Onshore Power Supply Systems

Recommendations for Tankers and Terminals

(First edition 2025)

Issued by the

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The Oil Companies International Marine Forum (OCIMF)
Founded in 1970, the Oil Companies International Marine Forum (OCIMF) is a voluntary association of oil companies having an interest in the shipment and terminalling of crude oil, oil products, petrochemicals and gas, and includes companies engaged in offshore marine operations supporting oil and gas exploration, development and production.

Our vision is a global marine industry that causes no harm to people or the environment.

Our mission is to lead the global marine industry in the promotion of safe and environmentally responsible transportation of crude oil, oil products, petrochemicals and gas, and to drive the same values in the management of related offshore marine operations. We do this by developing best practices in the design, construction and safe operation of tankers, barges and offshore vessels and their interfaces with terminals and considering human factors in everything we do.

Contents

Glossary

Authority having jurisdiction An organisation, office or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation or a procedure.

Auxiliary systems Systems that support the primary operations of a ship.

Berth A facility where a ship moors alongside.

Berthing Bringing a ship to berth until the ship is made fast.

Cable Management System (CMS) Equipment to control, monitor and handle the shore power cables on a terminal to ensure safe and efficient connectivity to the ship.

Cargo pumping system The system on a tanker used for loading and discharging liquid cargo.

Circuit breakers Automatically operated electrical switches designed to protect an electrical circuit from damage caused by overload or short circuit.

Class See Marine Classification Society.

Competent Person A person who has adequate training and experience to undertake the tasks they are required to perform within their job description.

Coupling The act of physically joining the ship connector and the ship inlet.

Deadweight (DWT) The difference between the displacement and the mass of the empty ship (lightweight).

Decoupling The act of physically separating the cable connector and the ship inlet. See 'Separation'.

De-energising The process of removing electrical power from a circuit or system, rendering it non-operational.

Disconnection Intentional interruption or breaking of the power supply by a circuit breaker.

Displacement The mass of water in tonnes displaced by a ship at a given draught.

Earthing The electrical connection of equipment to the main body of the 'earth' to ensure that it is at earth potential. On board ship, the connection is made to the main metallic structure of the ship. In industry practice, the terms 'earthing' and 'grounding' are often used interchangeably, despite some regional and technical distinctions. For clarity and consistency, the term 'earthing' has been used throughout this publication.

Electrical load The amount of electrical power consumed by all equipment and devices in a system at any given time.

Emergency Shutdown (ESD) A method that effectively stops the transfer of fluid and vapour between ship and terminal.

Energising The process of applying electrical power to a circuit or system.

Equipotential bonding The connecting of metal parts to ensure electrical continuity, intended to achieve equipotentiality.

Explosion-proof Electrical equipment is defined and certified as explosion-proof when it is enclosed in a case that is capable of withstanding the explosion within it of a hydrocarbon gas/air mixture or other specified flammable gas mixture. It must also prevent the ignition of such a mixture outside the case either by spark or flame from the internal explosion or as a result of the temperature rise of the case following the internal explosion. The equipment must operate at such an external temperature that a surrounding flammable atmosphere will not be ignited.

Flag state The government of the country in which the ship is registered. The authority that issues all certificates related to the operation of the ship and is responsible for inspections to ensure compliance with appropriate standards. Also known as Flag Administration.

Frequency converter A device that changes the frequency of electrical energy.

Hazard and Operability Study (HAZOP) A structured, team-based approach to investigate how a system or plant in operation deviates from the design intent and creates risk for personnel and equipment resulting in operability issues.

Hazard Identification Study (HAZID) A structured, team-based approach to identify hazards, their potential consequences, and requirements for risk reduction.

Hazardous area A place in which a sufficiently explosive atmosphere may occur to require special precautions to protect workers.

Hazardous zone A hazardous zone is a classification designation found within a hazardous area and is determined by an assessment based upon the frequency of the occurrence and duration that an explosive gas atmosphere may be present.

High voltage Nominal voltage exceeding 1000V AC or 1500V DC.

Ingress protection rating (IP) The degree of protection offered by electrical enclosures against the intrusion of dust or liquid. IEC standard 60529.

Inlet Also referred to as Ship inlet. Part incorporated in, or fixed to, the ship.

Interlocks A safety device used to prevent undesired states in equipment, ensuring that operations happen in the right order.

International Safety Management (ISM) Code The International Management Code for the Safe Operation of Ships.

Load factor A ratio that represents the relationship between actual power consumed and the maximum possible power that could be consumed. It is used to estimate expected electrical loads.

Lock Out/Tag Out (LOTO) Lockout/tagout practices and procedures safeguard workers from hazardous energy releases.

Low voltage Nominal voltage less than or equal to 1000V AC or 1500V DC.

Marine Classification Society A marine classification society, or classification organisation, is a non-governmental entity responsible for setting and upholding technical standards for the construction and operation of ships and offshore structures. These societies ensure that ships are built in accordance with the relevant standards and conduct regular inspections during the ship's service life to confirm ongoing compliance.

Marine loading arm A mechanical device used to load and discharge fluids from a tanker to a shore-based facility.

Maximum Electrical Load The largest amount of electrical power that a system can demand or consume.

Nominal voltage The designated voltage of an electrical system or circuit.

Onboard ship frequency The nominal frequency of the electrical power distribution system used on a ship.

Onshore Power Supply (OPS) The provision of shoreside electrical power to a ship when berthed.

Opening/closing circuits The actions of making or breaking an electrical connection to control the flow of electricity. Opening a circuit interrupts the flow, while closing a circuit allows the flow of electricity.

Phase In electrical engineering, this refers to the distribution of the load in an AC system. A 3-phase system divides the total electrical load across three conductors.

Pilot contact Low voltage contact in the shore power connector and ship inlet for equipment status and/or safety interlocking.

Plug The part intended to be attached directly to one flexible cable.

Port Authority A public or a private entity that under national law or regulation is empowered to carry out the administration, development, management and, occasionally, the operation of a port.

Power Management System (PMS) On tankers the Power Management System is in charge of controlling the electrical system to make sure that the electrical system is safe and efficient.

Rack-in The process of moving the high voltage circuit breaker from the disconnected position to the connected position. When a breaker is racked in, it is fully engaged with the bus bars and control circuits, making it ready to operate and carry current.

Rack-out The process of moving the high voltage circuit breaker from the connected position to the disconnected position. When a breaker is racked out, it is disengaged from the bus bars and control circuits, ensuring that it is isolated and safe for maintenance or inspection.

Responsible Person A person who has the skills, knowledge and experience to be able to recognise hazards and put sensible controls in place to protect personnel and others from harm.

Separation Is the physical isolation or disengagement of the connector from the ship inlet. See 'Decoupling'.

Ship Any vessel, including barges, that is designed to carry oil, liquefied gasses or chemicals in bulk. See 'Tanker'.

Ship connector High voltage shore power connector intended to be attached to flexible cable at the ship end. Also referred to as connector, cable connector, shore power connector, ship inlet and OPS connector.

Ship coupler Combined ship connector and ship inlet.

Ship inlet High voltage shore power inlet at ship connection point, incorporated in, or fixed to, the ship. Generally, with 3-phase power and protective earth (ground) pins plus pilot wire pins.

SOLAS The International Convention for the Safety of Life at Sea (SOLAS) is an international maritime treaty which sets out minimum safety standards in the construction, equipment and operation of merchant ships. The SOLAS convention is an instrument of the IMO.

Supply side and load side The supply side ends at the ship connector. The load side extends from the ship inlet towards the ship's grid.

The supply side refers to the point where electrical power is provided from the shore. This point is situated before any equipment or devices that consume or distribute the power. It encompasses the source of power and the initial segments of the power delivery infrastructure that directly connect to the shore power supply.

The load side refers to the equipment or devices that use the provided electrical power. This includes Cable Management Systems (CMS) and other devices that consume power for operation. It is located after all devices that regulate, control, or protect the power supply, such as disconnectors, vacuum contactors, transformers and protective relays. It represents the segment of the power distribution system where energy is converted into useful work or operational functions.

Tan Delta testing Tan Delta, also known as the loss angle or dissipation factor, measures the dielectric losses in cable insulation. Tan Delta testing evaluates the quality and condition of the cable insulation by measuring the phase angle difference between the applied voltage and the resulting current.

Tanker A ship designed to carry liquid petroleum or chemical cargo in bulk, including a combination carrier when being used for this purpose. Note: Product, Aframax, Panamax, Suezmax and VLCC are size classifications of oil tankers.

Terminal A place where tankers are berthed or moored to for the purpose of loading or discharging petroleum cargo.

Terminal Information Booklet (TIB) A document providing specific information about a terminal, including facilities, safety, and operational procedures.

VLF testing VLF refers to the use of a very low-frequency alternating current (AC) voltage to test electrical equipment, specifically high-voltage cables.

Abbreviations

AHJ	Authority Having Jurisdiction
ATC	Automatic Tap Changer
CMS	Cable Management System
DOL	Direct On Line
DWT	Deadweight
ESD	Emergency Shutdown
GHG	Greenhouse Gas
HAZID	Hazard Identification Study
HAZOP	Hazard Operational Study
HV	High Voltage
HVSC	High Voltage Shore Connection
Hz	Hertz
IAPH	International Association of Ports and Harbours
ICCP	Impressed Current Cathodic Protection System
ICS	International Chamber of Shipping
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IEV	International Electrotechnical Vocabulary
IMO	International Maritime Organization
IP	Ingress Protection
ISGOTT	*International Safety Guide for Oil Tankers and Terminals*
ISM	International Safety Management Code
KV	Kilovolt
LOA	Length Overall
LOTO	Lock Out/Tag Out
LV	Low Voltage
MVA	Megavolt Amps
NER	Neutral Earthing Resistor
OPS	Onshore Power Supply
PED	Potential Explosive Domain
PMS	Power Management System
PIC	Person in Charge (of the OPS system on the ship-side or terminal side)
PLC	Programmable Logic Controllers

SIGTTO	Society of International Gas Tanker and Terminal Operators
SMS	Safety Management System
SSSCL	Ship Shore Safety Checklist
STCW	The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers
TIB	Terminal Information Booklet
UPS	Uninterruptible Power Supply
VLCC	Very Large Crude Carrier
VLF	Very Low Frequency

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NFPA 68: Standard on Explosion Protection by Deflagration Venting

NFPA 70B: Recommended Practice for Electrical Equipment Maintenance

NFPA-496: Purged and Pressurised Enclosures for Electrical Equipment

1 Introduction

The adoption of an Onshore Power Supply (OPS) brings environmental advantages to maritime operations in ports and terminals. By using shore-based electrical power while at a berth, ships can stop running their onboard diesel generators, reducing their emissions. This could contribute to improved local air quality with potential Greenhouse Gas (GHG) emission reduction (depending on grid GHG intensity) and aid in compliance with environmental regulations.

To aid the uptake of OPS, OCIMF assembled a workgroup comprising industry experts from different organisations representing standardisation bodies, shipowners, ship operators, charterers, ports and terminals, and classification societies.

The OCIMF workgroup collected best practices for OPS systems and evaluated potential hazards to ensure the appropriate critical safeguards were considered in developing this guidance. The workgroup conducted a survey of tanker owners and operators, with responses representing 550 tankers of different types and sizes. The survey provided insight into each ship's electrical installations, cargo systems, and power consumption patterns, including electrical load demands when loading and discharging cargo.

The publication serves as guidance for the design, implementation, and operation of OPS systems for tankers and marine terminals. It encompasses the considerations necessary for safe, efficient and compliant OPS operations.

The publication is organised into three parts: Tanker, Marine Terminal, and Interface. Each part addresses critical aspects of OPS, from design and equipment specifications to operational procedures, maintenance protocols, personnel training and competency requirements.

This publication supersedes OCIMF's information paper *Onshore Power Supply Systems: Preliminary Design Recommendations for Tankers and Terminals.*

1.1 Purpose and scope

The primary purpose of this publication is to provide recommendations to assist personnel involved in the design, implementation, and operation of OPS systems for terminals and all tanker types, except gas carriers. It offers guidance on the safe and efficient delivery and use of shore-based electrical power to ships at a berth, promoting environmental protection and regulatory compliance.

This publication provides recommendations on, and examples of, certain aspects of OPS design, installation, and operation. However, it does not provide a definitive description of how OPS systems are to be implemented. Effective management of risk, demands Safety Management Systems (SMS), processes, controls and procedures that can quickly adapt to change. Therefore, the guidance given is, in many cases, focused on functional and performance requirements, and detailed procedures should be adopted by operators in the management of their operations. These procedures may exceed the recommendations contained in this publication and are strongly encouraged where they will further enhance the safety objective.

When adopting alternative procedures, operators should follow a risk-based management process that incorporates systems for identifying and assessing risks and demonstrating how they are safely managed. This publication provides guidance to further assist operators of tankers and marine terminals in the principles of safe management. For shipboard operations, this course of action must satisfy the International Safety Management (ISM) Code requirements.

In all cases, the guidance in this publication is subject to any applicable international, national or local regulations and is intended only to complement or strengthen those requirements. Companies responsible for operating tankers and terminals should ensure that they are aware of any such requirements and fully comply.

It is recommended that this information paper be accessible on board every tanker and marine terminal involved in OPS operations to provide guidance on operational procedures and the shared responsibility for operations at the ship/shore interface.

Certain subjects are dealt with in greater detail in other publications issued by the International Maritime Organization (IMO), the International Electrotechnical Commission (IEC), OCIMF or other maritime industry organisations. Where this is the case, an appropriate reference is made, and a list of these publications is given in the bibliography.

This publication does not make recommendations on the commercial aspects of OPS, such as pricing, contracts, or incentives. Information on these matters may be obtained from national authorities, port authorities and relevant industry stakeholders.

Finally, this publication is not intended to encompass barges, gas carriers, gas terminals or double-banking operations. Operators of such units may, however, wish to consider the guidance given to the extent that good tanker practice is equally applicable to their operations.

PART 1: TANKER

2 General

This section provides an overview of a typical OPS system and identifies the codes and standards that apply to the provision of shore power supply to oil, product and chemical tankers.

2.1 OPS system overview

An OPS system delivers power from the shore-side electrical grid to the tanker via high-voltage electrical cables, as depicted in figure 2.1.

Once the cables are connected and energised, the ship can synchronise its onboard electrical generators with the shore grid, transfer the electrical load to the shore, and disconnect its onboard generators. This load transfer can be completed without blacking out the ship. The ship's generators can then be shut down and placed in standby mode. From that point, the ship's electrical source is the shore-side grid. Normal at-berth operations can proceed.

Before the vessel departs, the OPS process is reversed: the ship powers on its electrical generators, shifts the electrical load back onboard, de-energises the OPS system, and disconnects the cables prior to departure.

A typical OPS system comprises shore-side components provided by the terminal and onboard components provided by the ship. The shore-side components typically include a power supply from the electrical grid, transformers, frequency converters, circuit breakers, protective relays, earthing switches, Cable Management Systems (CMS), and electric cables fitted with ship connectors. The onboard components typically include ship inlets, circuit breakers, earthing switches, protective relays, and receiving switchboards. Many OPS installations on tankers also include an onboard transformer to step down the voltage.

The CMS is responsible for delivering the cables to the correct position onboard the ship. For tankers, the point of OPS connection and disconnection is on the ship. The high-voltage power cables at the end of the CMS are fitted with a ship connector, and the ship is equipped with a matching ship inlet.

The size, position, and features of the OPS system are described in further detail in the following sections.

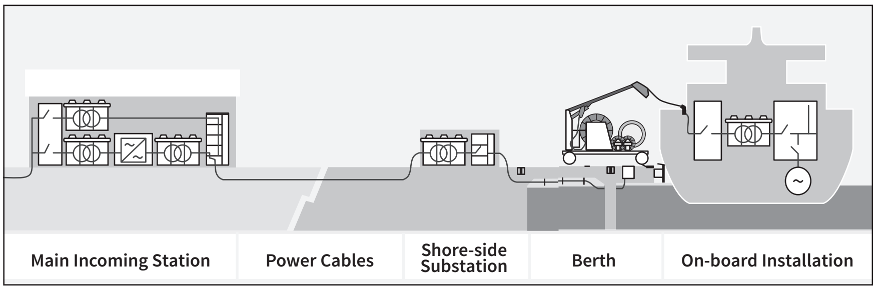

Figure 2.1: *Indicative overview of OPS system configuration – actual configurations may vary*

2.2 Codes and standards

The IMO has provided interim guidelines on the safe operation of onshore power in ports for ships engaged in international voyages, including tankers, in IMO MSC.1 circular 1675.

IEC/IEEE 80005-1, *Utility connections in port – Part 1: High Voltage shore connection (HVSC) systems – General requirements* outlines the technical requirements for High Voltage (HV) shore connection supplies. It aims to ensure interoperability and compatibility between ship and shore installations within pre-defined safety parameters.

If the ship's classification society has a high voltage shore power notation, it is recommended that the notation be applied to the tanker.

All relevant international and national regulations should be followed where applicable, along with local and regional terminal requirements.

3 Ship layout and design consideration

This section provides guidance for shipboard layout and location of the OPS equipment considering hazardous areas, structural design, interaction with other equipment, orientation, ship movement, access, equipment protection and human-oriented design.

3.1 Ship and shore electrical hazardous areas

On tankers, hazardous areas are sometimes described as Gas Dangerous Spaces and Areas. The arrangement of equipment in hazardous areas is defined as required by classification society rules. Typically, the designation of the hazardous zones is aligned with IEC 60092-502 *Electrical installations in ships – Tankers – Special Features.*

On terminals, similar standards may apply according to national regulations. Typically, the designation of the zones is aligned with IEC-60079-10-1, API RP 500, or API RP 505.

The OPS ship coupler point should be in a non-hazardous environment. Alternatively, a non-hazardous space may be created for the purposes of OPS. See section 4.12 Coupling space and compartment. Hazard rated inlet and coupler should not be used.

It is important to note that an OPS ship coupler point might be outside the ship's hazardous area but still considered within a hazardous area by the terminal. A terminal may require additional precautions before permitting OPS operations. Due diligence and risk assessments are critical.

The OPS ship inlet should be at a location that is considered non-hazardous by both the terminal and ship operator.

Prior to coupling or decoupling/separation of the OPS cables at the ship inlet, the coupling location should be confirmed hazard and gas free. The risk of a spark from making or breaking galvanic currents is present even when the OPS cables are deenergised and earthed.

If the ship inlet is in a space where ship systems are needed to create and maintain a non-hazardous boundary within a larger hazardous area, the space should be in a safe condition before any OPS circuits are coupled, energised, or decoupled/separated.

Hazardous area classification onboard a tanker is based upon IEC 60092-502 and additional requirements from flag state. Hazardous area classification onboard a tanker is approved by marine classification societies. Where the prescriptive requirements for the ship within SOLAS and related codes (IBC and IGC Codes) and the standards published by the IEC, such as, but not limited to IEC 60092-502, are not aligned, the prescriptive requirements in SOLAS and other relevant IMO instruments should take precedence and be applied (reference IMO MSC.1/Circ.1557/Rev.1).

Before installing OPS hardware onboard, the ship owner should have a class-approved hazardous area classification drawing that includes the OPS equipment. If OPS components are installed in or pass through a hazardous area, as defined by the ship's hazardous area classification drawing, that installation must adhere to the IEC 60092-502 and any additional flag state requirements.

3.2 Structural design requirements

OPS ship inlets may require additional external structures on the ship to support the equipment. Additional OPS equipment on the ship may include access platforms, cable guides, cableways, access barricades, and coupling rooms. For the on-deck coupling points, additional platforms may be needed to elevate the OPS equipment above the space needed for mooring, cargo operations, store handling, bunkering, and other routine ship activities. Additional structure may be needed to protect the OPS equipment from the weather and to maintain an appropriate arc flash boundary.

Careful consideration is needed when adding equipment and structure to fit harmoniously with existing ship systems and operations. New structures should not interfere with lifesaving or firefighting equipment. Nor should they inhibit the use of existing cranes onboard the ship. Existing evacuation routes should not be impeded by new OPS equipment and barricades.

In the machinery spaces, space should be allocated for shore power equipment such as receiving switchboards, transformers, and main switchboard extensions. Maintenance space should also be preserved both for OPS equipment and nearby ship systems. Additional cable supports may be needed in the machinery spaces for new cable routing. Marine classification society rules regarding segregation and routing of high voltage cables are to be followed.

Structural changes to the ship are to be done with the approval and inspection of the ship's classification society and the ship's flag state by the qualified designer, where considered necessary. Impacts to the ship's load line and the trim and stability of the ship should be evaluated in detail by the designer. Revised drawings are to be approved by a recognised organisation reviewing on behalf of the flag state. Impacts on normal and emergency operations and maintenance are to be evaluated by the ship owner prior to construction. A management of change procedure should be followed.

3.3 Location of the OPS inlet onboard the ship

The relative position of the OPS ship inlet onboard the ship is not prescribed. Ship owners and terminal operators should work together to determine the best location for the OPS ship inlet. Ship owners should complete a terminal compatibility study and risk assessment. The OCIMF working group determined that the preferred ship connection point is aft, near the accommodation/machinery spaces, but each ship owner/operator should make their own risk-based determination.

Per the IEC 80005-1 standard, the OPS ship inlet point should be outside of electrically classified hazardous areas. The inlet point should be in a non-hazardous area as identified by the ship's hazardous area plan and the terminal's hazardous area plan. A coupling space onboard the ship may be made non-hazardous by means of a hazard-free space such as a pressurised, gas-free compartment and/or other protective measures.

When the ship owner decides to position the OPS ship inlet away from the hazardous area, the preferred location is aft. This location is away from hazardous cargo tanks and close to the ship's switchboards and electrical protection systems. One challenge that should be considered is the variability in the length and shape of ships. The OPS CMS may need to reach far for an aft coupling point on some ships.

Alternatively, ship owners could position the ship inlet closer to the manifold, above the cargo tanks. This location allows terminals to position the OPS CMS closer to the cargo loading equipment, which may accommodate ships of different lengths.

If OPS inlets are close to the side of the ship near the manifold, then the positions should be as follows. To allow for the same positioning of the CMS on the terminal side, the OPS ship inlet should be aft of the cargo manifold on the port side of the ship and forward of the manifold on the starboard side of the ship. If the OPS coupler near the manifold is along the centreline of the ship the coupler position should be forward of the manifold area.

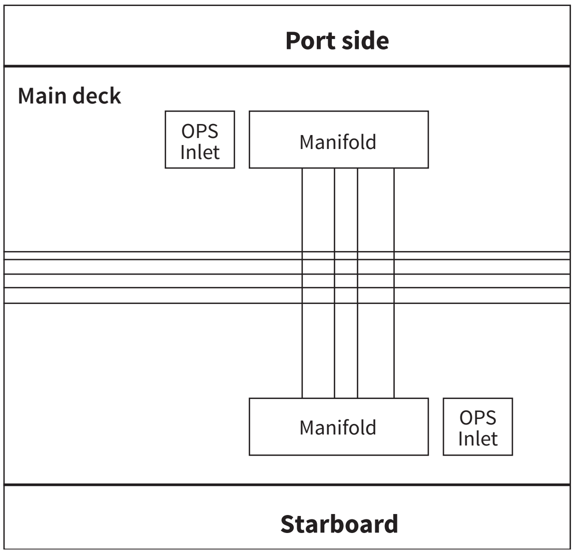

Figure 3.1: *Example of ship inlets positions with reference to the manifold when near the midship*

The OPS cable route should not transit a Hazardous Zone 1 electrical classified area.

3.4 Cable lifting

The recommended configuration is that cable lifting is managed as a function within the shore-based CMS. A detailed description of a CMS is outlined in Section 7.2.1 of IEC 80005-1, which includes provisions for:

- Moving the OPS cable to span the supply and receiving points (7.2.1(a)).
- Retrieving and stowing the cables after operations (7.2.1(h)).

It is recommended that cable lifting be entirely controlled from the shore to ensure smooth integration with other shoreside cable management functions.

According to IEC 80005-1 Annex F, which provides additional requirements for tankers, the CMS should be shore-supplied. However, this guide allows for using the ship's lifting appliances – such as midship or aft cranes – as an alternative.

Ships' cranes may be used for cable lifting in situations where shore-supplied systems are unavailable. The use of a ship's crane for OPS cable lifting requires agreement between the ship operator and the terminal operator before chartering the ship.

The ship's crane should be assessed for the intended service. The ship operator is responsible for providing details about the crane's working radius, lifting height, and safe working load. Typical marine provision cranes have limited reach past the ship side, and there is no expectation for ship owners to modify ships' cranes for OPS. The terminal operator should supply information on the maximum allowable lifting speed and any restrictions on cable bending. The terminal operator should share the expected working load based on the anticipated amount of cable deployed. Harnesses and other lifting devices should be supplied, attached, and maintained by the terminal operator.

If ships' cranes are used, they should not provide ongoing support to the OPS cables once they are positioned and secured. The ship's crane should be available for other functions once the cables are in place.

Any ships' cranes used for OPS cable lifting must comply with the requirements set forth in SOLAS Chapter II-1 Regulation 3-13 and the IMO MSC.1/Circ. 1663 *Guidelines for Lifting Appliances.*

As per the IMO MSC.1/Circ. 1663 *Guidelines for Lifting Appliances,* all personnel involved in a lifting operation should understand their roles. Effective communication between ship's personnel and shore-based personnel is crucial during the lifting operation. Specifically, the signals to start, coordinate, and halt the cable lifting operation should be clearly established.

Ship movements should be considered. The cable lift system, whether operated from shore or ship, should allow for the individual payout of cables to establish the correct leads for the coupler and the ship inlet.

The system should be able to ensure cable parameters are not exceeded while accommodating a wide range of movement due to:

- Variations in ship size and shore power connection box location.
- Changes in ship draught and trim (from ballast to laden).
- Tidal variations and ship motion around its moorings.

Operators should prevent damage to the cables from, but not limited to, the following causes:

- Excess bending, abrasion, immersion.
- Unintended contact with the ship, berth, or mooring lines.

For monitoring cable movement and preventing excess strain, see section 5.3 Cable movement monitoring and prevention.

3.5 Interaction of cabling with mooring system

As per IEC 80005-1 7.2.1(d) the position of the shore power coupler is to be positioned to avoid interference with the ship's mooring systems. The risk of a snapping mooring line damaging a high-voltage cable should be minimised. For that, high-voltage cables should be kept away from the snap-back area of mooring lines as far as practicable.

A berth/ship compatibility assessment for OPS as described in detail in section 16 is recommended when evaluating whether a ship can safely use the berth. Prior to berthing, the ship operator should complete a detailed mooring plan and share it with the terminal operator. While alongside, the ship personnel should be responsible for monitoring the OPS coupler.

When an emergency requires a rapid departure of the ship, the OPS system should be de-energised, decoupled, and removed from the tanker before mooring lines are released. See section 16.8 Emergency OPS decoupling procedure.

3.6 Interaction of cabling with gangway and cargo transfer equipment

OPS cables should not be attached to a gangway. OPS equipment should not interfere with the deployment, use, or stowage of gangways or pilot ladders. OPS cabling should not pass over or under a gangway. Personnel should have access to gangways without needing to pass through a barricaded arc flash zone around the OPS ship inlet.

