IEC PAS 80005-3

Edition 1.0 2014-08

PUBLICLY AVAILABLE SPECIFICATION

PRE-STANDARD

colour inside

Utility connections in port –
Part 3: Low Voltage Shore Connection (LVSC) Systems – General requirements

IEC PAS 80005-3:2014-08(en)

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UTILITY CONNECTIONS IN PORT –

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FOREWORD

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A PAS is a technical specification not fulfilling the requirements for a standard, but made available to the public.

This Publicly Available Specification (PAS) IEC/ISO 80005-3 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: Plugs, socket-outlets and couplers for industrial and similar applications, and for electric vehicles, of IEC technical committee 23: Electrical accessories and IEC technical committee 20:Electric cables, 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.

This PAS will eventually be replaced with an IEC/IEEE prefix and IEC/ISO/IEEE triple logo standard.

The text of this PAS is based on the following document:	This PAS was approved for publication by the P-members of the committee concerned as indicated in the following document
Draft PAS	**Report on voting**
18/1377/PAS	18/1390/RVD

Following publication of this PAS, which is a pre-standard publication, the technical committee or subcommittee concerned may transform it into an International Standard.

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.

This PAS shall remain valid for an initial maximum period of 3 years starting from the publication date. The validity may be extended for a single period up to a maximum of 3 years, at the end of which it shall be published as another type of normative document, or shall be withdrawn.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

This Publicly Available Specification (PAS) was developed jointly by IEC technical committee 18: Electrical installations of ships and of mobile and fixed offshore units in cooperation with IEC subcommittee 23H: Plugs, socket-outlets and couplers for industrial and similar applications, and for electric vehicles, of IEC technical committee 23: Electrical accessories and IEC technical committee 20:Electric cables, 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 intention of this PAS is to define requirements that support, with the application of suitable operating practices, efficiency and safety of connections by compliant ships to compliant low-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 PAS is intended to allow different ships to connect to low-voltage shore connection (LVSC) systems 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 PAS may find it impossible to connect to compliant shore supplies.

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

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

Clauses 1 to 12 are intended for application to all LVSC systems. They are intended to address mainly the safety and effectiveness of LVSC systems with a minimum level of requirements that would standardise on one solution. This PAS 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.

The other annexes in this PAS are ship-specific annexes which 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.

UTILITY CONNECTIONS IN PORT –

Part 3: Low Voltage Shore Connection (LVSC) Systems – General requirements

1 Scope

This PAS describes low voltage shore connection (LVSC) systems, on board the ship and on shore, to supply the ship with electrical power from shore.

This PAS is applicable to the design, installation and testing of LVSC systems and addresses:

- LV 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.

NOTE 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 LVSC systems will have practicable applications for ships requiring up to 1 MVA. Low-voltage shore connection systems not exceeding 250 A, with a maximum of 125 A per cable and not exceeding 300 V to earth are not covered by this PAS. High-voltage shore connection systems are covered by IEC/ISO/IEEE 80005-1.

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), *Explosive atmospheres*

IEC 60092-101:1994, *Electrical installations in ships – Part 101: Definitions and general requirements*

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

IEC 60092-301:1980, *Electrical installations in ships – Part 301: Equipment – Generators and motors*

IEC 60092-401:1980, *Electrical installations in ships – Part 401: Installation and test of completed installation*

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

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 60204-1:2005, *Safety of machinery – Electrical equipment of machines – Part 1: General requirements*

IEC 60228:2004, *Conductors of insulated cables*

IEC 60309-1:2012, *Plugs, socket-outlets and couplers for industrial purposes – Part 1: General requirements*

IEC 60332-1-2, *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 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60947-2:2006, *Low-voltage switchgear and controlgear – Part 2: Circuit-breakers*

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 61439 (all parts), *Low-voltage switchgear and controlgear assemblies*

International Convention for the Safety of Life at Sea (SOLAS):1974, *Consolidated edition 2009, Ch. II-1/D, Regulations 42, 43 and 45*

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 LV-flexible and control cables and their connection devices

3.2
plug and socket-outlet
a means enabling the connection at will of a flexible cable to fixed wiring. It consists of two parts:

Note 1 to entry: "plug and socket-outlet" corresponds to the French "prise de courant" that has no equivalent in English. It is anyhow required for the French version of this PAS.

[SOURCE: IEC 60309-1:2012, 2.1, modified (Note 1 to entry added)]

3.2.1
socket-outlet
the part intended to be installed with the fixed wiring (shore side) or incorporated in equipment

Note 1 to entry: A socket-outlet may also be incorporated in the output circuit of an isolating transformer.

Note 2 to entry: For the use of plugs, socket-outlets, and ship couplers, see Figure 5 – Diagram showing the use of accessories.

[SOURCE: IEC 62613-1:2011, 3.2 modified ("shore side" and Note 2 to entry added)]

3.2.2
plug
the part intended to be attached directly to one flexible cable, and to be connected to the shore socket-outlet

[SOURCE: IEC 62613-1:2011, 3.3 modified ("and to be connected to the shore socket-outlet" added)]

3.3
ship coupler
a means enabling the connection at will of a flexible cable to the ship. It consists of two parts:

[SOURCE: IEC 62613-1:2011, 3.4]

3.3.1
ship connector
the part intended to be attached to one flexible cable connected to the supply, and to be connected to the ship inlet

[SOURCE: IEC 62613-1:2011, 3.5 modified ("and to be connected to the ship inlet" added)]

3.3.2
ship inlet
the part incorporated in, or fixed to, the ship

[SOURCE: IEC 62613-1:2011, 3.6]

3.4
equipotential bonding
provision of electric connections between conductive parts, intended to achieve equipotentiality

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

3.5
low voltage
LV
a set of voltage levels used for the distribution of electricity and whose upper limit is generally accepted to be 1 000 V AC

[SOURCE: IEC 60050-601, 601-01-26]

3.6
person in charge
PIC
individual responsible for LVSC systems operations

3.7
pilot contact
a contact of the plug, ship inlet, socket-outlet and ship connector which signals correct connection and which is a safety-related component

