuit-breakers on shore and on board ship.

Fail-safe, hard-wired circuits shall be used for emergency shut-down. This does not preclude emergency shut-down activation commands from programmable electronic equipment, e.g. programmable protection relays.

The relay contacts of the safety circuit shall be designed according to IEC 60947-5-1 and for a rated insulation voltage of U_i = 300 V, a.c. 5 A, d.c.1 A.

To address the potential hazard to personnel of access to high-voltage connection cables that have not been discharged, the high-voltage power connections shall either:

a) be automatically earthed so that they are safe to touch immediately following the isolation from ship and shore electrical power supplies (this option shall be chosen where connection equipment may move into a potentially hazardous area); or
b) be arranged for manual earthing and routed and located such that personnel are prevented from access to live connection cables and live connection points by barriers and/or adequate distance(s) under normal operational conditions (this option shall not be chosen where connection equipment may move into a potentially hazardous area).

Barriers and/or adequate distance(s) shall be supported with operational procedures established to:

c) restrict un-authorized access to HVSC spaces;
d) control personnel access to HVSC spaces and areas when the HV connection is live. Locking arrangements may be considered; and
e) arrange for the safe discharge of HV conductors.

Where connection equipment may move into a potentially hazardous area (where flammable gas, vapour and/or combustible dust may accumulate) associated with the terminal or port berth area as a result of the ship inadvertently leaving the berthed position (slipping/breaking of moorings, etc.) all electrical powered HVSC equipment that is not intrinsically safe shall be automatically isolated, and HV equipment then automatically discharged, so that it will not present an ignition hazard.

The emergency shutdown facilities shall be activated in the event of:

f) loss of equipotential bonding, via the equipotential bond monitoring relays;
g) overtension on the flexible cable (mechanical stress) (see 7.2.2);
h) loss of any safety circuit;
i) activation of any manual emergency-stop;
j) activation of protection relays provided to detect faults on the HV connection cable or connectors; and
k) disengaging of power plugs from socket-outlets while HV connections are live (before the necessary degree of protection is no longer achieved).

Emergency stop push buttons, activating emergency shutdown facilities, shall be provided at:

l) an attended onboard ship control station during HVSC;
m) in the vicinity of the socket outlet;
n) at active cable management system control locations; and
o) at the shore side and ship circuit-breaker locations.

Additional emergency push buttons may also be provided at other locations, where considered necessary.

The means of activation shall be visible and prominent, prevent inadvertent operation and require a manual action to reset.

An alarm to indicate activation of the emergency shutdown shall be provided to advise relevant duty personnel when connected to HV shore supply.

For reliable operation of safety circuits the pilot cable length shall be considered.

5 HV shore supply system requirements

5.1 Voltages and frequencies

To allow standardization of the HV shore supply and link nominal voltage in different ports, HV shore connections shall be provided with a nominal voltage of 6,6 kV a.c. and/or 11 kV a.c. galvanically separated from the shore distribution system.

Galvanic separation on shore may be omitted if it is provided on board.

The operating frequencies (Hz) of the ship and shore electrical systems shall match; otherwise, a frequency convertor may be utilized on shore.

Where ships undertake a, repeated itinerary at the same ports and their dedicated berths, other IEC voltage nominal values may be considered (see IEC 60092-503).

At the connection point, looking at the socket/connector face, the phase sequence shall be L1-L2-L3 or A-B-C or R-S-T. A phase sequence indicator must indicate correct sequence prior to energizing or paralleling HVSC (see Figure 2). Figure 3 illustrates the balanced three-phase voltages in time domain.

If an observer looking at phase sequence rotation diagram is fixed at its location, phasors must rotate counter clockwise in reference to fixed observer to produce a clockwise indication on the phase sequence indicator (see Figure 2).

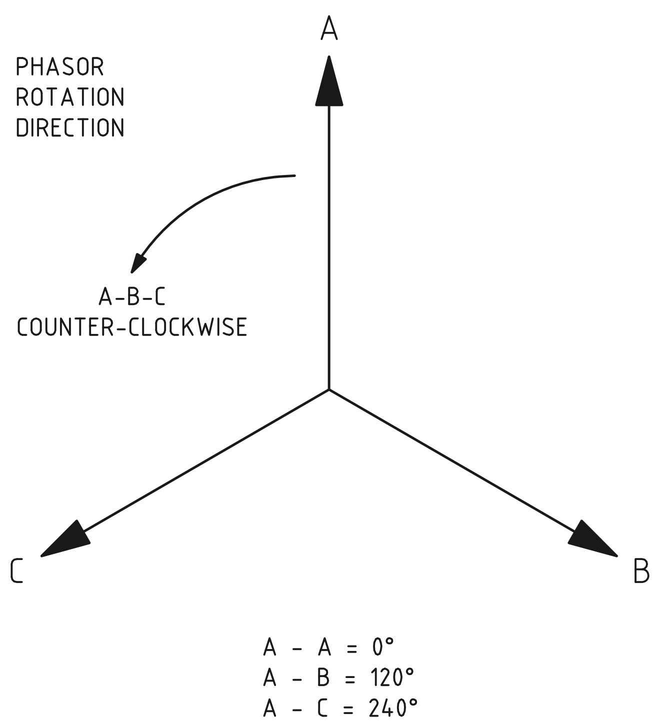


Figure 2 – Phase sequence rotation – Positive direction

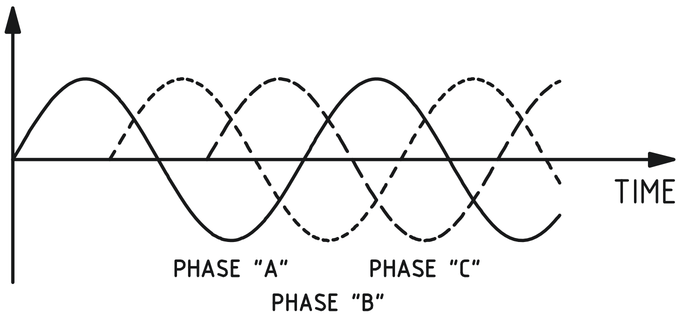


Figure 3 – Balanced three-phase variables in time domain

5.2 Quality of HV shore supply

The HV shore supply system shall have a documented voltage supply quality specification.

Ship electrical equipment shall only be connected to shore supplies that will be able to maintain the distribution system voltage, frequency and total harmonic distortion characteristics given below. For compliance, the compatibility assessment referred to in 4.3 shall include verification of the following:

a) voltage and frequency tolerances (continuous):
   1) the frequency shall not exceed the continuous tolerances ±5 % between no-load and nominal rating;
   2) for no-load conditions, the voltage at the point of the shore supply connection shall not exceed a voltage increase of 6 % of nominal voltage;
   3) for rated load conditions, the voltage at the point of the shore supply connection shall not exceed a voltage drop of -3,5 % of nominal voltage.

b) voltage and frequency transients:
   1) the response of the voltage and frequency at the shore connection when subjected to an appropriate range of step changes in load shall be defined and documented for each HV shore supply installation;
   2) the maximum step change in load expected when connected to a HV shore supply shall be defined and documented for each ship. The part of the system subjected to the largest voltage dip or peak in the event of the maximum step load being connected or disconnected shall be identified;
   3) comparison of 1) and 2) shall be done to verify that the voltage transients limits of voltage +20 % and −15 % and the frequency transients limits of ±10 %, will not be exceeded.

c) harmonic distortion:
   – for no-load conditions, voltage harmonic distortion limits shall not exceed 3 % for individual harmonic and 5 % for total harmonic distortion.

NOTE Additional recommendations are provided in IEEE Std 519™ and MIL STD 1399-680.

The above parameters shall be measured at the supply point (see 3.12).

The HV shore supply shall include appropriate rated surge arrestors to protect against fast transient overvoltage surges (e.g. spikes caused by lightning strikes or switching surges).

Different voltage and frequency tolerances may be imposed by the owners or authorities responsible for the shore supply system and these should be considered as part of the compatibility assessment to verify the effect on the connected ship load is acceptable.

Where the possible loading conditions of a ship when connected to a HV shore supply would result in a quality of the supply different from that specified in IEC 60092-101:2002, 2.8, due regard should be given to the effect this may have on the performance of equipment.

6 Shore side installation

6.1 General

Shore connection equipment and installations shall be in accordance with IEC 61936-1.

NOTE Local Authorities may have additional requirements.

The rating of the HVSC system shall be adequate for the required electrical load as calculated by 4.8.

Each ship shall be provided with a dedicated HV shore supply installation which is galvanically isolated from other connected ships and consumers. This may not be required where a HV shore supply is dedicated to supply only ships which have galvanic isolation on board. A risk assessment should be performed.

6.2 System component requirements

6.2.1 Circuit-breaker, disconnector and earthing switch

In order to have the installation isolated before it is earthed, the circuit-breaker, disconnector and earthing switch shall be interlocked in accordance with the requirements of IEC 62271-200.

The rated making capacity of the circuit breaker and the earthing switch shall not be less than the prospective peak value of the short-circuit current (I_{P}) calculated in accordance with IEC 61363-1.

The rated short-circuit breaking capacity of the circuit-breaker shall not be less than the maximum prospective symmetrical short-circuit current ($I_{\mathrm{AC(0,5T)}}$) calculated in accordance with IEC 61363-1.

An automatic operated circuit-breaker shall be provided.

6.2.2 Transformer

In the event adjustments are required to maintain the HV supply voltage within tolerances under load, then these adjustments shall be automatically controlled (see 5.2).

Transformers shall be of the separate winding type for primary and secondary side. The secondary side shall be star-configuration with neutral bushings (Dyn).

NOTE Dyn = Delta connected HV winding, star connected LV winding, with provision to connect to the neutral point.

The temperature of supply-transformer windings shall be monitored.

In the event of over temperature, an alarm signal shall be transmitted to the ship using the data-communication link (see 7.8). The alarm signal shall activate an alarm on board to warn relevant duty personnel.

Short circuit protection for each supply transformer shall be provided by circuit-breakers or fuses in the primary circuit and by a circuit breaker in the secondary. In addition, overload protection shall be provided for the primary and secondary circuit.

6.2.3 Neutral earthing resistor

The neutral point of the HVSC system transformer feeding the shore-to-ship power receptacles shall be earthed:

a) through a neutral earthing resistor; or

b) where frequency conversion of the shore supply is required, either through a neutral earthing resistor or through an earthing transformer with resistor on the primary side that provides an equivalent earth fault impedance.

NOTE For HVSC systems dedicated to tankers or liquefied natural gas carriers (LNGC) ship types, refer to ship specific annexes.

Where an equivalent earth fault impedance is chosen when frequency conversion of the shore supply is required, studies should be conducted to verify that earth fault protection and alarm arrangement will be effective (see 4.8 and 8.2.2). A secondary delta winding of the transformer, in combination with an earthing transformer with resistor on the primary side, suitable to compensate for possible circulating currents, are permitted provided that the requirements set forth in 4.8 and 8.2 are fulfilled.

The neutral earthing resistor rating in amperes shall not be less 1,25 times the preliminary system charging current. The rating shall be minimum 25 A continuous.

The continuity of the neutral earthing resistor shall be continuously monitored. In the event of loss of continuity the shore side circuit breaker shall be tripped.

An earth fault shall not create a step or touch voltage exceeding 30 V at any location in the shore to ship power system.

6.2.4 Equipment earthing conductor bonding

From the neutral earthing resistor’s earthing connection a system earthing conductor shall connect to a nearby system earthing electrode. An additional system bonding conductor shall connect the neutral earthing resistor’s earthing connection to the earthing bus of the primary shore power switchboard. Bonding shall be in accordance with 8.2.3 of IEC 60204-11:2000.

Equipment earthing conductors terminated at the shore power outlet box receptacles shall be connected to the ship and continued to the ship to create an equipotential bond between the shore and ship. This may require bonding to the ship switchgear earthing bus and or bonding to ship hull.

6.3 Shore to ship electrical protection system

The HV circuit-breaker on the secondary side of the transformer shall open all insulated poles in the event of the following conditions:

a) overcurrent including short-circuit,

b) over-voltage/ under-voltage, and

c) reverse power.

To satisfy this requirement, at least the following protective devices, or equivalent protective measures, shall be provided:

d) synchrocheck (25) or voltage sensing device (84) (for dead bus verification)

e) undervoltage (27)

f) reverse power (32)

g) load unbalance, negative phase sequence overcurrent (46)

h) instantaneous overcurrent (50)

i) phase time overcurrent (51)
j) earth fault overcurrent (51G)
k) overvoltage (59)
l) directional phase overcurrent (67)

Standard device designation numbers are shown in brackets above, as per IEEE Std C37.2™.

Alarms shall be communicated to the ship as common alarm (see 7.8).

The protection systems shall be provided with battery back-up adequate for at least 30 min. Upon failure of the battery charging or activation of the back-up system, an alarm shall be communicated to the ship (see 7.8).

6.4 HV interlocking

6.4.1 General

Operating personnel shall be protected from electrical hazard by an interlocking arrangement while plugging and unplugging of HV plug and socket-outlet connections.