OPS CMS should not restrict the cargo transfer system, hoses or loading arms. OPS cabling should not pass over or under the cargo transfer equipment such as hoses or loading arms. Cabling should not be connected to equipment used for cargo transfer. Loading arm style OPS CMS are acceptable, if the arm is dedicated to the OPS.

Cable lifting is the terminal's responsibility. Alternative arrangements and responsibilities for lifting would need to be agreed between all parties. See section 3.4 Cable lifting.

3.7 Accommodating varying ship orientation at a berth

The OPS CMS should be located onshore in accordance with IEC/IEEE 80005-1. Ships should be equipped with a high voltage inlet(s) to accommodate the ship connector from the shoreside CMS. The final coupling between connector and inlet should be onboard the ship.

A ship's orientation at a berth can be port-side-to, starboard-side-to, or even stern-to in some cases. The orientation is based on factors such as tide, current, terminal configuration, and cargo requirements. A specific ship orientation for OPS service is not prescribed here. Different terminals may opt to only prepare OPS service for a particular ship orientation based on local conditions. The ship's OPS ship inlet position should be part of the ship compatibility checks completed prior to chartering the ship.

To provide flexibility for berthing orientation, a ship may be designed with multiple OPS ship inlets. In these cases, the onboard OPS switchgear should be interlocked so that only one inlet can be active at a time.

The OPS ship inlet may be located anywhere between the ship side and the centreline. Smaller ships may favour a single centreline location which can serve different ship orientations. Due to the expected limited reach of onshore CMS, larger ships will require OPS inlets closer to the ship side. Also, it is preferable to have the connection close to the tanker's sides to minimise cable lengths running across the deck. Positioning the OPS ship inlet directly at the deck edge is not recommended, and space should be allowed for personnel to safely manoeuvre, bend, and guide the cable connectors into the inlets.

3.8 Accommodation for ship movement

Terminals may impose requirements on the ship for how OPS cable slack is managed if a CMS requires cable slack to absorb ship movement in the surge, sway and heave axes.

The onboard routing of cable should allow for cable movement without abrasion or pinch points.

The ship's OPS cable guides should be fitted with approved padeyes within the structure to allow for cable grips or other wire anchors that may deploy as part of the onshore CMS. The padeyes' safe working loads are to be documented and shared with the terminal during vetting. See sections 5.3 Cable movement monitoring and prevention, 9.2 Effective Cable Management System (CMS) and 10.8.1 Cable grip device.

3.9 Access restrictions at the OPS ship inlet point

The coupling may be completed manually by personnel or via an unmanned mechanical system. Only trained personnel from the ship or terminal should perform the coupling and decoupling.

The coupling should be made while the OPS system is de-energised, isolated and the earthing switch shore-side and onboard the ship are closed. Note, even while de-energised there is a risk of spark between ship connector and ship due to galvanic current.

With all high-voltage power systems, electric shock and arc flash are a serious hazard. To manage the hazard, the coupling space should have access control measures such as lockable compartment access or fixed barricades that restrict access. In consultation with the owner/operator, class and/or flag state the OPS system designer should be responsible for determining the safe perimeter around the OPS coupler. Potential arc-flash gases in the coupling space should be vented to a safe area.

Barriers should be put in place to prevent unauthorised access to the cable route. This may have implications for arranging the cable route in relation to emergency escape routes.

See section 11.7 for further detailed considerations on arc flash for electrical equipment.

3.10 Cable routing and protection

The OPS cable route from the ship side to the inlet should be protected from mechanical damage, dropped objects etc.

A dedicated cable raceway could be used to protect the cable, which should be a permanent part of the ship's structure. The ship's cable raceway should accommodate the minimum bending radius of the cable provided by the terminal. IEC/IEEE 80005-1 requires OPS cables to be bend-tested to a minimum radius of 10 times their external diameter.

A ship-side cable tension monitoring system may be integrated into the cable raceway. See section 5.3 Cable movement monitoring and prevention. The cable raceway should provide abrasion and chafing protection for the cables. As noted in section 3.8, the onboard cable routing should not impede the free movement of the cables to accommodate ship movement.

During the cable route design, the cable fill ratio should be calculated to ensure that the conduit size does not lead to overheating of the OPS cables. The design should be evaluated to ensure that the fill ratio does not exceed the limitations set by classification societies. When routed through a hazardous area of a tanker, screening should be in place to limit the effects of electromagnetic fields in the surrounding structure. This screening may be a part of the cable raceway.

The cable route of OPS should be suitable for different terminals ensuring physical protection against the marine environment and at the temperatures to which they are likely to be exposed.

Cables passing hazardous areas should comply with IEC 60092-502. They should be low-smoke, flame-retardant, halogen-free, and chemical-resistant, as per IEC 60092-353/354 standards. The cable route should not transit a Hazardous Zone 1 electrical classified area.

Cable routes should be equipped with appropriate warning notices to highlight the presence of high voltage and other hazards.

3.11 Human-centred design

Human factors should be considered at all stages of design. This should include ergonomic access, intuitive controls, and clear instructions.

Continuous, human-oriented, design improvement is needed. Shipbuilders are encouraged to seek operator feedback during the design phase and following delivery of the tanker and operation of the OPS to take the ship's feedback into account in their continuous human-centred design improvement.

The OPS high voltage cables will be heavy and have limited flexibility. Adequate space should be provided around the OPS ship coupler point to enable personnel to perform the coupling and decoupling operations. The coupling space should be free of obstructions. The OPS should be designed to allow easy access to the coupling space and to accommodate adequate space for landing the cable before the coupling. The OPS inlets should be positioned to allow personnel to safely and comfortably perform the coupling of the connectors.

The cable handling area should be equipped with appropriate warning notices to highlight the presence of high voltage and other hazards.

The space and the cable route should be free of obstructions. The OPS cable handling area should be coated with anti-slip paint. Additional lighting should be considered.

The onboard OPS circuit breakers should be operated from a control room or control station away from the OPS inlet. While the OPS system is energised, monitoring of the system should be from a manned control room onboard the ship.

OPS emergency stop buttons should be arranged according to class requirements. An OPS emergency stop button should be located within sight of the ship's OPS ship inlet but outside the arc flash range. The emergency stop button should be clearly labelled and protected from the weather.

4 Ship electrical equipment design

This section addresses the details to consider when designing electrical and associated equipment. Designing electrical equipment and installations requires adherence to safety codes, classification society rules and regulations, flag state requirements, and IEC standards. It encompasses the careful selection of correctly sized and rated equipment, the implementation of reliable circuit protection, and the incorporation of earthing and bonding measures, with consideration of environmental factors at the place of installation.

4.1 Power requirements, voltage, frequency, current and couplers

A survey was conducted to determine the actual power requirements onboard various types of tankers during their time at the berth. More than 500 ships participated in the survey, primarily INTERTANKO members. The results offer insights into their electrical installations, cargo systems, and power consumption patterns, including auxiliary loads while loading and discharging cargo.

The maximum electrical load for a ship at a berth occurs when it is discharging cargo. As part of the survey, information on design loads and onboard ship measurements for auxiliary systems was collected. The auxiliary systems' electrical load and the cargo system's expected load were combined to estimate the total electric load during discharge.

It is worth noting that there are limited real-world reference points for an 'all-electric' cargo pumping system. A conceptual approach was employed to estimate the electrical load equivalent for the non-electric cargo systems. The power required to operate these non-electric cargo pumping systems, such as diesel-hydraulic or steam turbine systems, was converted into a theoretical electric motor-powered equivalent.

Calculating the cargo system's expected electrical load during discharge involved taking the theoretical rated load of an equivalent electric cargo pumping system and multiplying it by a load factor. This load factor is a ratio derived from the measured and design electrical loads.

The equivalent electrical loads of cargo pumping systems were determined by examining the drive ends of steam turbines and diesel-driven hydraulic pumps. While the survey captured data on these systems' capacities and configurations, external references were used to provide supplementary information on drive ends.

As a result of the survey analysis described above, the shore power supply for ships is recommended to be a nominal voltage of 6.6kV AC, 3-phase, 3-wire, with protective earth and an operating frequency of 60Hz at the terminal side. The use of a high-voltage system allows the number of cables required to be significantly reduced. The power quality is to be in accordance with the requirements of IEC/IEEE 80005-1.

The number of cables and couplers should be project-specific, i.e. the terminal and the ship will define this number based on their needs. Additional engineering barriers, such as circuit breakers and means of earthing for each cable/coupler with interlocks, are recommended to prevent the threat of live ends. The use of safety end caps is recommended on all ship connectors and ship inlets. These protect the connector and inlet ends from exposure while the OPS system is not in use and are a means to verify connector coupling or non-coupling while in use. Non-coupling refers to selective coupling of less than the entire group of connectors on a system, for example, using only two out of three.

Terminals, ship owners, and other stakeholders should work together to determine the adequate sizing of the OPS system.

The ship should be able to accommodate a 350 amps (A) nominal current per connection.

The survey data indicates a total power demand of under 4.0 Mega Volt Amps (MVA) during loading operations for all tanker classes.

Table 4.1 shows the power needed for a maximum discharge for different ship classes. The maximum total apparent power demand of the largest ship class operating in that terminal can be used as a reference for defining the OPS system capability. On some occasions, only one individual ship in the survey had the maximum demand displayed on the table.

Tanker class	DWT	Survey population	Total apparent power demand (MVA)	No. of standard couplers at 6.6kV, 350A	Couplers capacity at 6.6kV, 350A (MVA)
Product/ Chemical	3k – 60k	70%	Average: 3.2	1	4.0
			Maximum: 6.4	2	8.0
Panamax	60k – 80k	6%	Average: 3.5	1	4.0
			Maximum: 4.0	1	4.0
Aframax	80k – 120k	16%	Average: 5.4	2	8.0
			Maximum: 5.8	2	8.0
Suezmax	120k – 200k	3%	Average: 6.9	2	8.0
			Maximum: 10.4	3	12.0
VLCC	200k – 320k	5%	Average: 8.2	3	12.0
			Maximum: 10.4	3	12.0

Table 4.1: *Total apparent power for cargo discharge from tanker survey and associated cables and couplers*

4.2 Further considerations on the voltage and the frequency

A standardised voltage of 6.6kV and a frequency of 60Hz is recommended. The paragraphs below give some background reasoning.

Based on the data recorded during the tanker survey there were not many ships with either 6.6kV or 11kV. The most standard voltages recorded were in the LV range, more specifically, 440/450/690 V. It was decided to adopt the 6.6kV standard, as stated in the IEC/IEEE 80005-1, Annex F – Additional requirements for tankers, section F.5.1 – Voltage and frequencies.

The IEC standard, although still only 'informative' states that: "Connections for tanker ships should be made at a nominal voltage of 6.6kV." For terminals that cater for all types of tankers 6.6kV is more practical.

4.3 System voltage dip and subsequent faults caused by high inrush current during operations

Abrupt changes in large loads, starting of large electric motors or transformers on board the ship can lead to voltage dips and short interruptions or even loss of the shore power supply and potential blackout of the ship. Those voltage dips, short interruptions, or fluctuations in power supply can affect electrical and electronic equipment.

Hence, the shore power supply voltage and frequency variations should stay within acceptable limits between no-load up to rated load for both steady state and transient conditions as defined in IEC/IEEE 80005-1.

This may require measures to minimise transformer current in-rush and/or prevent the initiation of large motors or the connection of other significant loads when the ship is supplied by the shore power.

This has particular significance as a substantial portion of the ship's main and emergency electric power systems operates at low voltage (LV). Consequently, a step-down transformer becomes necessary for those ships with LV distribution systems. The determination of the transformer's size (kVA rating) is influenced, among other factors, by the power requirements of the ship during shore connection.

Step-down transformers exhibiting a high in-rush current can potentially trigger a trip in the shore supply system. Consequently, it may be necessary to implement mitigating measures to reduce the in-rush current. Incorporating pre-magnetisation is the most effective mitigating measure, with significantly higher benefits when compared with using a specialised iron core design with low-saturation characteristics.

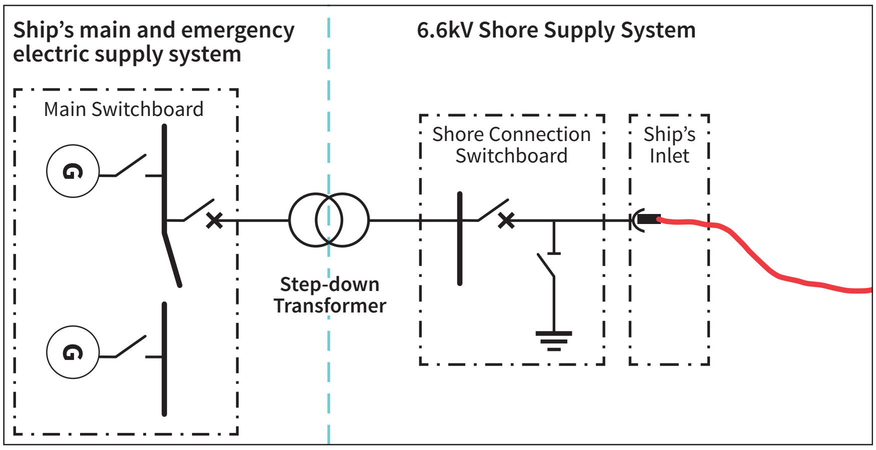

Figure 4.1: *Step-down transformer placement*

IEC/IEEE 80005-1 mandates synchronisation and load transfer to occur at the main switchboard of the ship. An exception that permits synchronisation between the ship and the shore power supply at the OPS switchboard on the ship could be advantageous in this respect.

This should be considered in the compatibility assessment conducted between the ship and the terminal. The compatibility assessment should include operational aspects such as starting and stopping of large consumers while using onshore power supply.

4.4 Safety system design, emergency stop, auto ejection, quick release and ESD permissives

The IEC 80005-1 standard and classification society rules provide conditions for automatic OPS de-energising during an emergency. Under those conditions, power must be interrupted, and conductors earthed automatically.

In those references, the term disconnection indicates galvanic isolation. Please see the IEC *International Electrotechnical Vocabulary (IEV)* terms 195-04-10, 442-04-16, and 904-03-15.

In that sense, automatic disconnection may be provided. However, there is no general requirement for the OPS onboard ships to be fitted with automatic cable quick-release decoupling mechanisms.

The terminal should verbally communicate with the ship in situations where terminal operating limits, as defined in the *International Safety Guide for Oil Tankers and Terminals (ISGOTT),* are reached. Ship procedures for normal and emergency situations should be updated to include the process for quickly transferring the load to ship power and disconnecting and separating the OPS coupler. Any effect(s) on Emergency Shutdown (ESD) systems, including cargo ESD systems, should be addressed.

If automatic disconnection is available, the ship's officers and crew should understand that OPS power may disconnect automatically, and the ship will be in a blackout condition until its standby power starts, as described in section 5.1 Standby onboard power.

General safety system design principle
The safety design principles for all HV shore connections follow these key guidelines:

- Access and handling of the shore-to-ship connection and interface equipment should only be possible when the switchgear on the supply (terminal) side and the consumer (ship) side are isolated and the shore-to-ship connection and interface equipment are earthed.

- Ship connectors and ship inlets are equipped with pilot contacts forming a safety loop to ensure that the ship connector and ship inlet are only energised when the connection is fully made.
- HV shore connections feature two independent safety loops. One is designed to provide permissives and to trip the shore-side switchgear, while the other is assigned to provide permissives and trip the ship's switchgear in any abnormal operating condition.
- Trip signals should activate both safety loops simultaneously. For example, one set of contacts from the emergency push button will open the safety loop on the shore side, while a second set of contacts will open the safety loop on the ship side.

Compatibility assessment
The compatibility assessment of the ship's shore power supply should be carried out to determine both shore and ship systems compliance in accordance with IEC 80005-1 and IEC 600092-503.

The OPS switching devices and their combination should have electrical and/or mechanical interlock arrangement to provide safe isolation before earthing and during operation.

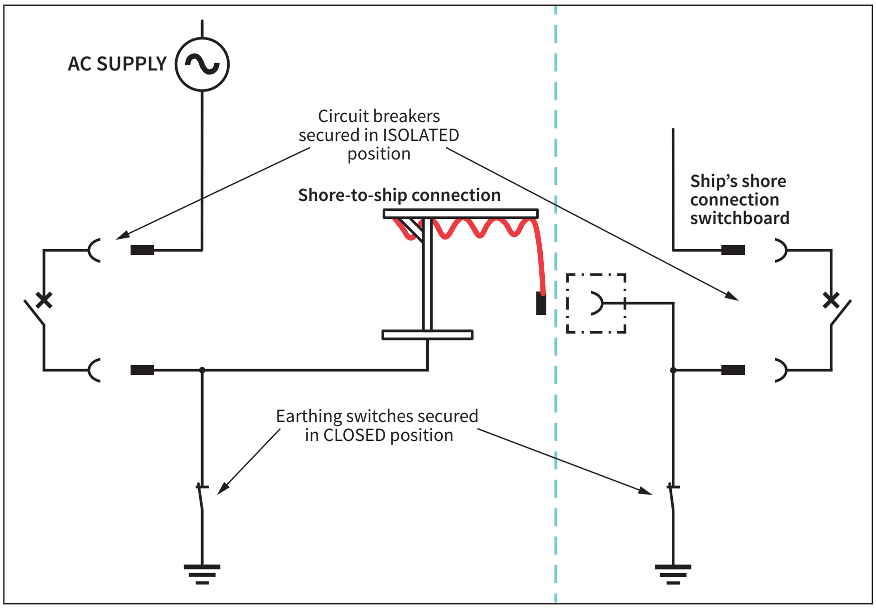

Figure 4.2: *Circuit breaker arrangement example*

The detailed description of the above design principles can be found in IEC/IEEE 80005-1. The requirements outlined, along with those in the subsequent and referenced paragraphs, are fully applicable to the shore power supply of ships, regardless of whether the supply point is midship or aft.

Emergency stop
Special attention is required concerning the placement of the emergency stop push button near the ship inlet. The button should be easily accessible without compromising the safety of the coupler. Specifically, any actions such as opening hatches and doors that lead to the loss of over-pressure and/or inert gas are deemed unacceptable. Achieving this may necessitate the installation of a certified-safe emergency stop button.

Safety loop trip
Ensuring continuous equipotential bond monitoring between the terminal and the ship is a mandatory requirement for all tanker OPS installations. The monitoring device should be installed on the terminal side, while the termination device is placed onboard the ship.

If the equipotential bond is not secured, it will prevent both the shore supply circuit breaker and the ship circuit breaker from closing, resulting in start-blocking or a missing permissive.

In the event of a loss of equipotential bond while supplying shore power to the ship, the safety loops will open, leading to the simultaneous opening of both circuit breakers, automatic disconnection and earthing.

The OPS cable should have a built-in signalling cable called the HVSC safety circuit. This system automatically cuts off the power and opens and earths circuit breakers on both sides if a signal is activated for any reason.

4.5 Physical protection of the coupling point

According to IEC 62613-1, the OPS coupler and inlet arrangement should be fitted with a mechanical securing device that locks the coupler in the engaged position and is designed so that an incorrect coupling cannot be made.

Regardless of the coupler Ingress Protection (IP) rating, it should be protected against the marine environment and mechanical damage by placing it in a weather-protected compartment. This compartment should provide access control to the coupler while energised.

4.6 Connection design

The connection design should be scalable to accommodate project-specific needs, with the number of cables and connectors determined by the terminal and ship requirements. This customisation demands specific interlocks, permissive actions and safety measures without the use of an additional separate control cable.

Cable individual payout is required from the terminal so that only the number of cables required by the ship should be deployed.

A ship coupler (ship connector and ship inlet), with a minimum of seven pilot contacts, is to be designed, manufactured and certified in accordance with IEC 62613-2 [2016], Annex J. This annex details 12kV, 500A, three-phase accessories.

Shore power system safety end caps are to be provided for all CMS cable connectors and ship inlets. See section 10.2.2 Safety end caps for further details on the required configuration of safety end caps.

While the detailed design of the safety circuit falls under the scope of IEC/IEEE 80005-1, certain key requirements are influenced by the application:

- Random selection of ship inlet for connection should be possible, i.e. a pre-set order or connection sequence is not desired.
- A ship having more ship inlets than ship connectors provided by the terminal should be still able to receive shore power.
- Regardless of configuration, a pin for ESD pre-warning coming from the terminal should be reserved for future use. Shutdown of the OPS system is not necessary.
- Ship inlets not in use should be disconnected, isolated and earthed.
- Once a system is in operation with a set number of plugs a reconfiguration should only be undertaken by restarting the whole connection sequence.

4.7 Frequency conversion

The survey of over 500 tankers found that 96% operate with 60Hz. Table 4.2 outlines the requirements for the provision and location of frequency conversion based on the onboard ship frequency and the terminal grid frequency. Adherence to these guidelines ensures compatibility between the ship's electrical system and the terminal's shore power supply.

Onboard ship frequency	Terminal grid frequency	Recommended location of frequency conversion	Notes
60Hz	50Hz	Terminal	Conversion is to be sized to the largest shore power load size for which the terminal is designed.
50Hz	60Hz	Onboard the ship	Terminal where 60Hz to 50Hz frequency conversion is not available.
50Hz	60Hz	Terminal	Terminal where there is already a frequency conversion on the terminal side, which can adjust to provide 50Hz shore power. In that case, the terminal should provide power at 50Hz.
50Hz	50Hz	None	No frequency conversion required.
60Hz	60Hz	None	No frequency conversion required.

Table 4.2: *Frequency conversion arrangement*

The terminal may need to design the frequency conversion to accommodate the largest ship it can handle. See section 4.1.

The design of the frequency converter should consider accommodating an overload relative to the base load for a specified duration. A power quality analysis should be carried out to determine if any harmonics are exceeding acceptable limits. Harmonic filters may need to be installed to block these harmonics.

4.8 Ship step down transformer design

The transformer required by IEC 80005-1 is the isolation transformer on the shore, which must isolate the ship from all shore-based loads and other ships. A further transformer may be necessary onboard the ship to convert from 6.6kV to the ship's standard voltage.

Wiring of the transformer secondary should match the ship earthing philosophy.

Transformers should be constructed in accordance with IEC 60076-1 and Class rules.

Transformer primary and secondary will be protected by short circuit and over current protection, 25KA as short-circuit withstand rating on the primary side is recommended.

Winding high temperature alarms and trip should be provided. The transformer is likely to be large relative to the capacity of the equipment feeding it, so the potential effects of transformer inrush current should be considered when designing the system. Inrush can be mitigated through transformer design, with the incorporation of pre-magnetisation circuits. Static frequency converters are likely to be equipped with both input and output transformers due to common mode disturbance and voltage adaptation. Using the shoreside frequency converter, if provided, to slowly ramp up the voltage to energise the transformer may be adapted, subject to agreement between the ship and terminal.

Transformer voltage regulation from no load to full load should be considered when designing the overall system to minimise voltage drop at the ships main bus bars. Onload automatic tap changing is not required but may be considered by the system designer, on condition that there is no provision made for separate control cables from ship to shore to control the tap changer from the ship. Spare pilot wires, if available, may be used for this purpose, otherwise the tap changer, if provided, would need to be controlled entirely from shore side only.

Ships with an onboard transformer may consider the option to manage the connection unearthed or if earthed with impedance not to trip immediately but to allow the ship to restore the power before tripping in case of single-phase fault.

Where the ship is installed with a step-down transformer, the ship's power system is to be protected against overvoltage.

4.9 Shore connection switchboard location and design

Switchboard location and design considerations should include, but not be limited to:

- The OPS switchboard on the ship location should consider the full range of cargo, bunkering and other operations.
- The switchboard should be installed in an access-controlled space.
- The switchboard should not be installed in a hazardous area.
- The switchboard should be installed as close as practicable to the connection point. If the distance between the OPS switchboard on the ship and the ship inlet exceeds a distance set by the ship's classification society, then short-circuit and overcurrent protection should be provided at the ship inlet to protect the ship's installation.
- The switchboard should be designed, manufactured, and tested in accordance with Class requirements.
- The switchboard should be provided with a circuit breaker to protect fixed HV electrical cables installed from that point onward. Circuit breakers in the OPS switchboard on the ship should be equipped with an under-voltage coil and remotely operated. The switchboard should have isolated switching and earthing of each inlet separately from other inlets to facilitate 1, 2 or 3 cable selective operations.
- The electrical parameters of circuit breakers, disconnectors and earthing switches should be in accordance with IEC 61363-1. Short-time ratings should be considered for the transfer operation from ship's to shore power.
- The line differential protection of shore connection switchboard should be considered as specified in IEC 60255-187-1.
- The protection and safety system of OPS should be continuously powered in accordance with IEC 60092-504.

4.10 Earthing of electrical equipment

Arrangements for OPS earthing should be provided as per IEC 80005-1. Handling of connectors should be possible only when the associated earthing switches are closed. It is recommended to have automatic earthing at both ship and shore and not to rely only on shore-side earthing.

The OPS sockets should be interlocked with the earth switch so that couplers cannot be inserted or withdrawn without the earthing switch in the closed position. The arrangement should be made to prevent inserting the coupler if the earthing switch is opened.

The earthing contacts should make contact before the power contacts do when inserting a coupler.

After the shore connection has been established the supply system is protected from earth fault by the OPS switchboard protection.

4.11 Protection of ship equipment due to power surge/dip, power factor, voltage regulation and surge protection

The terminal shore power supply should provide for appropriately rated surge arrestors as per IEC/IEEE 80005-1. See section 10.12.

The ship's power distribution system short-circuit current level should not exceed the short-circuit breaking and making capacities of circuit breakers installed onboard when the ship is connected to the terminal shore power supply.

Lightning protection should be generally considered for ships during load/unload operations. See IEC/IEEE 80005-1.

4.12 Coupling space and compartment

All operational phases pertaining to coupling, connecting, operation, terminating, disconnecting, and decoupling, should commence in a gas-free space or compartment.

Coupling space
A coupling space is where the OPS coupling takes place. A coupling space is classified as an 'other machinery space' and must adhere to the applicable requirements for such spaces.

Access to the coupling space may be through airlocks, which can function as the cable entrance (cable feedthrough) for the flexible shore connection cable from the shore-side supply system, ensuring that the stipulated requirements are not compromised. Furthermore, the space or compartment should be able to contain the thermal and pressure rise in the event of an internal arc initiated by the HV equipment within that space.

The coupling space should either continue to be a safe area or all non-explosion-proof equipment should be de-energised when positioning the flexible shore connection cable into or out of the space.

The design of the cable feedthrough for the flexible shore connection cable into the connection space in a hazardous area should ensure the maintenance of the required over-pressure during operation and/or other protection measures. When not in use, the cable feedthrough should be securely closed, maintaining gas and water tightness.

Coupling compartment
For tankers, the ship inlet and essential equipment for monitoring and controlling the HV shore connection should be enclosed in a coupling compartment. The cable feedthrough may be integrated into the compartment. The compartment should withstand thermal and pressure build-up from an internal arc. Ventilation requirements are defined by the applicable classification societies rules and regulations.

See section 5.6 for fire protection requirements applicable to coupling compartments.

A pressurised compartment is needed if the integrity of the compartment boundary is necessary to keep the connection outside of Zone 2 electrical classified area during normal conditions. It is either pressurised with clean air or purged with an inert gas such as nitrogen.