3.8
receiving point
connection point of the flexible cable on the ship

3.9
safe
condition in which safety risks are minimized to an acceptable level

3.10
supply point
the connection point of the flexible cable on shore

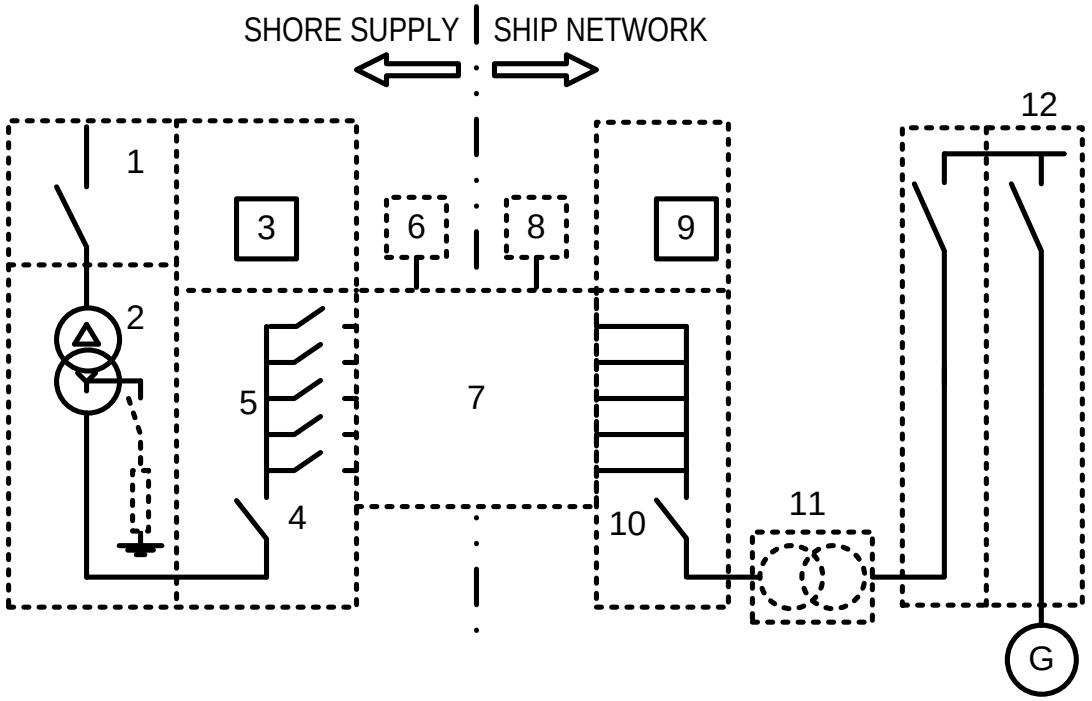
3.11
fail safe
a design property of an item which prevents its failures from resulting in critical faults

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

4 General requirements

4.1 System description

A typical LVSC system described in this PAS consists of hardware components as shown in Figure 1.



Key

1. SHORE SUPPLY SYSTEM
2. SHORE-SIDE TRANSFORMER AND NEUTRAL GROUNDING RESISTOR OR/AND IT SYSTEM
3. SHORE-SIDE PROTECTION RELAYING
4. SHORE-SIDE CIRCUIT-BREAKER
5. SHORE-SIDE FEEDERS CIRCUIT-BREAKERS
6. CONTROL SHORE
7. SHORE-TO-SHIP CONNECTION AND INTERFACE EQUIPMENT
8. CONTROL SHIP
9. SHIP PROTECTION RELAYING
10. ON-BOARD SHORE CONNECTION SWITCHBOARD
11. ON – BOARD TRANSFORMER (WHERE APPLICABLE)
12. ON-BOARD RECEIVING SWITCHBOARD

Figure 1 – Block diagram of a typical LVSC system

4.2 Distribution system

4.2.1 General

Typical distribution systems requirements used on shore are given in IEC 60364. Typical ship distribution systems requirements are given in IEC 60092-101.

NOTE IEEE 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 by the earth contacts of the plug, socket-outlet, ship connector and ship inlet.

Equipotential bonding shall be periodically checked (see 11.2.2).

NOTE The terms earth(ing) and ground(ing) are used throughout this PAS 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 LV 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 PAS 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 LV shore supply, LV shore supply response to step changes in load (see 5.2);

g) system study and calculations (see 4.8);

h) compatibility of shore side and ship side control voltages, where applicable;

i) distribution system compatibility assessment (shore power transformer neutral earthing);

j) functioning of ship earth fault protection, where applicable, monitoring and alarms when connected to a LVSC supply (see 8.2.2);

k) sufficient cable length;

l) compatibility of safety circuits, in accordance with 9.1;

m) consideration of hazardous areas, where applicable (see 4.6.4);

n) when a LV 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;

o) consideration of electrochemical corrosion due to equipotential bonding;

p) utility interconnection requirements for load transfer parallel connection.

4.4 LVSC 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 LVSC systems.

System integration of shore and ship LVSC 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 LVSC 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 LV 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.

NOTE 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

LVSC 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.

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 LVSC 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 LVSC 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 LVSC equipment or the cable management equipment.

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

4.6.4 Electrical equipment in hazardous areas

LVSC 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.

LVSC 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 hazardous areas; or

b) automatically isolated before entering the potentially hazardous area.

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

LVSC 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 LVSC system components, type tests and routine tests shall be performed according to relevant standards.

NOTE See IEEE Std C37.13:2008

To allow standardisation of the LV shore supply and link nominal voltage (see 5.1) in different ports, any equipment requiring conversion to nominal voltage shall be installed on board, see IEC 60092-201.

NOTE Additional recommendations are provided in IEEE 45.

The short-circuit contribution level from the LV shore distribution system shall be limited by the shore-side system to 16 kA r.m.s..

The 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 r.m.s..

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 r.m.s. for 1 s, and 40 kA peak.

4.8 System study and calculations

The shore-connected electrical system shall be evaluated based on electrical load profile during shore connection provided by ships. The system study and calculations shall determine:

a) 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.
b) the calculations may take into account any arrangements that:
   1) prevent parallel connection of LV 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) limit the load to be connected.

c) system charging (capacitive) current for shore and ship supply when IT system is employed;

d) this system charging current calculation shall consider the shore power system and the expected ship power including the on-line generator(s);

e) shore power transformer neutral earthing resistor analysis (see 6.2.3); and

f) transient overvoltage protection analysis (see 5.2).

NOTE Additional recommendations are provided in IEEE Std. 551.

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.

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 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 non safety 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, AC 5 A, DC 1 A.

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 equipment that is not intrinsically safe shall be automatically isolated so that it will not present an ignition hazard.

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

a) overtension on the flexible cable (mechanical stress) (see 7.2.2);

b) loss of any safety circuit;

c) activation of any manual emergency-stop;

d) activation of protection relays provided to detect faults on the LV connection cable or connectors; and

e) withdrawal of power plugs from socket-outlets or ship connector from ship inlet while LV 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:

f) an attended on-board ship control station during LVSC;

g) in the vicinity of the socket-outlet;

h) at active cable management system control locations; and

i) at the shore side and ship circuit-breaker locations.

Additional emergency-stop 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 LV shore supply.

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

5 LV shore supply system requirements

5.1 Voltages and frequencies

To allow standardization of the LV and link nominal voltage in different ports, LV shore connections shall be provided with a nominal voltage of 400 V a.c or/and 440 V a.c or/and 690 V a.c (see IEC 60092-201 for standard voltage values) galvanically separated from the shore distribution system.

NOTE See IEC 60038 and IEEE Std. 45 for standard voltage values.

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

Operating voltage and frequency shall be verified on board, prior to connection (see 8.5.3).

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

At the connection point, looking at the socket-outlet/ship connector face, the phase sequence shall be L1-L2-L3 or 1-2-3 or A-B-C or R-S-T, counter clockwise. A phase sequence indicator must indicate correct sequence prior to energizing or paralleling LVSC (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).