Operational procedures and interlockings to verify that non-fixed high-voltage cables are discharged before disconnection shall be established.

An independent means of voice communication should be provided between the ship and facility PIC (e.g. two way radios).

6.4.2 Handling of HV plug/socket-outlets

Handling of HV plug/socket-outlets shall only be allowed when the associated earthing switches on both ship and shore sides are closed.

Handling of the ship-side connector/inlets shall only be possible when the ship-side earthing switch is closed.

Handling of the shore-side plug/socket-outlets shall only be possible when the shore-side earthing switch is closed.

6.4.3 Operating of the high-voltage (HV) circuit-breakers, disconnectors and earthing switches

Arrangements shall be provided so that the circuit-breakers cannot be closed when any of the following conditions exist:

a) one of the earthing switches is closed (shore-side/ship-side);
b) the pilot contact circuit is not established (see 7.3.2);
c) emergency stop facilities are activated;
d) ship or shore control, alarm or safety system self-monitoring diagnostics detect an error that would affect safe connection;
e) the communication link between shore and ship is not operational, where applicable;
f) the permission from the ship is not activated (see 7.8);
g) the HV supply is not present; and
h) equipotential bonding is not established (via equipotential bond monitoring relays – see 4.2.2).

Arrangements shall be provided so that the disconnector cannot be closed, or the circuit breaker cannot be racked into the service position, when any of the following conditions exist:

i) one of the earthing switches is closed (shore side/ship side);
j) the pilot contact circuit is not established (see 7.3.2);
k) the communication link between shore and ship is not operational, where applicable; and
l) equipotential bonding is not established (via equipotential bond monitoring relays – see 4.2.2).

Arrangements shall be provided so that the earthing switches can only be opened when all of the conditions in 7.4 are fulfilled.

6.5 Shore connection convertor equipment

6.5.1 General

Where provided, converting equipment (transformers, rotating frequency convertors and/or semiconductor convertors) for connecting HV shore supplies to a ship electrical distribution system shall be constructed in accordance with IEC 60076 for transformers, and IEC 60146-1 series for semiconductor convertors, as applicable.

NOTE Refer to IEEE Std 1662™ for additional recommendations on testing HV power electronics.

Rotating convertors shall be designed and tested in accordance with IEC 60034.

The effect of harmonic distortion and power factor shall be considered in the assignment of a required power rating.

Transformer winding and semiconductor or rotating convertor temperatures shall be monitored and an alarm shall be activated to warn relevant duty personnel if the temperature exceeds a predetermined safe value.

The use of frequency convertors shall not reduce the selectivity of the largest on-board load while connected.

6.5.2 Degree of protection

The protection for electrical equipment shall be in accordance with IEC 61936-1, as applicable.

6.5.3 Cooling

Where forced or closed circuit cooling is used, whether by air or with liquid, an alarm shall be initiated when the cooling medium exceeds a predetermined temperature and/or flow limits.

Semiconductor-convertor equipment shall be so arranged that it cannot remain loaded unless effective cooling is maintained. Alternatively, the load may be automatically reduced to a level compatible with the cooling available.

Liquid-cooled convertor equipment shall be provided with leakage alarms. A suitable means shall be provided to contain any liquid which may leak from the cooling system so that it does not cause an electrical failure of the equipment.

Where liquid-cooled-heat exchangers are used in transformer-cooling circuits, there shall be detection of leakage and the cooling system shall be arranged so that the entry of cooling liquid into the transformer is prevented.

Where the semiconductors and other current carrying parts of semiconductor convertors are in direct contact with the cooling liquid, the liquid shall be monitored for satisfactory conductivity and an alarm shall be initiated if the conductivity is outside the manufacturer's limits.

The alarms shall be activated to warn relevant duty personnel.

6.5.4 Protection

In the event of overload, an alarm signal shall be activated to warn relevant duty personnel. The alarm shall be activated at a lower overload level than the circuit-breaker protection.

Alarms from the onshore protection equipment shall be transmitted to the ship, see 7.8.

7 Ship to shore connection and interface equipment

7.1 General

Ship to shore connection and interface equipment includes standardized HVSC systems, cables, earthing and communications between ship and shore.

A ship to shore connection cable installation shall be arranged to provide adequate movement compensation, cable guidance and anchoring/positioning of the cable during normal planned ship to shore connection and operating conditions.

The shore-side of the connection cable shall be fitted with a plug if a socket outlet will be used on shore. The body shall be arranged to protect all contacts.

The ship-side of the connection cable shall be fitted with a connector, if an inlet will be used on board.

Ship to shore connection cable extensions shall not be permitted

The suitability of plugs and sockets with regard to peak short-circuit withstand capability, shall be verified during the compatibility assessment (see 4.3).

The ship specific annexes provide additional requirements.

NOTE If an alternative to the standard arrangement of cable and HV plug and socket-outlets is designed, it is likely that the installation will not be able to connect to a compliant shore supply/ship without significant additional equipment and modification.

7.2 Cable management system

7.2.1 General

The cable management system shall:

a) be capable of moving the ship to shore connection cable, enabling the cable to reach between the socket-outlet and the inlet;
b) be capable of maintaining an optimum length of cable which minimizes slack cable, and prevents the tension limits from being exceeded;
c) be equipped with a device (e.g. limit switches), independent of its control system, to monitor maximum cable tension and maximum cable pay-out;
d) address the risk of submersion by prevention or by the equipment design;

e) be positioned to prevent interference with ship berthing and mooring systems, including the systems of ships that do not connect to shore power while berthed at the facility;

f) maintain the bending radius of cables above the minimum bending radius recommended by the manufacturer during deployment, in steady state operation and when stowed;

g) be capable of supporting the cables over the entire range of ship draughts and tidal ranges; and

h) be capable of retrieving and stowing the cables once operations are complete.

Where the cable management system employs cable reel(s), the HVSC system rated power shall be based on the operating condition with the maximum number of wraps of cable stowed on the reel that is encountered during normal operations. Where applicable the cable sizing shall include appropriate de-rating factors.

7.2.2 Monitoring of cable tension

The cable management system shall not permit the cable tension to exceed the permitted design value.

A means to detect maximum cable tension shall be provided, or where an active cable management system that limits cable tension is provided, means to detect the shortage of available cable length shall be provided with threshold limits provided in two stages:

Stage 1: alarm

Stage 2: activation of emergency shutdown facilities (see 4.9)

7.2.3 Monitoring of the cable length

The cable management system shall enable the cables to follow the ship movements over the entire range of ship draughts and tidal ranges, and the maximum range of allowable motion forward, aft or outward from the dock.

Where the cable length may vary, the remaining cable length shall be monitored and threshold limits are to be arranged in two stages:

Stage 1: alarm

Stage 2: activation of emergency shutdown facilities (see 4.9)

Consideration may be given to equivalent alternative measures (automatic break-away release, connectors with shear bolts and pilot lines, connection with ship/shore emergency shutdown system, etc.).

7.2.4 Connection conductor current unbalance protection

The ship and shore HV circuit-breakers shall be arranged to open all insulated poles in the event of a damaging current unbalance between multiple phase conductors (separate, parallel power cables and connectors).

The following protective devices, or equivalent protective measures shall be provided:

a) current balance between cables in parallel (46)

b) directional earth fault (67N)

Numbers in brackets refer to standard device designation numbers, as per IEEE Std C37.2.

Protective relays to satisfy this requirement shall be installed on board and/or ashore provided the connection is isolated in the event of unbalance detection.

7.2.5 Equipotential bond monitoring

The equipotential bond created by the ship to shore connection cables shall be constantly monitored. The scheme shall also be self-monitoring. Equipotential bond monitoring device shall be installed either on shore or on board where the cable management system is installed. Equipotential bond monitoring termination devices, where utilised, shall be installed on the other side.

7.2.6 Slip ring units

Slip ring units shall be tested according to IEC 62271-200 (excluding non-applicable tests) for:

a) HV test;
b) impulse voltage withstand test;
c) insulation resistance measurement;
d) heat run test with nominal current;
e) short circuit withstand test;
f) arc test, if accessible under energized conditions;
g) ingress protection test (IP rating).

Other testing standards may be considered.

7.3 Plugs and socket-outlets

7.3.1 General

Plugs and socket-outlets shall be in accordance to IEC 62613-1 and IEC 62613-2 and the following.

The plug and socket-outlet arrangement shall be fitted with a mechanical-securing device that locks the connection in the engaged position.

The pin assignment of power plug and socket-outlet shall be according to applicable ship annexes.

The plugs and socket-outlets shall be designed so that an incorrect connection cannot be made.

Socket-outlets and inlets shall be interlocked with the earth switch so that plugs or connectors cannot be inserted or withdrawn without the earthing switch in the closed position.

Handling of plug and socket outlets shall be possible only when the associated earthing switch is closed.

Plugs and socket-outlet connection shall be in areas where personnel will be protected in the event of an arc flash as a result of an internal fault in the plug and/or socket-outlet by barrier and access control measures. These measures shall be supported by access control procedures.

Plugs shall be designed so that no strain is transmitted to the terminals and contacts. The contacts shall only be subjected to the mechanical load which is necessary to provide satisfactory contact pressure, including when connecting and disconnecting.

Each plug shall be fitted with pilot contacts for continuity verification of the safety circuit. See applicable ship annexes for safety circuit descriptions. For single plug connections, a minimum of three pilots are required. If more than one cable is installed an interlocking shall be used so that no cable remains unused.

Contact sequence shall be in the following order:

a) connection:
   1) earth contact,
   2) power contacts, and
   3) pilot contacts.
b) disconnection:
   1) pilot contacts,
   2) power contacts, and
   3) earth contact.

Minimum electrical and mechanical ratings for plugs and socket-outlets are given in the annexes.

Support arrangements are required so that the weight of connected cable is not borne by any plug or socket termination or connection.

7.3.2 Pilot contacts

Pilot contact connections shall open before the necessary degree of protection is no longer achieved during the removal of an HV-plug or connector. Pilot contacts are part of the safety circuit.

7.3.3 Earth contact

The current-carrying capacity of the earth contact shall be at least equal to the rated current of the other main contacts.

7.3.4 Fibre optical plug/socket

The fibre optical connection shall be integrated on the ship plug. A fibre optical receptacle shall be mounted at the plug and at adjacent to the socket-outlet as well. Connection between these two parts shall be made with a separate cable with two plugs.

Fibre optical receptacle and plug shall be:

a) receptacle type box mounting according to MIL-DTL-38999K series III, class H, size 15, polarization N. Insert type 15-5 according to MIL-STD-1560A (5 contacts) F.O. terminals according MIL-PRF-29504/5C (socket type) plug;
b) type plug straight without spring finger according to MIL-DTL-38999K series III, class H, size 15, polarization N;
c) insert type 15-5 according to MIL-STD-1560A (5 contacts); and
d) F.O. terminals according to MIL-PRF-29504/4C (plug type).

7.4 Interlocking of earthing switches

The HV power contacts shall remain earthed until:

a) all connections are made and the pilot contact circuit (see 7.3.2) is closed;
b) no emergency stop switch is activated;
c) the communication link between shore and ship is operational;

d) ship or shore control, alarm or safety system self-monitoring properties detects that no failure would affect safety of connections; and

e) the permission from ship and shore is activated.

Interlocking shall be hardwired.

7.5 Ship to shore connection cable

Cables shall be at least of a flame-retardant type in accordance with the requirements given in IEC 60332-1-2. The outer sheath shall be oil-resistant and resistant to sea air, seawater, solar radiation (UV) and shall be non-hygroscopic. The temperature class shall be at least 90 °C, insulation, in accordance with Annex A. Correction factor for ambient air temperatures above 45 °C shall be taken into account (see IEC 60092-201:1994, Table 7). The maximum operating temperature shall not exceed 95 °C, taking into account any heating effects (e.g. as a result of cable coiling).

Due consideration should be given to requirements for smoke emission, acid gas evolution and halogen content for cables installed or stored in accommodation spaces and passenger areas.

Guidance for HV connection cable electrical ratings and specification is given in Annex A.

7.6 Independent control and monitoring cable

Control and monitoring cables shall be at least of a flame retardant type in accordance with the requirements of IEC 60332-1-2. The environmental requirements for the sheath shall be the same as described for the ship to shore connection cable in 7.5.

The control and monitoring cables, if integrated with the power cable assembly, shall be able to withstand internal and external short-circuits.

For details and further guidance, see Annex A.

7.7 Storage

Arrangements shall be provided for stowage when not in use, such that:

a) ship board equipment is stored in dry spaces;

b) shore based equipment shall comply with national standards;

c) removable equipment shall be stowed, stored and removed without damage;

d) equipment does not present a hazard during normal ship operation; and

e) during storage, the plugs, socket-outlets, inlets and connectors shall maintain their IP ratings.

NOTE Temporary coverings are not considered to satisfy this requirement.