The following requirements apply to a pressurised coupling compartment:

- If the compartment has a single door or hatch containing the ship inlet, it should only open into hazardous Zone 2. If doors open into hazardous Zone 1, an airlock according to classification societies rules and regulations is necessary.
- Compartment doors should have suitable interlocking to prevent accidental opening while the HV shore connection is energised.
- There should be a means to verify oxygen levels in the compartment from a safe location.
- Gas-freeing means should be provided for the coupling compartment.
- When conditions internal to the connection compartment exceed the safe operating envelope, a signal should go to the safety circuit, and the power should be cut immediately.

4.13 Onboard Power Management System (PMS)

Where installed, the electrical Power Management System (PMS) should include a terminal shore power mode.

Load transfer between normal ship's power and OPS mode using ship sources of electrical power and an external electrical power supply should be provided via short-time parallel operation between the two power sources. Where the load transfer can take place without blackout, i.e. a short-time parallel connection of the onboard generators and the terminal shore power supply, the automatic means of load transfer should be provided. The shore power voltage should be within the regulation range of the automatic voltage regulator of the onboard generators. Automatic means of synchronisation should be provided.

The terminal shore power mode should be compliant with all the ship's electrical characteristics, such as load demand monitoring, frequency control, and load inhibition.

The terminal shore power mode should have an inhibit function for the automatic start of onboard standby generators, except for the load transfer period, and should include blackout recovery.

The appropriate adjustment of heavy consumer starting, load shedding and preferential tripping should be considered for the terminal shore power connection.

A failure of the terminal shore power system should not affect the ship's power system if not in terminal shore power mode.

The emergency generator automatic start on the dead bus should operate normally if the ship is in terminal shore power mode. Interlocking means should be provided so that shore power is not automatically restored after an emergency shutdown or shore power trip. Instead, the ship's stand-by generator should start and supply the ship's electrical system.

5 Additional design considerations

This section addresses additional design considerations for the safe and reliable connection of ships to shore power, including standby power arrangements, safety devices and equipment, fire protection, and cable movement monitoring and prevention.

5.1 Standby onboard power

After the ship's source for main power is transferred to the OPS system, the ship's primary power generation systems can be stopped and placed in standby. The ship should put its main auxiliary generators as primary standby, with the emergency generator as backup. Following an unexpected loss of power from the OPS, the ship's systems should respond as they would for a dead-bus blackout from internal generators. The standby generator should start automatically and restore power for essential services within 30 seconds.

Ship-side OPS safety, control, alarm, monitoring and communication systems should be supplied from the ship's emergency power distribution. If OPS functions are critical for safety after a blackout, those functions should be supplied from a backup source of uninterrupted power.

5.2 Additional safety devices and equipment

The ship's power distribution system and PMS, if fitted, should be designed to transfer power between ship and shore seamlessly, without blackout.

The ship should monitor for phase sequence, frequency, voltage, amperage, and power factor of the power supplied by the OPS. It is recommended that the ship be fitted with a kilowatt hour meter, this is to allow for accurate billing by the OPS provider. Power quality monitoring is optional.

The ship's earth fault detection systems and insulation resistance monitoring system should remain operational while the ship is powered by the OPS.

The ship's Impressed Current Cathodic Protection System (ICCP) may conflict with the equipotential bonding of the OPS system. The ship owner should seek advice from the ICCP manufacturer/vendor regarding safe operation of the ICCP while OPS cables are connected.

5.3 Cable movement monitoring and prevention

For each flexible cable, the ship should be equipped with a fixed anchoring point, composed of a suitable pad eye with a minimum SWL capacity of 5 tonnes and a wire/chain used to connect the cable grip device supplied by the terminal to the anchoring point. Fixed anchoring points on the ship should be arranged such that they will not impose a bending stress on the flexible cables when they are in use. It is recommended to allow roughly 3 metres space from anchoring points to ship inlets to help avoid flexible cable bends that could be tighter than the minimum bending radius of the flexible cables while in use per the cable manufacturer's design characteristics. Figure 5.1 gives an indication of the arrangement of cable anchoring points. Installations may differ.

The terminal should supply a cable grip device that does not damage the cable. Cable grip devices may be integral to the CMS cables at the ship end and have adjustable positions along the cable between CMS support end and ship connectors at the end of flexible cables. Cable grip devices should generally be located 3 metres or greater from the ship connector end.

The possibility of the ship connector being pulled out of the ship inlet should be continuously monitored. The monitoring system should have two stages. The first stage alarm should notify the ship operators with a warning. The second stage alert should trigger the OPS shutdown.

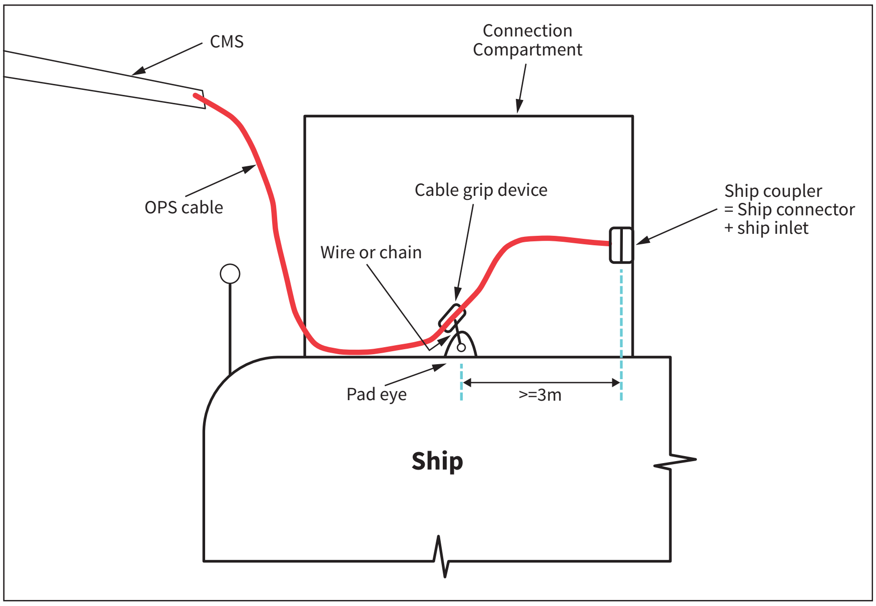

Figure 5.1: *Example of cable anchoring points arrangement*

5.4 Maintaining cargo system integrity in case of a sudden loss of power

Those ships' systems that would be adversely affected by the sudden loss of the OPS should be designed to safely shut down. Similar to interruptions in the ship's power, the ship team should be prepared to respond to a shore power blackout in accordance with the guidance in *ISGOTT.* An ESD system will trip in the event of a shore power blackout

Agreed emergency procedures between the ship and the terminal should include procedures for power loss. In case of a ship blackout while using OPS power, the ship operators should also check the status of the terminal before attempting to restore OPS power to the ship.

See section 11.4 for further guidance on fluid surge considerations due to loss of power.

5.5 Additional gas detection considerations

If the OPS ship inlet is in an enclosed coupling space that opens into a Hazardous Zone 2 area, a fixed gas detection system should be installed inside the coupling space. Sensors in multiple positions and redundancy of sensors should be considered. The gas detection system should be calibrated to detect the hazardous gases associated with the types of cargo the ship carries. The gas detection system alarm should be triggered at the 20% lower flammable limit. The alarms should sound locally at the coupling space and in a manned control space or alarm and monitoring system. At 40% lower flammable limit the OPS system should shut down and power should be cut to all non-explosion-proof equipment in the coupling space. All fixed gas detection systems should be approved by the ship's classification society.

If the ship's OPS coupling space is inerted during OPS operation, then the oxygen content in the room should also be monitored. The oxygen content in the room should not exceed 8% by volume while OPS is energised. If the oxygen content exceeds this limit, an alarm should be activated, and appropriate actions should be taken to restore the space to an inert condition. When preparing for OPS decoupling, the oxygen level in the coupling space must be restored to at least 19.5% prior to entry by personnel.

The use of portable gas detection equipment is recommended for use with all OPS coupling locations, regardless of position on the ship. Portable gas detection should be used to detect the presence of hazardous gases prior to connecting the OPS connector to the inlet. The portable gas detection system should be calibrated to detect the hazardous gases associated with the types of cargo the ship carries.

5.6 Fire protection

Electrical equipment fires may be caused by short circuit, overheating, or the spreading of fire from elsewhere.

All enclosed OPS coupling spaces should be fitted with fire detectors, integrated with the ship's main fire detection system. OPS coupling spaces should be fitted with public address and general alarm systems.

It should be possible to de-energise all equipment in the enclosed OPS coupling space from locations outside the space. OPS coupling space ventilation fans should be fitted with emergency stop buttons located outside the space. All ventilation inlets and outlets to an enclosed OPS coupling space should be fitted with dampers.

The ship's OPS ship inlet should be shielded from the spray of fire suppression systems. New OPS equipment should not block the spray of fire suppression systems on deck. It is recommended that enclosed OPS coupling spaces be outfitted with non-conductive fire suppression systems.

Ships' fire plans should be updated, and class approved, to reflect any changes.

5.7 Independent supply in different locations

Ships may be fitted with more than one group of ship inlets. Ships fitted with multiple independent OPS connections, e.g. port and starboard or aft and midship, should only be capable of energising one connection at a time. Other connections should be in an earthed condition with an interlock preventing them from closing.

5.8 Considerations for cargo pumping systems

An important consideration for ship owners is the power sources for cargo pumping systems. Some ship designs incorporate a hybrid mix of electric motors and diesel engines to drive hydraulic power packs within the cargo pumping system. This use of diesel engines to drive the cargo pumping system is a source of air emissions that works against the intent of OPS. However, the ship may be unable to achieve full discharge rates using electric motors alone. Along with the OPS itself, ship owners should evaluate ship designs and retrofits that allow the ship's cargo pumping system to fully discharge on electric power.

For ships that use steam turbine cargo pumping systems, it is not advisable to convert the cargo pumping system prime movers to electric motors. The complexity of the conversion limits the viability. For ships with steam driven cargo pumping system the focus should be on applying OPS to the auxiliary electric load.

5.9 Considerations for cargo tank inert gas

The inert gas system is a critical safety system for oil and chemical tankers. It is intended to prevent fire and explosion in the cargo tanks. The traditional sources for inert gas on tankers are the flue gas from the ship's boilers, an independent inert gas generator, or a vapour return line. If flue gas or the combustion exhaust from an inert gas generator is used, it is typically scrubbed and cooled before it is provided as an inert gas into the cargo tanks.

Nitrogen is an alternative inert gas for cargo tanks, one not derived from combustion. For moderate volumes, electrically driven nitrogen generators may replace fuel-based inert gas generation. Changes in cargo operations change the demand for inert gas and potentially for the electrical power load. As volume requirements increase, nitrogen generators require increasingly large amounts of electric power. Ship owners should carefully consider the design of their ships when specifying or retrofitting nitrogen-based inert gas systems.

6 Tanker operation

This section provides guidance on the safe and efficient operation of OPS systems for tankers and terminals. It addresses key aspects such as vetting and compatibility checks, pre-arrival communications, access restrictions, roles and responsibilities, connection and disconnection procedures, interaction with mooring operations, Simultaneous Operations (SIMOPS), emergency preparedness, physical protection, cable handling, pre-transfer conferences, minimum Personal Protective Equipment (PPE) requirements, firefighting procedures and independent verification.

6.1 Vetting and berth/ship compatibility checks with electrical connection

The ship operator should check compatibility prior to a planned OPS connection at a terminal. For details, see section 16.1 Ship screening and berth/ship compatibility checks.

6.2 Pre-arrival communication to terminal on electrical equipment

Verification of the compatibility checklist items should take place during the tanker/terminal pre-arrival communication process. For details, see section 16.2 Pre-arrival communications between ship and shore.

6.3 Managing access restrictions around electrical installation

Managing access restrictions around high-voltage electrical installations is crucial for safety and compliance with regulations.

A familiarisation programme for the Person In Charge (PIC) is recommended. It should include national maritime regulations, classification society rules, and standards that apply to high-voltage electrical installations and the OPS station onboard the ship.

Where high-voltage installations are present, restricted areas should be identified and clearly marked. An access control system should be in place to prevent unauthorised persons from entering these areas.

Emergency response procedures, encompassing evacuation plans, for high-voltage areas on the ship should be created and routinely updated. All crew members should be familiar with these procedures and restrictions for safe access.

6.4 Electrical connection procedure

There is a risk of sparking due to the potential difference between the ship and the shore. This risk should be managed and mitigated. The connection to the OPS should be carried out according to:

- Ships' procedures.
- National regulations.
- Rules of classification societies.
- Terminal procedures.

For details, see section 16.4 Managing hazardous areas.

6.4.1 Initial state

The procedure for connection to an OPS should always be up-to-date, and all personnel fully aware of their duties and responsibilities. A PIC should be appointed on board. The PIC should communicate with the responsible person ashore at the terminal.

The onboard ship PIC should coordinate the OPS operation with the Chief Officer and appropriate deck officer(s) before starting to ensure coordination with the cargo operation and any SIMOPS. If items in the Ship Shore Safety Checklist (SSSCL) (see appendix) relate to OPS, these should be considered before and/or during the cargo operation.

For further detail of the OPS coupling/decoupling process see section 16 Interface operation.

6.4.2 Safety check

The crew should visually inspect all electrical OPS equipment before each use. A system health check of the OPS and electrical PMS should be completed before any physical coupling of OPS equipment.

Ship personnel should exercise Lock Out/Tag Out (LOTO) confirmation to verify the system is de-energised, and safety earths are applied.

6.4.3 OPS cable

Due to its weight, the OPS cable and connector should be handled by the CMS. Manual handling should be avoided where possible.

The connector itself is heavy and can be sensitive to external impact. It is not uncommon for the connector to weigh 15-20kg. The cable's weight is about 10 to 12kg/m. See section 3.4 Cable lifting, for further details on cable lifting operations.

The PIC is responsible for routing the cable onboard in a suitable manner to protect it from impact, abrasion and sharp edges. Consideration should be given to onboard activities such as lifting or cargo operations.

During the terminal call, the OPS cable should be regularly checked by the responsible crew onboard the ship. See checklist K: Tanker – Repetitive checks during power transmission, in the appendix.

6.4.4 Coupling the OPS cable

The connection of the OPS should be carried out according to international guidelines and comply with national regulations and rules of classification societies. It should also be carried out in accordance with the ship's procedure and checklist.

When the ship inlet is located inside a pressurised gas-free compartment, the seal around the cable inlet at the door to the OPS station should be fixed after the connection and the door is closed. Permanently installed combustible gas and/or oxygen detectors should be available in the OPS station. When conditions internal to the connection compartment exceed the safe operating envelope, a signal should go to the safety circuit, and the power should be cut immediately.

Before coupling or decoupling, it should be ensured that there is no flammable atmosphere in the vicinity of any connection locations. A portable multi-gas detector is recommended for that purpose. According to *ISGOTT,* tankers should be equipped with at least two portable multi-gas detectors. Persons involved in connecting the OPS cable should carry such a gas detector as a risk prevention measure. All parties should be aware of the relevant hazardous area.

The crew should be aware of additional risks when it comes to OPS coupling/decoupling on a ship. For example, the compartment where the OPS coupling occurs may be filled with inert gas. Before entering such a compartment, it should be confirmed there is adequate oxygen present.

Cables should be verified de-energised, and the shore-side supply should be open and isolated before connecting the ship connectors to the ship inlet. The power conductors should be earthed onshore while de-energised. The ship inlet should be earthed to the ship's hull using an earthing switch.

The coupling of the OPS may follow the sequence below:

1. Initial state – disconnected.
2. Safety check, SSSCL item 51 signing.
3. No flammable atmosphere in the coupling space.
4. The OPS cable is handled.
5. Coupling of OPS cable to the ship inlet anchor point.
6. Remove and store safety end caps from OPS cables and ship inlets that are selected for use at time of coupling.
7. Coupling of OPS cable to ship's power system.
8. The cable movement monitoring device is in place and active.

6.5 Operating shore power system procedure

After the OPS cable is connected, four main steps may follow:

1. Pre-operational checklist completion before energising.
2. Initiation of power transmission.
3. Power supply supervision.
4. Finishing the power transmission.

6.5.1 System pre-operational checklist before energising the system

Specific steps should be completed before the OPS power supply can start and provide power to the ship. The OPS checklist is unique to each ship and examples are shown below.

For all ships:

- Activate controls to close pilot wire signals into OPS cables.
- Verify no faults and normal shore power system status on ship and shore.
- When all parameters of the OPS safety loop onboard and ashore are in normal condition, it should indicate that shore power is available.

In addition, examples associated with a coupling in a pressurised gas-free compartment are shown below:

- After the OPS coupling in the compartment, the door is closed.
- The cable entry is sealed.
- The coupling compartment is pressurised and verified gas-free. It can be pressurised with air or inert gas, such as nitrogen.

Ship-side and shore-side breakers should immediately open if any parameter of the safety loop indicates a breach.

6.5.2 Initiation of power transmission

The initiation of power transmission involves checks by both PICs to confirm that the OPS system, ship and shore side, is free of alarms and ready to operate.

Before handling any cable, connectors or ship inlets, the shore-side PIC and ship-side PIC confirm that the OPS system is de-energised and both earthing switches are closed. The PIC on board should prepare the ship-side switchgear to receive shore-side power. Earth switches should be closed on the selected inlets to be used and for the selected group of inlets if there is more than one OPS connection area on the ship.

After completion of the coupling process, both PICs confirm that access restrictions and safe areas have been established. Following this conformation, earthing switches are opened shore-side and ship-side for the selected inlets. The PIC on board authorises the terminal personnel to switch on the power by closing their shoreside supply breaker.

After confirming the phase sequence and voltage level, the onboard PIC closes the ship's shore connection circuit breaker.

The ship's power grid is synchronised to the shore supply via the ship's PMS. The PMS transfers the load from the ship to shore and stops the ship's generator after the load has been transferred.

6.5.3 Supervision of power supply

The ship's PMS should be monitored to ensure correct functioning. The ship's PIC should be alerted immediately in case of abnormal situations while the ship receives shore power.

6.5.4 Finish the power transmission

The ship PIC should communicate to the terminal PIC the intention to terminate the shore power supply.

The PIC should ramp up the onboard power, generators or batteries before the shore power transmission is cut to secure a stable power feed onboard the ship. The PIC initiates, through the ship's power management, the start of a ship generator and its synchronisation to the main switchboard. The PMS gradually transfers the load from the shore supply to the generator. Upon completion of load transfer, the power-management system opens the supplying shore circuit breaker in the main switchboard.

The ship PIC opens the circuit breaker in the OPS switchboard on the ship and authorises the terminal personnel to switch off the power feed at the OPS ashore.

6.5.5 Electrical disconnection procedure

The disconnection of the OPS should be carried out according to international guidelines and comply with national regulations and class rules.

The disconnection of the OPS cable is to be carried out in accordance with the ship's procedure and checklist.

The ship PIC and terminal PIC should confirm that all circuit breakers are open and isolated. See section 16.7.3 OPS de-energising and decoupling.

Ship and terminal PIC mutually agree to close the respective earthing switches to allow safe handling of the connector.

The shore-side earthing switches for power cables should close automatically after the cable is de-energised, to discharge the cables. The power cable earthing switches onboard the ship should be closed before removing the power cables from the sockets. The ship-side earthing switches should close only after the shore-side earthing switches are confirmed closed. Automatic closure of the ship-side earthing switches should follow classification society requirements.

6.5.6 Decoupling the OPS cable

The decoupling of the OPS cable should be carried out in accordance with the ship's procedure and checklist.

The terminal's OPS procedure should be followed to ensure good coordination between the ship and the terminal.

The ship's PIC's primary responsibility is to supervise the preparation and decoupling of the OPS cable.

The connector compartment's pressurisation should be shut down and ventilated before the door is opened and the cable is disconnected. If inert gas has been used, an adequate oxygen level should be ensured before opening the door and entering the compartment.

It is essential that there is no flammable atmosphere in the vicinity of the coupler when the cable is disconnected and brought ashore. Persons involved in disconnecting the OPS cable should carry a multi-gas detector.

6.6 Managing interaction between mooring operations and electrical equipment

A ship should be in the correct position at the berth at all times when the OPS is connected.

Regular checking of the ship's mooring is one of the most critical safety checks throughout the period the OPS is connected, especially during the cargo operation.

Particular attention should be paid to possible rapid changes in wind speed and direction, current strength and direction at the berth, tidal changes, effects of passing traffic, and changes in the ship's freeboard due to cargo and ballasting operations.

Risk analyses have found that a rapid movement of a ship damages the coupling of the OPS on board. Another risk identified is that if the ship moves away from the berth (excursion), the OPS cable may come between the ship and the quay and can be pinched if the ship moves back towards the quay again, which could significantly damage the cable.

The ship PIC should be on site, monitoring the OPS cable handling, coupling, decoupling and cable path on deck. The PIC should ensure sufficient personnel are available for safe cable handling.

The ship's crew should regularly check both the ship's mooring arrangements and the position of the OPS cable in accordance with checklist K: Tanker – Repetitive checks during power transmission.

6.7 SIMOPS impact on electrical installation and hazardous areas

SIMOPS are activities that take place at the same time in the same area, or that could directly or indirectly affect the safety of any other activity on the ship or at the terminal.

Avoid SIMOPS whenever practicable. If they cannot be avoided, SIMOPS should be carefully managed through risk assessment, toolbox talks and work practices.

A SIMOPS risk assessment should study the intended operations, the OPS coupling/decoupling and operation and identify any additional hazards introduced by undertaking the activities simultaneously.

The risk assessment should consider factors such as the following:

- Approval level: in accordance with company procedures and SMS requirements.
- Supervision: each operation should be adequately supervised, and the OPS operation taken into account.
- Distraction: operations should be controlled from a common location, e.g. single control room for engine or cargo operations.

- Communications: there should be enough communications equipment with separate channels for each operation and contingency arrangements agreed.
- Knowledge and skills: personnel undertaking the tasks should be sufficiently trained and experienced to safely complete the assigned tasks. Personnel should be informed about risks of the OPS coupling and operation.
- Fatigue: work and rest hour requirements should not be compromised by the demands of the SIMOPS.
- Current and expected environmental conditions.
- Critical tasks.
- Coordination of SIMOPS tasks.
- Maintenance activities.
- Contingency plans.

Using the factors identified, the level of risk should be assessed and risk reduction measures evaluated. A hierarchy of control principles should be used to prioritise those measures and to identify further any additional safety barriers required. Additional hazards introduced by the SIMOPS should also be highlighted and further reviewed during the assessment.

6.8 Ship readiness to evacuate in an emergency and decoupling

Local, national and international regulations require tankers at a berth to be ready to depart at short notice. While a tanker is moored at a terminal, its boilers, main engines, steering machinery and other equipment essential for manoeuvring should be ready so the ship can move away from the berth in an emergency. See *ISGOTT* section 21.7, Agreement to carry out repairs.

The ship operators should be aware of the time required to decouple and separate an OPS should the ship have to leave in the event of an emergency. In *ISGOTT,* SSSCL Part 5A (Pre transfer conference) item 32, there is a clear requirement to state the notice period for a ship to be ready to move from the berth. The ship's officer should consider the time required for the safe removal of connected OPS cables when discussing this requirement with the terminal.

A terminal may allow some additional time needed before the ship can depart while the ship is alongside and is connected to an OPS.

Any unplanned situation that causes the ship to lose operational capability, particularly the safety systems of the OPS, should be immediately communicated to the terminal.

6.8.1 Emergency OPS decoupling and separation

In the event of an emergency departure from the berth, it is important that the ship can quickly decouple the OPS cable without jeopardising safety. See section 16.8 Emergency OPS decoupling procedure.

6.9 Physical protection of the electrical installation while alongside

In addition to being clearly signposted around the OPS on board, the OPS coupling compartment itself should be protected if there is a risk of physical impact in the form of crane movement.

Moreover, the terminal may require the OPS cable to be protected. The cable path on board, from the ship's rail to the coupling point, should be inspected, and where appropriate, the cable should be protected. Particular attention should be paid to cabling in ladders, risk of sharp edges, chafing and sharp bends.

6.10 Ship shore pre-operation conference to cover operating limits

During the ship shore pre-transfer conference, it should be established in writing what environmental conditions/limits apply to the OPS operation, when to stop it and when to disconnect and take ashore. See *ISGOTT* section 21.4 Pre-transfer conference and *ISGOTT* SSSCL Part 5A.

While berthed, the ship's personnel should regularly check known or planned passing traffic, which might move the ship in its moorings, and environmental conditions, such as wind speed, wind direction, current, tide, sea and swell, to ensure good management of the ship's moorings and the safety of the OPS cable and coupling.

Ship and terminal representatives should regularly exchange information about monitored environmental conditions and weather forecasts.

6.11 Firefighting procedures

Electrical equipment involved in a fire or the vicinity of a fire, known as class C fire, may cause electric shock or burns to firefighters.

Electric shock may result from contact with live electrical circuits. It is not necessary to touch one of the conductors of a circuit to receive a shock. A stream of water or foam can conduct electricity to firefighters from live electrical equipment. When firefighters stand in water, the chances of electric shock and the severity of shocks may be significantly increased.

Burns may result from direct contact with hot conductors, equipment or sparks thrown off by these devices. Electric arcs can also cause burns. Persons at a distance from the arc may receive eye burns.

When any electrical equipment, including OPS equipment, is involved in a fire, its circuit should be de-energised and earthed. In considering the application of a fire extinguishing agent, an electrical circuit or panel should always be treated as still energised.

The ship PIC and the terminal representative should clearly understand the first response to a fire so that the correct fire extinguishing medium is used on the OPS coupling on board. For an electrical fire the most suitable extinguishers to use are either the carbon dioxide or dry powder types.

6.12 Independent verification, class for ISM and vetting

A ship with an OPS facility on board may be inspected by various organisations during a terminal visit. An inspection may be carried out by the ship's classification society and during an ordinary vetting, such as the Ship Inspection Report Programme (SIRE).

In addition, some cargo owners, terminals, Port Authorities and Port State Control may carry out independent inspections.

It is recommended that the ship's operator develops an internal checklist for independent inspection. Such a checklist could include the following checkpoints:

- Procedures for coupling, operation and decoupling of the OPS.
- Procedures regarding supervision of the OPS coupling and the mooring for the ship.
- Clear division of responsibilities on board.
- Training.
- PPE.
- Emergency decoupling of OPS.
- Firefighting equipment and first response action.
- Compliance with regulations, standards, port and terminal requirements.

6.13 Protection of the sockets when not in use

When the OPS onboard is not in use, the socket should be completely covered with a protection cap or lid and well secured. The door to the OPS compartment should be permanently closed to ensure effective weather protection for the electrical equipment.

6.14 Procedures in case of a safety system failure

If any of the safety systems of the OPS fail, a critical safety measures procedure should be followed. The content of the critical safety measures procedure should be divided into specific steps that can be followed.

Whatever the nature of the OPS safety system failure, the primary action is always to ensure that the crew or other personnel on board are not exposed to the risk of injury or death. Subsequently, measures should be taken to ensure the ship's safety and evaluate whether the cargo operation has to be stopped.

Direct safety measures should be taken based on the type of safety system that has stopped working. The main safety systems are described in sections 6.14.1 and 6.14.2.