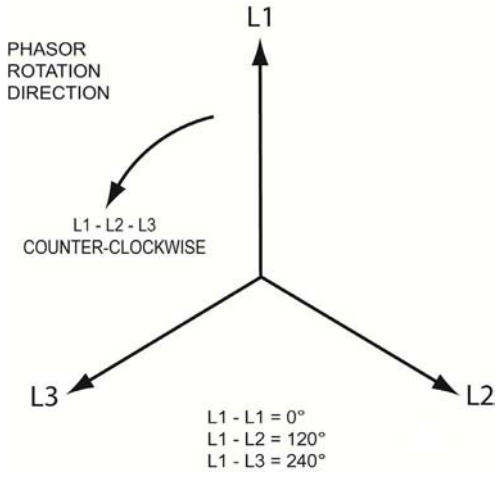


Figure 2 – Phase sequence rotation – Positive direction

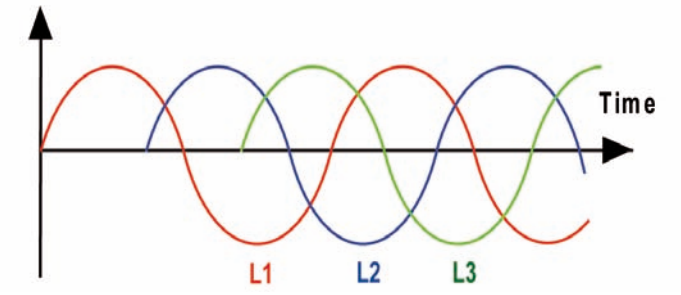


Figure 3 – Balanced three-phase variables in time domain

5.2 Quality of LV shore supply

The LV 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 –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 LV shore supply installation;
   2) the maximum step change in load expected when connected to a LV 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:
   1) 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 3.10).

The LV 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 LV 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 installations shall be in accordance with IEC 60364.

NOTE Local Authorities may have additional requirements.

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

Each ship shall be provided with a dedicated LV shore supply installation which is galvanically isolated from other connected ships and consumers.

6.2 System component requirements

6.2.1 Circuit-breaker and disconnector

The rated making capacity of the circuit-breaker(s) shall not be less than the prospective peak value of the short-circuit current (I_P) calculated in compliance with IEC 61363-1. The circuit-breaker(s) shall be in conformity with IEC 60947-2.

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

NOTE Additional recommendations are provided in IEEE Std. 551.

A circuit-breaker(s) with built in disconnection function shall be provided.

A motor-operated circuit-breaker(s) shall be provided.

6.2.2 Transformer

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

The temperature of supply-transformer shall be monitored.

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.

NOTE 1 Dyn=Delta connected primary winding, star connected secondary winding, with provision to connect to neutral.

NOTE 2 In the event of over temperature, an alarm may activate to advise relevant duty personnel.

6.2.3 Neutral earthing resistor

The neutral point of the LVSC system transformer feeding the shore-to-ship power receptacles shall be earthed through a neutral earthing resistor, or in the event when shore LVSC utilizes IT system then neutral earthing resistor shall be disconnected or may be omitted. Special care should be taken during the design and operations phases related to IT systems (see IEC 60364).

NOTE For LVSC systems dedicated to Offshore Supply, Service and Working Ships and Container and Tankers refer to ship specific annexes.

Where an equivalent earth fault impedance is chosen when frequency conversion of the shore supply is required, studies shall 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 shall be minimum 16 A 5 s, 5 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 25 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 (or earthing for IT system) 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 of any transformer shall be in accordance with 8.2.3 of IEC 60204-1:2009.

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 LV shore-side 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) voltage sensing device (84) (for dead bus verification)

e) undervoltage (27)

f) reverse power (32)

g) instantaneous overcurrent (50)

h) phase time overcurrent (51)

i) earth fault overcurrent (51G)

j) overvoltage (59)

In the event of IT system employed, the earth fault protection functions can be achieved by different methods.

NOTE ANSI standard device designation numbers are shown in brackets above, as per ANSI/IEEE C37.2.

Each three-phase feeder to the ship shall be protected independently by dedicated circuit-breaker. All LV circuit-breaker(s) on feeders shall trip simultaneously. The following protective devices, or equivalent protective measures, shall be provided:

a) instantaneous overcurrent (50)

b) phase time overcurrent (51)

c) earth fault overcurrent (51G)

For internal sockets-outlets, plugs, connectors and inlets protection in case of abnormal increased contacts resistance (refer to manufactures specifications) an additional protection may be provided: negative phase sequence overcurrent (46) or internal thermal sensor or equivalent.

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 activated.

6.4 LV interlocking

6.4.1 General

Operating personnel shall be protected from electrical hazard by an interlocking arrangement while plugging and unplugging of LV plug and ship connectors.

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

6.4.2 Operating of the low-voltage (LV) circuit-breakers and disconnectors

Arrangements shall be provided so that the circuit-breakers, with built in disconnection function cannot be closed when any of the following conditions exist:

a) the pilot contact circuit is not established (see 7.3.2);

b) emergency-stop facilities are activated;

c) ship or shore control, alarm or safety system self-monitoring diagnostics detect an error that would affect safe connection;

d) the permission from the ship is not activated (see 8.5.5); and

e) the LV supply is not present.

6.5 Shore connection convertor equipment

6.5.1 General

Where provided, converting equipment (transformers, rotating frequency convertors and/or semiconductor convertors) for connecting LV 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.

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 60529 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.

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.

7 Ship-to-shore connection and interface equipment

7.1 General

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

Physical compatibility between ship and shore shall be assumed by the following rules:

a) Ships have the necessary number of inlets according to their maximal power demand while connected to LVSC system;

b) Shore systems have the necessary number of socket-outlets according to the maximal power that can be supplied;

c) Ship is connected only to the necessary number of socket-outlets according to their maximal power demand (all ship inlets shall be connected); other idle socket-outlets shall be de-energized, with the safety loop open;

d) Each connection cable from shore to ship is controlled and protected independently, and has an independent safety loop;

A common main on-board shore connection circuit-breaker shall be used on-board.

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 ship connector, if a ship inlet will be used on board.

Ship-to-shore connection cable extensions shall not be permitted.

The suitability of plugs and socket-outlets 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 LV plugs and socket-outlets is used, 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 located according to the ship annexes;

b) be capable of moving the ship-to-shore connection cable, enabling the cable to reach between the socket-outlet and the ship inlet;

c) be capable of maintaining an optimum length of cable which minimizes slack cable, and prevents the tension limits from being exceeded;

d) be equipped with a device (e.g. limit switches), independent of its control system, to monitor maximum cable tension and maximum cable pay-out;

e) address the risk of submersion by prevention or by the equipment design;

f) 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;

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

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

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

Where the cable management system employs cable reel(s), the LVSC 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 LV circuit-breaker(s) 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), see 6.3.

7.3 Plugs and socket-outlets

7.3.1 General

The plug, socket-outlet, ship connector and ship inlet shall be in accordance with IEC 60309-1 and IEC 60309-5[1] and the following clauses.

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

The contact layout of the plug, socket-outlet, ship connector and ship inlet shall be according to Annex B.

The plug, socket-outlet, ship connector and ship inlet shall be so designed that an incorrect connection cannot be made, see IEC 60309-1.

The socket-outlets and ship inlets shall be in areas where personnel will be protected in the event of an arc flash during the connection/disconnection, as a result of an internal fault, by barrier and access control measures. These measures shall be supported by access control procedures.

Plugs and ship connectors shall be so designed 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, see IEC 60309-1.

Each plug, socket-outlet, ship connector and ship inlet shall be fitted with pilot contacts for continuity verification of the safety circuit. For single-cable connections, a minimum of four pilot contacts is required. If more than one cable is installed, an interlocking system shall be implemented so that no cable remains unused.

Contact sequence shall be in the following order (see IEC 60309-1):

---

1 To be developed by the IEC.

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.