7.8 Data communication

Where required by the specific ship type annex, the data-communication link between ship and shore arrangements shall be used for communicating the following information:

a) shore transformer high-temperature alarm (see 6.2.2);

b) HV shore supply circuit-breaker protection activation (see 6.3);

c) permission to operate HV circuit-breakers for HV ship to shore connection (see 6.4.and 8.5.5);

d) if ship or shore control, alarm or safety system self-monitoring properties detect an error that would affect safety of connection, see 6.4.3 and 4.9;

e) indication of emergency stop activation (see 4.9);

f) where provided, shore control functions in accordance with Clause 9;

g) indication of emergency disconnection of the shore supply (see 4.9); and

h) failure of the battery charging or activation of back-up system (see 6.3).

The communication protocol for communication link between ship and shore shall be defined.

Functionality, performance and design shall be based on IEC 60092-504.

8 Ship requirements

8.1 General

The instrumentation described shall be at all locations where load transfer and synchronization are performed.

On ships without HV power generation systems, additional efforts may be required so that ship personnel in charge is aware of HV safe operating practices and of the operation of the ship's HVSC system.

8.2 Ship electrical distribution system protection

8.2.1 Short-circuit protection

The maximum prospective short-circuit current for which HV-shore supply or ship-electrical-system / equipment is rated shall not be exceeded at any point in the installation by connecting to HV-shore supplies. This shall be addressed as part of the compatibility assessment (see 4.3 and applicable ship annexes).

Where connection to more than one HV-shore supply is possible, measures shall be taken to prevent HV-shore supplies from being connected in parallel if the maximum prospective short-circuit current is exceeded at any point in the installation.

8.2.2 Earth fault protection, monitoring and alarm

Earth fault protection, monitoring and alarm devices shall be of a type designed to operate effectively when connected to a HVSC supply with distribution system earthing in accordance with 6.2.3. Subclause 6.2.3 requires distribution system earthing that may differ from the ship's.

Where device settings are required to be changed when connected to a HVSC supply, means shall be provided for personnel to readily change settings. The protection settings in use shall be clearly indicated at the control station.

8.3 Shore connection switchboard

8.3.1 General

A shore connection switchboard shall be provided at a suitable location, as close as possible to the receiving point.

The distance between supply point and receiving point shall be as short as possible.

The shore connection switchboard shall be in accordance with IEC 62271-200, service continuity LSC1.

The switchboard shall include a circuit-breaker to protect the ship electrical equipment downstream. In no case shall the protection at the shore connection switchboard be omitted.

8.3.2 Circuit-breaker, disconnector and earthing switch

In order to have the installation isolated before it is earthed, the circuit-breaker, disconnector and earthing switch shall be interlocked in accordance with the requirements of IEC 62271-200.

The rated making capacity of the circuit breaker and the earthing switch shall not be less than the prospective peak value of the short-circuit current (I_P) calculated in accordance with IEC 61363-1.

The rated short-circuit breaking capacity of the circuit-breaker shall not be less than the maximum prospective symmetrical short-circuit current ($I_{AC(0.5T)}$) calculated in accordance with IEC 61363-1.

An automatic operated circuit-breaker shall be provided.

8.3.3 Instrumentation and protection

The shore connection switchboard shall be equipped with:

a) voltmeter: all three phases;
b) short-circuit devices: tripping and alarm;
c) overcurrent devices: tripping and alarm;
d) earth-fault indicator: alarm; and
e) unbalanced protection for systems with more than one inlet.

The protection systems shall be provided with battery back-up adequate for at least 30 min, see IEC 60092-504:2001, 9.6.2.5. Upon failure of the battery charging or activation of back-up system, an alarm shall be activated to warn relevant duty personnel.

Alarms and indications shall be provided at an appropriate location for safety and effective operation.

8.4 On board transformer

Transformers, if any, shall be of the separate winding type for primary and secondary side. The secondary side shall be star configuration.

If the transformer supplies LV-systems, a shield winding shall be provided between HV and LV winding.

The neutral point of the transformer shall be connected to the main switchboard according to the earthing method used for the main distribution system.

Galvanic separation between the shore and on board systems shall be provided.

An on board transformer may not be required if the ship’s network is designed for the shore supply voltage and the neutral point treatment is in line with the ship systems and the galvanic separation is done on shore.

When necessary, means shall be provided to reduce transformer current in-rush and/or inhibiting the starting of large motors, or the connection of other large loads, when a HV supply system is connected (see 4.8 and 5.2).

8.5 On board receiving switchboard connection point

8.5.1 General

A panel shall be provided as an on board receiving switchboard.

Where parallel connection of the HV-shore supply and ship sources of electrical power for transferring of load is arranged, synchronising devices shall be provided.

NOTE An on-board receiving switchboard connection point is normally a part of the main switchboard (see Figure 1).

8.5.2 Circuit-breaker and earthing switch

The rated making capacity of the circuit breaker and the earthing switch shall not be less than the prospective peak value of the short-circuit current (I_P) calculated in accordance with IEC 61363-1.

The rated short-circuit breaking capacity of the circuit-breaker shall not be less than the maximum prospective symmetrical short-circuit current ($I_{AC(0.5T)}$) calculated in accordance with IEC 61363-1.

An automatic circuit-breaker shall be provided.

An earthing switch shall be installed if the main switchboard rated voltage exceeds 1 000 V a.c.

8.5.3 Instrumentation

If load transfer via parallel connection is chosen, the instrumentation shall be:

a) two voltmeters;
b) two frequency meters;
c) one ammeter with an ammeter switch to enable the current in each phase to be read, or an ammeter in each phase;
d) phase sequence indicator, and
e) one synchronising device.

One voltmeter and one frequency meter shall be connected to the switchboard busbars; the other voltmeter and frequency meter shall enable the voltage and frequency of the shore connection to be measured.

If load transfer via blackout is chosen, the instrumentation shall be at least:

f) one voltmeter;
g) one frequency meter;
h) one ammeter with an ammeter switch to enable the current in each phase to be read, or an ammeter in each phase; and
i) phase sequence indicator.

The voltmeter and the frequency meter shall enable the voltage and frequency of the shore connection to be measured (see 9.2).

8.5.4 Protection

Tripping and alarm criteria for the circuit-breaker shall be:

a) short-circuit: tripping with alarm,

b) overcurrent in two steps:
   1) alarm, and
   2) tripping with alarm,
c) earth fault:
   1) alarm,
   2) tripping if required by the type of isolation system used,
d) over-/under-voltage in two steps:
   1) alarm, and
   2) tripping with alarm;
e) over-/under-frequency in two steps:
   1) alarm, and
   2) tripping with alarm;
f) reverse power: tripping with alarm*, and
g) phase sequence protection with alarm and interlock.

To satisfy this requirement, at least the following protective devices, or equivalent protective measures, shall be provided:

h) synchrocheck (25)*
i) undervoltage (27)
j) reverse power (32)*
k) phase sequence voltage (47)
l) overload (49)
m) instantaneous overcurrent (50)
n) overcurrent (51)
o) earth fault (51G) or (59N)
p) overvoltage (59), and
q) frequency (81) (under and over).

NOTE The phase sequence protection protects the ship's system against wrong phase connection.

Numbers in brackets refer to standard device designation numbers as per IEEE Std C37.2.

Tripping of unessential consumers and restoration of ship power should be considered where these measures could prevent complete power loss.

Protection functions marked with an asterisk (*), may be omitted when load transfer via blackout is chosen.

8.5.5 Operation of the circuit-breaker

Arrangements shall be provided so that the circuit-breakers cannot be closed when any of the following conditions exist:

a) one of the earthing switches is closed (shore-side/ship-side);
b) the pilot contact circuit, see 7.3.2, is not established;
c) emergency-stop facilities are activated;
d) ship or shore control, alarm or safety system self-monitoring properties detect an error that would affect the safety of the connection;

e) the data-communication link between shore and ship is not operational, where applicable;

f) the HV supply is not present;

g) equipotential bonding is not established (via equipotential bond monitoring relays – see 4.2.2); and

h) earth fault on ship distribution system is detected.

It is recommended to have one PIC on the ship and one facility PIC. PICs should have high-voltage training and HVSC system specific training.

An independent means of voice communication should be provided between the ship and facility PIC (e.g. two way radios).

For ships on a regular service trade, PIC may be responsible for both ship and shore HVSC operations.

Where HVSC operations are conducted concurrently with cargo transfer operations the PIC responsible for cargo operations should not also be responsible for HVSC operations**.**

If synchronization is established from shore, interlocking may be different.

8.6 Ship power restoration

When the ship main source of electrical power is shut down and failure of the connected HVSC supply occurs, shore connection circuit-breakers shall automatically open followed by:

a) starting of the emergency source of electrical power to supply emergency services equivalent to SOLAS CH II-1/D, Reg. 42 for passenger ships or 43 for cargo ships; and

b) automatic connection of the transitional source of electrical power to emergency services, equivalent to SOLAS CH II-1/D, Reg. 42 for passenger ships or 43 for cargo ships; and

c) starting and connecting to the main switchboard of the main source of electrical power and sequential restarting of essential services, in the shortest time practical. This shall be automatic in the event of emergency shut-down activation.

Failures include loss of HV power or disconnection (including activation of emergency shutdown or electrical system protective device activation).

It may be necessary to consider necessary relaxations of the requirements for automatic starting and connection of ship sources of electrical power for existing ships constructed prior to the introduction of the relevant part of SOLAS 2009 CH II-1/D, Regs. 42 or 43. In such cases, alternative measures for the restoration of ship power acceptable to the relevant authorities should be provided.

An alarm shall be provided to advise relevant duty personnel. The alarm shall indicate the failure that caused the activation.

9 HVSC system control and monitoring

9.1 General requirements

Ship equipment shall be protected and controlled by the ship’s own protection and control systems.

If the shore supply fails for any reason, supply by the ship’s own generators is permitted, after disconnecting shore supply.

Load transfer shall be provided via blackout or automatic synchronization.

9.2 Load transfer via blackout

Interlocking means shall be provided so that the shore supply can only be connected to a dead switchboard. The interlocking means shall be arranged to prevent connection to a live switchboard when operating normally or in the event of a fault, e.g. a fault in the blackout monitoring circuit.

The simultaneous connection of a HV-shore supply and a ship source of electrical power to the same dead section of the electrical system shall be prevented (see 8.5.3 and 8.5.4).

9.3 Load transfer via automatic synchronization

9.3.1 General

HV-shore supply and ship source(s) of electrical power in temporarily parallel shall be in accordance with the following:

a) load shall be automatically synchronized and transferred between the HV shore supply and ship source(s) of electrical power following their connection in parallel;
b) the load transfer shall be completed in the shortest time practical without causing machinery or equipment failure or operation of protective devices and this time shall be used as the basis for defining the transfer time limit; and
c) any system or function used for paralleling or controlling the shore connection, shall have no influence on the ship's electrical system, when there is no shore connection.

The transfer time limit should be defined and made available to responsible personnel. Where the transfer time limit is adjustable to match the ability of an external source of electrical power to accept and shed load, the procedure for setting this limit should be addressed in operating instructions.

Where operation of only designated or a restricted number of ship source(s) of electrical power is required to permit the safe transfer of load between a HV shore supply and ship source(s) of electrical power, the arrangements shall fulfil this requirement before and during parallel connection.

The instrumentation and protection requirements contained in 8.5.3 and 8.5.4 shall be met for parallel transfer.

9.3.2 Protection requirements

If the defined transfer time limit (see 9.3.1) for transferring of load between HV-shore supply and ship source(s) of electrical power is exceeded, one of the sources shall be disconnected automatically and an alarm shall be provided to advise relevant duty personnel. Special care shall be taken not to exceed the maximum permissible load steps of the generator sets (see IEC 60092-301).

Where load reductions are required to transfer load, this shall not result in loss of essential services for ship's safety.

10 Verification and testing

10.1 General

All HV systems components shall have passed type tests and routine tests according to relevant standards.

The HV system, including control equipment, shall be tested according to a prescriptive test program.

Tests shall be performed to demonstrate that the electrical system, control, monitoring and alarm systems have been correctly installed and are in good working order before being put into service. Tests shall be realistic and simulations avoided as far as is practicable.

If the equipment has not been used for a period of 30 months, the initial tests shall be repeated.

NOTE Such tests are intended to indicate the general condition of the installation. However, satisfactory test results do not in themselves necessarily ensure that the installation is satisfactory in all respects.

10.2 Initial tests of shore side installation

10.2.1 General

These tests shall verify that the shore side installation complies with this standard to achieve a certificate of conformity.

Tests shall be performed after completion of the installation.

10.2.2 Tests

The following tests shall be performed:

a) visual inspection;
b) power frequency test for HV switchgear assemblies and voltage test for cables (see IEC 62271-200 and IEC 60502-2);
c) insulation resistance measurement;
d) measurement of the earthing resistance;
e) function test including correct settings of the protection devices;
f) function test of the interlocking system;
g) function test of the control equipment;
h) phase-sequence test (see Figure 2);
i) function test of the cable management system where applicable; and
j) additional tests if requested by national regulations.