6.14.1 OPS deck compartment overpressure

If the pressure of the pressurised coupling compartment, as described in section 12, falls below the set alarm value, the High Voltage Shore Connection (HVSC) safety circuit is activated, and the OPS automatically cuts off the power supply. When a pressurised connection compartment is located in a designated non-hazardous area, the loss of pressure in the coupling compartment may give an alarm on the ship to alert personnel that pressurisation has failed. This alarm can then become an automatic shutdown of the OPS after a pre-determined time interval.

6.14.2 OPS deck compartment gas detectors

If installed oxygen sensors or combustible gas detectors indicate an unsafe condition, the HVSC safety circuit is activated, and the OPS automatically cuts off the power supply.

6.14.3 Safety Management System

Comprehensive SMS procedures for the operation of the OPS should be in place. Below are examples of such procedures:

- Coupling, operation and decoupling of the OPS.
- Supervision of the OPS coupling for the ship.
- Safety system failure.
- Blackout situation onboard.
- Blackout or power supply failure ashore.
- Emergency shutdown and decoupling of OPS.
- Communications.
- Training.

The Master, Chief Engineer and PIC should ensure that the procedures are available and followed by operation personnel. The procedures should be periodically reviewed to ensure that their contents are up to date, as required by the SMS.

7 Inspection and maintenance

This section provides guidance on the inspection and maintenance of OPS systems on board tankers. It addresses periodic inspections by operational personnel, minimum inspection recommendations for maintenance technicians, critical equipment assessment, maintenance programme development, and specific inspection and maintenance recommendations for OPS equipment.

7.1 Periodic structured rounds of equipment for integrity by operations

Simple processes, such as pre-operating checks and visual observations by operation crew members, can help identify any potential problems early.

The crew should perform visual inspections before each use. The general visual inspection and pre-berthing check should include the OPS compartment and associated components. Examples of such components are:

- OPS door and cable entry and its cable sealing.
- Ventilation system(s).
- Lights.
- Junction boxes.
- O_2 and combustible gas detectors.
- Audible and visual alarms.

7.2 Minimum inspection recommendations of equipment by maintenance technician, pre-use, monthly and annually

A successful maintenance regime optimises equipment availability and enables safer operations. The inspection and maintenance of installations covered by this standard should be carried out only by experienced personnel.

Maintenance should be conducted by following maintenance procedures, national regulations, and manufacturer's recommendations. Since the onboard OPS station may be located in a hazardous area, it may be appropriate to consult the standard IEC 60079-17: *Explosive Atmospheres – Part 17: Electrical Installations Inspection and Maintenance. Tankers – Special Features.*

Tests, inspections, and maintenance should be recorded in the ship's Maintenance Services System.

7.2.1 Critical equipment assessment

The criticality of individual items of the OPS equipment needs to be assessed. A risk assessment should be carried out to identify and quantify potential risks and used in developing the maintenance programme.

See OCIMF *Safety Critical Equipment and Spare Parts Guidance.*

7.2.2 Maintenance programme

All electrical OPS equipment on board should be examined at intervals not exceeding six months or more frequently if mandated by local regulations, classification societies or company requirements.

The maintenance programme may consist of the following structure:

- OPS equipment inventory such as, but not limited to:
  - Lights and light switch in the OPS station.
  - Ventilation system.
  - Junction boxes.
  - Ex lights.
  - Cable entry and its cable sealing.
  - Fixed and portable OPS firefighting systems.
- Critical equipment and components such as, but not limited to:
  - Shore power socket cabinet and pilot loop connections.
  - OPS station door limit switch, part of the safety loop.
  - OPS station pressure difference sensor, part of the safety loop.
  - OPS station O_2 content gas detector, part of the safety loop.
  - OPS combustible gas detector, part of the safety loop.
  - OPS station N_2 supply.
- Remaining life assessment due to the maintenance schedule.

Tag	Type of equipment	Component	Failure Mode	Susceptibility	Consequence	OPS criticality	Period
#1	Power socket	Cap	Mechanical	Low	Medium	Low	Yearly
		Pilot connection		High	High	High	Monthly

Table 7.1: *Example of maintenance structure*

7.3 Inspection and maintenance recommendations of OPS equipment

The electrical equipment and system of the OPS station should be inspected according to the manufacturer's recommendation.

The planned inspection programme should include but not be limited to:

- General inspection of the OPS station – that it is clean and tidy and that no unnecessary materials are stored in the space.
- Labelling and signage.
- Correct functioning of ventilation.
- Correct functioning and calibration of gas detectors.
- No moisture or corrosion on any electrical equipment or junction box.
- Correct functioning of alarms and function buttons.
- Control of operational manoeuvres of ship crane(s), if applicable for OPS cable lifting.
- Checking emergency switches.
- Checking the relay protection indication.
- Checking the load switch and its operation.
- Checking the safety loop system.
- Control of earth leakage separators.
- General check of the OPS system when it is commissioned and shore power supply is activated to the ship's PMS.

8 Training

This section provides guidance for training and competency assessment for ship's crew and personnel responsible for the ship-to-shore power coupling.

OPS operations are to be managed and executed by qualified and competent individuals in accordance with international rules and regulations, as well as national and local terminal regulations and requirements.

All crew requirements should be in accordance with the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) regulations and MSC.1/Circ.1675. Personnel are to have received familiarisation training and be authorised by the PIC for OPS operations.

The training and competency guidance in this section is intended for the ship's crew during operational conditions and is not intended for design, installation, decommissioning or other abnormal activities.

8.1 Competency recommendations of electrical coupling/decoupling team

Safe operation of OPS requires skills and technical proficiency beyond that required during normal operating conditions. It is therefore important that suitable training is offered to crew to complement existing experience.

It is recommended that Masters, Deck Officers and Engineering Officers, as well as all crew members involved with the OPS operations, have relevant experience and safety training. The PIC should be familiar with safety-critical operations on the ship, and in the connecting of the shore power supply, power transfer and disconnection.

Such a training programme should have provided knowledge, understanding and proficiency required for operating OPS in particular, including electrical safety. General training is recommended on CMS, lifting appliances and manual handling.

Crew members should be familiar with operating and training manuals specifically for OPS operations.

The relevant training and experience for OPS may include the following, as appropriate to the crew members and expected tasks:

- Electric shock.
- Electrical hazards and avoidance.
- Explosion protection.
- Types of protection.
- Markings.
- Certification and applicable standards.
- Procedures for normal and abnormal operations.
- Permit to work systems.
- Lockout/Tagout (LOTO).
- Safe isolation.
- Supervision before, during and after use.

Intervals of training and refresher training should comply with any specific regulations, and should not exceed five years.

8.2 Verification of competency of electrical coupling/decoupling team

The competency of the crew members should be verified, at intervals compliant with any specific regulations, and generally not exceeding five years, on the basis of sufficient evidence that the person:

- Has the necessary skills required for the scope of work;
- can act competently across the specified range of activities; and
- has the relevant knowledge and understanding underpinning the competency.

It is recommended that applicable crew members hold documentary evidence of having satisfactorily completed a training programme for high-voltage operation and safety of shore power systems.

There should also be documentary evidence of having completed appropriate on-the-job training, which may include simulation training.

8.3 Competency and training of maintenance team

The ship crew should be familiar with the planned maintenance programme for OPS systems, including the knowledge of LOTO and equipment earthing procedures to ensure personnel safety. The training is to include the maintenance plan to establish periodic testing of equipment and components.

Ship crew are to be trained and familiar with the appropriate provisions for the storage of OPS equipment when not in use.

8.4 Training and drills recommendations to handle abnormal conditions and emergencies

The ship crew should perform regular drills for emergency conditions, including emergency shutdown, emergency decoupling, blackout, electrical fire, electrical shock, electric arc, and ship power restoration procedures. See section 16.8 Emergency OPS decoupling procedure.

PART 2: MARINE TERMINAL

9 Berth layout and design consideration

This section provides guidance on berth layout and design considerations for OPS systems at tanker terminals. It addresses the location of shore coupling points, electrical classification areas, effective CMS, civil marine structural design requirements, interaction with mooring systems, gangways, and cargo transfer equipment, accommodating varying ship sizes and orientations, provisions for ship movements, and considerations for unscheduled departures.

9.1 Location of shore coupling and alternative considerations

Terminals and ship owners should work together to determine the best location for the CMS equipment and onboard OPS ship coupler points. A comprehensive terminal compatibility study and risk assessment are advisable for ship owners. See sections 3.3 Location of the OPS inlet onboard the ship, 15.2 Hazardous area classification and 15.3 Hazardous areas.

The OPS ship coupler point should be outside a hazardous area or in a gas-free, safe, pressurised space. The relative position of ship/shore coupling is not prescribed and is based on case-specific evaluations by involved parties.

Ship owners can position the coupling point mid-ship above the cargo area or, alternatively, aft, outside the cargo area. A safe location is in the engine casing.

Positioning the coupling point mid-ship allows terminals to position their CMS near the cargo loading equipment and accommodate various ship sizes. A significant drawback to the mid-ship position is the proximity to hazardous cargo, which demands extra precautions.

The positioning of the CMS and onboard OPS ship coupler points should be arranged to align with each other, considering three directions: vertical as measured by the elevation above the waterline; longitudinal along the forward/aft axis; and transversal along the port/starboard axis. The CMS may have limited movement and reach. Similarly, ships cannot be shifted along the berth due to the cargo transfer system's alignment needs. Also, the CMS should be strategically placed to prevent interference with fixed berth structures, ship equipment, and operational and escape routes.

When the coupling point is not along the ship's centreline, it is recommended to place the coupling points at both the port and starboard sides of the ship. For couplings near the mid-ship, the CMS should be to the right of the cargo manifold when facing the ship.

If the tanker has a connection space along the centreline of the vessel above the cargo tanks, it is recommended that the coupling point should be forward of the manifold area. The terminal should consider the orientation for ships with this arrangement.

If the ship owner decides to position the coupling point away from the cargo area, the logical spot is aft, above the main machinery space. This location is further from hazardous cargo and closer to the ship's electrical protective relays and switchgear. However, one limitation to an aft coupling is the significant variation in ship designs. The onshore CMS may need to reach far across the water with some ships.

When aft coupling is selected, in cases with a significant variance in ship dimensions, it is recognised that it may be impractical to reach aft with a single CMS.

The variation of the ship's freeboard during loaded and unloaded states should be considered. It is vital that the onshore CMS can always connect to the ship without any undue strain on the cable.

Considerations should be made for the shore power coupling points' elevation and interference with mooring systems.

See section 15 Design.

9.2 Effective Cable Management System

The handling of cable(s) and connector(s) should be assisted by a terminal CMS. This is a dedicated onshore mechanical installation that carries the electrical cable(s) and connector(s) from an onshore position to the onboard inlet(s). The main considerations are listed below:

- A CMS reduces the manual handling of the connectors and cables, reducing the risk of damage and related safety risks.
- A CMS protects the cables from external influence, such as falling objects, and from the influence of third party works/activities, etc.
- A CMS carries the cable(s) to the ship inlet(s)/socket(s), thus minimising their influence on the potentially hazardous and potentially congested operational areas onshore and onboard.
- A CMS may facilitate, although not be a strict requirement, placing the installation outside the terminal's hazardous area, while still being able to reach the sockets onboard.
- A CMS may facilitate more efficient operations.

In specific cases, designers may be forced to deviate from this. These specific cases may, for instance, include when a CMS would be a significant obstacle for other operations on a combined tanker and breakbulk terminal, or when only a very limited number of annual OPS operations are foreseen.

A gangway is not a CMS, nor is a loading arm. The OPS equipment should not be attached to the gangway or be fitted piggy-back onto a loading arm.

CMS design is heavily influenced by its position and site-specific interaction with mooring lines, product/cargo handling equipment at the berth and the variability in ship sizes, orientation and movements, which are described in this section.

In case of multiple cables, individual payout is required from the terminal so that only the number of cables required by the ship should be deployed. While in stored position in the CMS, cables are to be earthed and isolated, and each ship connector is to be covered with a safety end cap and an electric isolation cover. See section 10 Electrical equipment design.

Typically, two main types of CMS installed on shore can be considered as follows:

- A dedicated cable manipulator, similar to a crane but dedicated to transfer flexible cables/accessories, able to 'present' connectors at the end of the flexible cables to the onboard operator.
  - The operator on board, coordinated with shore, takes connectors/cables and connects them to the ship inlet.
  - On the shore-side flexible cables, close to the connector, a cable grip is typically installed to allow the release of mechanical traction from the connector.
  - The grip should be connected to an appropriate anchoring point on the ship.
  - A cable guide may be required on the ship to control the HV flexible cable bending radius.
- A cable reel installed on berth that allows the uncoiling of the flexible cable by an external equipment, i.e. davit, crane or winches on board, keeping under control the maximum traction of the flexible cable.
  - On the shore-side flexible cables, close to the connector, a cable grip is typically installed to allow the release of mechanical traction from the connector.
  - The grip should be connected to an appropriate anchoring point on the ship.
  - A cable guide may be required on the ship to control the HV flexible cable bending radius.
  - The use of cable reels adds derating factors that should be compounded by the CMS designer typically resulting in larger cables needed to satisfy the derating factors. It also adds the need to have a separate dedicated cable reel and slip ring system for each power cable in the OPS if the 1-2-3 selective cable system is required.

The main advantages/challenges of each system are listed below:

- Cable manipulator
  - Advantages
    - HV connector is directly presented to the operator by onshore equipment, reducing the need for equipment on board.
    - Flexible cable is ‘protected’ on the structure, reducing to a minimum the flexible cable ‘suspended’ between shore and ship.
    - Manipulator can be designed to skip hazardous area, reducing related design challenges.
  - Challenges
    - Flexibility may be limited once the system is designed.
    - Depending on the dimensions of the manipulator, the structure may have an important impact on shore, requiring dedicated foundations on an already crowded area.
    - Automatic following of the ship can be complex.
- Cable reel
  - Advantages
    - Increased flexibility as the catenary will be able to compensate for the different position of the coupling point on the ship.
    - A more standardisable design, as the same design can be ‘shared’ in different berths.
    - Can be installed in a pressurised chamber.
    - Ship movements are compensated by slack of cable in the catenary.
  - Challenges
    - Flexible cables are exposed on the catenary.
    - Requires equipment on board, i.e. a crane/winch to lift cables.
    - In case of single slipring with multiple cables, all of them should be connected to ship inlets.
    - Typically results in larger cables needed to satisfy the derating factors.

9.3 Civil marine structural design requirements

OPS may require additional structures to support the equipment and to provide safe access to the OPS for operations and maintenance. Additional structures may be required to assist the OPS equipment to not interfere with mooring operations, cargo operations, stores, bunkering and other routine ship activities. For the civil marine structures, normal design requirements for such structures apply.

In most cases, the OPS would either be placed on the existing (un)loading platform or on a dedicated platform or monopile. Mobile crane solutions may also be an option when ample space is available.

In case of placement on an existing platform, a structural evaluation of the existing facilities is required, in which horizontal wind load on the CMS is a critical factor.

In case of a new dedicated platform/support, it is recommended to position this well outside the area where ships are able to move while (de)berthing. Failing to do so, will impose significant horizontal loads onto the dedicated OPS platform, that may cause the platform to become much heavier than strictly required for its primary function.

9.4 Interaction of cabling with mooring design and operations

The OPS will operate in the same 3D environment of ship movement while berthed as the mooring arrangement. The OPS should therefore be an integrated part of the mooring arrangement design.

As per IEC 80005-1 7.2.1(d) the OPS CMS is to be positioned to prevent interference with the ship’s mooring systems.

Prior to the ship being chartered, the terminal should complete a ship-shore compatibility assessment that includes a mooring analysis with OPS equipment.

Mooring analysis and OPS compatibility assessments should consider, but not be limited to, the following:

- Tidal changes, (un)loading operations and other local conditions that may affect both the OPS and mooring equipment.
- The working and final positions of mooring lines.
- Tug and linesman operational areas while (de)berthing.
- The possibility of mooring arrangement failure (broken line, any other likely damage).

9.5 Interaction with gangway and cargo transfer equipment

The OPS equipment should be designed and positioned so as not to be affected by nor interfere with the gangway and cargo transfer equipment. The OPS should be an integrated part of the topside design that includes all berth equipment.

All possible positions and movements during (de)coupling and operation of the OPS, and all positions and movements of other equipment during operations should be considered.

Potential interaction includes scenarios where the OPS cable is hit and damaged by the movement of the gangway as a result of tidal movements. Positioning the gangway over the OPS cable introduces the risk of falling objects damaging the cable.

As recommended by *ISGOTT,* in most cases the gangway is located aft of the manifold closest to the accommodations to avoid having the ship personnel needing to cross the fire risk area.

The operational interaction between OPS and cargo transfer equipment, including the order of coupling, is discussed in section 16 Interface operation.

9.6 Accommodating varying ship sizes and orientation

The scope of this publication, in terms of which ships it applies to, is discussed in section 4. Ships using OPS may vary in size (length, breadth, freeboard) and thus the position of the coupling. Due to potential manifold offset, the relative position of the ship to the berth may vary further. It should be noted that the manifold bank on the ship has a certain width that may be 10m or more. The same is true for the row of loading/discharging arms or hoses. As a specific combination of arm(s) and manifold may be required per loading/discharging operation, the ship may not be centrally moored at the berth. The ship position may vary due to orientation at the berth, whether port-side-to or starboard-side-to. These variables should be taken into account when designing an OPS.

For most cases a flexible CMS, either moving or telescopic/knuckle boom from fixed point, would facilitate connecting a wide range of ship designs, whether coupling is midships or aft.

It is recognised that terminals with a large variance in dimensions of ships at a berth may struggle to reach all possible positions for the coupling. Terminals may choose to target their OPS, providing maximum operational flexibility to a majority of the tanker fleet, while potentially providing less operational flexibility to the largest or smallest ships.

Tankers are in principle able to perform cargo transfer over either side. Orientation of the ship at the berth is not always up to the terminal operator and can be as recommended by the local pilots or port authority/operator. For river berths or those with prevalent currents or waves, the ship bow may need to face into the current. At other locations, the port, terminal or company policy may require the ship to be facing to sea to quickly depart in an emergency. A tidal window with limited available time for the (de)berthing manoeuvre may dictate orientation. Terminals should consider these potential restrictions when converging in design variables for an OPS, and consult local port authorities in the process.

Refer to section 9.1 for considerations on location of coupling versus ship orientation. Refer to section 3.7 for considerations on ship orientation from an onboard perspective.

9.7 Accommodation for ship movements, surge, sway and heave

Moored ships will move at a berth. Surge, sway and heave are motions induced in the ship by environmental factors such as wind, waves and current, or by the hydrodynamic effect of a passing ship. Additionally, ships may move due to varying load conditions during cargo transfer changing draft and trim.

Other local, external factors that may lead to ship movements should be determined case specifically.

When designing an OPS, all potential movements of moored ships should be studied to determine the required operational window of the CMS.

The exact method of position management by the onshore OPS is not prescribed. Technology may differ between terminals.

The CMS itself may also move, due to wind force, among other factors. Especially in cases with a larger variance in ship size, where the CMS is necessarily large, this may lead to even larger relative movements between ship and CMS.

The CMS should allow all ship movements that can be expected. Designers may choose to either have the CMS automatically follow the ship's movements, or to provide slack in the cable. The latter may keep the installation simpler. When providing slack, the cable should be protected from overbending and damage, also from getting caught by other objects while moving.

Unscheduled departure is a separate issue, discussed in section 16.8. Refer to section 3.8 for considerations on ship movements from an onboard perspective.

10 Electrical equipment design

This section provides guidance on the electrical equipment design considerations for OPS systems for ships and terminals. It addresses the variation in power demand between loading and discharging operations, connection design, frequency conversion, shore transformer design, shore switchboard location and design, voltage considerations, cabling and reel design, earthing of electrical equipment, safety system design, protection of ship equipment, protection of shore utility, additional gas detection considerations, additional fire protection for electrical equipment and backup/redundant supply arrangements.

10.1 Variation in power demand for loading vs discharge operations minimum, typical and maximum power requirements

Estimated maximum electrical load levels for shore power per ship class are given in section 4.1. The tanker electrical loads are shown for the condition of discharging cargo and will exceed electrical loads seen on the same ship class when they are loading cargo. In general, the electrical load while discharging is significantly greater than the electrical load while loading and the shore power system should be sized to accommodate the worst-case discharge electrical load. For a terminal designed for ship loading only, a separate study should be undertaken to understand the electrical load required.

Ships may vary between these load categories depending on ship-specific electrical load characteristics. The intent is to group all tankers into the nearest larger load size that exceeds the known ship loading. The terminal side of the shore power system can then be sized to accommodate the largest ship class that can use that terminal.

10.2 Connection design

Tanker shore power connection designs are to be made in accordance with IEC/IEEE 80005-1, Annex F. The connection system is to include terminal located CMS that are physically able to extend the power supply cables from terminal side to the ship inlet. Shore power supply cables will include integral pilot wires and earth conductors. Ship inlets are to be located at the ship to connect with the shore-side cable end connectors when shore power is used. When shore power connectors are not in use, both the ship inlets and the shore-side cable ends from the CMS should be protected with removable safety end caps.

Shore connection power supply, control interlocking and equipotential earthing connectors and their associated safety end caps should be manufacturer rated for outdoor marine use in high moisture and corrosive conditions. Couplings will be made in non-hazardous locations.

10.2.1 Ship couplers

A ship coupler (ship connector and ship inlet), with a minimum of seven pilot contacts, is to be designed, manufactured and certified in accordance with IEC 62613-2, Annex J. This annex details 12kV, 500A, three-phase accessories.

Ship couplers are to include three phase power terminals, a protective earth terminal, and seven pilot wires. Connectors at the ship end of CMS cables should include sockets that include power, protective earth and pilot wires for each shore power cable. Ship inlets at ship coupling location are to include pins for each power, protective earth and pilot wire that are compatible with the sockets in the CMS cable's ship connectors. General intent is that ship side (load) is to plug into shore side (supply) with pins on the ship side and sockets on the shore side. The OPS system should be able to deliver a minimum nominal current of 350A per connection. The power rating of connectors should be 500A to give ample margin of safety for 350A loads. Ship connector and ship inlet should be tested against IEC 62613-1, IEC 62613-2 Annex J, IEC/IEEE 80005-1-2019 and class type-approved for marine applications.

Ship connectors are to include design features such that upon coupling the connectors to the ship inlets, the first pin/socket to make electrical contact will be the protective earth pin. The second pin/sockets to make contact will be the phase conductors and the last pin/sockets to make contact will be the pilot wires. The sequence is reversed upon making a decoupling. The electrical protection systems at both sides of the coupling will be electrically interlocked through the pilot wire system to assure that neither of the supply side or load side cable circuit breakers can close until all safety and operating conditions are satisfied. Shore power cables, connectors and ship inlets will always be de-energised and earthed internally at the switchgear from both sides when they are not in active use to carry shore power.

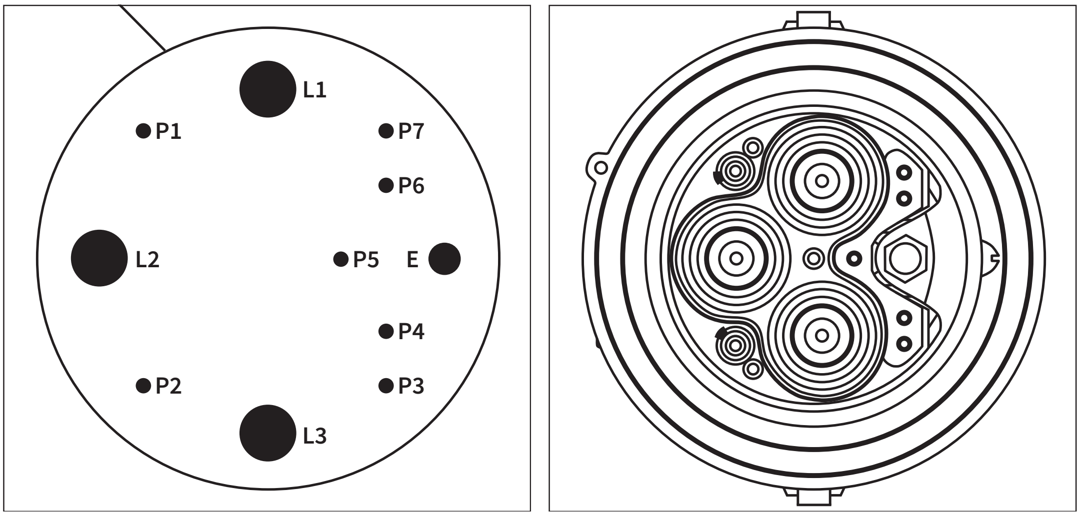

Figure 10.1: *Connector's contact arrangements (Source- IEC/IEEE 80005-1, Annex B fig. B.3 left and IEC 62613-2 Annex J right)*

Legend

L1, L2, L3	= phase A, B, and C power, 6.6kV
E	= protective earth
P1, P2, P3, P4, P5, P6, P7	= pilot wires

Pilot wire systems used for interlocking within the shore power connectors are to include control wires in accordance with IEC/IEEE 80005-1, Annex F. Control wiring and connectors are to be rated for the voltage class and current required per the international standards. Pilot wires will be integral to the shore power cables when handled on the CMS systems from shore to ship.

10.2.2 Safety end caps

Shore power system safety end caps should be provided for all CMS cable connector and ship inlets. They give waterproof protection to the connectors or inlets they serve and are otherwise to be manufacturer rated for outdoor marine use in high moisture and corrosive conditions. Safety end caps should include corrosion resistant tether lines to secure them to their respective connectors or inlets when they are removed and uncoupled from the connectors or inlets. They should be physically compatible with the connectors or inlets they serve and of unique design, i.e. not interchangeable per side of use. The intent is that caps for CMS connectors will be compatible only with the connectors and include the necessary pins to engage into the connector's sockets, while the caps for ship inlets will be compatible only with the inlets and include the necessary sockets to engage with the inlet's pins. Caps should not interfere with pins and safety loop.

CMS cable connector safety end caps should be interchangeable between cable connectors and include shorting provisions to earth all phase conductors and pilot wires to the protective earth conductor when the cap is installed on the connector. They should also include internal pilot wire connections to electrically interlock the shore-side power supply system to prevent closing the supply circuit breaker to that cable when its end is capped. Each CMS supply cable should be serviced by a single dedicated and controlled circuit breaker at the supply point on the terminal.

Ship inlet safety end caps should be interchangeable between ship inlet connectors and include shorting provisions to earth all phase conductors to the protective earth conductor when the cap is installed on the connector. They should also include internal pilot wire connections to electrically interlock the ship side power load system to prevent closing the load circuit breaker to that inlet when it is capped. Each ship inlet will be serviced by a single dedicated and controlled disconnector and earthing switch at the shore power receiving switchgear on the ship.