A safety loop circuit for one feeder is shown in Figure 4a).

A safety loop circuit for more than one feeder (here three feeders ship is shown) is shown in Figure 4b).

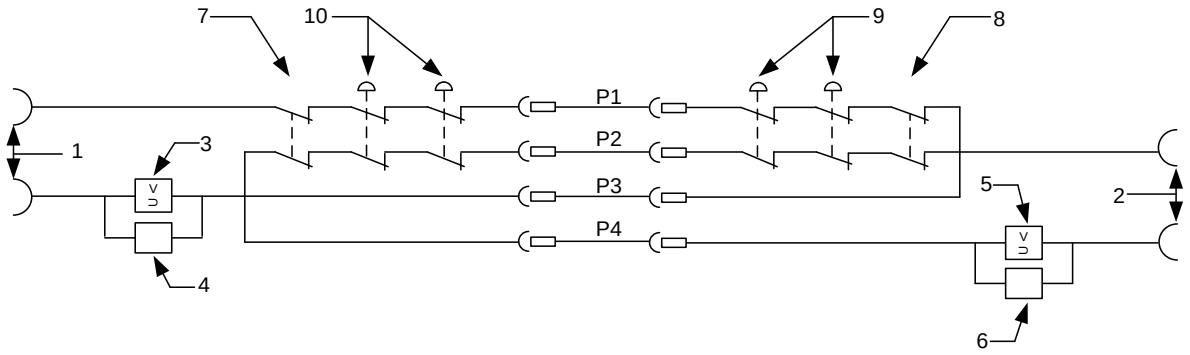


Figure 4a)

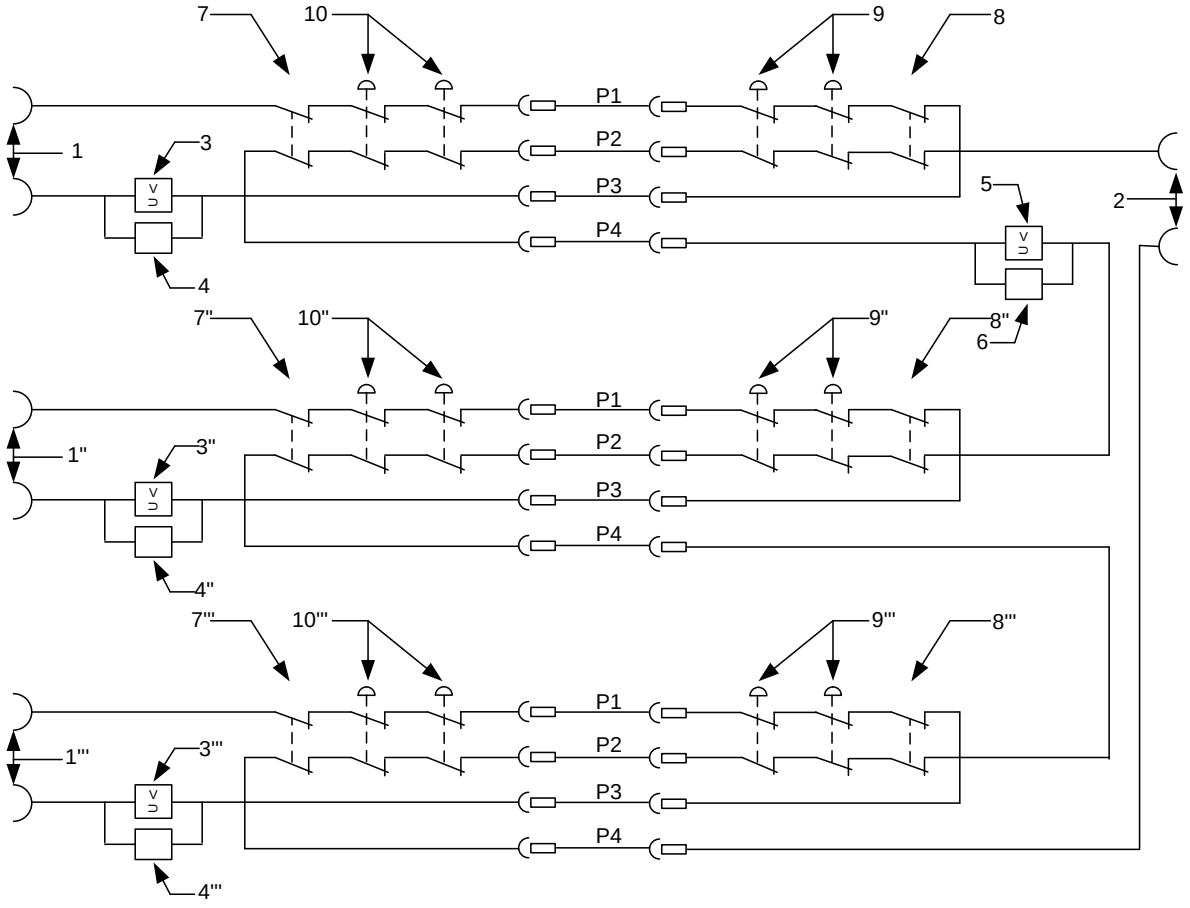


Figure 4b)

Key

1. CONTROL POWER PILOT LOOP SHORE
2. CONTROL POWER PILOT LOOP SHIP
3. FEEDER CIRCUIT BREAKER UNDERVOLTAGE COIL SHORE
4. SAFETY CIRCUIT COIL ON SHORE
5. MAIN CIRCUIT BREAKER UNDERVOLTAGE COIL SHIP
6. SAFETY CIRCUIT COIL ON SHIP
7. CONTROL EMERGENCY SHUTDOWN SHORE
8. CONTROL EMERGENCY SHUTDOWN SHIP
9. MANUAL EMERGENCY SHUTDOWN SHIP(TWO SHOWN)
10. MANUAL EMERGENCY SHUTDOWN SHORE(TWO SHOWN)

Figure 4 – Safety loop circuit for one feeder (a) or three feeders (b), for LVSC system.

The safety loop system shall allow the connection at shore of ships with a different number of feeders (see 7.1).

The opening of one safety loop during connection shall trip both shore and ship safety loops, also on all feeders.

In case of failure of shore feeder circuit breaker(s) opening, a safety backup shall consist in opening a shore-side circuit breaker.

In case of failure of ship on-board circuit breaker opening, a safety backup shall consist in opening an on-board receiving switchboard circuit breaker.

Each plug, socket-outlet, ship connector and ship inlet handling shall not be permitted if they are not disconnected from shore and ship installations.

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 LV-plug or ship 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.

7.4 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 shall 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 LV connection cable electrical ratings and specification is given in Annex A.

7.5 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 7.4.

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.

7.6 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, ship inlets and ship connectors shall maintain their IP ratings.

Temporary coverings are not considered to satisfy this requirement.

8 Ship requirements

8.1 General

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

8.2 Ship electrical distribution system protection

8.2.1 Short-circuit protection

The maximum prospective short-circuit current for which LV-shore supply or ship-electrical-system / equipment is rated shall not be exceeded at any point in the installation by connecting to LV-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 LV-shore supply is possible, measures shall be taken to prevent LV-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 LVSC supply with distribution system earthing in accordance with 6.2.3. The requirement to distribution system earthing described in 6.2.3 may differ from that used on the ship.