10.3 Initial tests of ship side installation

10.3.1 General

These tests shall verify that the ship side installation complies with this standard. The target is to achieve a test certificate.

Tests shall be performed after completion of the installation.

These tests shall be conducted as witness tests together with the appropriate authorities.

10.3.2 Tests

The following tests shall be performed:

a) visual inspection;
b) power frequency test for HV switchgear assemblies and voltage test for cables (see IEC 62271-200 and IEC 60502-2);

c) insulation resistance measurement;
d) measurement of the earthing resistance;
e) function test including correct settings of the protection devices;
f) function test of the interlocking system;
g) function test of the control equipment;
h) phase-sequence test (see Figure 2);
i) function test of the cable management system, where applicable; and
j) integration tests to demonstrate that the shipside installations like power management system, integrated alarm, monitoring and control system work properly together with the new installation.

10.4 Tests at the first call at a shore supply point

10.4.1 General

A compatibility assessment study according to 4.3 shall be performed.

Upon completion of the tests in 10.2.2 and 10.3.2, the tests of 10.4.2 shall be conducted.

10.4.2 Tests

The following tests shall be performed as an integration test of the complete HVSC system:

a) visual inspection;
b) power frequency test for HV switchgear assemblies and voltage test for cables, see IEC 62271-200 and IEC 60502-2;
c) insulation resistance measurement;
d) measurement of the earthing resistance;
e) function test of the protection devices;
f) function test of the interlocking system;
g) function test of the control equipment;
h) equipotential bond monitoring test;
i) phase-sequence test, see Figure 2;
j) function test of the cable management system; and
k) integration tests to demonstrate that the shore and shipside installations work properly together.

The power frequency test for HV switchgear assemblies and voltage test for cables and insulation resistance measurement and measurement of the earthing resistance shall be performed only if one of the installations, shore side or ship side, has been out of service or not in use for more than 30 months.

11 Periodic tests and maintenance

11.1 General

A record of annual maintenance, repair, equipment modifications and the test results shall be available for the shore and ship side HVSC system.

11.2 Tests at repeated calls of a shore supply point

11.2.1 General

If the time between port calls does not exceed 12 months and if no modifications have been performed either on the shore side or ship side, or both, the verification in 11.2.2 shall be conducted.

If this time is exceeded, the tests according to 10.4.2 shall be performed.

NOTE The time between port calls means same ship at the same shore supply point.

11.2.2 Verification

The following shall be performed or provided:

a) visual inspection;

b) confirmation that no earth fault is present;

c) statement of voltage and frequency; and

d) an authorized switching and connection procedure or equivalent.

Procedures should include an approved “Lock-out, Tag-out” system that is jointly controlled by the ship and shore PIC.

12 Documentation

12.1 General

For the HVSC system and each control apparatus, the manufacturer shall deliver documentation concerning principles of operation, technical specifications, mounting instructions, required start up or commissioning procedures, fault-finding procedures, maintenance and repair, as well as lists of necessary test facilities and replaceable parts.

12.2 System description

A complete system description, including circuit diagrams, specifying set points and operation instructions, shall be prepared by parties responsible for shore and ship HVSC systems.

The parties responsible for shore and ship HVSC systems, shall provide a testing and verification program for the whole installation that will demonstrate compliance with the specification.

Annex A
(informative)

Ship to shore connection cable

A.1 Rated voltage

The standard rated voltages U_0/U (U_m) of the cables considered are as follows:

$$U_0/U\ (U_m) = 6/10\ (12)\ \text{kV r.m.s}$$

The standard rated voltages U_0/U (U_m) of the neutral cables considered are as follows:

$$U_0/U\ (U_m) = 1{,}8/3\ (3{,}6)\ \text{kV r.m.s}$$

Where:

U_0 is the rated voltage between phase conductor and earth or metallic screen for which the cable is designed;

U is the rated frequency voltage between phase conductors for which the cable is designed;

U_m is the maximum value of the highest system voltage which may be sustained under normal operating conditions at any time and at any point in the system. It excludes transient voltage conditions and rapid disconnection of loads.

A.2 General design

A.2.1 General

The cables should be constituted as follows: power cores with copper conductors, conductor screen, insulation, insulation screen. The power cores should be laid up with earth cores with copper conductor and semi conducting layer. Pilot and fibre-optic elements, if specified in the applicable ship annexes, should be laid up in the interstices of the power cores.

NOTE IEC 60092-350:2008, 4.6, provides further information regarding the use of inner coverings. IEC 60092-350:2008, 4.7 provides further information regarding the use of inner sheathing.

The neutral cables are constituted as follows: core with copper conductor, insulation and outer sheath.

Where an alternative to the recommendations of Annex A is proposed, it is possible that the installation will not be suitable for connection to a compliant shore supply/ship. Application of an alternative should be documented and made available to personnel in charge of the compatibility assessment.

A.2.2 Conductors

All conductors should be flexible (class 5 of IEC 60228 or Table 11 of IEEE Std 1580™-2001). The conductors should be plain or metal-coated copper conductors.

A.2.3 Insulation of power cores and neutral core

The insulating compounds should be extruded cross-linked solid dielectric designated as EPR, HF EPR, HEPR or HF HEPR in IEC 60092-351 or IEEE Std 1580.

Electrical and non-electrical characteristics of the insulation system should be as specified in IEC 60092-351 or IEEE Std 1580 for the type of insulating compound used.

Insulation thickness should be in accordance with IEC 60092-354, or IEEE Std 1580 for the standard rated voltages.

Insulation thickness for the neutral core should be in accordance with IEC 60092-353 for the standard rated voltages.

A.2.4 Screening

Screening of individual power cores should consist of a conductor screen and an insulation screen.

The conductor screen should be non-metallic and should consist of an extruded semi-conducting compound or a combination of an extruded semi-conducting compound and a semi-conducting tape. The conductor screen should be firmly bonded to the insulation.

The insulation screen should consist of a non-metallic semi-conducting layer and, if necessary to fulfil the cable test requirements within this annex, in combination with a metallic layer.

The metallic layer, if any, should be applied over the individual cores and should comply with the requirements of Clause 12 of IEC 60092-354:2003, or IEEE Std 1580.

National authorities having jurisdiction may require a metallic component in the insulation screen.

A.2.5 Earth conductors

A.2.5.1 General

Earth conductors should be flexible copper conductors according to class 5 of IEC 60228 or Table 11 of IEEE Std 1580 forming together at least 50 % of the power core cross section.

A.2.5.2 Conductor screen of earth conductors (optional)

The conductor screen, when used, should be non-metallic and should consist of an extruded semi-conducting compound, according to IEC 60092-354 or IEEE Std 1580.

A.2.6 Pilot element with rated voltage U_0/U (U_m) = 150/250 (300) V

A.2.6.1 Conductors

Pilot conductors should be flexible, plain or metal-coated copper conductors according to IEC 60228 class 5 or Table 11 of IEEE 1580-2001; with a minimum cross section area of 1,5 mm^2.

A.2.6.2 Insulation

The insulation of pilot conductors should be extruded cross-linked solid dielectric of one of the types indicated in A.2.3.

Electrical and non-electrical characteristics of the insulation system should be as specified in IEC 60092-351 or IEEE 1580 for the relevant type of insulating compound used.

Thickness of insulation should be in accordance with IEC 60092-376 or IEEE 1580 for the relevant insulation type.

Pilot cores should be laid up as required by the specific ship type annex. A wrapped covering with tapes or an extruded covering is permitted over the laid up cores. Screening is optional.

A.2.7 Optical fibres

Optical fibres should consist of at least six 62,5/125 gradient fibres. Optical fibres should be according to IEC 60793-2-10 product specification A1b.

There should be no breakage of the optical fibres after conclusion of the mechanical bending test (see A.3) of the cable.

A.2.8 Cabling

The three power cores, the earth core(s), the pilot element and the optical fibres should be laid up.

A.2.9 Separator tape

If separator tape is used it should be wrapped around the assembled cores and should consist of a suitable, non-hygroscopic material.

A.2.10 Outer sheath

The outer sheathing material should have a high level of mechanical properties per IEC 60092-359 or IEEE 1580. Thermoplastic polyurethane (TPU) in accordance with EN 50363-10-2 is also an acceptable material. For all sheath materials, the minimum tensile strength should be 15 N/mm^2. Minimum elongation at break should be 300 %. The minimum thickness at any point of the extruded outer sheath should be 6 mm for high voltage cables and 2,5 mm for separate neutral cable.

A.2.11 Markings

A.2.11.1 Indication of origin

Cables sheaths should be permanently marked repeatedly throughout their length with an indication of origin with the manufacturer's name and/or registered trademark, rated voltage (U_0/U), construction (number of cores and cross sectional area of power conductors, earth conductors, pilots and fibre type of fibre optics) and the relevant standard.

EXAMPLE Manufacturer's name or trademark" 3x185/95 + 3x1.5 + 6x 62.5/125 6/10 kV IEC/ISO/IEEE 80005-1.

A.2.11.2 Continuity

Continuity should be in accordance with IEC 60092-354, (IEC 60092-353, for neutral cable) or IEEE Std 1580.

A.2.11.3 Durability

Durability should be in accordance with IEC 60092-354, (IEC 60092-353, for neutral cable) or IEEE Std 1580.

A.2.11.4 Legibility

Legibility should be in accordance with IEC 60092-354, (IEC 60092-353, for neutral cable) or IEEE Std 1580.

A.3 Tests on complete cables

For these tests, reference is made to the relevant clauses of IEC 60092-350 or IEEE Std 1580.

For test methods for insulation and sheaths reference should be made to the appropriate part of IEC 60811.

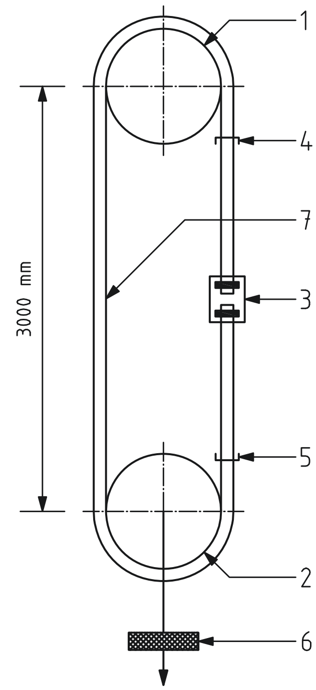
Routine tests, special tests and type tests should be conducted in accordance with IEC 60092-354 or IEEE Std 1580 with the following additions or modifications:

a) Bending test (see Figure A.1):
   1) The test should consist of 5 000 cycles of operation.
   2) After 2 500 cycles, the cable should be rotated 180 degrees.

b) The diameter of the bending reels should be 10 $D \pm 5$ %;

   where:
   1) D is the actual external diameter of the cable sample, in millimetres.
   2) Tensile force should be 15 N/mm^2 of power cores.
   3) Maximum % of broken wires for each conductor and metallic screen, if required, should not exceed 20 %.
   4) Maximum % of broken optical fibres to be 0 %.

On completion of this test, the sample should be subjected to a partial discharge measurement. The magnitude of discharges at 1,73 U_0 should not be higher than 10 pC.



KEY

1. UPPER BENDING REEL
2. LOWER BENDING REEL
3. CLAMP
4. UPPER POINT OF RETURN
5. LOWER POINT OF RETURN
6. TENSIONING DEVICE
7. SPECIMEN MOVEMENT

Figure A.1 – Bending test arrangement

c) Sunlight-resistance test on outer sheath (duration of test 720 h):

1) The test should be performed in accordance with ISO 4892-2:2006, Table 3, test method A, cycle no. 2.

2) Maximum permissible change: tensile strength ± 40 %, and elongation at break ± 40 %.

d) Abrasion test on outer sheath:

1) The test should be performed in accordance with ISO 4649:2010, test method A.

2) Relative volume loss, ΔV_{rel}: max 300 mm^3.

e) Flame propagation test:

The test should be performed in accordance with IEC 60332-1-2.

f) Behaviour of completed cable at low temperatures:

The test should be performed in accordance with IEC 60092-350:2008, 8.9.1, 8.9.2, and Annex E, or IEEE Std 1580. The test should be conducted at -40 °C ± 2 °C.

g) Resistance between earth conductor and semi-conductive layer:

The resistance between earth conductor and semi-conductive layer should be maximum 500 ohm before and after bending test.