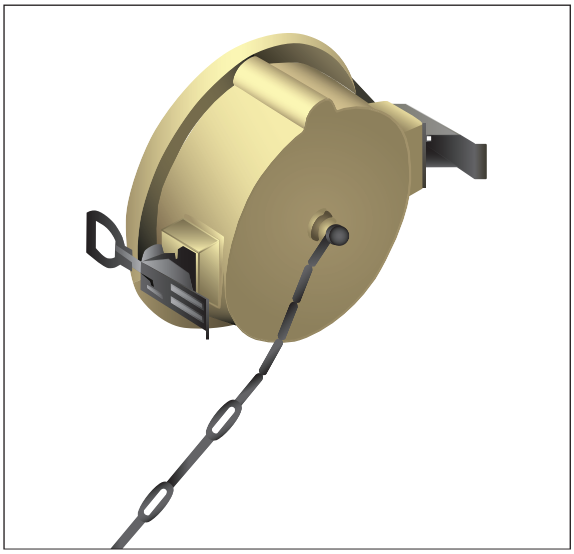

Figure 10.2: *Example of ship connector safety end cap (Source: Proconet)*

10.2.3 OPS cables and associated systems

Connection systems are to allow use of the number of ship inlets necessary on the ship to carry the estimated maximum shore power load per that ships size class or specific characteristic electrical load. The OPS should be generally designed to support the maximum electrical power load size of ship that can moor at that berth.

Dependant on their power requirements it is possible that ships do not need more than one connection, where multiple connections are provided. The CMS should pay out only the cables that are needed for the couplings. Unused ship inlets will have their safety end caps remain in place when not in use. Each cable should have a dedicated circuit breaker and safety loop that prevent the cable from energising when not connected onboard. Interlocking should be used to ensure that unused inlets or CMS shore power supply cables will be automatically de-energised and earthed.

While in stored position, cables are to be earthed and isolated, and each ship connector is to be covered with a safety end cap and an electric isolation cover, which aims to reduce the risk of sparking while handling the ship connectors onboard the ship for connection.

The CMS system from shore should be designed to dispense out the number of cables needed for the maximum load it can service on its terminal. For example, a large terminal capable of servicing the largest VLCC’s will be equipped with CMS equipment including three shore power cables in order to manage the largest loads. That same CMS equipment will be capable of selectively dispensing one, two or three cables as needed for small, medium or large loads. Each shore power cable within a CMS will be rated for maximum 350 amps at 6.6kV, which gives it a maximum apparent load capacity of approximately 4.0MVA per cable.

If the CMS design does not allow cables to dispense individually and there is a discrepancy between the number of ship inlets and connectors from shore, unused cables or inlets may be parallel to energised cables or inlets when shore power is in use.

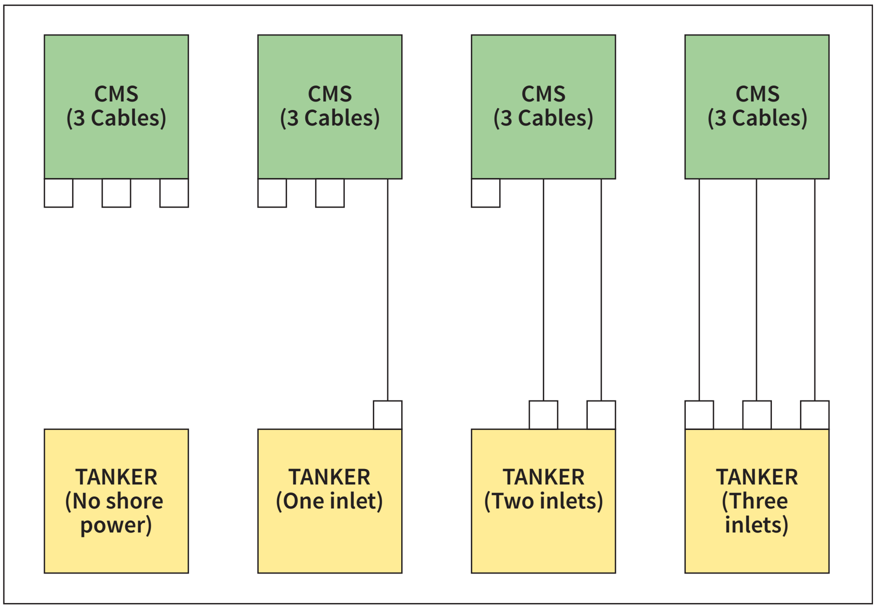

Figure 10.3: *Terminal can supply all ship sizes by selective operation of 3-cable CMS*

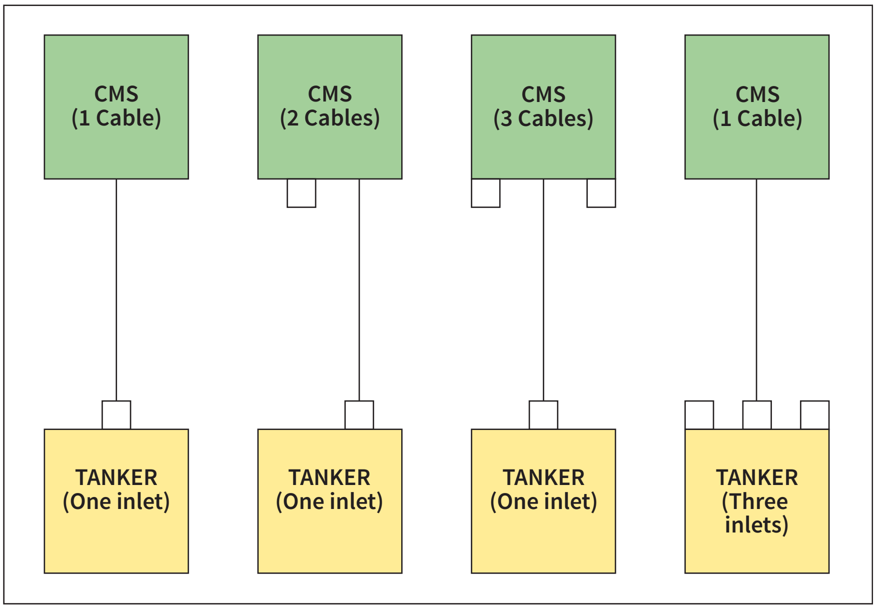

Figure 10.4: *Discrepancy between CMS and ship inlet*

Where there is a discrepancy between quantity of ship inlets and quantity of connectors from shore, the ship operator and the terminal operator should agree in advance as to the limitation of the desired shore power connection to be made. The ship may need to operate at a reduced capacity while on shore power from a terminal side system that is designed for smaller load ships, or the terminal may need to supply power to a smaller ship than the terminal CMS system and shore power supply is sized to support.

10.3 Frequency conversion

Table 4.2 in section 4.7 Frequency conversion outlines, the requirements for the provision and location of a frequency converter based on the onboard ship frequency and the terminal grid frequency. The design should accommodate the frequency conversion for the largest ship that can be handled based on section 10.1.

The design of the frequency converter should consider accommodating an overload with respect to base load for a specified duration. A power quality analysis should be carried out to determine if any harmonics are exceeding acceptable limits. Harmonic filters may need to be installed to block these harmonics.

10.4 Shore transformer design

Shore power transformer design is to be made in accordance with the IEC/IEEE 80005-1, Annex F, and international high voltage shore power standards, and sized in accordance with the largest ship that can safely berth at that terminal. Transformer sizing is to be based on the naturally cooled thermal rating of the transformer with the maximum connected ship apparent load as described in section 9.1. Transformers are to be installed in non-hazardous classified areas and should be equipped with outer enclosures to suit the environmental conditions of where they are installed.

The designer should estimate the maximum apparent load for their specific terminal location based on consideration of the largest ships that could normally visit there plus any ship specific load characteristics that may influence the magnitude of the ship load. Standard transformer sizes that are commonly available for the 1, 2 or 3 cable serviced ship class loads are typically 5000kVA, 7500kVA and 12000kVA respectively based on the 350 Amp cable size at 6.6kV, 3-phase. In strict accordance with IEC/IEEE 80005-1, the shore power transformer must only service a single ship when in operation. This is to help prevent an earth fault or voltage disturbance from one ship impacting operations and electrical safety on another ship.

Transformers should include resistance earthed neutral systems on the secondary and generally be of delta connected primary and wye connected secondary configuration (i.e. Dyn11 type configuration). Transformers should be of separate winding type on primary and secondary.

Transformer primary may include an Automatic Tap Changer (ATC) system that is sized for the primary distribution voltage used within the terminal. The ATC is intended to help regulate shore power supply voltage during changes of load from the ship due to use of large transfer pumps and other large load equipment within the ship. It also helps to regulate shore power supply voltage from utility or cogeneration power source voltage fluctuations. The need for a possible ATC system on the shore power transformers should be evaluated by the system designer based on specific supply and load characteristics of the terminal for which the shore power system is being designed and for the typical ships that will visit that terminal.

If an ATC system is used, the control of the ATC should be made from shore-side only, unless there are spare pilot wires available for use. There is no provision for additional control wires or cables from ship to shore. The system designer should specify shore power transformers to meet estimated load requirements and fault level conditions from the power supply. The fault level contribution from the HV shore distribution system, and the fault level contribution from the onboard running induction motors and generators at the shore power coupling point on the ship, should be in accordance with IEC/IEEE 80005-1, Annex F.

Transformer winding materials are recommended to be made from copper for the greatest thermal efficiency. The transformer may be oil filled type or dry type. Design consideration can be made to cast coil dry type transformers for lower maintenance, lower risk of fire or explosion, better performance to intermittent loading usage, lower environmental impact risk and lower risk of degradation over service life. Oil filled transformers may also be used but will need additional oil containment and flammability risk mitigations, and higher maintenance. Transformer enclosures should be designed according to the installation location of the transformers and will generally be outdoors, unless designed for installation into a well-ventilated indoor space. The designer should include fan cooling as per their design requirements but should not rely entirely on fan cooling to carry the full rated load expected for the transformer under normal loading conditions.

Transformers should include, as a minimum, the transformer protective features in accordance with IEC/IEEE 80005-1, Annex F. They may be prefabricated and pre-integrated into unit substations with adjoining primary and secondary switchgear and other associated equipment as required.

Transformers should be located on the terminal areas as close as practical to their shore power loads. They are to be manufactured to meet the requirements of the Authority Having Jurisdiction (AHJ) at the terminal's location to achieve local compliance with all applicable codes and standards enforced by the AHJ.

Transformers should provide galvanic insulation and neutral should be earthed. A shore power supply system using a frequency converter should provide galvanic insulation and the same neutral-earth configuration. See section 10.6 Voltage consideration. The transformer design should be built according to the converter requirements.

10.5 Shore switchboard location and design

The shore power switchboard refers to the switchboard, including switchgear, that is required at the secondary side of the shore power transformers. It has direct protection and control responsibility for the shore power supply to the ship. Shore power protection features should be in accordance with the protection requirements of IEC/IEEE 80005-1. An upstream switchboard serves as the primary protection for the shore power transformer and backup protection to the secondary side. Additionally, the upstream switchboard provides upstream supply side interface protection for utility or site cogeneration requirements.

Shore power switchboards may be integral to unit substations or as standalone switchboards, depending on the designer's choice and the physical requirements of the terminal site.

Switchboard equipment may also be indoor or outdoor, depending on the specific site requirements. If located outdoors, the switchgear should be provided with outdoor-rated enclosures that are suitable for high moisture and corrosive marine environments.

Switchgear is to be installed in non-hazardous classified areas on the terminal. It should be manufactured to IEC or ANSI equipment standards in accordance with the AHJ at the terminal's location.

Switchboard technology selection and the manufacturer's features and options will be at the discretion of the system designer and the specific requirements of the terminal operator and AHJ. Shore power supply switchgear must include an automatic earthing switch on the load side of the circuit breaker to facilitate automatic earthing of the shore power supply feeder when not in use.

The shore power connector system described in section 10.2 requires that the shore power supply feed to the CMS on the terminal side includes a dedicated 3-phase disconnector and earthing switch for each cable in the shore power connection system. This requirement is matched on the ship side, where each shore power inlet will also be wired directly to a dedicated and independent 3-phase disconnector and earthing switch. Individual disconnection and earthing for each CMS cable and at each ship inlet is required to safely operate the system with the selective 1, 2 or 3 cable or inlet system. These individual cable disconnectors and earthing switches may be integral to the shore power switchboard or be remote and located at the CMS connection point, depending on the particular terminal design.

The shore power supply switchboard will act as the power source to all shore power CMS connection points on a given berth and is required to include a single shore power source circuit breaker. If there is only one CMS connection point on a berth, then the switchboard will only need a single 3-phase circuit breaker, disconnector and earthing switch to supply power to that single CMS supply point.

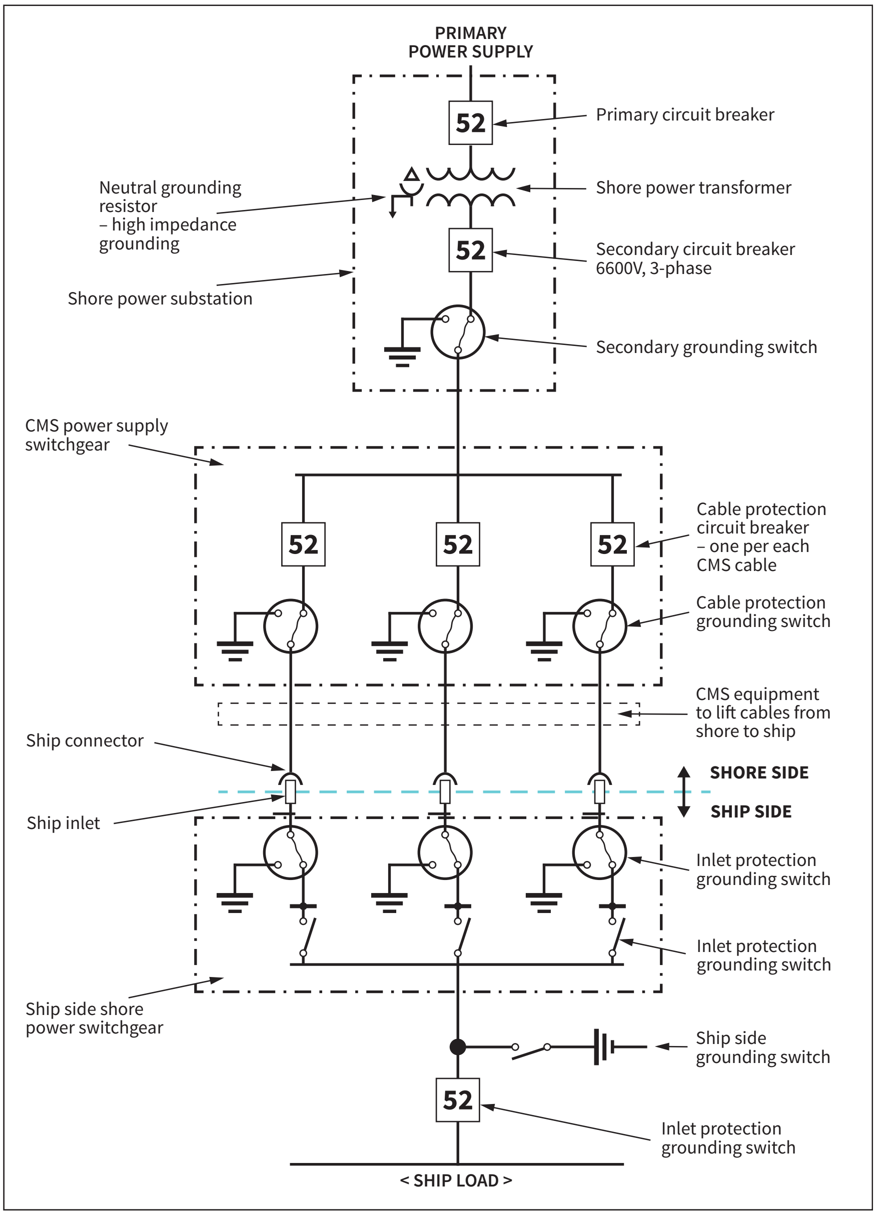

Figure 10.5: *Typical Single Line Diagram for 1-2-3 Selective Shore Power System (Source: Moffatt & Nichol)*

If the shore power supply point and CMS connection point are more remote from each other, it is suggested that the designer consider the use of a separate stand-alone switchboard at the CMS connection point and a single supply circuit breaker at the shore power supply switchboard. In this case, a single 3-phase circuit breaker with load-side earth switch can be used at the shore power supply switchboard and the remote CMS connection point will be required to have the individual dedicated 3-phase disconnector and earthing switches for each CMS cable.

Berths fitted with multiple independent CMS connections should be capable of energising only one connection at a time. Other connections should be in an earthed condition with an interlock preventing them from closing.

In the case of multiple connection points on the same berth, it is suggested that the dedicated and independent 3-phase disconnector/earthing switch required for each cable in the CMS system be located at the CMS connection point to help reduce equipment space impact at the shore power switchboard and keep the CMS connection switchgear as compact as possible.

10.6 Voltage consideration

Ship shore power operating voltage should be 6,600 V, 3-phase, 3-wire, from the shore power supply at the terminal side. Power quality should be in accordance with the general requirements of IEC/IEEE 80005-1 plus the tanker ship specific requirements of Annex F of this standard. Neutral of 6,600V shore power transformer secondary should be earthed through a high impedance Neutral Earthing Resistor (NER). The NER acts to reduce earth fault current and limit earth potential rise voltages throughout the shore power system and give a convenient point to detect earth fault current and apply protection. The NER system will normally be located near to the shore power supply transformer.

10.7 Cabling design including consideration for ship movements – freewheel

Cabling design integral to the CMS is to allow for flexible movement between the CMS cable support point and the ship inlets and for flexible ranges of motion within the CMS itself. Cables need to be flexible enough to be handled when couplings are made or disconnected and not overstress the cables' minimum bending radius or tensile limits during handling or when in operation.

CMS equipment design may vary between the configuration required for particular terminals and the CMS manufacturer's design for the equipment necessary to manage the support and reach required for the CMS cables. Some CMS systems may include a telescopic boom that reaches out to the inlet position on the ship. In the case of a telescopic boom, the shore power cables need to be flexible enough to safely wrap onto mono-spiral cable reels to accommodate the overall cable length when the CMS boom is fully retracted.

CMS equipment may also include folding articulated support arms where the shore power cabling remains attached in its overall length to the support arms and does not require cable reel storage. In such cases, there will still be a length of free-hanging shore power supply cable at the ship end, but the cables that are permanently attached to the folding articulated support arms will need to have sufficient flexibility to safely bend through all ranges of motion imposed by the folding support arms.

The CMS system is required to allow for the range of motion between the ship and the berth. The free-hanging loop of cables near the ship inlet will accommodate a small amount of motion, but the larger relative motions possible by draft or tidal changes need to be accommodated by the CMS equipment itself. This may include automatic tensioning and freewheeling type systems to maintain a minimum and maximum amount of slack cable between the final CMS support point and the ship, plus automatic CMS support position adjustments over the entire time duration of shore power usage per a given connection. Automatic movements of the CMS to keep the free-hanging loop constant are allowed and should be designed to be reliable.

Cables will be equipped with connectors at the ship end, as described in section 10.2 Connection design, and a fixed anchoring point as described in section 5.3 Cable movement monitoring and prevention.

Cables passing hazardous areas should comply with the IEC 60092-502. Cables should be low-smoke, flame-retardant, halogen-free type and chemical-resistant as per IEC 60092-353/354. The cable route should not transit a Zone 1 electrical classified area.

10.8 Reel design

For CMS that change cable length when reaching from terminal to ship, the overall shore power cable length may be stored on mono-spiral cable reels internal to the CMS system or be stored through adjustable loops in a cassette type system when the CMS system is fully retracted. The mono-spiral or adjustable loop type cable storage system should be provided integral to the CMS equipment for all cables that form part of the shore power connection system. Cable reel systems should include slip ring type connectivity for power, earthing and control type wiring.

The cable reel or adjustable loop system should be motorised to dispense cable when the CMS system is extending and store cable when the CMS system is retracting. Each individual CMS shore power cable should be able to dispense independently of any other shore power cables in the same CMS system.

Cable reel and associated slip ring systems should be located in non-hazardous classified areas wherever possible. Reel equipment should be fabricated from materials that are suitable for an outdoor marine environment. Use of stainless steel or other highly corrosion resistant material is recommended. Slip ring enclosures are to give weather-tight protection for the sliding contacts and wiring internal to the slip ring mechanism. If the CMS system is located inside a hazardous classified area, then all CMS equipment must be certified for use in that classification of hazardous area.

CMS systems should include design features to automatically allow for ship movement when shore power connections are in use. This may include automatic position sensing and control to maintain a safe working clearance from the ship end of the CMS system and the ship. The CMS positioning system should allow for ship movements such as draft changes, tidal variations and large wave motions that may cause relative movement between ship and ship end of CMS system. It is expected that the CMS system will provide a steady fixed support position when shore power connections are in use, but that systems to allow for ship movement will automatically adjust to maintain a safe working clearance between CMS equipment and the ship.

CMS systems that are physically attached to the ship while in use will require freewheeling features to allow the CMS system to safely follow the motion of the ship while the shore power connection is operated. Where required, the attachment point needs to be integrated to any quick release type system that is used to allow for quick disengagement of the shore power system in an emergency.

CMS systems are to be located on the terminal 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 terminal.

10.8.1 Cable grip device

The terminal should supply a cable grip device for each cable to be attached to the ship's fixed anchoring point. The cable grip device should not damage the cable. This device may be permanently fixed to the cable. If that is the case, the impact on the CMS design should be considered.

10.9 Lifting equipment including consideration for ship movements

CMS equipment is required to lift and support the full quantity of cables and their connectors and accessories as per the shore power connections described in section 10.2 Connection design. This includes up to three high voltage shore power 3-phase cables with integral protective earth and pilot wires. All shore power cables will include connectors at their ship ends and a permanently attached cable strain relief sleeve that can be anchored to the ship when the cables are in use. Safety end caps will also be provided as described in section 10.2 for the 3-phase shore power cables and these devices will remain on the connector ends for cables that are not in use or on all power connectors when the CMS is decoupled from the ship and not is use.

CMS equipment should be designed by the manufacturer to support the weight of all cables, connectors and accessories that are to be used for the shore power connections and unused power cables in cases where not all power cables are used during a coupling. In addition to this weight allowance, the CMS manufacturer should allow for wind and possible ice loading per the geographic location and environmental conditions of the terminal site.

CMS equipment should also be designed by the manufacturer to withstand seismic conditions of the geographic location of the terminal site.

Shore power cables may also be lifted into position under special cases by the on-board ship cranes. In these cases, the ship crane should be capable of reaching the positions needed and have the load capacity for this purpose. Where the ship cranes are used, they are generally only used to lift cables into position and then detach from the load or to lift the cables from the ship and detach afterwards. Ship side cranes are not normally expected to maintain constant lift and support of the shore power cables while those cables are in use. Suitable cable support saddles should be provided when non-CMS dedicated cranes are used. Cable support saddles should maintain the cables in a position that prevents them from being bent beyond their minimum bending radius limits and otherwise protect them from mechanical stress and damage while handling. See section 3.4 Cable lifting.

10.10 Earthing of electrical equipment

A system's earthing conductor should connect from the NER of the shore power supply transformer secondary to a nearby system earthing electrode. An additional system-bonding conductor should be included in the shore power cables to assure that shore-side earthing is connected to ship earthing during shore power operations. The system-bonding conductors should be integral with the shore power cables and establish an equipotential bond when shore power cables are coupled through ship connectors to the ship side inlets.

System bonding is to be made in accordance with IEC 60204-11 and/or IEEE 80 depending on the geographic location of the terminal and the specific site requirements imposed by the AHJ for the terminal site.

The pilot wire systems used in each shore power supply cable should include an equipotential monitoring device. These devices should be installed at the shore power supply point at the shore side of the CMS, where the CMS connects to 6.6kV shore power for each cable. Devices are to monitor continuity to earth through a dedicated pilot wire in the pilot wire system and use a termination diode device on the ship side to confirm the continuity.

10.11 Safety system design – emergency stop, auto ejection, quick release and ESD permissives

Safety system designs should generally be in accordance with IEC/IEEE 80005-1. Emergency stop systems are to be provided on board the ship and on the terminal electrical systems to effectively initiate a manually activated emergency stop when needed by operations persons on ship or on terminal. The safety loop, as described in section 10.2 Connection design, should include overlapping safety loops from ship and from shore so that an emergency stop activation from the shore or ship will immediately trip out the shore power supply circuit breaker and the cable protection circuit breakers at both sides of the shore power connection.

Emergency stop circuits should be hardwired throughout the control and safety system. The safety system circuits should be designed so that emergency stopping, de-energisation and earthing of HV shore power link is possible and reliable upon activation of an emergency stop (E-stop) pushbutton anywhere in the overall shore power system when it is in operation and there is shore power coupling from shore to ship.

If fibre optic links are used in the emergency stop safety circuit, they should be controlled by devices that meet the performance and reliability requirements of IEC 60834-1: *Teleprotection Equipment of Power Systems.*

Copper-based hard wire connections are required for pilot wire systems between ship and shore up to the CMS supply point protection on shore. The CMS supply point protection should be able to shut down the OPS supply to the ship in the event of a pilot wire tripping signal. Upstream protective devices in the direction towards the power source may be interconnected with fibre optic based links where site distances are large as described above, provided that the CMS supply point, which is hardwired to the pilot wire safety system, is capable of tripping out the OPS system operations.

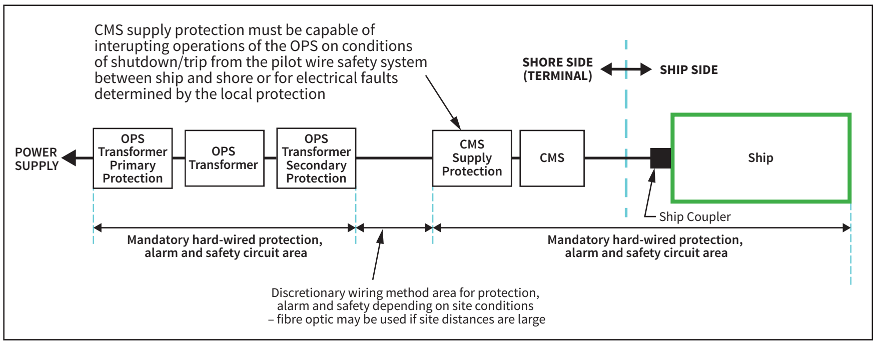

Figure 10.6: *Safety wiring method overview*

The terms ‘auto ejection’ and ‘quick release’ pertain to mechanisms intended for physically decoupling the ship connector from a ship inlet or establishing a breakpoint/weak link to separate the coupling without manual intervention. There is no general requirement to implement such a system.

Operational permissives from the shore power protection and control system are to be in accordance with the IEC/IEEE 80005-1.

Cargo ESD systems should be entirely separate and independent from OPS shore power systems where both may be used on the same ship.

10.12 Protection of ship equipment due to power surge/dip – power factor, voltage regulation and surge protection

The protection of ship equipment should be covered by the internal circuit breakers and protection systems on board the ship. The shore power system should be connected to the ship’s power distribution through dedicated cable protection circuit breakers, one per each ship inlet as described in section 10.2 Connection design, plus a main incoming circuit breaker that is dedicated for shore power use. The onboard main incoming breaker for shore power should be controlled by the ship’s electrical protection systems and include provisions for synchronising to allow temporary paralleling between ship and shore during the shore power connection process.