Where device settings are required to be changed when connected to a LVSC 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 61439.

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 and disconnector

In order to have the installation isolated before it is connected, a circuit-breaker with built in disconnection function shall be provided.

The circuit-breaker shall be in conformity with IEC 60947-2.

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

NOTE Additional recommendations are provided in IEEE Std. 551.

A motor-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 cable.

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

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

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 LV 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 LV-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

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

NOTE Additional recommendations are provided in IEEE Std. 551.

A motor-operated circuit-breaker shall be provided.

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.

Above functions could be built in a multifunction instrument.

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

a) one voltmeter;
b) one frequency meter;
c) one ammeter with an ammeter switch to enable the current in each phase to be read, or an ammeter in each phase; and
d) 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).

Above functions could be built in a multifunction instrument.

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:

a) synchrocheck (25)*
b) undervoltage (27)
c) reverse power (32)*
d) phase sequence voltage (47)
e) overload (49)
f) instantaneous overcurrent (50)
g) overcurrent (51)
h) earth fault (51G) or (59N)
i) overvoltage (59), and
j) frequency (81) (under and over).

NOTE 1 The phase sequence protection protects the ship's system against wrong phase connection.

NOTE 2 In the event of IT system employed, the earth fault protection functions can be achieved by different methods.

ANSI standard device designation numbers as per ANSI/IEEE 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) the pilot contact circuit, see 7.3.2, is not established;
b) emergency-stop facilities are activated;
c) ship or shore control, alarm or safety system self-monitoring properties detect an error that would affect the safety of the connection;
d) the LV supply is not present; and
e) earth fault on ship distribution system is detected.

It is recommended to have one PIC on the ship and one facility PIC.

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 LVSC operations.

8.6 Ship power restoration

When the ship main source of electrical power is shut down and failure of the connected LVSC 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 LV 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 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 LVSC 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.

Synchronization shall be performed on-board.

General operating procedure for connection and disconnection of LVSC system are presented in Annex F.

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 LV-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

LV-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, synchronisation shall have a time out function, and load shall be transferred between the LV 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 LV 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 LV-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 LV systems components shall have passed type tests and routine tests according to relevant standards.

The LV 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 PAS 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 LV switchgear assemblies and voltage test for cables (see IEC 60092-401);
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 PAS. 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 LV switchgear assemblies and voltage test for cables (see IEC 60092-401);
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 LVSC system:

a) visual inspection;
b) power frequency test for LV switchgear assemblies and voltage test for cables, see IEC 60092-401;
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 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 LV 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 LVSC 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 of equipotential bonding;

c) confirmation that no earth fault is present;

d) statement of voltage and frequency; and

e) an authorized switching and connection procedure or equivalent.

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

12 Documentation

12.1 General

For the LVSC 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 LVSC systems.

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

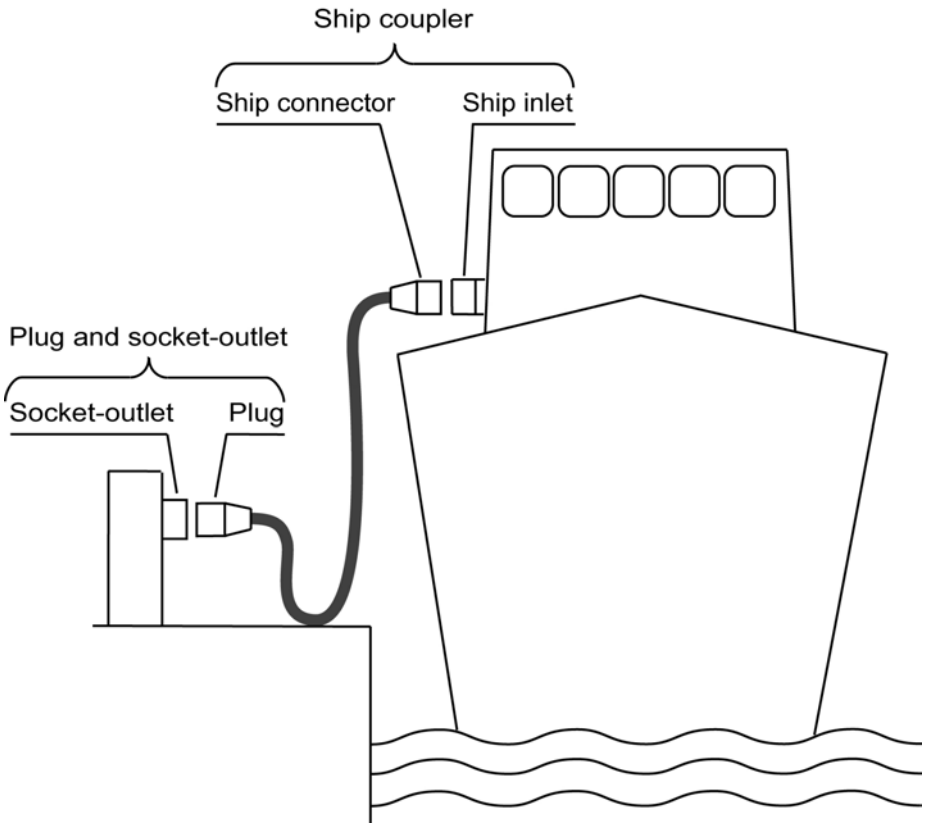


Figure 5 – Diagram showing the use of accessories

Annex A
(normative)

Ship-to-shore connection cable[2]

A.1 Rated voltage

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

$$U_0/U\ (U_m) = 0{,}6/1\ (1{,}2)\ \text{kV r.m.s}$$

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 Rated section / type

The standard section and type of the cables considered are as follows:

3 Phases + Earth + 4 Pilot wires, 185 mm²

A.3 General design

A.3.1 General

The cables should be constituted as follows: three power cores and one or multiple earth core(s) with copper conductors, insulation, and outer sheath. Pilots should be laid up in the interstices of the power cores and earth core(s). Pilots P1/P2 and P3/P4 shall be separated laid up.

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.

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.3.2 Conductors

All conductors should be flexible (class 5 of IEC 60228). The conductors should be plain or metal-coated copper conductors.

NOTE See also Table 11 of IEEE Std 1580:2001.

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2 This Annex will be developed by cable experts (IEC TC20/IEC SC18A) – work is ongoing.

A.3.3 Earth conductors

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

NOTE See also Table 11 of IEEE Std 1580:2001.

A.3.4 Pilot conductors

Pilots element shall be rated with insulation voltage of U_i = 300 V, AC 5 A, DC 1 A.

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

NOTE See also Table 11 of IEEE 1580:2001.

A.3.5 Cabling

The three power cores, the earth core(s), the pilot elements shall be laid up.

Annex B
(normative)

Ship-to-shore connection plugs, socket-outlets, ship connectors and ship inlets[3]

B.1 Rated voltage

The standard rated voltages U_0/U (U_m) of the plugs, socket-outlets, ship inlets and ship connectors are as follows:

$$U_0/U\ (U_m) = 690\ \text{V r.m.s}$$

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.

B.2 Rated type

The standard plug, socket-outlet, ship inlet and ship connector are as follows:

3 Phases + Earth + 4 Pilot wires, 350 A

B.3 General design

B.3.1 General

The plug, socket-outlet, ship inlet and ship connector shall be heavy duty.