Annex B
(normative)

Additional requirements for Roll-on Roll-off (Ro-Ro) cargo ships and Ro-Ro passenger ships

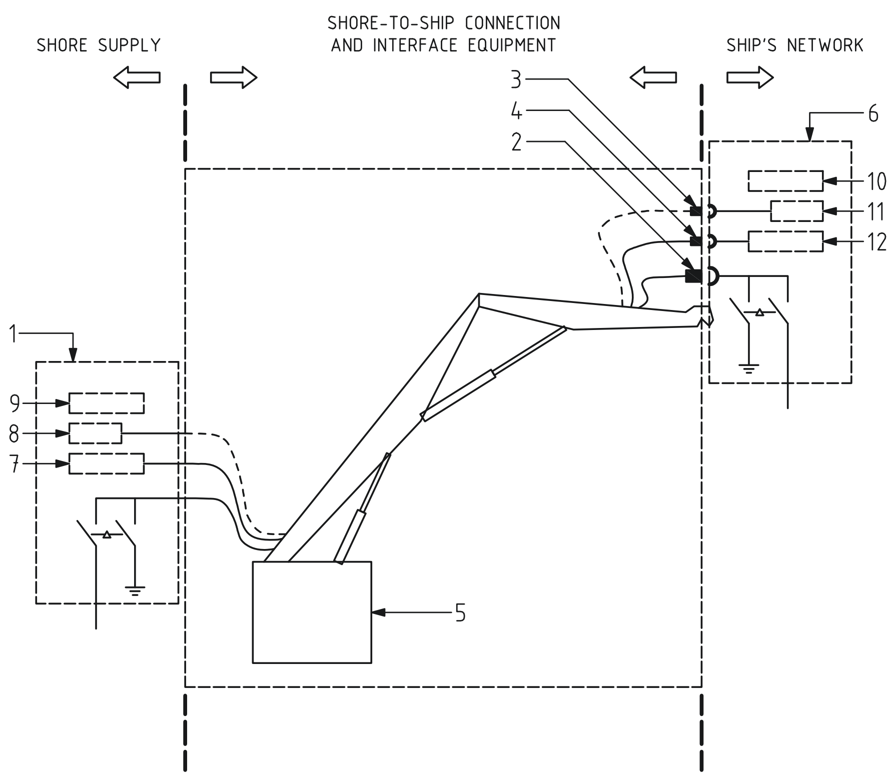
B.1 Scope

This annex describes the additional requirements on HVSC systems of Ro-Ro cargo ships and Ro-Ro passenger ships, excluding pure car carriers.

The numbering in this annex follows that of the main body of the text. Hence, the numbering is not necessarily continuous. Any content which is not explicitly mentioned, applies, without modification. For example B.4.1 refers to 4.1 in the main body.

B.4.1 System description

The general system layout is shown in Figure B.1.



KEY

1. HV-SHORE SUPPLY SYSTEM WITH SOCKET-OUTLETS
2. HV-PLUG
3. FIBRE OPTIC COMMUNICATION FOR CONTROL AND MONITORING (POSSIBLY INTEGRATED IN POWER CABLE)
4. PILOT WIRES (INTEGRATED IN PLUG AND SOCKET)
5. CABLE HANDLING SYSTEM, HERE SHOWN AS ON SHORE CRANE
6. SHORE CONNECTION SWITCHBOARD
7. INTERLOCKS WITH PILOT WIRE SHORE SIDE
8. CONTROL SHORE SIDE
9. PROTECTION RELAYING SHORE SIDE
10. PROTECTION RELATING SHIP SIDE
11. CONTROL SHIP SIDE
12. INTERLOCKS WITH PILOT WIRE SHIP SIDE

Figure B.1 – Example for general system layout

B.4.6.4 Electrical equipment in areas where flammable gas or vapour and/or combustible dust may be present

HVSC systems shall not be installed in areas which may become hazardous areas, such as car decks, upon failure of required air changes per hour during loading and offloading cargo or during normal operation.

B.5.1 Voltages and frequencies

The nominal voltage shall be 11 kV a.c.

Nominal voltage of 6,6 kV a.c. may be used in regional waterborne transportation services.

B.6.2.3 Neutral earthing resistor

Where a shore side transformer is used, the star point shall be earthed, through a neutral earthing resistor of 335 ohm continuous rated.

Nominal voltage of 6,6 kV will require a 200 ohm continuous rated resistor.

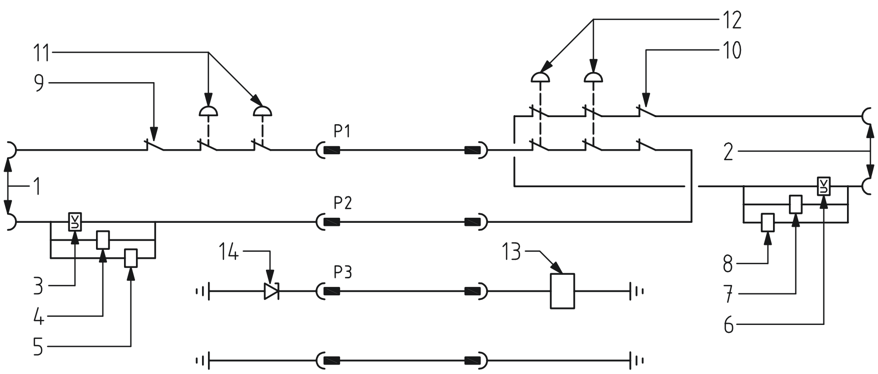
B.7 Ship to shore connection and interface equipment

One cable shall be used for HVSC system up to a power demand of 6,5 MVA.

B.7.2.1 General

The cable management system shall be fitted at the shore side facility for Ro-Ro passenger ships and Ro-Ro cargo ships (see Figure B.1).

Figure B.2 shows an example of safety circuits.



KEY

1. CONTROL POWER PILOT LOOP SHORE
2. CONTROL POWER PILOT LOOP SHIP (VT FED FROM SHORE POWER SOURCE)
3. CIRCUIT BREAKER UNDERVOLTAGE COIL (SHORE)
4. SAFETY CIRCUIT COIL ON SHORE
5. EARTHING SWITCH PERMISSION SHORE SIDE
6. CIRCUIT BREAKER UNDERVOLTAGE COIL (SHIP)
7. SAFETY CIRCUIT COIL ON SHIP
8. EARTHING SWITCH PERMISSION SHIP SIDE
9. CONTROL ES SHORE (EMERGENCY SHUTDOWN)
10. CONTROL ES SHIP (EMERGENCY SHUTDOWN)
11. MANUAL ES SHORE (TWO SHOWN)
12. MANUAL ES SHIP (TWO SHOWN)
13. EQUIPOTENTIAL BOND MONITORING DEVICE
14. EQUIPOTENTIAL BOND MONITORING TERMINATION DEVICE

Figure B.2 – Example of a safety circuit

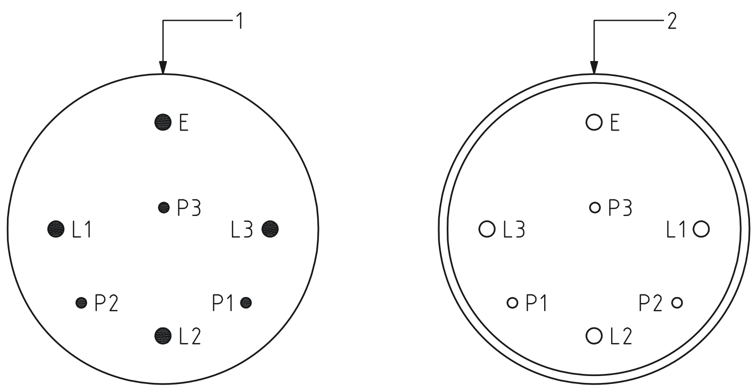
B.7.2.5 Equipotential bond monitoring

Equipotential bond termination device shall meet the following requirements:

a) Characteristic: Zener Diode
b) Zener voltage: 5,6 V ± 0,03 Vdc @ 100 mA
c) Forward Voltage: 0,5 ± 0,1 Vdc @ 100 mA
d) Maximum impedance: 20 mOhm @ 100 mA
e) Operating Temperature: -40 °C to 60 °C
f) Current range: 2 mA to 25 A
g) Frequency range: 0 kHz to 20 kHz, -3 db

B.7.3.1 General

General arrangement of plug and socket-outlet shall be in accordance to IEC 62613-2:2011, Annex FF and Figure B.3 below.



KEY

1. POWER PLUG FACE (SHIP SIDE)
E. EARTH
L1. PHASE A – PHASE R
L2. PHASE B – PHASE S
L3. PHASE C – PHASE T
2. POWER SOCKET FACE (SHORE SIDE)
P1. PILOT LINE 1
P2. PILOT LINE 2
P3. PILOT LINE 3

Figure B.3 – Power plug and socket pin assignment

The maximum short-circuit current is 16 kA / 1 s and a maximum peak short-circuit current of 40 kA, see IEC 62613-1.

Each plug and socket outlet shall be fitted with three pilot contacts.

Design and dimensions of a power plug, see IEC 62613-1 and IEC 62613-2.

B.7.3.2 Pilot contacts

Pilot contacts are part of the safety circuit (see 4.9 and Figure B.2).

Annex C
(normative)

Additional requirements for cruise ships

C.1 Scope

This annex describes the additional requirements for high-voltage shore connection systems of cruise ships.

The numbering in this annex follows that of the main body of the text. Hence, the numbering is not necessarily continuous. Any content which is not explicitly mentioned, applies, without modification. For example, C.4.1 refers to 4.1 in the main body.

C.4.1 System description

The general system layout is shown in Figure C.1.

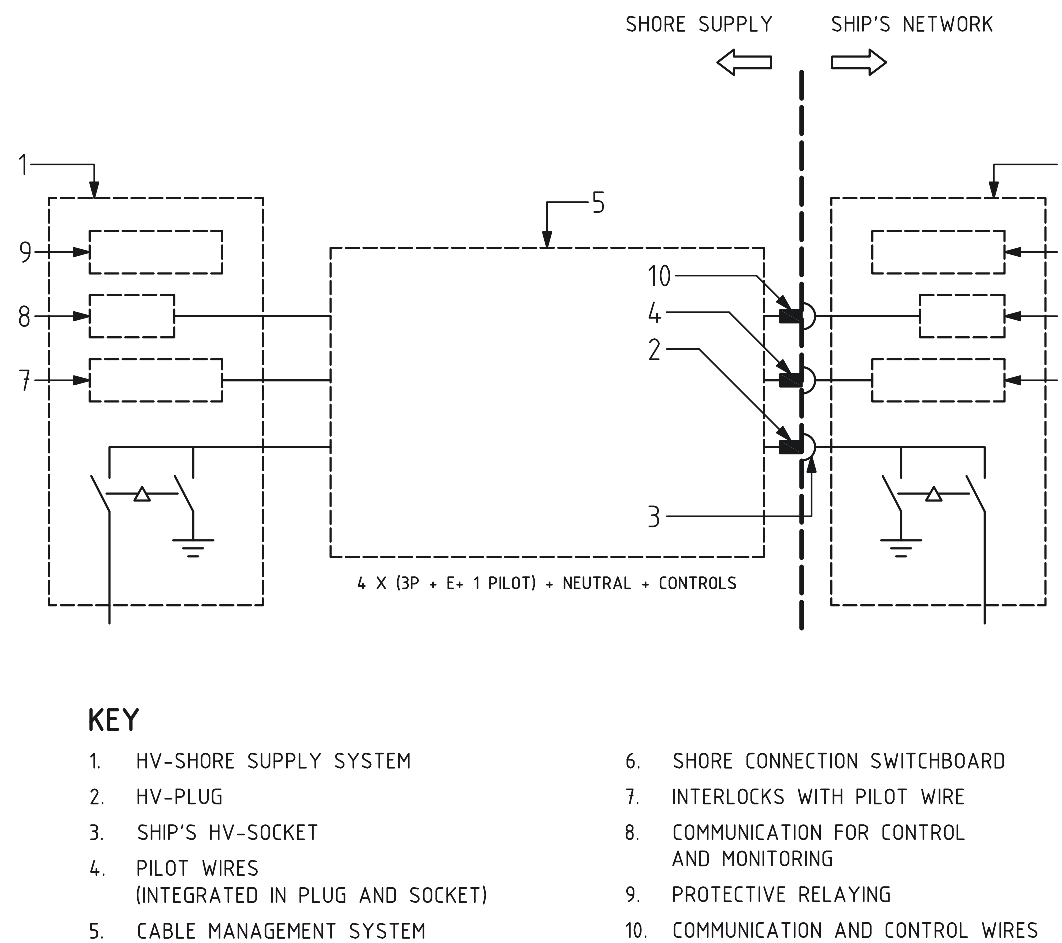
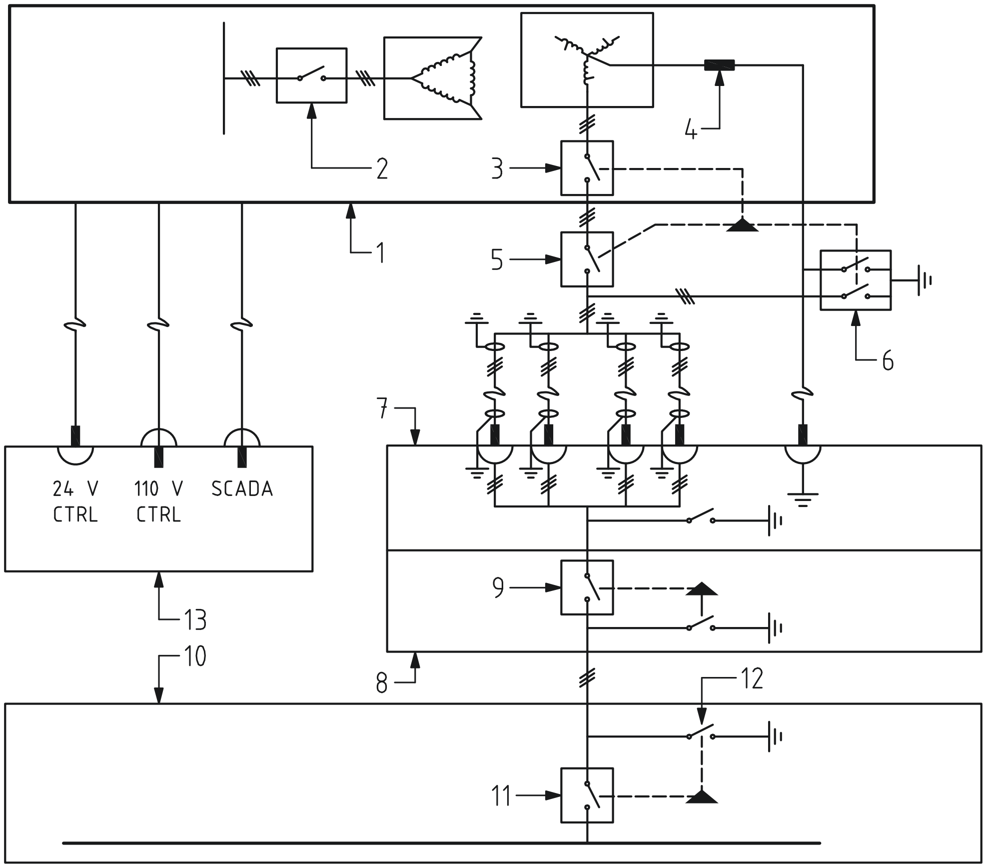