The quality of HV shore supplied power should be in accordance with IEC/IEEE 80005-1. This standard covers continuous voltage and frequency tolerances and response limits for stepped loads and acceptable limits for harmonic distortion.

The terminal side shore power system designer should design the shore power supply system for electrical performance and protective features that follow the requirements of IEC/IEEE 80005-1.

The HV shore power supply system should include provision of appropriate rated surge arrestors to protect against fast transient overvoltage surges, such as spikes caused by lightning strikes on the supply grid or switching surges.

Electrical protection features on the shore-to-ship side of the shore power system are to be in accordance with IEC/IEEE 80005-1, Part 6.3, including:

- Instantaneous overcurrent (ANSI/IEEE device 50, IEC 61850 device PIOC).
- Overcurrent protection, AC inverse time (ANSI/IEEE device 51, IEC 61850 device PTOC).
- Reverse power (ANSI/IEEE device 32, IEC 61850 device PDOP).
- Earth fault overcurrent (ANSI/IEEE device 51G, IEC 61850 device PTOC).
- Unbalanced cable protection (ANSI/IEEE device 46, IEC 61850 device PTOC).
- Dead bus voltage sensing (ANSI/IEEE device 25, used only for voltage sensing, IEC 61850 device RSYN).
- Undervoltage (ANSI/IEEE device 27, IEC 61850 device PTUV).
- Overvoltage (ANSI/IEEE device 59, IEC 61850 device PTOV).
- AC directional overcurrent (ANSI/IEEE device 67, IEC 61850 device PTOC).

Protection systems on the terminal side shore power system should be provided with battery back-up that is adequate for at least 30 minutes.

Electrical protection features on the ship side of the shore power system should be in accordance with IEC/IEEE 80005-1, Part 8.5.4, including:

- Instantaneous overcurrent (ANSI/IEEE device 50, IEC 61850 device PIOC).
- Overcurrent protection, AC inverse time (ANSI/IEEE device 51, IEC 61850 device PTOC).
- Reverse power (ANSI/IEEE device 32, IEC 61850 device PDOP).
- Earth fault overcurrent (ANSI/IEEE device 51G, IEC 61850 device PTOC).
- Phase sequence voltage unbalance (ANSI/IEEE device 47, IEC 61850 device PTOV).
- Synchrocheck (ANSI/IEEE device 25, used for closed transfer momentary paralleling of shore to ship, IEC 61850 device RSYN).
- Undervoltage (ANSI/IEEE device 27, IEC 61850 device PTUV).
- Overvoltage (ANSI/IEEE device 59, IEC 61850 device PTOV).
- Frequency (ANSI/IEEE device 81, under and over, IEC 61850 device PTUF, PTOF).

Protection systems on the ship side shore power system should be provided with battery back-up that is adequate for at least 30 minutes. Protective device equivalents from IEC 61850 and IEC 60617 may also be used.

10.13 Protection of shore utility, reverse power and impact to cogeneration operations

Reverse power protection should be provided within the shoreside portion of the shore power system in accordance with IEC/IEEE 80005-1 and as described in section 10.12 of this paper. Magnitude of reverse power and duration of its presence should be determined by the terminal shore power system designer in accordance with the agreed tolerable limits of the upstream utility power supply or the on-site cogeneration power supply, whichever is the primary source of power to the shore power system.

The terminal shore power system designer is required to establish communication with the onshore power supply utility and/or the site cogeneration power supply operators. The protective settings needed in the shore power system for reverse power are to be discussed and agreed with these operators of the upstream power supply.

10.14 Additional gas detection considerations

The need for additional gas detection features on the terminal side of the shore power systems should be determined and will depend on the hazardous classifications of the terminal areas and on the particular type of gas hazard that is being allowed for. Terminals will generally be classified to one of the following American Petroleum Institute (API) recommendations:

- *API Recommended Practice 500: Recommended Practice for Classification of Locations of Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2.*
- *API Recommended Practice 505: Recommended Practice for Classification of Locations of Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2.*

Additional recommended practices or guidelines may also apply to the terminal depending on the geographic location of the terminal site and the local AHJ over the site.

Added gas detection is to help protect the terminal and ship from the risk of spark ignition of the hazardous gas caused by the operations of the shore power system while:

- It is actively delivering shore power.
- It is being moved into position to deliver shore power.
- It is being moved back to its storage position.
- It is parked in a storage condition when not delivering shore power.

The shore power system will generally be installed in non-hazardous classified areas wherever practical. Where portions of the shore power system need to be located or pass through hazardous rated areas, the shore power system components that are exposed to the hazardous areas are required to be manufacturer certified for safe use in the particular hazardous classified areas that they will be exposed to. Shore power equipment manufacturers are responsible for providing suitable enclosures and certified equipment components for use in the classified areas where they will be installed, exposed to or operated within.

Where added gas detection devices are used at the on-terminal side of the shore power system, they should be wired to appropriate alarms and shut-down interlocks as required to assure safety under all operational, positioning or storage conditions of the on-terminal shore power supply system.

Where clean air or nitrogen purge systems are used to maintain a non-hazardous condition within an enclosure or building housing shore power equipment, the loss of purge pressure should automatically alarm and trip out the energy sources of the shore power system and all other auxiliary power sources that could be active in that pressurised area and not already protected by appropriate hazardous area rated enclosures and fittings. The loss of purge pressure signals the immediate escalation of combustion hazard risk, and all sources of energy should be immediately de-energised and earthed at their points of power supply to prevent risk of ignition. Access doors and hatch covers that open into the purged space should also be interlocked to trip out the energy sources in the purged space if the access doors or hatch covers are opened during purge operations.

As per section 6.14.1 OPS deck compartment overpressure, where the OPS coupling deck compartment is located in designated non-hazardous areas on the ship, the loss of pressure in the coupling compartment may first generate an alarm and then initiate a shutdown of the OPS after a predetermined time limit, as the risk is low.

10.15 Additional fire protection for electrical equipment – foam suppression

The need for additional fire protection will depend on the fire protection systems that are already in place at a terminal. The addition of on-terminal shore power systems is not expected to add combustion risk to the terminal but may have internal fire risk within its components and system. Exterior fire suppression is recommended to be based on foam type fire suppression systems. Interior fire suppression systems inside electrical equipment rooms or enclosures are recommended to be with 'Clean Agent' type fire suppression systems that will not damage equipment upon activation.

Electrical equipment area fires are categorised by NFPA as Type C and require use of non-conductive type fire suppressants to extinguish the fire.

10.16 Backup/redundant supply – shore protection relays and UPS

The on-terminal shore power control, monitoring and protection systems are to include backup/redundant power supplies that will allow a minimum of 30 minutes of operations time following a black-out of the normal power supply. This is intended to allow time for an orderly stop of operations during a power supply blackout. When normal power supply is lost, the shore power protection system should open all controlled circuit breakers and close earthing switches until normal power has been confirmed as being restored and a new supply connection to the ship can be re-established. The on-ship shore power control, monitoring and protection systems should also include a similar feature, made in accordance with IEC/IEEE 80005-1.

Quick release systems should not automatically release unless activated by emergency release signals. The protection and control system may initiate the release signal but only on conditions that are appropriate for emergency release. Loss of normal power supply is not an immediate cause for emergency release.

If OPS power from the terminal side is not restored within a reasonable time, typically 30 minutes, then terminal operations may decide to disengage a shore power system that is connected to a ship. This would involve decoupling the shore power cables and returning the CMS equipment to its on-terminal storage position.

CMS equipment should include provisions for operation in the event of an outage of normal site power with sufficient capacity to meet widely accepted safety standards, generally 90 minutes. A portable emergency power source/generator, hydraulic accumulator or other means should allow for retraction and storage of the CMS equipment from a fully deployed CMS crane at its greatest extension of reach. A UPS system should be used to provide backup control power to operate the safety loops and other controls associated with the CMS operation. It is also essential that all contactors and disconnectors can be safely opened after shoreside power has failed.

11 Additional design considerations

This section addresses additional design considerations for OPS systems, encompassing pressurised building design for electrical equipment in hazardous areas, shore power generation considerations, ship/shore electrical isolation, fluid surge considerations due to shore power loss, environmental considerations for electrical equipment rooms, considerations for berths with Emergency Release Systems (ERS) and auto mooring line release systems, considerations for shore electrical equipment, shore physical barriers around electrical equipment, human factor design considerations, and corrosion protection for electrical equipment in marine environments.

11.1 Pressurised building design

The following provides general design guidance on pressurised buildings for shore electrical equipment if located in a hazardous Zone 1 or Zone 2. Any high voltage equipment that is not certified for installation in a hazardous area should be located inside a safe pressurised gas-free compartment.

Pressurised gas free compartments should meet requirements of NFPA-496 *Purged and Pressurised Enclosures for Electrical Equipment* or equivalent local or national standard and should be designed and confirmed to have positive pressure.

A pressure indicator or pressure switch should be installed on the pressurised gas-free compartments to confirm the mandatory minimum enclosure pressure. A flow indicator may be used in place of a pressure indicator if it can be shown that the indicator will adequately prove the required pressurisation under all potential conditions.

Potential arc-flash gases in the compartment should be vented to a safe area.

The pressurised gas free compartment should be provided with a system that will either maintain the atmosphere at less than 5% oxygen by volume (for inert gas purged system) or ensure that no flammable materials can back diffuse.

For an inert gas purged system, the oxygen content of the enclosure should be monitored by either providing a continuous oxygen monitoring and alarm system set at 2% oxygen or providing a flow switch on the purge gas set to ensure that adequate purge gas is continuously supplied.

A pressure switch on the purge gas feed is normally not acceptable due to the potential for blocking the purge gas flow while still maintaining pressure. Whichever method is used, the installation should be tested at start up to confirm the placement of the oxygen sensor or the flow switch setting.

The oxygen concentration should be measured with a meter calibrated within the last 30 days. The oxygen concentration should be measured at several places distributed throughout the compartment. The exact sample locations should be determined by the site Safety Health and

Environment coordinator but should not be less than 1 per 0.1m³ with a minimum of three places regardless of size.

The sensor should be located at the point of the lowest reading, or the flow switch should be set to trip at a value that ensures no reading is more than 2% oxygen by volume.

For an air purged system, the flammable gas content of the enclosure should be monitored by either providing a continuous combustible gas monitoring and alarm system set at 20% of the lower flammable limit or providing a flow switch on the purge gas set to ensure that adequate purge gas is continuously supplied. Purged enclosures with only metallic piping components inside are not considered to be a source of sufficient flammable leakage to require inert gas purging unless special circumstances (special fittings, rapid heating and cooling, components with a history of failure, etc.). Purged enclosures with glass and/or plastic components are a source of sufficient flammable leakage to require inert gas purging unless there are special circumstances (flow restrictors, extended history of safe operation, etc.).

Consideration should be given to whether special provisions against accidental opening are required and what are the most suitable provisions based on the safety review hazard analysis. Enclosures which are alarmed and designed to cut power do not require special provisions against accidental opening. Bolted or screwed enclosures which require at least four bolts or screws to be removed to be opened do not require special provisions against accidental opening but should be provided with a sign to warn against opening. Quick opening doors or enclosures with less than four bolts or screws should have special provisions against accidental opening based on the safety review hazard analysis.

If required, the special provisions should consist of providing a sensor that will cut all power upon opening the door or providing a magnetic lock to prevent the door from being opened while power is still on.

11.2 Shore power generation

While this publication is not meant to define shore power generation design requirements for the berth, this is an important factor for terminal operators and designers. A stable power source with sufficient backup capabilities should be available. The following should be considered:

- Number of berths and operations requiring onshore power supply simultaneously.
- Demand required for normal operations and emergency situations.
- Size of ships.
- Loading vs discharge operations.
- Reliability of the utility.

Redundancy will be an important component of the engineering design for shore power. This will include the number of source feeds required and the type of switchgear required, whether manual or automatic. The terminal operator will want to minimise outages and spurious shutdowns from both a reliability and safety perspective. The facilities should be designed to provide a high level of reliability.

11.3 Ship/shore electrical isolation

The interface between a ship and its berth is a potential pathway for electrical current flow, posing risks such as electrical ignition of hydrocarbon vapours. Hazards can arise from phenomena such as static electricity and galvanic potential difference from ship to terminal.

Galvanic currents can also produce arcing, which occurs when there is an abrupt interruption in an electrically continuous path. For instance, a spark might be generated when a non-insulated loading arm disconnects from a ship manifold. To mitigate this, terminals should continue to use electrical isolation measures in hazardous areas such as insulating flanges or non-conductive hose lengths.

When passing, connecting, or disconnecting an earthed connector from shore to ship, there is a risk of sparking from making/breaking galvanic currents when it contacts the ship's hull, which should be considered and mitigated. Further information can be found in *ISGOTT* and in the SIGTTO paper, *A Justification for the use of Insulation Flanges (and Electrically Discontinuous Hoses) at the Ship/Shore and Ship/Ship Interface.*

Shore power cables and their mechanical construction or protection should be suitable for the hazardous area classification they may pass through during handling into position, for use and during use.

OPS cables should be kept well away from cargo transfer equipment to avoid incidental contact between statically charged piping and earthed OPS conductors.

If insulating flanges or electrically discontinuous hoses are installed, introducing equipotential bonding with a high-voltage shore connection should not elevate risks of sparking. This maintains protective measures during hose and loading arm connections and disconnections.

Equipotential bonding is provided through earth conductors of the shore power cables. No separate bonding cable is required. Equipotential bonding is provided additionally to the one established by sea water and metallic hull through earth conductors of the shore power cables.

11.4 Fluid surge considerations due to loss of power

Ship and terminal operators must ensure that the loss of shore power does not cause emergency isolation valves to close if this could create hydraulic pressure exceeding the design limits of any hose connection, flange rating, or piping, as defined by national codes such as ASME B31.3 or equivalent regulations. Exceptions should only occur if mandated by local regulations. The loss of shore power should result in no action to the valve unless protective measures are in place to prevent overpressure in piping, hoses, and marine loading arms. When designing OPS, the 'loss of power' scenario should be considered in the Hazard Identification Study/Hazard Operability Study (HAZID/HAZOP) process.

11.5 Environmental considerations

Electrical equipment rooms house a variety of equipment, which may need varying environmental conditions. Rooms with electrical equipment may have heat-generating equipment and/or heat-sensitive equipment, such as Programmable Logic Controllers (PLC). Electrical rooms may have transformers and sensitive control panels for lighting or environmental systems, and in some cases, electrical and mechanical equipment may be stored within the same space.

The design engineer should clearly define and understand the environmental requirements for all equipment installations in the room. As much as possible, equipment spaces that have higher temperature requirements should be in locations where natural ventilation is accessible. Storage of cylinders or other products within the space may change the ventilation requirements to meet other codes, such as NFPA 55 or NFPA 68.

11.6 Berths with ERS and auto mooring line release systems

Sites with means of automated release systems to separate the ship from the berth, such as marine loading arm Emergency Release Systems or centralised mooring line release systems, should consider how to stop power to the ship in a safe and orderly manner and separate the cable from the ship. Sites may need to consider centralised berth PLC programming that initiates an OPS shutdown concurrent with berth ESDs for closing valves and stopping pump(s). Sequencing and timing delays may also be needed to minimise excessive hydraulic pressures due to the shutdown and allow the ship to switch back to ship power and leave the berth without hinderance. Installation considerations should be on a site-by-site basis and with the appropriate HAZOP and/or scenario-based risk assessment completed.

11.7 Arc flash considerations for electrical equipment

Arc flash is the accidental release of thermal energy dissipated as radiant, convective and conductive heat between two electrodes of sufficient potential difference. Electric arcs are essentially releases of energy. Electric arcs produce intense heat, sound blast and pressure waves and can ignite clothes and cause severe burns. 80% of electrical-related injuries are burns caused by arc flashes. Arc flash occurs at electric circuits that are typically >150 VAC and can occur in places such as electrical rooms, motor control centres, high voltage switchgear, and transformers.

Arc flashes are typically caused by:

- Accidental contact by worker or tool while working on or near energised equipment.
- Equipment failure.
- Insulation failure due to degradation, damage or defect.
- Dust build-up/high humidity/condensation between conductors.
- Overvoltages across narrow gaps, e.g. due to lightning strikes.
- Improperly designed or used equipment.
- Inadequate work procedures.
- Foreign objects and animals (rodents) between busbars.

The severity of the injury depends on three factors:

- Power or essentially the amount of energy at the arc.
- Distance of the worker from the arc.
- Duration of the arc.

Injuries may include:

- Blinding light to the eye, temporary blindness.
- 2nd or 3rd degree burns to unprotected skin.
- A pressure wave that can knock a person down.
- Molten metal that can splatter and burn into skin tissue.
- Flying metal parts launched away from source.
- Sound at levels that could permanently damage hearing.
- Electric shock.

Possible mitigations include the following:

- Increase distance from energy
  - Arc flash boundary.
- Eliminate the energy source
  - LOTO equipment.
  - Avoid working on live equipment.
  - Safe work procedures.
- Arc flash PPE
  - Sufficient cal/cm^2 rating.

Arc-flash suits should be worn for all electrical rack-in and rack-out works as per local requirements and terminal procedures. The arc-flash suit should comprise face shield, hearing protection, body cover, leggings and leather protectors over V rated gloves to protect from arc blast.

Potential arc-flash gases in the pressurised compartment should be vented to a safe area.

11.8 Shore physical barriers around electrical equipment

Protective shields, barriers or insulating materials should be used to protect each employee from shock, burns, or other electrical injuries while that person is working near exposed energised parts that might be accidentally contacted or where dangerous electric heating or arcing might occur.

Local regulations may differ, but normally equipment at 50V or greater should be isolated from people and labelled with a warning sign and equipment at 600V or greater should be in complete, insulated, secure, and marked enclosures.

Operators or maintenance personnel around high voltage systems should be trained in the correct safety procedures and precautions when dealing with energised equipment.

LOTO procedures should be in place to prevent accidental energisation of electrical equipment during maintenance or repair work. This involves turning off the power source and securing it with a lock or tag to prevent someone from accidentally turning it back on.

11.9 Human factor design

11.9.1 Substation location

Elevated substation buildings located within about 100m of a potential hydrocarbon source may be subject to restrictions associated with Potential Explosive Domain (PED). Due to congestion under the substation, there is the possibility of hydrocarbon vapours pooling under the substation and causing a secondary explosion that could increase the overpressure radius in the event of a hydrocarbon release and ignition.

Spacing from potential release sources should be such that substation buildings are in non-hazardous areas. Ventilation should not be used to make the substation building non-hazardous.

Where the hazard Zone 2 area is between ground and 60cm above ground, the substation building may be elevated 60cm above ground to meet this requirement. Elevated substation buildings should be designed with at least three sides open between ground and floor. The ground should slope away from the substation building to prevent any liquid hydrocarbon spill from flowing under the substation building. When a substation building is raised 60cm or more, the space under the substation building may be enclosed on all four sides and solidly filled from ground to floor level. Substation buildings contain equipment that is a potential ignition source and, therefore, should be located in unclassified areas. Refer to API 505 and IEC 60079 for further guidance. When direct burial cables are used to enter an elevated substation building, allowance should be made for the bending radius of direct buried cable and to ensure that, in the event of a release, hydrocarbon cannot accumulate in the earth/trench in which the cable is buried.

11.9.2 Fire detection

A fire detector should be installed in each room within a substation building. The final number and location of fire detectors should be determined by the design engineer and the process safety engineering representatives for the site. A common alarm for each substation building's fire detectors should individually sound in the main control or room. Each alarm should be identified with the location of the fire detector. Alarms should be both visible and audible.

11.9.3 Substation doors

At least one single and one double door should be provided at opposite ends of indoor substation buildings, opening outward. The single door and double door should be used for access and egress of personnel and should be equipped with a lock that accommodates the plant master key for substations buildings. If the size of the double door is too cumbersome to be used as an emergency exit door, then a second single door should also be provided. All doors should be steel with solid upper and lower panels. Doors should be at least 900mm wide and should be provided with horizontal, full-width panic bars. Doors should open outward to allow immediate access to the exit. This ensures egress for personnel inside a substation building in the event of an emergency.

11.9.4 Switchgear control battery location

For standard construction outdoor substations, batteries should not be located in the equipment enclosure. An adjacent weatherproof enclosure should be furnished. This requirement eliminates the potential shock hazards during battery maintenance. The following provisions should be made for sufficient diffusion and ventilation of gases from the battery(ies). This prevents the accumulation of an explosive mixture within the building, room, or battery enclosure.

For battery installations, the building, or room, ventilation system should provide an air exchange rate adequate to prevent the accumulation of an explosive mixture. Battery enclosures, if used, should have ventilating louvres.

Determination of air exchange requirements should be based on the charge method and battery manufacturer/vendor's estimate of H_2 evolved.

Where mechanical ventilation systems are used to provide adequate air exchange to prevent accumulation of an explosive mixture, an independent alarm on the control room annunciator should be provided for each battery installation. This alarm should sound when the substation building ventilation system is not operating. During charging, batteries produce hydrogen. To prevent the accumulation of an explosive mixture, ventilation to keep the hydrogen level below 2% by volume should be provided.

11.9.5 Exposed live parts – fences and gates

Main substations and transformer yards may have exposed live parts and should be protected to deter entry by unauthorised personnel. Protection installations should follow local guidelines and may include:

- Chain link perimeter fencing, meeting minimum height requirements, surmounted with offset barbed wire.
- Two access gates, opening outward, on opposite sides to provide multiple escape routes during an emergency.
- Gates with provisions for padlocking.
- Lighting as appropriate.

11.9.6 Clearances

Clearances should meet applicable industry standards. The spacing requirements are intended to provide safe conditions when working on electrical equipment and permits safe egress during an emergency.

The area around arc flash vents should be kept clear per the manufacturer's recommendations. Manufacturing requirements for keeping areas around vents clear should be followed to ensure arc flash rating of gear is maintained.

11.10 Corrosion protection

The following are typical causes for corrosion-related concerns to electrical equipment in marine environments:

- Extreme moisture, such as tropical climates where all 12 months have a mean temperature above 18^{o}C and seasonal variations are dominated by precipitation and/or environments promoting fungus growth.
- High condensation risks, high humidity and warm moist air cooling and condensing on cooler component parts.
- Marine exposure promoting corrosion by salt spray or presence of chlorides in air.
- Copper-attacking contaminant leakage, e.g. ammonia, acetylene, hydrogen sulphide.
- Solvent and corrosive chemical spillage and spray areas.
- Conducting and corrosive dust fallout areas.
- Powder and nonconducting material fallout areas.

When determining protective requirements, the environmental exposure level (pollution level) may need to be specified per IEEE C37.100.1 or IEC 60815-1.

Design engineering may also want to develop and specify those protective measures most suitable for the terminal location. These protective measures may involve the following:

- Selection of materials and coatings from vendor's available options.
- Use of localised temperature/humidity control and air filtering.
- Modifications to plot layout.
- Use of moisture-resistant insulating materials and increased creepage distances.
- Require extensive use of space heaters.

Below are some of the conditions and protective treatments that may be required:

Extreme moisture
When a terminal location is specified to be tropical or subtropical, exposure to extreme moisture should also be assumed for the purpose of protective treatments.

Certain classes of electrical equipment may require special treatment or protection, or both, to guard against extreme moisture conditions and fungal growth. It should be determined what equipment requires special treatment and/or protection and the extent to which special treatment or protection is required.

Marine exposure
Insulators in marine exposure may require protection measures when fog or drizzle follows sunny days and accumulated salt spray. Protective measures may be the same as for conducting and corrosive dusts.

Exposed insulators in marine exposure may need to be qualified in accordance with the salt fog test as defined in IEC 60507 or IEEE 4.

Corrosion protection may be provided to all electrical components exposed to marine environments in accordance with API RP 14F and API RP 14FZ. Enclosures and outdoor equipment, including all mounting hardware, may need to be protected both externally and internally from corrosion due to marine environments.

It is recommended that equipment has an IP rating suitable for the environment where it is located considering ambient conditions and the potential for the ingress of salt water.

Enclosures subjected to high humidity may need to contain space heaters to control the humidity level.

Copper-attacking fumes
Protection against acetylide formation is required for all copper, silver or gold not isolated from atmospheric contact where exposure to acetylene is possible.

Protection against copper oxidation is required where exposure to hydrogen sulphide is possible.

The following protective measures should be taken:

- All underground electrical conduit installation entering a power distribution building should be sealed and all conduit stub-ups to electrical equipment, such as power transformers, motors, motor controllers, disconnect switches, etc., in the field should be sealed.
- Exposed copper, such as ground busses, should be coated.
- Enclosures containing exposed electrical connections should be sealed or pressurised.
- Exposed electrical connections should be insulated or coated.
- For substations, control buildings, and other enclosures for power, control, and instrumentation, acceptable methods include use of air conditioning, pressurising from clean air source, or air filtering.

Solvents and corrosive chemicals
Protection is required for cables exposed frequently or for prolonged periods to materials that will degrade cable insulation. Plasticised and rubber-like insulation may be degraded by acids, aromatics, cycloparaffins, phenol, and other materials with highly solvent properties.

Frequent exposure should be assumed for above ground cables within striking or splashing distance of likely point of leakage, such as pump glands and valves.

Prolonged exposure should be assumed for underground cables in areas where spills and washdowns can occur, unless the entire area involved is concrete paved and drained. Spills or washdowns should be assumed to occur around pumps, storage tanks, and loading facilities.

Cables in aboveground conduits are considered protected, whereas cables in underground conduits are considered not protected. Cables requiring protection should be rerouted to avoid exposure to the extent possible.

When routing cannot provide protection, cables should be protected from attack by protective sheaths or jackets. Lead sheaths are suitable for most agents; nylon jackets are suitable for some. Neoprene alone is not an acceptable jacket.

Conducting and corrosive dusts
Plants in which conductive or corrosive solids are ground, crushed, mixed, dried, bagged, loaded, conveyed or otherwise handled in a way likely to release dust, should be considered as exposing the electrical facilities to dust. Other plants may be specified to have dust exposure from neighbouring facilities.

Floor troughs and floor raceways should not be used for cableways in dusty locations.

Cable supports, for systems other than completely enclosed wiring systems, in dusty locations should be of a design that allows essentially continuous access along the runs for cleaning.

Exposed insulators and bushings, such as in open-wire lines and outdoor switchyards, should be avoided in dusty locations if possible.

If exposed insulators or bushings are used in dusty locations a dust diagram should be prepared by the contractor, showing the predicted fallout density pattern. Plant layout should be arranged to keep the vulnerable equipment in areas of minimum fallout. Conversion to cable and enclosed equipment should be used as much as is practical, for example, lightning arresters. Wide-skirt fog-type insulators should be used. Clearances in dually fed switchyards should be sufficient to allow safe and convenient cleaning of the insulators and bushings of either feed, with the other in service, by personnel without electrical training. Over-insulation should not normally be used. When used, it should only be used for conditions of light fallout.

Powders and nonconducting material
Electrical equipment in powder-handling plants should be enclosed in a pressurised, well-filtered enclosure or building. The requirements of section 4.5 should apply. Top entry of conduit into enclosures is permitted if the powder is non-corrosive.