The plug, socket-outlet, ship inlet and ship connector shall be rated for minimum of 16 kA r.m.s. for 1 s, and 40 kA peak.

One type of plug, socket-outlet, ship inlet and ship connector shall be used for all types of the ships.

The number of feeders varies according to the power transferred from shore to ship as shown in Table B.1.

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3 This Annex will be developed in cooperation with IEC SC23H – work is ongoing

Table B.1 – Number of feeders function of power demand and voltage

Power demand kVA	Voltage V		
	400	440	690
250	2	1	1
500	3	2	2
750	4	3	2
1 000	5	4	3

B.3.2 Configuration

Connection configuration with a mobile cable reel is as shown in Figure B.1.

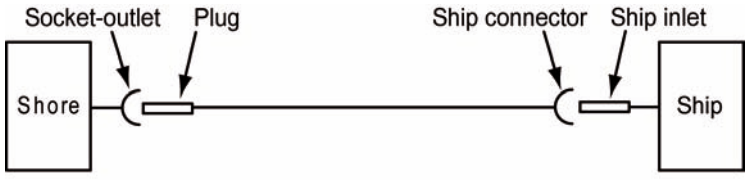


Figure B.1 – Connection with mobile cable reel

Connection configuration with a fixed cable reel on shore side is as shown in Figure B.2.

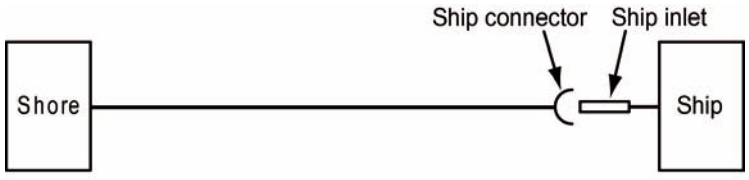


Figure B.2 – Connection with fixed cable reel

Annex C
(normative)

Additional requirements for Offshore Supply, Service and Working Ships

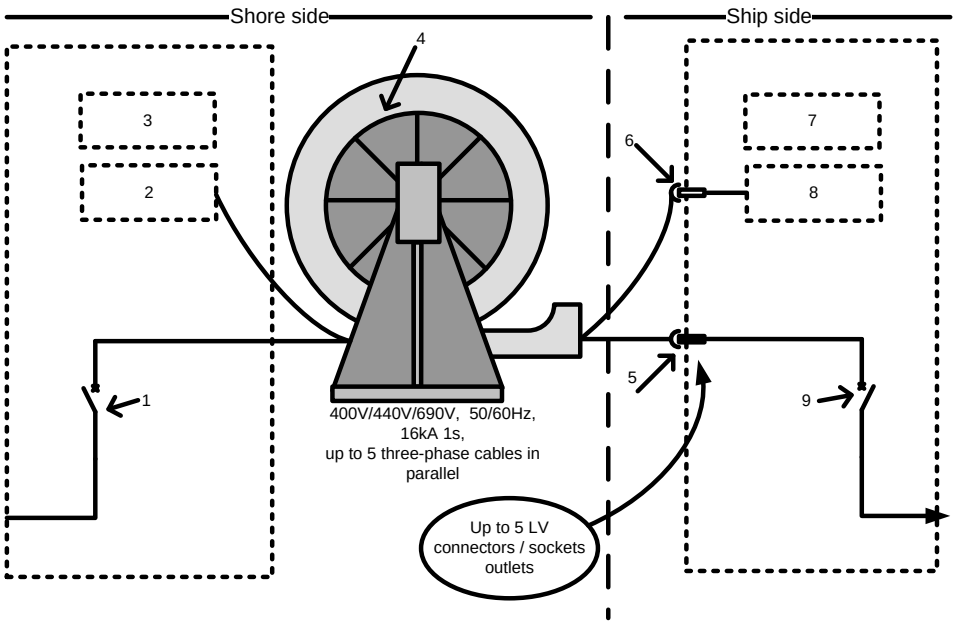
C.1 Scope

This annex describes the additional requirements on LVSC systems for Offshore Supply, Service and Working 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 makes reference to 4.1 in the main body.

C.4.1 System description

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



Key

1. SHORE-SIDE MAIN OR/AND FEEDERS CIRCUIT-BREAKER(S)
2. INTERLOCKS WITH PILOT WIRES SHORE SIDE
3. SHORE-SIDE PROTECTION RELAYING
4. CABLE HANDLING SYSTEM, HERE SHOWN AS ON SHORE CABLE REEL
5. LV-PLUG
6. PILOT WIRES (INTEGRATED IN PLUG AND SOCKET)
7. SHIP PROTECTION RELAYING
8. INTERLOCKS WITH PILOT WIRE SHIP SIDE
9. ON-BOARD SHORE CONNECTION SWITCHBOARD

NOTE The on-board shore connection switchboard will most likely be located above cargo decks, where in this example the cable monitoring will be a part of the onshore reel.

Figure C.1 – Example for general system layout

C.6.2.3 Neutral earthing resistor

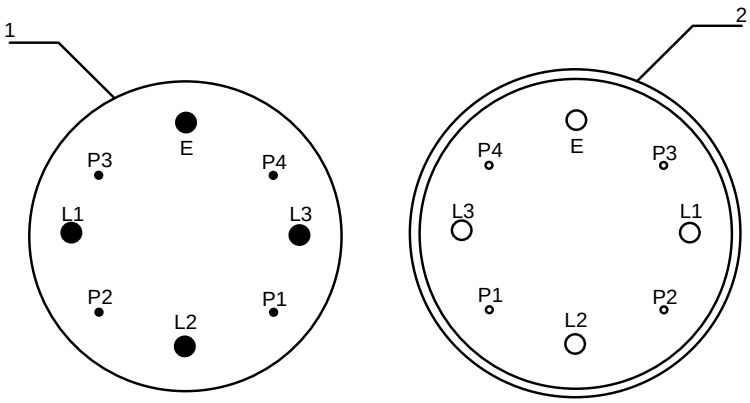
Where applicable, shore-side transformer star point shall be earthed through a neutral earthing resistor rated 25 Ω.

C.7.2.1 General

The cable management system shall be fitted at the shore-side facility (see Figure C.1).

C.7.3.1 General

General arrangement of the plug and socket-outlet shall be as shown in Figure C.2, in accordance with IEC 60309-5[4].



Key

1	PLUG/SHIP INLET FACE	2	SOCKET-OUTLET/SHIP CONNECTOR FACE
E	EARTH	P1	PILOT 1
L1	PHASE 1 – A – R	P2	PILOT 2
L2	PHASE 2 – B – S	P3	PILOT 3
L3	PHASE 3 – C – T	P4	PILOT 4

Figure C.2 – Power plug and socket-outlet contact assignment

The maximum short-circuit current is 16 kA / 1 s and a maximum peak short-circuit current of 40 kA, in accordance with IEC 60309-5.

Each plug, socket-outlet, ship connector and ship inlet shall be fitted with four pilot contacts.

For the design and dimensions of a power plug socket-outlet, ship connector or ship inlet, see IEC 60309-5.