Figure C.1 – General system layout

To supplement general system layout provided in Figure C.1, Figure C.2 is provided to show a detailed representation of an example of a cruise ship HVSC system single line diagram.



KEY

1. SHORESIDE SUBSTATION
2. TRANSFORMER PRIMARY CIRCUIT BREAKER
3. TRANSFORMER SECONDARY CIRCUIT BREAKER
4. NEUTRAL GROUNDING RESISTOR
5. DOCK DISCONNECT SWITCH
6. DOCK GROUND SWITCH
7. SHIP'S SHORE CONNECTION CUBICLE
8. SHIP'S BREAKER CUBICLE
9. SHORE CONNECTION CIRCUIT BREAKER
10. SHIP'S RECEIVING SWITCHBOARD
11. RECEIVING CIRCUIT BREAKER
12. GROUND SWITCH
13. SHIP'S CONTROL CUBICLE

NOTE

a. DUAL SECONDARY 11 kV AND 6.6 kV TRANSFORMER MAY BE USED

b. 24 V CTRL IS 24 VOLTS DC, 110 V CTRL IS 110 VOLTS DC, AND SCADA IS SUPERVISORY CONTROL AND DATA ACQUISITION

Figure C.2 – Cruise ship HVSC system single line diagram

Figure C.3 shows an example of safety and control circuits.

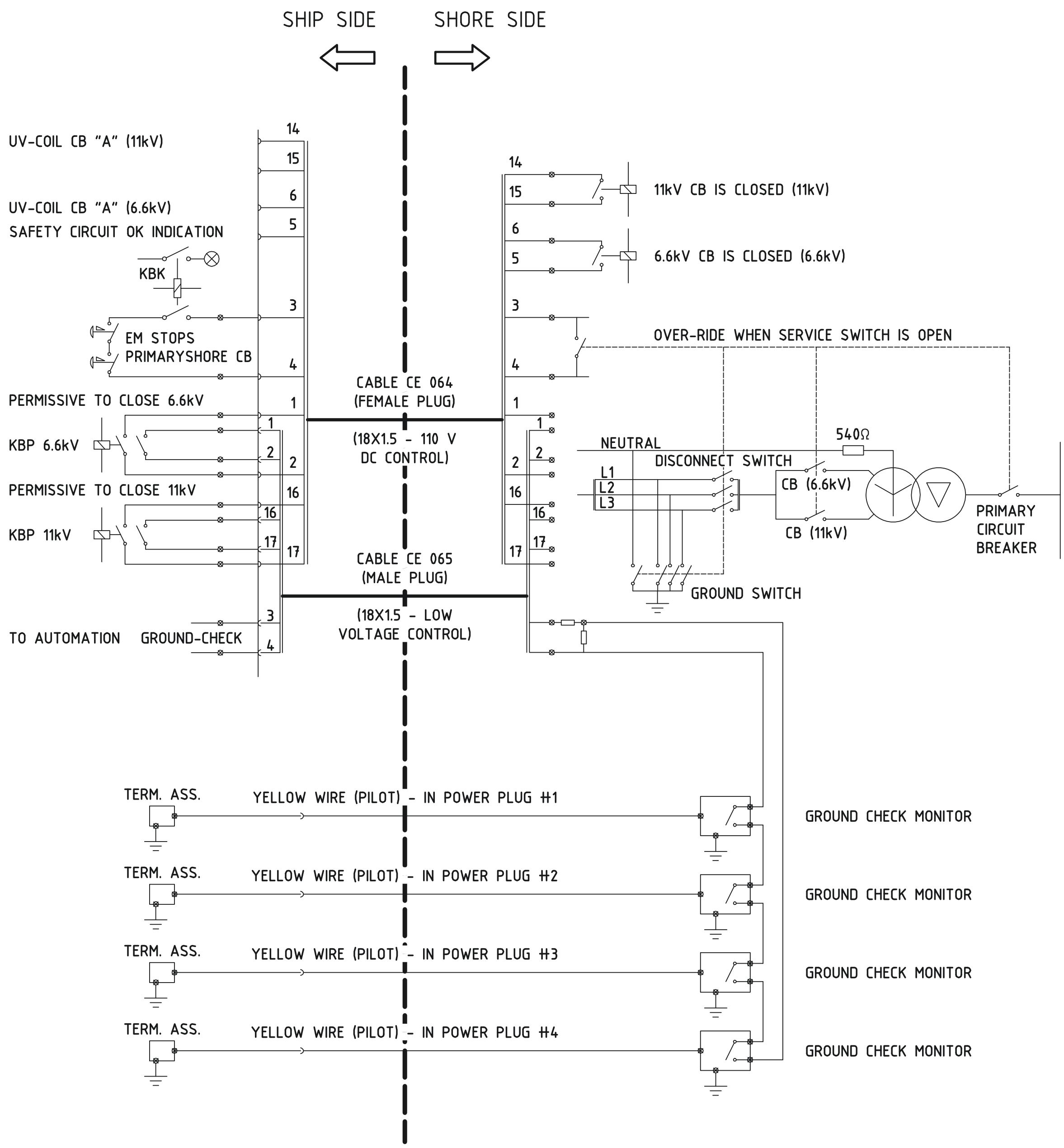


Figure C.3 – Example of safety and control circuit

C.4.3 Compatibility assessment before connection

Assessment that the ship provides effective earthing.

C.4.4 HVSC system design and operation

Periodic verification of the earthing system is required.

Personnel conducting verification and maintenance should be suitably qualified and experienced.

C.4.7 Electrical requirements

The HVSC system shall be rated for at least 16 MVA (but 20 MVA is recommended where practical) at nominal ship system voltages of 11 kV a.c. and/or 6,6 kV a.c.

Consideration may be given to a HVSC system with a lower rating where only ships with lower power demands will be required to connect.

Measures shall be taken so that ships with power demands higher than the HVSC system rating will reduce their power demand prior to connecting.

Analysis of the existing (2009) cruise ship fleet suggests that a minimum shore supply rating of 20 MVA at the nominal system voltages described will be required for ports visited regularly by a variety of cruise ships in the near to medium term. Analysis shows that the majority of cruise ship electrical systems have a nominal operating frequency of 60 Hz.

Designers may give consideration to rating connection equipment for 6,6 kV a.c. HVSC systems for 11 kV a.c. characteristics where inadvertent connection of the ship socket-outlet and connection switchboard to an 11 kV a.c. shore supply is considered to be reasonably foreseeable.

Some ships may require on board isolation transformer.

The prospective short-circuit contribution level from the HV shore distribution system shall be limited by the shore-sided system to 25 kA rms.

The prospective short-circuit contribution level from the on board running induction motors and the generators in operation shall be limited to a short circuit current of 25 kA rms for 1 s.

C.6 Shore side installation

Neutral continuity check with trip function shall be provided.

C.6.2.3 Neutral earthing resistor

The shore side transformer star point shall be earthed, through a neutral earthing resistor of 540 ohms continuous rated, and bonded only to the shipside (see Figure C.2).

NOTE Present (2009) typical cruise ship HV distribution systems are earthed via high resistance earthing resistors that are installed on each of the ship's generators star point to earth connection. By using this earthing system on each of the generators, the earth fault current can be limited according to the size of the resistor, while on the shore HV earth fault current can range from a minimum value that exceeds the rating of the ship HV installation.

C.7.3.1 General

General arrangement of connector located ashore shall be according to Figure C.4.

Each 3-phase HV plug or socket-outlet shall have:

a) 3 phase current carrying contacts, (L1, L2, L3);
b) one earth contact (see Figure C.4 below); and
c) one pilot contact for ground-check monitoring.

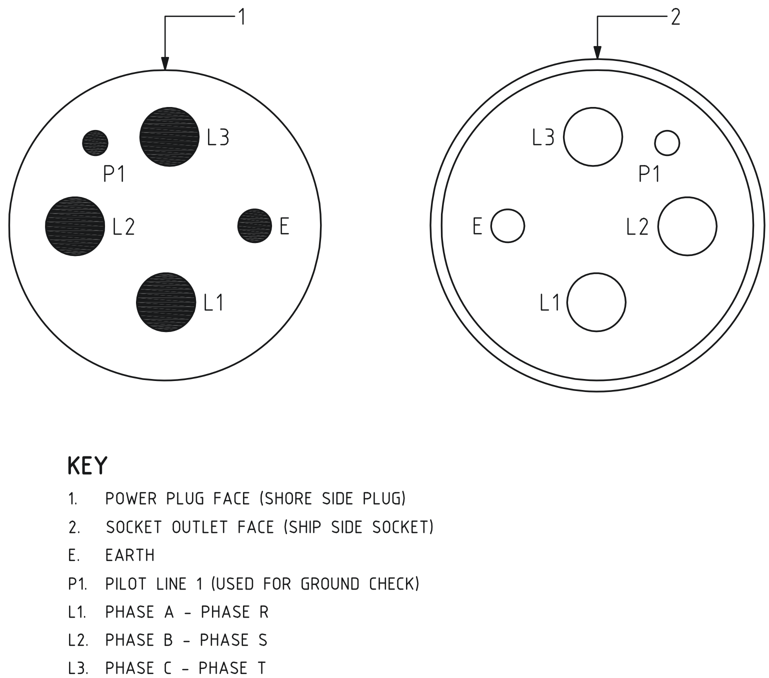


Figure C.4 – Shore power connector pin assignment

General arrangement of power plug and socket-outlet shall be in accordance to IEC 62613-2:2011, Annex GG, and Figure C.4. The neutral plug and socket-outlet shall be in accordance to IEC 62613-2:2011, Annex HH.

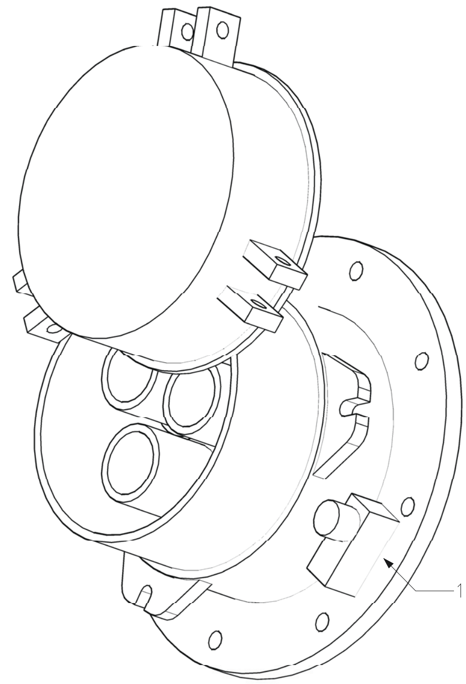
Size, quantity and rating of cables shall be sufficient to meet the maximum power rating and voltage that the terminal can supply to the ship.

NOTE Typically (2009), cruise ships utilize four (4) power 3-phase couplers, each rated 500 A and one neutral single pole connector rated 250A.

The maximum short-circuit current is 25 kA / 1 s and a maximum peak short-circuit current of 63 kA.

In addition, the power plugs as well as the neutral plug shall be fitted with fail-safe limit switches that are activated only when the plug and socket-outlet are properly mated (see Figure C.5).