12 Terminal operation

This section provides guidance on the operational aspects of OPS systems at terminals. It addresses operational responsibilities, pressurisation system failure procedures, cable handling between ship and shore, berth operator field verification, electrical connection and disconnection procedures, minimum PPE requirements, physical protection of electrical cabling, interaction with mooring operations, SIMOPS impact, emergency evacuation procedures, managing access restrictions around shore electrical installations, and cybersecurity protection.

Due to differences among terminals and ships, operations may vary. It is ultimately the responsibility of the terminal to ensure shoreside operations are managed and executed by qualified individuals in accordance with local regulations and requirements. The system operation should take into consideration the risk analysis performed for the specific OPS installation.

12.1 Operational responsibilities

The following table outlines general roles and responsibilities associated with shore power operations. Roles or job titles may vary across terminals. The table is provided as guidance only. Responsibilities should be assigned accordingly within the terminal's personnel structure.

Role	Responsibility
Terminal Safety PIC	• Implement the necessary safety measures to ensure personnel who may enter or work at the terminal are familiar with the safety hazards and precautions which may exist • Execute emergency procedures when applicable
Terminal Operator Terminal Operations Technician	• Assist with communication between terminal and ship • Support shore power connect/disconnect process
Terminal Electrical PIC	• Perform shore power tasks while adhering to local operating, maintenance, and safety procedures. • Support shore power connect/disconnect process

Table 12.1: *Roles and responsibilities associated with shore power operations*

12.2 Pressurisation system failure

Shoreside applications that incorporate a pressurised system, such as a non-hazardous coupling compartment, should ensure the pressurisation system is functioning as intended before each use. In the event that a pressurisation system experiences a failure, no connections should be made until the system is repaired and confirmed to be functioning within designed limits. For instances where a pressurisation system fails after a coupling has been made, the electrical system should be de-energised before any personnel attempt to decouple the cables within/near the cabinet. Refer to section 13 Inspection and maintenance for additional guidance regarding periodic maintenance and checks. See also section 16.4 Managing hazardous areas.

12.3 Cable handling between ship and shore

The terminal is responsible for infrastructure to support cable handling between the terminal and the ship. Alternative arrangements for cable handling need to be agreed upon between all parties during the vetting process. See section 3.4 Cable lifting and section 16.6 Cable handling between ship and shore, including safe manual handling practices.

12.4 Cable retrieval

Prior to cable decoupling and retrieval using the CMS, the shore power system should be de-energised and earthed with LOTO in place.

Once the connectors are disconnected from the receptacles, safety end cap and electric isolation covers should be placed onto the connectors.

When retrieving the cable(s), pinching, stretching, dragging, excess bending, or even inadvertent contact with the cable(s) should be avoided.

Unless designed, the cable should not freely hang between the shore and the ship without adequate support. The cable(s) should not hang in or be extracted through the water.

See section 16 for additional details regarding the decoupling process.

12.5 Berth pre-connection checks and tests

Prior to each ship's arrival, the terminal PIC of the OPS system should verify the shoreside electrical equipment and power systems are in good working condition. This may include VLF cable testing. Section 13 Inspection and maintenance provides additional guidance.

All electrical OPS equipment should be visually inspected before each use.

12.6 Electrical connection procedure

Connection and energising procedures may vary across terminals and ships. See section 16 Interface operation for guidance.

12.7 Shore power supply interruption

In case of abnormal termination, the shore power supply should not resume unless the initial cause for power loss is understood.

12.8 Electrical disconnection procedure

De-energising and decoupling procedures may vary across terminals and ships. See section 16 Interface operation for detailed guidance.

12.9 Physical protection of the electrical cabling while alongside

Appropriate protection of the electrical cabling is a necessary part of ensuring the safety and reliability of the shore power system. Cable(s) should be stored in a manner to prevent trip hazards and minimise interference with routine operations at the facility. Covers, connector caps and cable support structures should be considered to protect shoreside cables from unintended damage or exposure. Protection from environmental forces should also be considered.

12.10 Managing interaction between mooring operations and electrical equipment

All mooring operations should be completed before starting the shore power coupling process. Unmooring should not take place until shore power is fully decoupled. At no point should mooring lines be used to support the cables.

12.11 SIMOPS impact on electrical installation and hazardous areas

Cargo transfer should not take place during cable coupling/decoupling. Terminal maintenance activities may be carried out during cargo operations while shore power is in use, but the terminal needs to consider whether these activities can be conducted safely without interrupting power to the ship. Refer to *ISGOTT* guidance regarding SIMOPS.

12.12 Emergency departure

In the event of an emergency, a ship may need to disengage from the terminal unexpectedly and quickly. See section 16 Interface operation for guidance.

12.13 Managing access restrictions around shore electrical installation, safety and security

The terminal should install signage to denote areas of restriction as it pertains to the shore power system. This includes signage to communicate any hazards for when the system is idle, as well as when the system is in use. Signage should include required qualifications for entering a restricted area, along with PPE requirements.

12.14 Cybersecurity protection

Terminal operations should be conducted in such a manner as to prevent a breach of cybersecurity.

A cyber security risk assessment should consider threats to cyber safety and cyber security, as attacks on either can harm personnel, the environment and the tanker or terminal. For guidance, refer to *ISGOTT* section 6.4, Cyber safety and security.

13 Inspection and maintenance

This section provides guidance on the inspection and maintenance of OPS systems at terminals. It addresses applicable codes and standards, outlines general tasks for maintaining equipment integrity, and provides recommended inspection and maintenance practices for mechanical technicians and competent electrical personnel.

The sections below are intended to provide guidance on applicable codes and standards that govern maintenance work as well as recommended maintenance practices for shore power applications.

13.1 Codes and standards

All local, state, and national codes should be followed while conducting maintenance and inspections on shore power equipment. Inspection and maintenance standards may vary depending on the location of the operation. Widely adopted maintenance standards include, but are not limited to:

- NFPA 70B (North America).
  - *Electrical Equipment Maintenance.*
- ANSI/NETA MTS (North America).
  - *Maintenance Testing Specifications for Electrical Power Equipment.*
- IEC 60300-3-14 (International).
  - *Maintenance and Maintenance Support.*
- EEMUA Publication 186 (Europe).
  - *Guidance for Safe Installation, Inspection, and Maintenance Work in Potentially Hazardous Atmospheres.*
- IEC60079-17 *Explosive Atmospheres – Part 17: Electrical Installations Inspection and Maintenance.*
- IEC 80005-1 Part 11 – *Periodic Tests and Maintenance.*

13.2 Equipment integrity

Cables will normally be de-energised and earthed when they are not in use, except under special circumstances where cables may be temporarily energised for maintenance purposes. When CMS cables are temporarily energised for maintenance, they should be coupled to open circuit ship inlets or fitted with temporary live end cap fittings to prevent overstressing the insulation in the ship connectors. Uncoupled ends of CMS cable should not be energised in any circumstance to avoid potential damage at the uncoupled ship connectors' end. CMS systems will generally dispense out a free-hanging length of shore power supply cable from the load end of the CMS to the ship inlet point. Unused cables will remain retracted inside the CMS equipment.

The following tasks are provided as guidance to facility personnel involved with shore power operations. Frequency of task completion is the responsibility of the terminal. Individuals should be trained and competent in the tasks being performed.

Operations should monitor and enforce the following:

- Keep work area clear from debris and non-pertinent objects.
- Barricades are adequate and in place to prevent unauthorised personnel from entering the shore power equipment area.
- Shore power equipment is stored correctly and secured.
- Handrails and guardrails should be inspected to ensure integrity.

13.3 Inspection recommendations of equipment by mechanical technician – pre-use, monthly and annually

Pre-use

Perform the recommended pre-use inspection on the equipment as outlined by the manufacturer. In addition, the items below should be addressed:

- Check for oil/grease leaks in the CMS.
  - Cranes.
  - Reels.
- Check for signs of physical damage to equipment.
  - Cranes.
  - Reels.
  - Cable lifting harness.
  - Chains/slings/ropes.

Monthly

Perform the recommended monthly maintenance/inspection on all equipment as outlined by the manufacturer. In addition, the items below should be addressed:

- Correct alignment of CMS equipment.
  - Cranes.
  - Reels.
- Inspect mounting of CMS equipment.
  - Bolts are in place and torqued appropriately.
  - Tie down chains are in place where applicable.
- Oil/grease.
  - Check that the appropriate oil and grease amounts are present on applicable equipment.

Annually

Perform the recommended annual maintenance/inspection on all equipment as outlined by the manufacturer. In addition, the items below should be addressed:

- Crane inspection.
- Cable testing.

13.4 Inspection and maintenance of equipment by Competent Person

Note: Earthing tools and an HV-tester/probe should be available.

Pre-use

Perform the recommended pre-use inspection on the equipment as outlined by the manufacturer. In addition, the items below should be addressed:

- Cables and connectors.
  - Cable jacketing should be inspected for damage.
  - Cable connectors should be inspected for foreign debris and damage/corrosion to connection pins.
- Transformers.
  - Transformers should be inspected for physical damage and all compartments should be verified closed and secured.
- Switchgear.
  - Switchgear should be inspected for physical damage and all compartments should be verified closed and secured.

Monthly
Perform the recommended monthly maintenance/inspection on all equipment as outlined by the manufacturer. In addition, the items below should be addressed:

- Cables and connectors.
  - Cable jacketing should be inspected for damage.
  - Cable connectors should be inspected for foreign debris and damage to connection pins.
  - Ensure cable raceways are intact and applicable seal-offs are poured.
- Transformers.
  - Check for physical damage and ensure cooling fins are clear.
  - Check for oil leaks.
  - Check oil level.
  - Check N_2 pressure.
- Switchgear.
  - Check for physical damage to enclosure and operating mechanisms.
  - Check interlocking systems.
  - Verify compartment heaters are operational.
  - Inspect batteries (DC control system).

Annually
Perform the recommended annual maintenance/inspection on all equipment as outlined by the manufacturer. In addition, the items below should be checked on an annual basis and/or every five years at a minimum:

- Cables and connectors.
  - Clean exposed cables and inspect stress cones for damage.
  - Test cables and connectors using a VLF/Tan Delta test.
- Transformers.
  - Clean bushings.
  - Verify cooling fan operation.
  - Inspect/service tap changer.
  - Perform insulation resistance tests.
  - Perform insulation power factor test.
  - Perform turns ratio test.
  - Conduct thermographic inspection.
- Switchgear.
  - Lubricate moveable components.
  - Clean and test fuses.
  - Clean and test circuit breakers.
  - Clean and test bussing, bushings, and lightning arrestors.
  - Perform insulation resistance tests.
  - Measure contact resistance.
  - Calibrate protective relays.

14 Training

All inspection and maintenance should be carried out according to the manufacturer's guidelines and the work undertaken only by staff who have had specific training.

This section provides general guidance for training and competency assessment for personnel responsible for the shore to ship power connection and should be considered when setting out the competency requirements for the installation and periodic inspections. Due to geographic and legislature differences among terminals and ships, training/certification requirements will vary. It is ultimately the responsibility of the terminal to ensure shore-side operations are managed and executed by qualified/competent individuals in accordance with local regulations and requirements.

The competence, training and qualifications of those responsible for the initial design and installation of the equipment is not covered in this section only the ongoing operation, inspection and maintenance competency requirements.

14.1 Competency and qualification recommendations of coupling/decoupling team

Operatives/technicians should be able to demonstrate their competency and provide evidence of attaining electrical safety training relevant to the nature of the task being conducted. Examples include LOTO and electrical hazard awareness and avoidance.

Operatives/technicians should have specific training on cable handling including the CMS, cranes, hoists, etc. employed at the terminal. They should also have manual handling training. Training should follow manufacture recommendations and terminal procedures.

For potentially explosive atmospheres:
Operatives/technicians should be able to demonstrate their competency and provide evidence of attaining the knowledge and skill requirements specified below relevant to the types of protection and/or types of equipment involved.

Operatives/technicians should have, to the extent necessary to perform their tasks, understanding of the following:

- The general principles of explosion prevention.
- The general principles of types of protection and marking.
- The additional importance of permit to work systems and safe isolation in relation to explosion protection.
- The need for continuous monitoring of the equipment before and during use.
- Certification and relevant parts of the applicable standards.

14.2 Recommended training framework for coupling/decoupling team

Operatives/technicians should have, to the extent necessary to perform their tasks, the following:

- Electrical safety awareness training – LOTO, electric shock/arc risks.
- Knowledge of how to use PPE correctly and an understanding of the potential hazards of working with high voltage electricity.
- Complete recognised training for particular area – for example ComPex Foundation (ExF) or equivalent to meet the requirements of IEC60079 – for situations involving equipment installed and used in potentially explosive atmospheres.

An in-house training programme should be developed that covers the required skills to allow safe working on equipment installed in potentially explosive atmospheres.

Intervals of training/refresher training should not exceed five years.

14.3 Ongoing verification of competency of coupling/decoupling team

The competency of the operatives/technicians should be verified and attributed at intervals not exceeding the site's documented frequency, for example five years, based on sufficient evidence that the person:

- Has the necessary skills required for the scope of work.
- Can act competently across the specified range of activities.
- Has the relevant knowledge and understanding underpinning the competency.

14.4 Competency and training of maintenance team

The maintenance team members should be able to demonstrate their competency and provide evidence of attaining the knowledge and skills required to safely carry out work on electrical equipment, having completed a recognised training programme documented by their employer.

They should be able to safely complete electrical isolations so as to prevent the inadvertent re-energisation of equipment to the level applicable to the task.

Maintenance team members should be able to recognise unsafe applications and prevent them from becoming energised and posing a safety risk.

Extra requirements for work in potentially explosive atmospheres:
Responsible persons should be able to demonstrate their competency and provide evidence of attaining the knowledge and skill requirements specified below, relevant to the types of protection and/or types of equipment involved:

- General understanding of relevant electrical engineering.
- Practical understanding of explosion protection principles and techniques.
- Understanding and ability to read and assess engineering drawings.
- Working knowledge and understanding of relevant standards in explosion protection, particularly IEC 60079-10-1, IEC 60079-10-2, IEC 60079-14 and IEC 60079-19 or equivalent.
- Basic knowledge of quality assurance, including the principles of auditing, documentation, traceability of measurement and instrument calibration.

The competency of responsible persons should be verified and attributed at intervals not exceeding the site's documented frequency, for example five years, based on sufficient evidence that the person:

- Has the necessary skills required for the scope of work.
- Can act competently across the specified range of activities.
- Has the relevant knowledge and understanding underpinning the competency.

14.5 Competency and training of terminal operators

The berth operators, having completed a recognised training programme documented by their employer, should be able to demonstrate their awareness of the specific risks and hazards associated with the equipment in use on the berth and when to summon assistance if required.

They should be able to recognise an abnormal/unsafe situation involving the relevant equipment and know how to escalate appropriately.

Extra requirements for work in potentially explosive atmospheres:
Persons working in these areas should receive relevant additional training specific to the visual identification of defects on equipment used in potentially explosive atmospheres and know the procedure for escalating the issue in order for it to be resolved in a suitable manner.

The competency of responsible persons should be verified and attributed at intervals not exceeding the site's documented frequency, for example five years, based on sufficient evidence that the person:

- Has the necessary skills required for the scope of work.
- Can act competently across the specified range of activities.
- Has the relevant knowledge and understanding underpinning the competency.

OCIMF's *Marine Terminal Operator Competence and Training Guide* has no specific recommendations for OPS operations, but it does have general guidance on establishing training and assessing competence.

14.6 Training and drills recommendations to handle abnormal conditions and emergencies

Terminal personnel should perform regular drills for abnormal and emergency conditions. To develop the appropriate training, the following should be considered:

- Develop credible case studies for abnormal situations and test response.
- Monitor equipment failure rates and determine the rate of risk identification to assess whether the level of training is adequate.
- Periodically carry out practice drills on the actual equipment to assess response. These should be added to the existing drills already performed for both fire and spill response.
- Emergency services at terminal, or locally, should be aware of the HV installation, and training and drills of the emergency scenarios should include emergency response whenever appropriate.

PART 3: INTERFACE

15 Design

This section addresses the OPS design interface philosophy, compatibility design characteristics and evaluation between ship and berth, electrical protection coordination confirmation, cable handling procedures, design guidance for electrical isolation, start-up and system commissioning procedures, and considerations for pressurised building design.

15.1 OPS Design interface philosophy

The OPS interface design should simultaneously comply with port state requirements, flag state requirements and classification society requirements. In areas where these jurisdictions are silent, the OPS interface design should follow IEC standards for high voltage shore power and high voltage connectors. Following that, the OPS interface should follow the best practices set forth by the tanker industry. Best practices are consolidated in this publication and will continue to be refined by early adopters of the technology.

15.2 Hazardous area classification

Hazardous area classification for marine terminals is generally driven by national regulations. Hazardous area classification onboard tankers is based on classification society rules, which are based on international standards. Therefore, significant differences may exist between hazardous area classifications for the same situation.

As a result, a location onboard may be considered non-hazardous from a ship's perspective but hazardous from a terminal perspective. The areas that OPS equipment passes through when being deployed should also be considered.

Ignition sources may not only originate from electricity while the OPS is in operation. Sparks may occur when metal parts touch, or due to static electricity while connecting de-energised parts.

Before the OPS system commissioning, it should be confirmed that the installation and operational procedures meet all requirements as posed by the hazardous area classifications.

15.3 Hazardous areas

Hazardous areas may vary depending on the Terminal. Refer to section 15.2 Hazardous area classification, for designing equipment within hazardous areas. Compatibility of the terminals hazardous area classification and the ship hazardous area classification should be verified as part of the compatibility checks. See section 16.1 Ship screening and berth/ship compatibility checks and section 16.4 Managing hazardous areas.

If shore power couplings are made within a hazardous area, they should be done within a non-hazardous coupling compartment. Cables should be de-energised and isolated during the cable transfer and coupling process. The potential for spark generation within the hazardous area from the use and handling of equipment should be managed and mitigated. Refer to section 12.2 Pressurisation system failure, for additional considerations when working within pressurised gas free compartments.

15.4 Compatibility design characteristics and evaluation between ship and berth

When evaluating whether a ship can safely use the berth, terminal operators should complete a berth/ship compatibility check where the physical parameters of the ship should be checked against the design characteristics of the berth:

- Displacement.
- LOA.

- Beam.
- Moulded depth.
- Draft.
- Parallel body.
- Max/min manifold height.
- Manifold position.

See section 16.1 Ship screening and berth/ship compatibility checks for further detail regarding OPS compatibility.

15.5 Electrical protection coordination confirmation between ship and berth

In various regions and industries, terminology may vary, including phrases like protection relay coordination, discrimination, coordination study or selectivity report. All these terms denote an analysis of an electrical system with the objective to ensure that in a system with series-connected overcurrent protection devices, only the device nearest to the electrical fault promptly isolates the fault. This allows the remaining portion of the electrical system to continue operating without disruption.

In the context of HV shore power supply, this means that a failure at the largest consumer in operation while at a berth should not trip the shore power supply, but only isolate that faulty consumer.

The installation of electrical systems and components to facilitate HV shore power supply to a ship may take place in differing circumstances, which presents challenges in preparation of a selectivity study.

The basis of every selectivity study is a short circuit calculation to determine the different short circuit fault levels in the electrical installation. These fault levels will determine the selection of switchgears, cables, circuit breaker, etc. with respect to their required short circuit withstand ratings and are the basis for the protection coordination. IEC/IEEE 80005-1 has addressed these issues by determinations and definition for short circuit calculations and general requirements with respect to protection coordination.

A central role in this context is directed to the compatibility assessment in IEC/IEEE 80005-1 describing the characteristics and particulars of the interface between terminal and ship. This assessment describes, among other things, the necessary data to conduct a correct protection coordination.

To facilitate such coordination, the terminal may declare:

- Short circuit level at the supply point.
- Protection settings of the upstream circuit breakers protection relays.
- Operational short time overload capacity of the shore supply.
- Protection against lightning as per IEC 62305-4 or other recognised standards.

The ship may declare:

- Short circuit current contribution from the ship’s generator during parallel operation for load transfer.
- Largest single consumer and its starting characteristic with respect to starting current.

15.6 Design guidance to prove electrical isolation between ship and shore

The interface between a ship and its berth is a potential pathway for electrical current flow, posing risks such as electrical ignition of hydrocarbon vapours. Hazards can arise from phenomena such as static electricity and galvanic potential difference from ship to terminal.

Galvanic currents can also produce arcing, which occurs when there is an abrupt interruption in an electrically continuous path. For instance, a spark/ignition might be generated when a non-insulated loading arm disconnects from a ship manifold. To mitigate this, terminals should continue to use electrical isolation measures, an insulating flange or a single segment of an electrically discontinuous hose, in hazardous areas. Flanges and hoses should be designed and tested in compliance with *ISGOTT* and tested at the frequency and minimum resistance listed in that standard. At no time should marine loading arms or hoses be connected without such protections in place and correctly functioning.

When passing, coupling, or decoupling an earthed connector from shore to ship, there is a risk of sparking from making/breaking galvanic currents when it contacts the ship's hull, which should be considered and mitigated. Further information can be found in *ISGOTT* and in the SIGTTO paper, *A Justification for the use of Insulation Flanges (and Electrically Discontinuous Hoses) at the Ship/Shore and Ship/Ship Interface.*

Shore power cables, CMS, cranes, and their mechanical construction or protection should be suitable for the hazardous area classification they may pass through during handling into position for use and during use. See section 3.10 Cable routing and protection.

OPS cables should be kept well away from cargo transfer equipment to avoid incidental contact between statically charged piping and earthed OPS conductors.

Having an OPS does not circumvent the protection provided by insulating flanges or electrically discontinuous hoses at the ship manifold.

Equipotential bonding is provided through earth conductors of the shore power cables. No separate bonding cable is required. Equipotential bonding is provided additionally to the one established by sea water and metallic hull through earth conductors of the shore power cables.

15.7 Start-up/system commissioning

Before the first connection of an OPS between a ship and a terminal, it should be preceded by a commissioning that includes a trial. The commissioning starts with a specific ship registering its interest in using a port's OPS.

The main steps in a commissioning, in addition to those described in IEC/IEEE 80005-1, are:

- The ship should review and confirm that it meets the terminal's technical requirements.
- The terminal will review the technical confirmation provided by the ship to ensure that the systems are compatible.
- The ship and the terminal should agree on the maximum kVA OPS can deliver and the commercial conditions for power supply.
- The ship will conduct a trial at the relevant terminal, supervised by the terminal representative.
- The ship and terminal should evaluate the trial and agree on possible adjustments or improvements.

The trial is crucial to ensuring an efficient and safe power supply via OPS. A trial should include the following elements:

- The ship operating envelope and its compatibility with the OPS and CMS. Ship movement should not interfere with the OPS connection, and no activity, such as cargo, crane, or gangway operation, should be close to the OPS coupling area or the cable.
- Safe handling of the cable and how it is routed to the OPS station should be clarified during the trial.

- A joint check of the OPS safety loop check should be conducted, including alarm settings. Particular attention should be paid to:
  - Possible difference in frequency between shore and ship.
  - Inrush current to onboard transformers.
  - Earthing switches requirements and settings.
  - Physical trip limit sensor settings such as nitrogen, combustible gas and oxygen detectors, door switch, etc.
- Monitoring and control systems on board and ashore including signal lamps.
- Checking of operation of circuit breakers.
- Checking the functionality of control and selector switches.
- Checking the functionality of current and voltage transformers.
- Checking the functionality of heater switches.
- Emergency stops and procedure.
- Blackout recovery.
- Additional signal cable requirements, if applicable.

16 Interface operation

This chapter provides guidance on the operational aspects of the ship/shore interface regarding the OPS. It addresses ship screening and berth/ship compatibility checks, pre-arrival communications, roles and responsibilities, managing hazardous areas, PPE requirements, cable handling, sequencing of OPS coupling and decoupling, emergency decoupling procedures, minimum staffing and competency considerations, and the use of an OPS Ship Shore Safety Checklist (SSSCL).

16.1 Ship screening and berth/ship compatibility checks

Terminals and ships share joint responsibility for ensuring compatibility with the OPS, both technically and in terms of safety.

IEC/IEEE 80005-1 contains requirements for ship and shore electrical compatibility checks to be performed during the vetting process. These reviews will need to be carried out at the time of ship nomination and vetting, weeks if not months before ship arrival. The ship's and terminal's OPS electrical equipment requirements should be listed in a checklist with references to class rules, national and international standards.

This information is again shared as part of the pre-arrival communication (e.g. 72 hours in advance) between ship and terminal to ensure a safe and efficient operation on arrival.

At a minimum, the compatibility of the following items should be verified during the vetting process. These items are in addition to the checklists defined by *ISGOTT:*

- Is the OPS designed to an IEC standard?
- Has the ship an OPS ship inlet onboard suitable for a HVSC?
- Ship power requirements:
  - Ship electrical equipment design (see section 4).
  - Expected load at time of synchronisation.
  - Maximum expected load.
  - Anticipated large transient loads.
  - Largest Direct on Line (DOL) motor.
  - Typical power factor.
- Terminal and ship hazardous areas.
- Hazardous classification area onboard ship vs electrical classification of equipment.

- Frequency, voltage and number of cables between ship and terminal.
- Shore power coupling position on the ship in respect to the terminal CMS. Provide a general arrangement showing the equipment:
  - Port and/or starboard coupling.
  - Aft and/or midship coupling.
- Capabilities for cable handling:
  - Shipboard and/or shoreside cranes to safely move the cables between ship and terminal.
  - Lifting device limitations, including lifting capacities and swing radius.
- Compatibility of coupling compartment with terminal cables:
  - Sealing mechanism where required for hazardous location.
  - Cable restraint.
  - Cable movement monitoring and prevention.
- How much cable length is needed on board to allow the coupling of the connector with the ship inlet?
- Does the ship's OPS station meet the requirement for a non-flammable gas atmosphere where the OPS cable coupling will occur (typically, IEC 60092-502)?
- Is the OPS connection compartment located in a hazardous area of the ship?
- If the OPS connection compartment is in a hazardous area of the ship, is the compartment fitted with the necessary sensors to monitor the hazard zone boundary such as door position sensors, gas detection monitors, oxygen level sensors, or pressure sensors?
- Is there a cable movement monitoring device installed and connected to the OPS?
- Do the terminal and ship have procedures and checklists to handle the OPS cable, coupling/decoupling and an OPS operation?
- Do the terminal and ship each have a designated PIC fully aware of their responsibilities?
- Mooring arrangement and potential for clashes with cables.
- Gangway location and potential clashes with cables. See appendix, Pre-arrival checklists A1 and A2.

If an incompatibility is identified between the terminal and ship shore power systems, the operation should be evaluated further before arrival or attempts to connect the shore power supply.

16.2 Pre-arrival communications between ship and shore

Verification of the following items should take place during the pre-arrival communication process. These items are in addition to the checklists defined by *ISGOTT:*

- Validation that shore power equipment is in safe working order.
  - This includes applicable testing of the cable(s) before arrival.
  - If a non-hazardous pressurised coupling compartment exists, verification should be provided stating this compartment is in safe working condition.
- Confirmation shore power supply is available.
- Agreement on the action to be taken in the event of loss of shore power.
- Emergency decoupling procedures, including equipment specifically designed to facilitate an emergency decoupling.
- Agreement on the ship's position on the berth considering the shoreside CMS operational envelope, the length of cable needed to connect to the OPS connection point on the ship, and the appropriate cable routing on board.
- Agreement on the number of cables to be used.
- Notification of restricted areas.
- Notification of environmental conditions, including cold weather, snow and ice, that may affect the operation.

