Deliverable D2.1

Report on the analysis of the standards relevant to shipside installation for shore side electricity supply

Co-financed by the Connecting Europe Facility of the European Union

Activity	2
Task	Analysis of the standards relevant to shipside installation for shore side electricity supply
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LIST OF ABBREVIATIONS AND ACRONYMS

Abbreviation	Meaning
CEF	Connecting Europe Facility
CO2	Carbon Dioxide
EC	European Commission
EU	European Union
HVSC	High Voltage Shore Connection
LVSC	Low Voltage Shore Connection
SO2	Sulphure Dioxide
SSE	Shore Side Electricity
TEN-T	Trans-European Transport Network

EXECUTIVE SUMMARY

Within EALING project, main target of which is to study, promote and boost Shore Side Electricity solutions across 16 TEN-T network EU maritime ports, Deliverable D2.1 refers to the analysis of those standards that govern shipside installation for shore side electricity supply.

Chapter 1 *Introduction* provides an outline of Activity 2 and the specific scope of this report. In **Chapter 2** *Regulatory Framework – Shipside installation and requirements* there is a breakdown of the existing regulatory framework related to Shore Side Electricity supply for vessels, focusing directly or indirectly on the development of regulations and directives for shipside installations at both European and International level. Afterwards, the afore mentioned regulations and directives are analyzed in detail and the forthcoming regulations are presented as well. **Chapter 3** *Technical & Operational Guidelines/ Standards – Shipside Installation and Requirements* includes the breakdown and the in-depth analysis of those technical and operational guidelines and standards that are relevant to the Shore Side Electricity supply from the side of the ship. Across the main body of this chapter, the IEC, IMO, IEEE, EMSA, CENELC, IET and different classification societies guidelines can be consulted. Finally, similarly to the previous chapter, the forthcoming developments on technical and operational standards and guidelines are mentioned. **Chapter 4** *Identification Of Challenges* provides information about a series of challenges that have been identified during the developments of the report and of EALING project as a whole. Lack of information, potential overlaps, technical challenges as well as preliminary harmonization guidelines, are analyzed. Last but not least, the main conclusions of the report are summarized in **Chapter 5** *Conclusions*, paving the way for the development of the Deliverable D2.2 of EALING Activity 2.

1 INTRODUCTION

1.1 Objectives of the Activity

The main objectives of *Activity 2 – Maritime Fleet Adaptation* of the EALING Action (2019-EU-TM-0234-S) are the detailed examination of the existing and forthcoming maritime electrification standards across the ports of the consortium of EALING project and of the vessels operating in these ports as well as the identification of the technical elements that could be harmonized for resulting into a proposal to International Maritime Organization (IMO). Based on the fact that the majority of the vessels calling at the European ports are not ready for Shore Side Electricity (SSE), as extracted by the studies carried out within EALING Project, due to the design and arrangement of their electrical appliances and the infrastructure, including the shore connection panel, main and auxiliary switchboards and the distribution system, the harmonization of the relevant legislative framework and the maritime electrification standards across the participating European TEN-T core and comprehensive maritime ports of the EALING Action is considered necessary.

In particular, it should be noted that the electrical standards and the regulatory framework are not uniform and the procedure of connecting and disconnecting the shore power supply is arranged on an ad hoc basis as per port or as per Member State. Therefore, the harmonization of the port to vessel compatibility in relation to the under-study vessels, including Ro-Ro vessels, containerships and car carriers, will be examined and proposed. To result in recommendations on best practices for vessels' retrofitting, the examination of several different scenarios, including various general arrangements for different ships, will be conducted.

Additionally, taking as a reference the International Maritime Organization (IMO) guidelines for a harmonized technical, legal and regulatory framework on maritime fleet adaptation for electrification, and based on the results of previous EU co-funded projects and potentially existing legislative framework across the involved Member States, operational recommendations will be provided.

In the context of the main objectives of the related regulatory framework on SSE for vessels calling at European ports, the development of a SSE framework for both international shipping and inland waterways is based on the technical aspects and business case elements for emission abatement methods such as SSE that were presented on relevant studies and legislative proposals, building on earlier experience with SSE technology and focusing strongly on the high potential of the use of SSE in the improvement of local air quality in ports and in association, improvement of life quality in the cities and areas surrounding ports.