These fail safe limit switches shall be part of, and activate the emergency shutdown, if the plug is moved from the mated position while live, see 4.9.



KEY
1. FAIL-SAFE LIMIT SWITCH

Figure C.5 – The power inlet fitted with fail-safe limit switch

C.8.1 General

Connection between the neutral and ship's hull shall be robust and durable for proper bonding.

Annex D
(normative)

Additional requirements of container ships

D.1 Scope

This Annex describes the additional requirements on HVSC systems of container ships.

The numbering in this annex follows that of the main body of the text. Hence, the numbering is not necessarily continuous. Any content which is not explicitly mentioned, applies, without modification. For example, D.4.1 makes reference to 4.1 in the main body.

D.4.1 System description

The general system layout is shown in Figure D.1.

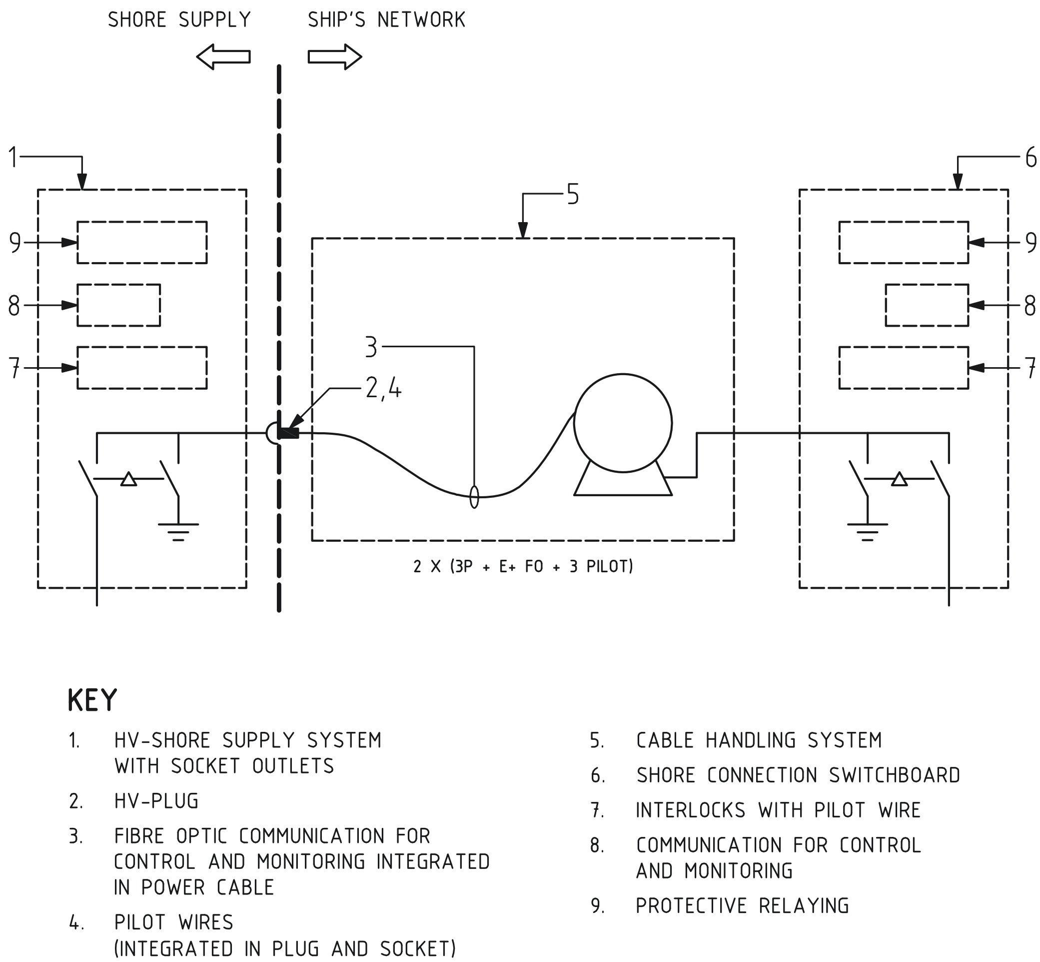


Figure D.1 – General system layout

D.5.1 Voltages and frequencies

The nominal voltage of the HVSC shall be 6,6 kV.

D.6.2.3 Neutral earthing resistor

The shore side transformer star point shall be earthed, through a neutral earthing resistor of 200 ohm continuous rated.

D.7 Ship to shore connection and interface equipment

Two parallel cables with three pilot conductors each shall be used for HVSC systems up to a maximum power demand of 7,5 MVA.

D.7.2.1 General

The cable management system shall be located on board ship.

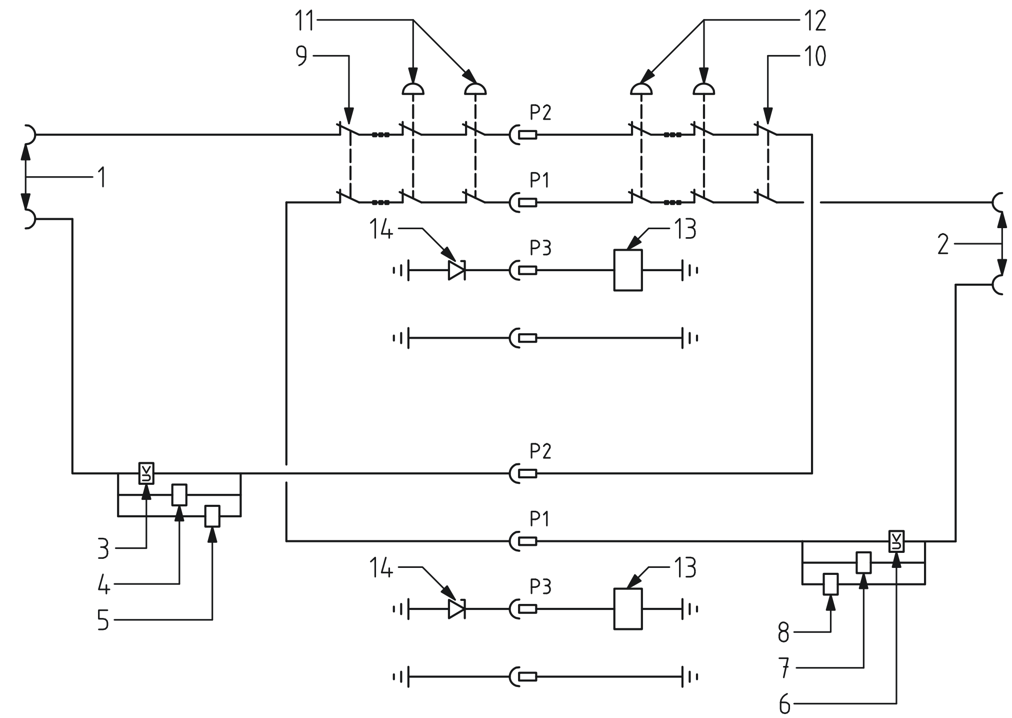
D.7.2.5 Equipotential bond monitoring

Equipotential bond termination device shall meet the following requirements:

a) Characteristic: Zener Diode;
b) Zener voltage: 5,6 V ± 0,03 Vdc @ 100 mA;
c) Forward voltage: 0,5 ± 0,1 Vdc @ 100 mA;
d) Maximum impedance: 20 mOhm @ 100 mA;
e) Operating temperature: -40 °C to 60 °C;
f) Current range: 2 mA to 25 A; and
g) Frequency range: 0 kHz to 20 kHz, -3 db.

Figure D.2 shows an example of equipotential bond monitoring.

NOTE Other methods of monitoring the equipotential bond are under development.



KEY

1. CONTROL POWER PILOT LOOP SHORE
2. CONTROL POWER PILOT LOOP SHIP (VT FED FROM SHORE POWER SOURCE)
3. CIRCUIT BREAKER UNDERVOLTAGE COIL (SHORE)
4. SAFETY CIRCUIT COIL ON SHORE
5. EARTHING SWITCH PERMISSION SHORE SIDE
6. CIRCUIT BREAKER UNDERVOLTAGE COIL (SHIP)
7. SAFETY CIRCUIT COIL ON SHIP
8. EARTHING SWITCH PERMISSION SHIP SIDE
9. CONTROL ES SHORE (EMERGENCY SHUTDOWN)
10. CONTROL ES SHIP (EMERGENCY SHUTDOWN)
11. MANUAL ES SHORE (TWO SHOWN)
12. MANUAL ES SHIP (TWO SHOWN)
13. EQUIPOTENTIAL BOND MONITORING DEVICE
14. EQUIPOTENTIAL BOND MONITORING TERMINATION DEVICE

Figure D.2 – Safety circuits

D.7.3 Plugs and socket-outlets

The maximum short-circuit current is 16 kA / 1 s and a maximum peak short-circuit current of 40 kA, see IEC 62613-1.

Each plug and socket outlet shall be fitted with three pilot contacts.

General arrangement of plug and socket-outlet shall be in accordance to IEC 62613-2:2011, Annex CC, and Figure D.3 below.

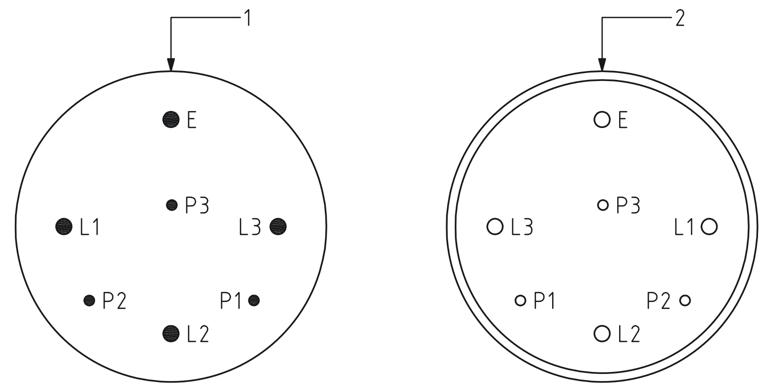


Figure D.3 – Power plug and socket pin assignment

D.7.3.2 Pilot contacts

For the purposes of this annex, pilot contacts are parts of the safety circuit.

D.7.6. Independent control and monitoring cable

Pin configuration shall be as in MIL-STD-1560A pin A and B.

D.7.8 Data communication

Data communication shall be performed utilizing fibre optic systems. Emergency shutdown functions shall be performed with pilot conductors (see IEC 62613-1, IEC 62613-2 and Annex A).

Annex E
(normative)

Additional requirements of liquefied natural gas carriers (LNGC)

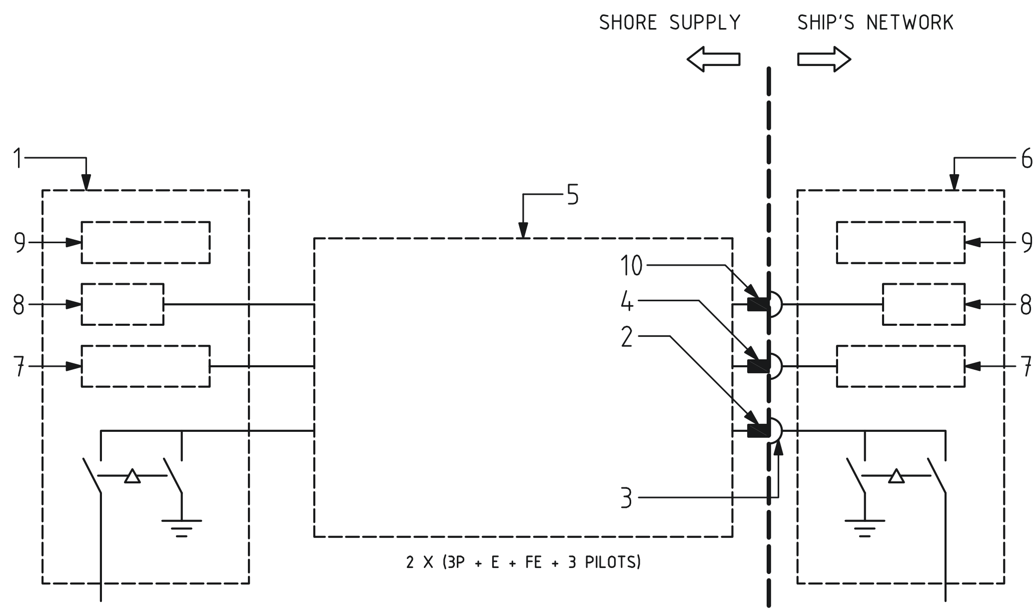
E.1 Scope

This annex describes the additional requirements for HVSC systems for liquefied natural gas carriers (LNGC).

The numbering in this annex follows that of the main body of the text. Hence, the numbering is not necessarily continuous. Any content which is not explicitly mentioned, applies, without modification. For example, E.4.1 refers to 4.1 in the main body.

E.4.1 System description

The general system layout is shown in Figure E.1.