- Validation of personnel qualifications.
- Confirmation that any connection housing is in safe working condition.
- Any necessary approvals and documentation are exchanged, including written approval from the port authority, if required, before the first connection.

In any instance where equipment or systems relevant to shore power are not in working order, communication should take place to ensure the terminal and ship are aware of the circumstances. It is ultimately up to the terminal and ship to determine the severity of issues and the ability to safely use the shore power system within its intended design.

Outages for the shore power system should also be communicated in a timely manner to allow the terminal or ship to plan accordingly.

16.3 Roles and responsibilities for coupling/decoupling teams

The connection to a shore-based high-voltage power grid should be directed by the PIC ashore, in collaboration with the PIC onboard the ship. In some cases, the same person can assume both roles, but this arrangement is not preferred. The PICs are responsible for ensuring that procedures, safety rules, instructions on handling the OPS cable, and checklists are followed to ensure a safe OPS operation.

The PIC onboard is a crew member who is trained in and knowledgeable about the principles and technical standards applicable to electrical installations on a ship. The PIC is responsible for the OPS system onboard the ship.

The terminal PIC is the electrical technician qualified and responsible for coupling, decoupling, energising and de-energising the OPS system, including tests and preparation.

When first calling at a new terminal, before the first OPS connection, a specific risk assessment of OPS operations should be conducted. The risk assessment should be appropriately documented, and the documentation should be kept available for inspection.

The risk management for OPS operation should be concerning hazards that can cause explosion, fire, sparking, short-circuiting, arcing, electric shock, personal injury, material damage or malfunction.

16.4 Managing hazardous areas

The potential for spark generation within the hazardous area from the use and handling of equipment should be risk-assessed, managed and mitigated.

Cables should be de-energised and isolated during the cable transfer and coupling process. The coupling of OPS on a ship may be affected, depending on the hazardous area in which the coupling point is located and its current risks.

Different types of ignition sources, such as hot surfaces, mechanical sparks, and fixed and portable electrical equipment, should be considered in the OPS coupling/decoupling risk assessment(s).

The ship's crew should be aware that the ship may be in an extended hazardous area covering the whole ship, including the accommodation block and aft decks, during a cargo operation.

When the OPS is in operation, no one should be in the vicinity of the OPS coupling.

To ensure that the crew is aware of the hazards of an OPS operation, general information should be given to all new crew, and clear signs should be posted on and in the vicinity of the OPS installation on board.

Temporary barricades or hazard warning tape may also be used to help restrict and control access around the OPS cables on the ship. The intent is to keep non-authorised persons away from the cables while they are in use.

16.5 Minimum PPE requirements for coupling/decoupling

The appropriate PPE should be identified as an outcome of the risk assessment. PPE requirements should consider electrical and environmental hazards for the area of work.

The PIC should check that PPE is in good working order and is fit for purpose and that personnel are using the appropriate PPE before starting coupling/decoupling procedures.

For emergency use, there should be earthing tools and an HV-tester/probe available.

When working around water, personal flotation devices in accordance with local regulation or requirements should be used.

16.6 Cable handling between ship and shore, including safe manual handling practices

Cable handling should only be performed by trained and qualified individuals. Effective communication between the terminal and ship should be established before cable handling. Specifically, the signals to start, coordinate, and halt the cable lifting operation should be clearly established. Throughout the cable handling process, the shore power system should be de-energised and earthed with LOTO in place. All personnel supporting the cable handling process should exercise caution around the lifting area if the cable is overhead.

Throughout the handling process, it is important to ensure the cable(s) do not exceed their designed bend radius. Appropriate support, such as an engineered device, mechanical protection, or strategic lift points, should be considered.

To handle the OPS cable safely, it is essential to plan the route of placement of the cable from the shore and the ship inlet. The ship should inform the terminal where the OPS ship inlet is located and how much cable length is needed from the ship's rail to the OPS ship inlet on board. Cables should be paid out individually so that a correct lead can be established for the coupler and ship inlet.

The crew and terminal personnel should pay particular attention to the fact that sharp edges and other features may cause mechanical abrasion to the cable when it is laid out for coupling to the ship.

Cable protection and connector protection may be needed as a part of the CMS ashore.

The OPS cable should always be handled with care during lifting operations. It should not be dragged over a surface or rolled in a manner that twists the cable.

The OPS cable should not be allowed to contact a hot surface such as a steam pipe.

It is essential that neither the crane hook nor the cable connector come into contact with or strike any metal part of the ship, as a spark may occur. Protection should be provided at any point where chafing or rubbing can occur. Lifting bridles and saddles should be provided, and certified lifting straps should be used.

Personnel on the ship should assume OPS cables are energised if they are coupled to inlets unless the ship-side PIC has verified and communicated to the crew that they are not energised.

A safety barrier system should be erected after cables are coupled to prevent unprotected persons from exposure to the cables.

16.7 Sequencing of OPS coupling and decoupling

Coupling, decoupling, energising, and de-energising procedures may vary across terminals and ships, but the following provides minimum guidance to consider. It is recommended no other operational tasks take place during the process. All mooring operations should be completed prior to commencing the shore power connection process. Unmooring should not take place until shore power is fully disconnected.

The execution of tasks should only be carried out by trained and qualified individuals with the appropriate PPE.

16.7.1 OPS coupling and energising

It is recommended that no other operational tasks take place during the coupling process. Tasks should only be carried out by trained and qualified individuals and closely monitored. Connection and energising procedures may vary across terminals and ships, but the following provides minimum guidance to consider:

- Before cable handling or coupling of the system:
  - Terminal and ship PIC should have discussed critical items included in the OPS Ship Shore Safety Checklist (see section 16.10, appendix).
  - The appropriate terminal and ship personnel should exercise LOTO confirmation to verify the system is de-energised and safety earths are applied.
- Required personnel, tools and equipment are available.
- Appropriate PPE confirmed and used.
- Once de-energised, connector and inlet contacts should be inspected. If any damage to the connector or inlet contacts is present, coupling should not proceed.
- Refer to sections 12.3 and 16.6 for detailed guidance on cable handling. Once the cables are in place, the ship can proceed with coupling.
- Once all applicable cables are coupled, terminal and ship personnel should jointly verify all couplings are complete. Once verified, personnel can remove LOTO locks and tags.
- Ship's PIC, in communication with the shore-side PIC, will open the ship-side safety earthing switch.
- The shore-side PIC will open the shore-side earthing switch.
- The shore-side PIC will close the shore-side disconnect switch.
- The shore-side PIC will close the shore-side breakers associated with the shore power system upon request by the ship-side PIC.
- Shore-side system will be energised through to the incoming breaker.
- Ship will go to single generator operation and synchronise to the shore power supply.
- Load is to be transferred from the ship's generator to the shore-side supply, and the ship's generator shuts down.
- Once the ship is operating on shore power, normal operations can resume, including connecting the cargo equipment.

A joint check of the OPS safety loop check, including alarm settings, should be conducted. The shore power supply, including safety systems, should be continuously monitored by the terminal and ship when in operation.

16.7.2 Consideration for ship movements

Once the cable is in place and the coupling made, cable payout should be adjusted to accommodate changes in relative motion between the ship and shore. This can be automatic or manual. The cable and the coupler should be protected from excess tension. Environmental conditions and ship movement should be monitored.

Cable tension between ship and shore should be monitored and hazardous conditions alarmed.

Excess cable tension or excess cable payout should initiate a safe system shutdown.

The CMS should be arranged to prevent overheating of coiled sections.

Excess cable should also be monitored to prevent the cable from becoming trapped or immersed in water.

Cable tension, cable payout, and cable overheating are a terminal responsibility unless otherwise agreed.

16.7.3 OPS de-energising and decoupling

De-energising and decoupling procedures may vary across terminals and ships, but the following provides minimum guidance to consider:

- Before decoupling, the ship should follow its procedures to shift from shore power to ship-supplied power. That is the ship should start an auxiliary generator and synchronise to shore power.
- The ship-side PIC, in communication with the shore-side PIC, should reduce the proportion of power supplied by the onshore supply. Once the ship's generator is supplying approximately 90% of the ship's total load, the incoming circuit breaker to the main switchboard should be opened, followed by the opening of the circuit breaker in the OPS switchboard onboard the ship.
- Before load transfer from shore to ship, cargo operations should stop, and all cargo equipment be disconnected.
- Once the ship supplied power is fully transferred to the ship, the shore-side PIC will, upon request of the ship PIC, open the breakers associated with the shore power system.
- The shore-side PIC will verify that there is no voltage present in the system.
- The shore-side PIC will open the disconnect switch and communicate to ship.
- After confirmation that the shipside earthing switch is closed the shore-side PIC will close the shore-side earthing switch. The shore-side PIC confirms with the ship-side PIC that the onboard system is isolated, and the earthing switch is closed.
- Personnel should apply LOTO locks and tags where applicable to confirm the de-energisation of the system.
- Once LOTO is in place, ship personnel can proceed with decoupling the connectors from the inlets.
- Required personnel, tools and equipment are available.
- Appropriate PPE confirmed and used.
- Once the cable is decoupled and stowed, terminal and ship personnel can proceed to remove LOTO.

Any issues encountered during the OPS operation should be documented and reported.

16.8 Emergency OPS decoupling procedure

In the event of an emergency, when a ship may need to disengage from the terminal unexpectedly, it is important that the ship can quickly decouple the OPS cable without jeopardising safety.

The ship may leave the berth in an unplanned manner, for example, after breaking of mooring lines. As a result, loading arms/hoses and the OPS coupling may break loose, not necessarily at the same moment. In such scenarios, the OPS may still be energised simultaneously with the presence of explosive atmospheres.

The terminal and ship should have an emergency plan developed for their respective systems. These plans should address energy isolation points and personnel responsibilities.

If possible, the cargo operation should be terminated, associated cargo equipment disconnected, and blind flanges secured to the manifolds before starting the procedure of decoupling the OPS cable.

It is not advised to manually decouple the cables without a plan to isolate the system safely.

Consideration should be given to including such scenarios in case-specific HAZID/HAZOP. Scenarios in the HAZID should include:

- Ship movement beyond the allowable envelope of loading arms.
- Breaking of mooring lines and OPS cables.

- Breaking of mooring lines, but not the OPS cables, causing the latter to sweep over manifold and berth deck area when the ship is moving.
- Securing a non-flammable gas atmosphere in the vicinity of the OPS cable connection.
- For compartment arrangements, ensuring a safe oxygen level for a person to enter an enclosed space, such as the deck compartment where the OPS coupling is located and where nitrogen gas may have been present.
- Personnel requirement onshore and on the ship for handling the OPS cable and bringing it back to the terminal.
- In an emergency departure, there is always a risk that simultaneous operations may affect each other. Such operations should be coordinated with the decoupling of the OPS cable and taking the OPS cable ashore. Ships may start moving along or out of the berth, damaging the cable or the OPS station.
- External factors such as cold weather, ice and snow can make rapid handling difficult and should also be considered.

16.9 Minimum staffing and competency considerations for coupling/decoupling

The optimal manning levels and equipment requirements should be determined based on the primary mission of conducting cargo operations using OPS. Achieving this requires effective coordination between the ship and the terminal, which adds complexity to the process.

There are no set minimum staffing requirements for OPS. To accomplish a safe and efficient OPS operation, the operational procedures and competency targets should be established prior to launching a crew training programme. Required manning for a safe operation should be part of those procedures. This will make a new OPS system operation an integral part of shipboard routine operation so that the OPS operation on the ship side can be self-reliant.

For a ship's use of OPS at a berth, the connection point is an interface between the direct power supply of the shoreside terminal and the power generation on the side of the ship. The interface should, therefore, be a controlled process.

As the architecture of the OPS system becomes increasingly automated, minimal crew intervention will be required. Fail-proof automatic systems may allow for efficient and safe operation; however, they still require complete knowledge about their functioning.

A growing number of ships, notably ferries, cruises, ro-pax and container ships, already have OPS systems in operation. Using OPS for tankers presents other risks and special training needs compatible with the unique features of tanker operations.

New system installations add new crew training requirements for the risks inherent in the use of OPS, including but not limited to coupling, operation, decoupling and maintenance.

The STCW Convention contains regulations for crew training on ships subject to the International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF Code). However, it is not certain whether IMO and the ship's flag administration will implement crew certification for OPS under STCW.

At present, there is no comprehensive set of tanker crew training programmes for OPS. However, the industry can benefit from the following guidelines as a basis for crew training:

- The IMO *Interim Guidelines on the Safe Operation of Onshore Power Supply (OPS) Service in Port for Ships Engaged on International Voyages* (MSC.1/Circ.1675, 2023). These provide general guidelines on the safe operation of OPS service in port on ships. In particular, para.6.1 reads: "The company, as defined in SOLAS regulation IX/1.2, should ensure that onboard personnel involved in OPS operation are familiarised with the onboard OPS system for safe operation in accordance with STCW regulation I/14, paragraph 1.5."

- IMO International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) Regulation I/14, paragraph 1.5, which reads: "Each Administration shall require every such company to ensure that seafarers, on being assigned to any of its ships, are familiarised with their specific duties and with all ship arrangements, installations, equipment, procedures and ship characteristics that are relevant to their routine or emergency duties."
- EMSA *Shore-Side Electricity, Guidance to Port Authorities and Administrations* Part 2, 2023. This guidance is intended to provide a controlled interface between power supply from the port side to direct power supply for ships at berth. Note that the controlled interface also applies to power connections between the utility or distribution grid and the terminal. It highlights the importance of regular training for emergency response and handling of high voltage cables.

Training should consist of basic and advanced model courses at an approved training facility, plus minimum seagoing experience, including familiarisation. This would serve as a minimum training framework.

Tanker operators are recommended to establish a training programme that considers the crew roles and responsibilities addressed in this guidance and implement it on a voluntary basis.

16.10 OPS Ship Shore Safety Checklist

The appendix contains an example of an OPS safety checklist that can be used as reference and completed in addition to *ISGOTT's* Ship Shore Safety Checklist (SSSCL). The OPS safety checklist aims to confirm that terminal and ship operator have discussed critical items that include:

- PPE and physical barriers to protect personnel from high voltage equipment.
- Frequency, voltage and number of cables required between ship or shore.
- Hazardous rating of the power connectors, cables, CMS vs ship and terminal hazardous areas.
- Confirmation that required periodic maintenance and alarm testing has been conducted.
- Discussion of audible and visual alarms pertaining to OPS and associated significance.
- Procedure for lock out and tag out prior to coupling.
- Gas-free confirmation of coupling areas.
- Permitting requirements of ship or terminal prior to coupling.
- Confirmation that ship/shore electrical isolation is functioning on arms or hoses.
- Sequencing for coupling and decoupling.
- Steps to be taken due to loss of shore power.
- Steps to be taken in an emergency and need to evacuate a berth; ship readiness.
- Potential for clashing between electrical cables and mooring lines/gangways/cargo handling equipment.

The OPS safety checklist should contain the above items and any additional site-specific requirements. It should be signed off by both the ship and terminal person during the appropriate steps. The verification of the checklist's items should include a physical walk around by both the ship and terminal personnel to inspect the equipment before use.

Copies of the signed-off safety checklist should be filed and stored by both the ship operator and terminal operator for future reference. Filed copies should include name and signatures of both ship and terminal parties involved and a clear indication of the date/time when the safety checklist was prepared and of the ship's name and IMO number.

Appendix: Example of OPS safety checklists

Date and time	
Tanker name and IMO number	
Tanker operator name and signature	.... *Signature*
Terminal	
Terminal operator name and signature	.... *Signature*

A1: Tanker – Pre-arrival

Item	Check	Status	Remarks
1	Is the compatibility of the shore power systems according to IEC/IEEE 80005-1 confirmed? (15.4, 16.1)	Yes ☐	
2	Is the shore power equipment in safe working order? (16.2)	Yes ☐	
3	Is the ship's position on the berth agreed upon? (16.2)	Yes ☐	
4	Are restricted areas and personnel qualifications validated? (6.3, 8.2)	Yes ☐	
5	Is written approval from the port authority obtained, if required? (16.2)	Yes ☐	
6	Is the terminal's checklist for technical requirements reviewed? (16.1)	Yes ☐	
7	Are all necessary safety circuits and equipment present and ready? (4.4, 5.2, 6.14)	Yes ☐	
8	Are emergency decoupling procedures agreed? (16.2)	Yes ☐	
9	Are the steps to be taken in an emergency and need to evacuate a berth agreed? (6.8, 16.8)	Yes ☐	
10	Are the steps to be taken in the event of loss of shore power agreed? (16.2)	Yes ☐	

A2: Tanker – Pre-arrival if using a pressurised gas-free coupling compartment – additional checks

Item	Check	Status	Remarks
10	Is the non-hazardous coupling compartment in safe working condition? (4.12, 6.5.1)	Yes ☐	
11	Are all coupling compartment safety circuits operational? (4.12, 6.5.1)	Yes ☐	
12	Is the pressurisation system functioning correctly? (4.12, 6.5.1)	Yes ☐	
13	Is the functionality of the oxygen and gas detectors verified? (5.5, 6.4.4, 6.5.1)	Yes ☐	
14	Is the integrity of the seal around the cable inlet checked? (5.5, 6.4.4, 6.5.1)	Yes ☐	

B: Terminal – Pre-arrival

Item	Check	Status	Remarks
15	Is the compatibility of the shore power systems according to IEC/IEEE 80005-1 confirmed? (15.4, 16.1)	Yes ☐	
16	Is the shore power equipment in safe working order, including the testing of cables verified? (12.5, 16.2)	Yes ☐	
17	Is the operational envelope of the CMS and the length of the cable(s) needed appropriate? (9.2, 16.1)	Yes ☐	
18	Are restricted areas and personnel qualifications validated? (12.13, 14.3)	Yes ☐	
19	Are any necessary approvals and documentation provided to the ship? (12.5, 16.2)	Yes ☐	
20	Are emergency decoupling procedures agreed? (16.2)	Yes ☐	
21	Are the steps to be taken in an emergency and need to evacuate a berth agreed? (12.12, 16.3, 16.8)	Yes ☐	
22	Are the steps to be taken in the event of loss of shore power agreed? (16.2)	Yes ☐	

C: Tanker – After mooring and before cable handling

Item	Check	Status	Remarks
23	Is the mooring operation completed? (6.4.2, 16.7)	Yes ☐	
24	Is communication with the terminal's PIC established? (16.6, 16.7)	Yes ☐	
25	Is LOTO confirmation exercised to verify the system is deenergised and safety earths are applied? (6.4.2, 16.6, 16.7)	Yes ☐	
26	Has a visual inspection of all OPS equipment been completed? (6.4.2)	Yes ☐	
27	Have the connector and inlet contacts been inspected for damage before proceeding with coupling? (6.4.2, 16.7)	Yes ☐	
28	Is the coupling space confirmed gas-free and safe? (6.4.4)	Yes ☐	
29	Is the readiness of crew, necessary equipment and PPE confirmed? (16.5, 16.7, 16.9)	Yes ☐	

D: Terminal – After mooring and before cable handling

Item	Check	Status	Remarks
30	Is communication with the ship's PIC established? (16.6)	Yes ☐	
31	Is LOTO confirmation exercised to verify the system is deenergised and safety earths are applied? (16.6, 16.7.1)	Yes ☐	
32	Is a visual inspection of all OPS equipment completed? (12.5, 13.3, 16.7.1)	Yes ☐	
33	Has the connector and inlet contacts been inspected for damage before proceeding with coupling? (12.5, 13.3, 16.7.1)	Yes ☐	
34	Are all required safety measures and checks completed? (12.5, 13.3, 16.7.1)	Yes ☐	
35	Is the readiness of terminal personnel, necessary equipment and PPE confirmed? (14.3, 16.5, 16.7, 16.9)	Yes ☐	

E: Tanker – Cable handling

Item	Check	Status	Remarks
36	Is the number of cable connection to be used defined? (16.2)	Yes ☐	
37	Is the OPS cable handled and positioned correctly? (16.6)	Yes ☐	
38	Is the cable located to prevent damage? (16.6)	Yes ☐	
39	Once the cables are in place, can the ship proceed with coupling? (6.4.4, 16.6, 16.7.1)	Yes ☐	
40	Are the cables supported using onboard anchor points? (5.3)	Yes ☐	
41	Are all couplings verified as complete, and can personnel remove LOTO locks and tags once verified? (16.7.1)	Yes ☐	

F: Terminal – Cable handling

Item	Check	Status	Remarks
42	Are the cable ends paid out individually using shore CMS? (9.2, 16.6)	Yes ☐	
43	Are all couplings verified as complete, and can personnel remove LOTO locks and tags once verified? (16.7.1)	Yes ☐	

G: Tanker – After OPS coupling and before initiation of power transmission

Item	Check	Status	Remarks
44	Is the OPS safety loop operational? (4.4, 6.5.1, 15.7)	Yes ☐	
45	Is the ship's PMS ready for synchronisation? (4.13, 6.4.2, 6.5.1, 6.5.2)	Yes ☐	
46	Is the pressurised gas-free compartment sealed and pressurised if used? (4.12, 6.4.4, 6.5.1)	Yes ☐	

H: Terminal – After OPS coupling and before initiation of power transmission

Item	Check	Status	Remarks
47	Is the shore power system ready to supply power? (12.5, 13.3, 16.7.1)	Yes ☐	
48	Are all safety checks and system readiness confirmed? (12.5, 13.3, 16.7.1)	Yes ☐	

I: Tanker and Terminal – After OPS coupling and before initiation of power transmission

Item	Check	Ship Status	Terminal Status	Remarks
49	Verify no faults in the shore power system status. (16.7.1)	Yes ☐	Yes ☐	
50	Ensure all parameters of the OPS safety loop are in normal condition. (16.7.1)	Yes ☐	Yes ☐	
51	Ensure that all safety checks are documented and signed off. (16.10)	Yes ☐	Yes ☐	

J: Tanker and Terminal – Power transmission

Item	Check	Ship Status	Terminal Status	Remarks
52	Is coordination between ship and shore to synchronise the power systems established? (16.7.1)	Yes ☐	Yes ☐	
53	Has the ship's PIC opened the ship-side safety earthing switch? (16.7.1)	Yes ☐	Yes ☐	
54	Has the terminal PIC opened the shoreside earthing switch and closed the disconnect switch? (16.7.1)	Yes ☐	Yes ☐	
55	Has the terminal PIC closed the shoreside breakers upon authorisation from the ship? (16.7.1)	Yes ☐	Yes ☐	
56	Is the shore side system energised to the incoming breaker? (16.7.1)	Yes ☐	Yes ☐	
57	Has the ship gone to single generator operation and synchronised to the shore power supply? (16.7.1)	Yes ☐	Yes ☐	
58	Is the load transferred from the ship's generator to the shore side supply and the ship's generator shut down? (16.7.1)	Yes ☐	Yes ☐	
59	Is the power transfer process monitored? (16.7.1)	Yes ☐	Yes ☐	
60	Did normal operations resume once the ship operates on shore power, including connecting the cargo equipment? (16.7.1)	Yes ☐	Yes ☐	

K: Tanker – Repetitive checks during power transmission

Item	Check	Time	Time	Time	Time	Time	Time	Remarks
Interval time: ___________hrs								
61	Is the ship's PMS regularly checked for correct functioning? (6.5.3)	Yes ☐	Yes ☐	Yes ☐	Yes ☐	Yes ☐	Yes ☐	
62	Are all safety systems functioning correctly? (6.14.1,6.14.2, 7.1)	Yes ☐	Yes ☐	Yes ☐	Yes ☐	Yes ☐	Yes ☐	
63	Is the OPS cable secure and undamaged? (6.6)	Yes ☐	Yes ☐	Yes ☐	Yes ☐	Yes ☐	Yes ☐	
64	Is the cable checked for no tension on the coupler? (6.6)	Yes ☐	Yes ☐	Yes ☐	Yes ☐	Yes ☐	Yes ☐	
65	Is the ship's position and mooring monitored to prevent any strain on the OPS cable? (6.6)	Yes ☐	Yes ☐	Yes ☐	Yes ☐	Yes ☐	Yes ☐	
66	Are the environmental conditions that may affect the OPS checked? (6.10)	Yes ☐	Yes ☐	Yes ☐	Yes ☐	Yes ☐	Yes ☐	
Initials								

L: Terminal – Repetitive checks during power transmission

Item	Check	Time	Time	Time	Time	Time	Time	Remarks
Interval time: ___________hrs								
67	Is the shore power system continuously monitored? (16.7.1)	Yes ☐	Yes ☐	Yes ☐	Yes ☐	Yes ☐	Yes ☐	
68	Are all safety systems functioning correctly? (16.7.1)	Yes ☐	Yes ☐	Yes ☐	Yes ☐	Yes ☐	Yes ☐	
69	Is the status of the CMS and cable integrity verified? (16.7.2)	Yes ☐	Yes ☐	Yes ☐	Yes ☐	Yes ☐	Yes ☐	
70	Is the ship's position and mooring monitored to prevent any strain on the OPS cable? (16.7.2)	Yes ☐	Yes ☐	Yes ☐	Yes ☐	Yes ☐	Yes ☐	
71	Are the environmental conditions that may affect the OPS checked? (16.7.2)	Yes ☐	Yes ☐	Yes ☐	Yes ☐	Yes ☐	Yes ☐	
Initials								

M: Tanker and Terminal – Power transmission finalisation

Item	Check	Ship Status	Terminal Status	Remarks
72	Is the auxiliary generator synchronised to shore power? (16.7.3)	Yes ☐	Yes ☐	
73	Is the load gradually transferred from shore power to the ship's generators? (16.7.3)	Yes ☐	Yes ☐	
74	Is a stable power feed onboard ensured before disconnecting shore power? (16.7.3)	Yes ☐	Yes ☐	
75	Once the ship's generators are supplying 90% of the total load, is the ship's shore power breaker opened? (16.7.3)	Yes ☐	Yes ☐	
76	Once the ship supplied power is fully restored, does the terminal verify that the ship's breaker is in the open position and open the shoreside breakers associated with the shore power system? (16.7.3)	Yes ☐	Yes ☐	
77	Is no voltage verified in the system? (16.7.3)	Yes ☐	Yes ☐	
78	Does the terminal's PIC open the disconnect switch? (16.7.3)	Yes ☐	Yes ☐	
79	Is the disconnect switch opened and earthing switch closed? (16.7.3)	Yes ☐	Yes ☐	
80	Are LOTO locks and tags applied, and the de-energisation of the system confirmed? (16.7.3)	Yes ☐	Yes ☐	
81	Is the pressurised compartment (if applicable) vented before opening? (6.5.6, 16.7.3)	Yes ☐	Yes ☐	
82	Is the OPS cable safely decoupled and stored, following all safety protocols? (16.7.3)	Yes ☐	Yes ☐	
83	Once the cables are decoupled and stowed, can terminal and ship personnel proceed to remove LOTO? (16.7.3)	Yes ☐	Yes ☐	
84	Is all OPS equipment inspected for any damage or wear? (13.2)	Yes ☐	Yes ☐	
85	Are any issues encountered during the operation documented and reported? (16.7.3)	Yes ☐	Yes ☐	

OCIMF

Our vision

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