4 To be developed by the IEC.

Annex D
(normative)

Additional requirements for Container Ships

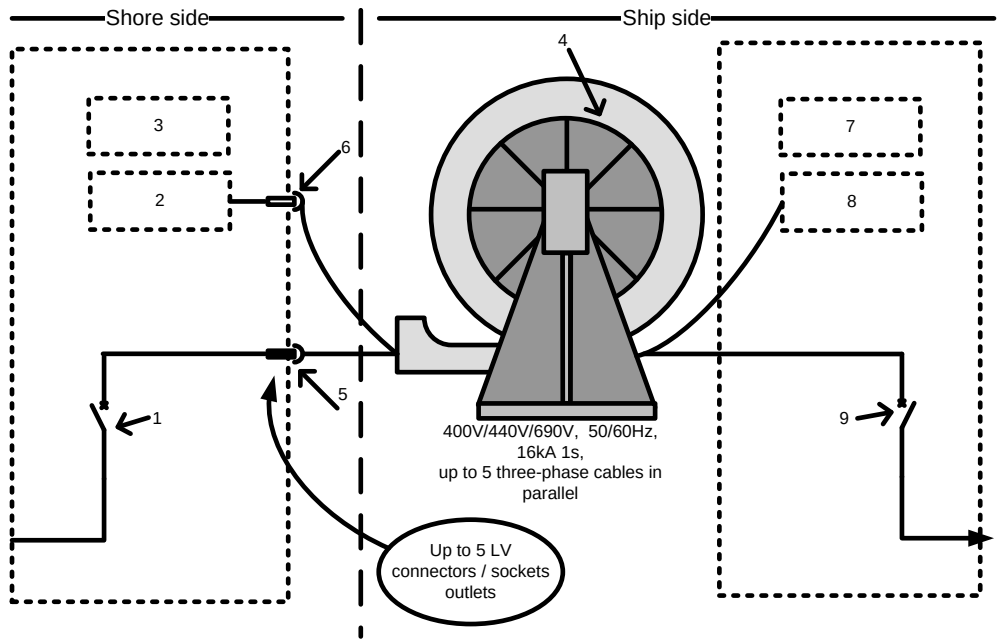
D.1 Scope

This annex describes the additional requirements on LVSC systems for 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.



Key

1. SHORE-SIDE MAIN OR/AND FEEDERS CIRCUIT-BREAKER(S)
2. INTERLOCKS WITH PILOT WIRES SHORE SIDE
3. SHORE-SIDE PROTECTION RELAYING
4. CABLE HANDLING SYSTEM, HERE SHOWN AS ON SHIP CABLE REEL
5. LV-PLUG
6. PILOT WIRES (INTEGRATED IN PLUG AND SOCKET)
7. SHIP PROTECTION RELAYING
8. INTERLOCKS WITH PILOT WIRE SHIP SIDE
9. ON-BOARD SHORE CONNECTION SWITCHBOARD

Figure D.1 – Example for general system layout

D.6.2.3 Neutral earthing resistor

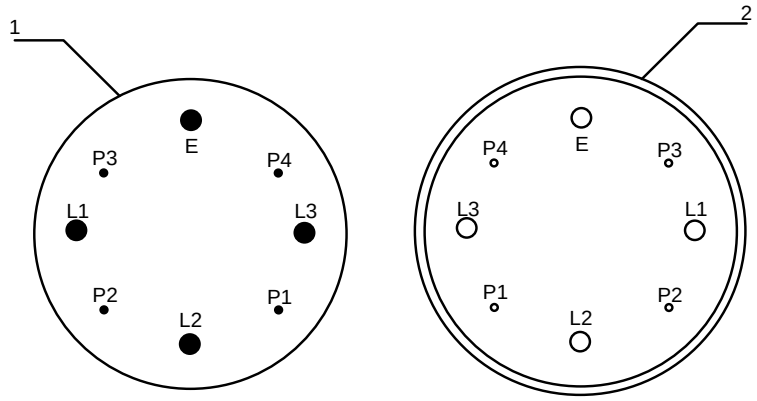
Where applicable, shore-side transformer star point shall be earthed through a neutral earthing resistor rated 25 Ω.

D.7.2.1 General

The cable management system shall be fitted at the ship-side facility (see Figure D.1).

D.7.3.1 General

General arrangement of the plug and socket-outlet shall be as shown in Figure D.2, in accordance with IEC 60309-5.



Key

1	PLUG/SHIP INLET FACE	2	SOCKET-OUTLET/SHIP CONNECTOR FACE
E	EARTH	P1	PILOT 1
L1	PHASE 1 – A – R	P2	PILOT 2
L2	PHASE 2 – B – S	P3	PILOT 3
L3	PHASE 3 – C – T	P4	PILOT 4

Figure D.2 – Power plug and socket-outlet contact assignment

The maximum short-circuit current is 16 kA / 1 s and a maximum peak short-circuit current of 40 kA, in accordance with IEC 60309-5.

Each plug, socket-outlet, ship connector and ship inlet shall be fitted with four pilot contacts.

For the design and dimensions of a power plug socket-outlet, ship connector or ship inlet, see IEC 60309-5.

Annex E
(normative)

Additional requirements for Tankers

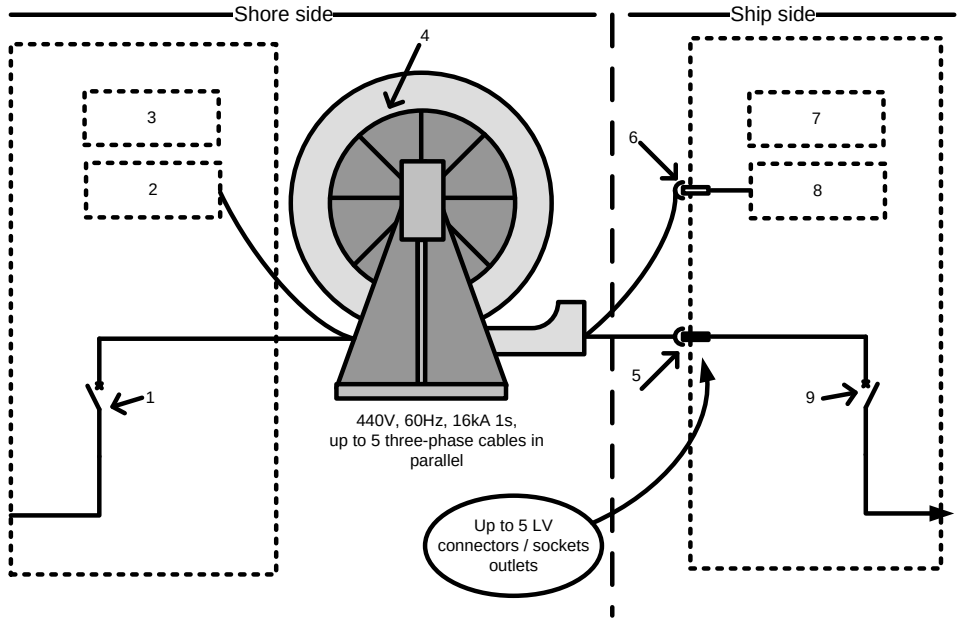
E.1 Scope

This annex describes the additional requirements on LVSC 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 E.4.1 makes reference to 4.1 in the main body.