KEY

1. HV-SHORE SUPPLY SYSTEM
2. HV-PLUG
3. SHIP'S HV-SOCKET
4. PILOT WIRES (INTEGRATED IN PLUG AND SOCKET)
5. CABLE MANAGEMENT SYSTEM
6. SHORE CONNECTION SWITCHBOARD
7. INTERLOCKS WITH PILOT WIRE
8. COMMUNICATION FOR CONTROL AND MONITORING
9. PROTECTIVE RELAYING
10. COMMUNICATION AND CONTROL WIRES

Figure E.1 – General system layout

E.4.3 Compatibility assessment before connection

In addition to the requirement set forth in 4.3 the following items shall be observed:

a) Compatibility of shutdown system and disconnection equipment (see also 4.9); and
b) Availability of shore power supply for cargo operations

E.4.7 Electrical requirements

The prospective short-circuit contribution level from the HV shore distribution system shall be limited by the shore-sided system to 25 kA rms.

The prospective short-circuit contribution level from the on board running induction motors and the generators in operation shall be limited to a short circuit current of 25 kA rms.

NOTE Special requirements apply to the distribution systems of LNG tankers (see IEC 60092-502).

E.4.9 Emergency shutdown including emergency stop facilities

Emergency shutdown is initiated in two steps: ESD-1, when the ship moves past the warning range, and ESD-2, when the ship moves past the maximum range of movement of the ship.

Means shall be provided to facilitate emergency physical disconnection of the HVSC cables in the event of ESD-2 (movement of the ship away from the dock) being detected.

Disconnection may be triggered by an "active" system employing an external mechanical force or by a ‘passive’ system employing a weak link in the design. Suitable "passive" systems may be fitted at the ship or shore side or as part of a coupler in the HVSC power cable.

LNG-ESD may be initiated manually, by fusible links, by process deviation or by excessive movement of the loading arms. The LNG-ESD signal is passed between ship and shore (or vice versa) and causes cargo pumps and compressors to be stopped and cargo valves to be closed on ship and shore.

E.5.1 Voltages and frequencies

Connections for LNGCs shall be made at a nominal voltage of 6,6 kV a.c. and a frequency of 60 Hz.

E.6.1 General

An analysis of the existing (2009) LNGC fleet suggests that the physical location of the HVSC point should be in accordance with the following tables.

Table E.1 – LNGC 140 000 – 225 000 m^3

HVSC Point	Dimension (metres)	
	Minimum	Maximum
From cargo manifold centre-line	112,0	130,0
Above design waterline	5,35	8,85
From berthing line	0	11,5

Table E.2 – LNGC > 225 000 m³

HVSC Point	Dimension (metres)	
	Minimum	Maximum
From cargo manifold centre-line	120,0	149,0
Above design waterline	5,55	9,05
From berthing line	0	11,5

E.6.2.3 Neutral earthing resistor

The HVSC system shall operate with the neutral point of the system transformer feeding the shore-to-ship power receptacles unearthed where the LNGC connected to the system is designed with an insulated or high resistance earthed power system for compliance with the requirements of SOLAS 2009 Ch II-1/D, Regulation 45.4.3 and IEC 60092-502.

Where an earthing impedance designed for compliance with the SOLAS requirements is provided onshore, or an on-board transformer is provided for galvanic separation or voltage matching, an insulated neutral on the shore side may not be required.

E.7 Ship to shore connection and interface equipment

Generally three parallel cables shall be used for HVSC systems up to a maximum power demand of 10,7 MVA.

E.7.2 Cable management system

The connection and interface equipment shall protect the ship fixed equipment from damage in the event that emergency disconnection occurs.

In the event of emergency disconnection, the design of the connection and interface equipment shall mitigate the risk of:

- disconnection before the HVSC power cables are isolated and earthed;
- damage to the ship fixed equipment;
- cable tension exceeding the level permitted by the cable manufacturer;
- release of stored mechanical energy causing equipment or cables to make uncontrolled movement in any attended area on the ship or onshore; and
- cables fouling the ship propeller(s) and/or rudder(s).

NOTE A coupler fitted to the HVSC power cable to facilitate emergency physical disconnection is not considered a cable extension.

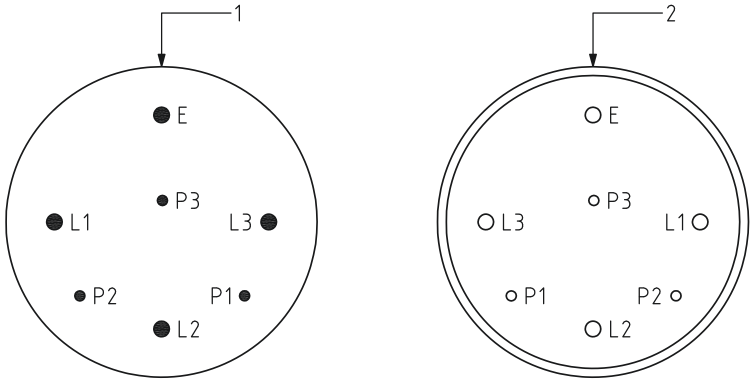
The cable management system shall be located on shore (see Figure E.1).

E.7.3 Plugs and socket-outlets

General arrangement of plug and socket-outlet shall be in accordance to IEC 62613-2:2011, Annex CC, and Figure E.2 below.

The maximum short-circuit current of 25 kA / 1 s and a maximum peak short-circuit current of 63 kA.

Each plug and socket outlet shall be fitted with three pilot contacts.



KEY

1. POWER PLUG FACE (SHIP SIDE)	2. POWER SOCKET FACE (SHORE SIDE)
E. EARTH	P1. PILOT LINE 1
L1. PHASE A – PHASE R	P2. PILOT LINE 2
L2. PHASE B – PHASE S	P3. PILOT LINE 3
L3. PHASE C – PHASE T	

Figure E.2 – Power plug and socket pin assignment

E.7.6 Independent control and monitoring cable

Certified intrinsically safe or fibre optic systems may be a suitable means of communication.

It is recommended that hotline telephones are provided as the means of voice communication required between ship and shore control locations.

E.8.6 Ship power restoration

An emergency shutdown philosophy shall be agreed between terminal and ship during compatibility assessment of the HVSC system. It shall cover actions in the event of the following situations:

- manual shutdown of cargo operations;
- loss of electrical power (initiates LNG-ESD);
- LNG-ESD;
- ESD-1;
- ESD-2; and
- simultaneous release of mooring hooks.

The HVSC shutdown system shall be self-contained and the emergency shutdown philosophy shall not require additional signals to be transmitted from ship to shore (or vice versa) by the existing LNG terminal shutdown system. However, the LNG terminal shutdown system shall provide ESD-1 & ESD-2 signals to the HVSC shutdown system.

The LNG-ESD shall not be required to have an automatic effect on the HVSC system.

The ESD-1 shutdown shall be communicated from shore to ship via the HVSC control system and shall initiate automatic starting, synchronization and connection of the ship main source of power followed by isolation and earthing of the shore power connection(s) both onshore and onboard.

The ESD-2 shutdown shall be communicated from shore to ship via the HVSC control system and shall trigger an emergency stop as described in 4.9 (i.e. the immediate opening of all the shore supply circuit-breakers etc.) and earthing of the shore power connection(s) both onshore and on board.

Additional emergency stop switches are required on shore in the terminal control room where the HVSC controls are located and at the cable management system operating location.

Annex F
(normative)

Additional requirements for tankers

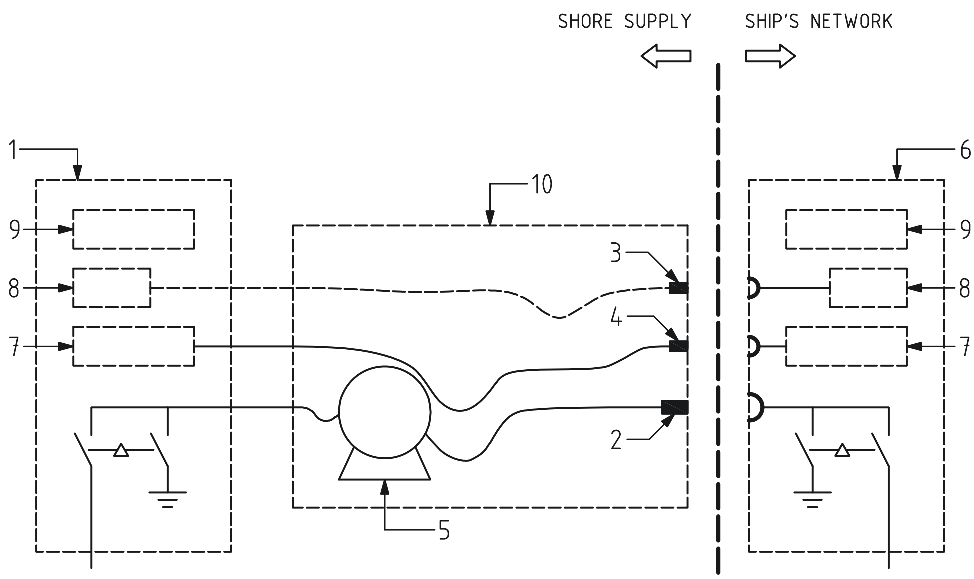
F.1 Scope

This annex describes the additional requirements for HVSC systems of tankers.

The numbering in this annex follows that of the main body of the text. Hence, the numbering is not necessarily continuous. Any content which is not explicitly mentioned, applies, without modification. For example, F.4.1 refers to 4.1 in the main body.

F.4.1 System description

The general system layout is shown in Figure F.1.



KEY

1. HV-SHORE SUPPLY SYSTEM
2. HV-PLUG
3. CONTROL AND MONITORING (SEPARATE CABLE MANAGER WITH COPPER WIRES)
4. PILOT WIRES (INTEGRATED IN PLUG AND SOCKET)
5. CABLE HANDLING SYSTEM
6. SHORE CONNECTION SWITCHBOARD
7. INTERLOCKS WITH PILOT WIRE
8. COMMUNICATION FOR CONTROL AND MONITORING
9. PROTECTIVE RELAYING
10. SHORE-TO-SHIP CONNECTION AND INTERFACE EQUIPMENT

Figure F.1 – General system layout

F.4.7 Electrical requirements

The prospective short-circuit contribution level from the HV shore distribution system shall be limited by the shore-sided system to 25 kA rms.

The prospective short-circuit contribution level from the on board running induction motors and the generators in operation shall be limited to a short circuit current of 25 kA rms.

NOTE Special requirements apply to the distribution systems of tankers (see IEC 60092-502).

F.5.1 Voltages and frequencies

Connections for tanker ships shall be made at a nominal voltage of 6,6 kV a.c.

F.6.2.3 Neutral earthing resistor

Other earthing arrangements may be allowed because of the need to limit earth fault current in hazardous areas.

F.7 Ship to shore connection and interface equipment

Minimum two parallel cables shall be used for HVSC systems. Each cable shall have a power rating of 3.6 MVA.

Analysis of the existing tanker fleet suggests that up to three cables may be required.

F.7.2 Cable management system

F.7.2.1 General

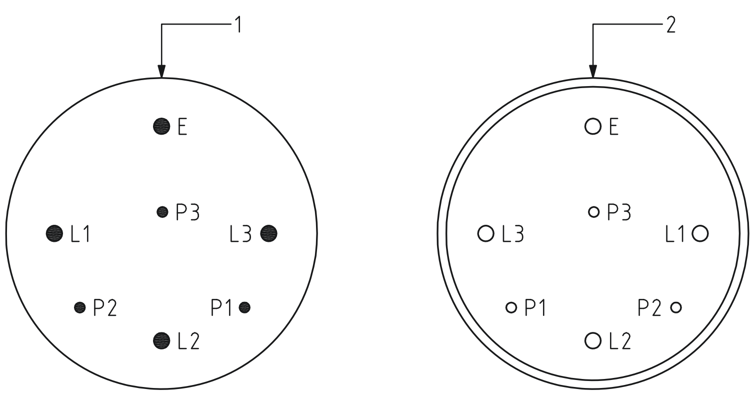
The cable management system shall be located on shore (see Figure F.1).

F.7.3 Plugs and socket-outlets

The maximum short-circuit current is 16 kA / 1 s and a maximum peak short-circuit current of 40 kA, see IEC 62613-1.

General arrangement of plug and socket-outlet shall be in accordance to IEC 62613-2:2011, Annex CC, and Figure F.2 below.

Each plug and socket outlet shall be fitted with three pilot contacts.



KEY

1.	POWER PLUG FACE (SHIP SIDE)	2.	POWER SOCKET FACE (SHORE SIDE)
E.	EARTH	P1.	PILOT LINE 1
L1.	PHASE A – PHASE R	P2.	PILOT LINE 2
L2.	PHASE B – PHASE S	P3.	PILOT LINE 3
L3.	PHASE C – PHASE T		

Figure F.2 – Power plug and socket pin assignment

F.7.6 Independent control and monitoring cable

Certified intrinsically safe or fibre optic systems may be a suitable means of communication.

It is recommended that hotline telephones are provided as the means of voice communication required between ship and shore control locations.

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