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Therefore, EU Commission published a recommendation identifying the relevance between specific technical elements of SSE and associated costs and clearly outlined that Member States should consider the installation of shore side electricity for use by ships at berths in ports. Particularly in ports where air quality limit values are exceeded or where public concern is expressed about high levels of noise pollution, and especially in berths situated near residential areas. In this context, EU Member States should report to the EU Commission on actions they intend to take to reduce ship emissions in ports in these areas as part of their national policies and climate plans and the development of harmonized international standards for shore side electrical connections was recommended too.

Moreover, co-funding programmes such as Connecting Europe Facility (CEF), Horizon Europe, earlier Framework Programmes, and others, have taken due account of the relevance of projects for SSE or hybrid/electric ships boosting the electrification of the maritime fleet of vessels calling at the European TEN-T core and comprehensive maritime ports. This has been achieved through supporting capital investment, improvement of SSE projects feasibility status and allowing for positive return on investment of projects that gained favorability from sharing the investment risk within a context of EU co-financing support. Towards the same direction, regarding standardization, significant effort has been put into the development of standards for both seagoing ships and inland waterways vessels, with a view for compatibility and interoperability of SSE in the ship-shore interface, contributing in this way to safety of operations. At the same time, standardization allows for reassurance in the adoption of SSE.

In parallel to the EU SSE infrastructure development, there are private industry initiatives as well, developing different projects particularly focused on ship-specific/company-specific arrangements for shore side electricity supply typically in specific dedicated terminals, focusing on cases with domestic passenger ships and small ferries. Customized SSE solutions that are developed and tailor-made for specific vessels demand and operating profile allow for a low-risk business case to be explored. However more and more non-dedicated SSE services are expected to be deployed in the future.

1.2 Objectives of the Deliverable

The main objective of D2.1 "Report on the analysis of the standards relevant to shipside installation for shore side electricity supply for the vessels operating in the ports of the consortium" is to carry out the analysis of the standards relevant to shipside installation for shore side electricity supply for the vessels operating in the ports of the consortium. The existing legislative framework including both IEC/IEEE 80005 series and IMO Interim Guidelines on SSE for ships engaged in International Voyages, IET and IACS (International Association of Classification Society) Guidelines as well as the

EMSA Guidance on Shore Side Electricity (SSE) could be utilized as a reference for the analysis of the standards relevant to shipside installation for SSE dedicated to vessels.

In order to achieve the expected outcome of this deliverable, parameters such as level of different ship's preparedness for SSE, power requirements at berth, existence of Shore-Power Switchboard panel onboard (Voltage and Current Rating), location of SSE connection (if any) along the ship's length/height above the waterline and typical load profile at berth have been taken into consideration for analysing thoroughly the regulatory framework and the standards relevant to shipside installations for shore side electricity supply for the vessels operating in the participating TEN-T core and comprehensive ports of EALING Action. Such critical inputs have been gathered from shipping lines, ship-owners, shipyards, classification societies, flag administrations, national shipping associations, energy providers, Port Authorities of each Member State concerned and form the European Community Ship-owners' Associations (ECSA).

More specifically, SSE stakeholders in the present context could be assisted with a number of technical and standardization references, but there is still a certain amount of uncertainty with respect to the regulatory framework and administrative burden associated with the development of SSE. It is widely known that many aspects have to be considered when harmonizing regulations regarding SSE for ships. First, when handling (high voltage) electricity, basic electrical safety rules must always be followed. From the institutional point of view, national and international jurisdiction, as well as industrial standards, must be followed and for every ship, the requirements imposed by its class, its flag and the port of call must be met.

For instance, for the inspection of a shore-based power supply system, an IEC/ISO/IEEE standard is commonly referred to internationally, whereas, for the shipboard power receiving system, someone should refer to the specifications of the classification society of each ship. The inspection system in each classification society is formulated on the basis of ship connection in each country and includes different inspection requirements. Therefore, even though the ship might comply with its class regulations, inconsistency between shipboard power receiving equipment and shore-based power supply system may still exist, which can lead to the unsuccessful operation or even severe damage when the ship is connected to SSE. This highlights the importance and thus, the need for a harmonized European regulatory framework in order to achieve the goal of a more competitive and sustainable TEN-T maritime Network through the electrification of maritime transport.