E.4.1 ystem description

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



Key

1. SHORE-SIDE MAIN OR/AND FEEDERS CIRCUIT-BREAKER(S)
2. INTERLOCKS WITH PILOT WIRES SHORE SIDE
3. SHORE-SIDE PROTECTION RELAYING
4. CABLE HANDLING SYSTEM, HERE SHOWN AS ON SHORE CABLE REEL
5. LV-PLUG
6. PILOT WIRES (INTEGRATED IN PLUG AND SOCKET)
7. SHIP PROTECTION RELAYING
8. INTERLOCKS WITH PILOT WIRE SHIP SIDE
9. ON-BOARD SHORE CONNECTION SWITCHBOARD

Figure E.1 – Example for general system layout

E.4.9 Emergency shutdown including emergency-stop facilities

Intrinsically Safe (IS) barriers shall be provided on ship and on the shore for the safety circuits. The safety circuit shall be designed according to IEC 60079-11.

E.5.1 Voltages and frequencies

To allow standardisation of the LV shore supply and link nominal voltage in different ports, LV shore connections shall be provided with a nominal voltage of 440 V AC galvanically separated from the shore distribution system.

The operating frequency shall be 60 Hz.

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

E.6.2.3 Neutral earthing resistor

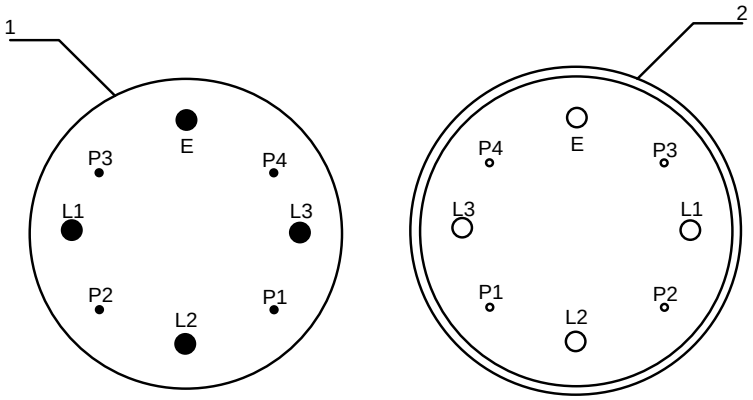
LVSC utilizes IT system, so neutral earthing resistor shall be disconnected or may be omitted. Special cares should be taken during the design and operations phases related to IT systems (see IEC 60364).

E.7.2.1 General

The cable management system shall be fitted at the shore side facility (see Figure E.1).

E.7.3.1 General

General arrangement of the plug and socket-outlet shall be as shown in Figure E.2, in accordance with IEC 60309-5.



KEYS

1	PLUG/SHIP INLET FACE	2	SOCKET-OUTLET/SHIP CONNECTOR FACE
E	EARTH	P1	PILOT 1
L1	PHASE 1 – A – R	P2	PILOT 2
L2	PHASE 2 – B – S	P3	PILOT 3
L3	PHASE 3 – C – T	P4	PILOT 4

Figure E.2 – 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, in accordance with IEC 60309-5.

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

For design and dimensions of a power plug, see IEC 60309-5.

The parameters of the IS barrier and cable length property limitations are given in Figure E.3 and a replacement for Figure 4 in the main body in Figure E.4.

Figure E.3 – IS Barrier and cable properties (to be developed)

Figure E.4 – Safety loop circuit for LVSC system in tankers (to be developed)

Annex F
(normative)

General operating procedures

A low voltage shore connection system operation, on shore and on board, shall include procedures shown in Figure F.1.

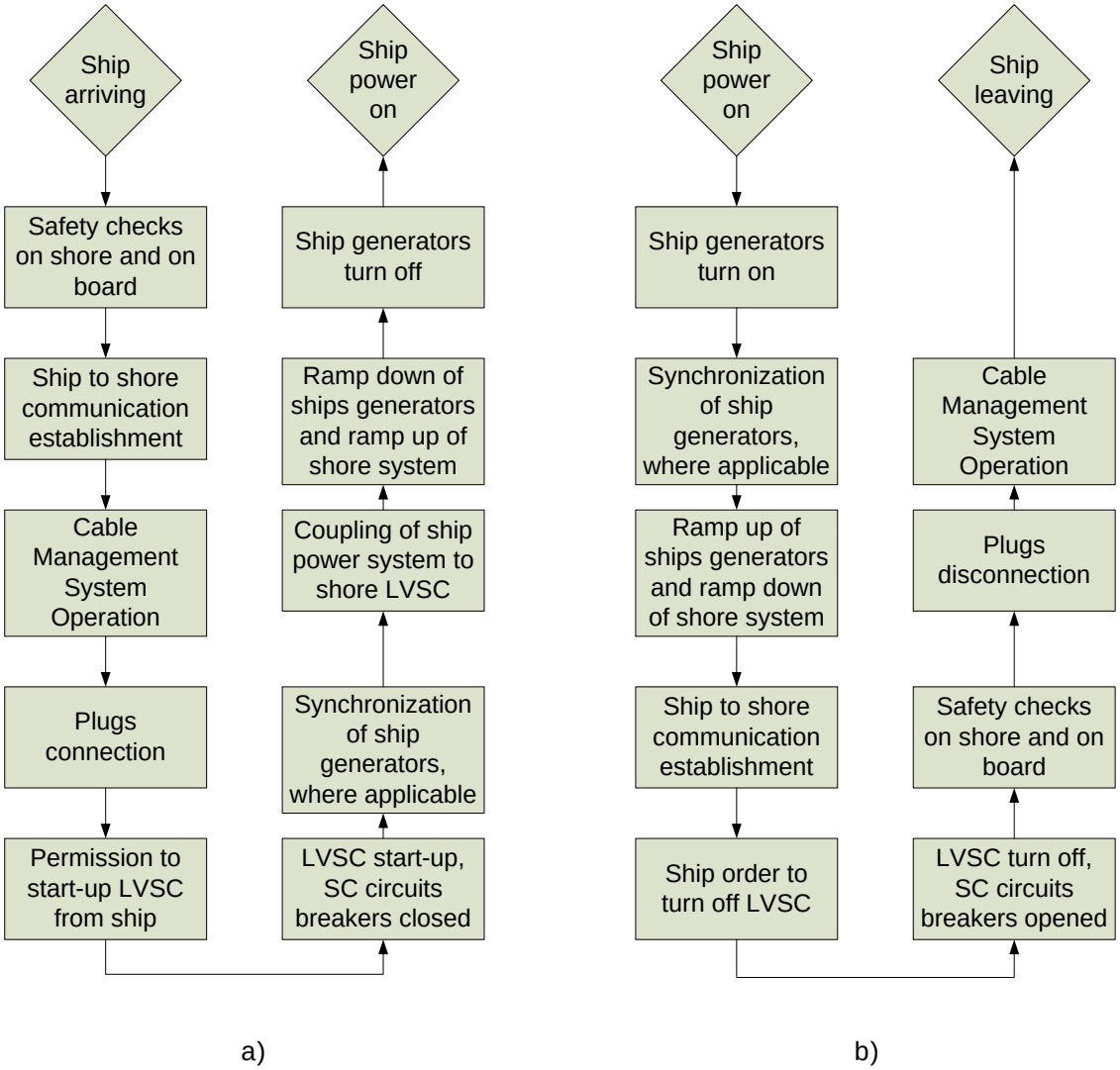


Figure F.1 – LVSC general operating procedures for connection a) and disconnection b)

These procedures may depend on the ship type, the shore substation design, and port maintenance requirements.

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