2 REGULATORY FRAMEWORK – SHIPSIDE INSTALLATION AND REQUIREMENTS

2.1 Breakdown of the Existing Regulatory Framework related to Shore Side Electricity

For presenting in detail the specific regulatory framework for the shipside installation and the requirements for shore side electricity supply for the vessels operating in the participating TEN-T core and comprehensive maritime ports of the EALING Action, a breakdown of the existing regulatory/legislative framework related to SSE supply for vessels has been conducted focusing directly or indirectly on regulations and directives for shipside installations development at both international and European level. The following existing international and European regulations will be thoroughly analyzed in this chapter.

In the context of the existing EU regulations (directly or indirectly) related to the SSE application on ships, the European Union has set itself the binding goal of achieving climate neutrality by 2050 through the European Climate Law, as part of the European Green Deal. This requires a significant reduction in current greenhouse gas emissions over the next few decades. As an intermediate step on the road to climate neutrality, the EU has a commitment to reduce its emissions by at least 55% by 2030. The European Union is currently revising its climate, energy and transport-related legislation as part of the so-called Fit for 55 package. The aim is to align the current rules with the 2030 and 2050 targets. The package also includes a number of new initiatives. With regard to SSE in maritime ports, the provisions have been made fully consistent with the FuelEU Maritime proposal. The European transport Ministers adopted a common position ('general approach') related to the FuelEU Maritime proposal on 2 June 2022.

As concerns the green fuels' adoption in maritime transport, the Fit for 55 package aims to address road transport and also waterborne transport. The aim of the proposal on using renewable and low-carbon fuels in maritime transport (Fuel EU Maritime) is to reduce the greenhouse gas intensity of energy consumed on board ships by up to 75% by 2050 by promoting the use of cleaner fuels on ships. Despite progress in recent years, maritime transport still relies almost exclusively on fossil fuels and is a significant source of greenhouse gases and other harmful pollutants.

The EU's energy taxation rules will also support GHG emission reduction by putting forward minimum rates of taxation on the relevant fuels used for the intra-EU ferry, fishing and freight vessels.

In June 2022, the EU Council agreed on a general approach to the two draft regulations. Once negotiations with the European Parliament (in the so-called "trilogies") are completed, the new EU legislation can finally be adopted.

Regarding the emissions trading regime in maritime transport, the EU Parliament called in April 2021 for the shipping industry to be integrated into the EU Emissions Trading System (ETS) and, in this context, to increase the Union-wide quantity of allowances. The extension of the ETS system to maritime transport will apply to emissions from voyages within the EU, emissions generated at berth in an EU port, and half of the emissions from voyages outside the EU. The system will be open, allowing industries to use allowances for compliance. No free allowances are to be allocated to the industry, but only a portion of the emissions generated therein will have to be covered by allowances in the first three years. By 2026, shipping companies will only have to surrender allowances on a pro-rata basis. This proportion will be gradually increased. In 2023, shipping companies are liable to surrender allowances for 20% of their emissions, in 2024 for 45% and in 2025 for 70% of their emissions. From 2026, there will be an obligation to surrender 100%. The system will be subject to the EU's MRV Regulation for measurement, reporting and verification. In line with this regulation, companies will be considered the responsible entity and will account for CO2 emissions from tank to propeller.

As for the intention of the EU Commission regarding SSE, its use abates air pollution produced by ships as well as it reduces the amount of GHG emissions generated by maritime transport. SSE represents an increasingly clean power supply available to ships in view of the growing share of renewables in the EU electricity mix. While only the provision of SSE connection points is covered by EU Directive 2014/94/EU, the demand for and, as a result, the deployment of this technology has remained limited. Therefore, specific rules should be established to mandate the use of SSE by container ships and passenger ships (including cruise ships), the two ship categories which are producing the highest amount of emissions per ship while moored at the quayside, according to the data collected within the framework of Regulation (EU) 2015/757 in 2018.

Different SSE projects and solutions have been tested for ships at anchorage, but no mature and scalable technical solution is currently available. For this reason, the obligation to use SSE is limited, for the time being, to ships moored at the quayside. Nevertheless, the Commission should regularly reassess the situation, with a view to extending this obligation to ships at anchorage, when the necessary technologies are mature enough. In the meantime, EU Member States should be allowed to impose such obligations to ships at anchorage, for example, in ports that are already equipped with such technology or are located in areas where any pollution should be avoided.

Considering the positive effects of SSE on local air pollution and the need to incentivize the ramp-up of this technology in the short term, the carbon footprint of the production of electricity supplied at berth should be counted as zero. The Commission should envisage the possibility to factor in the GHG emissions associated with the electricity delivered via SSE at a later stage.

The following existing international and European regulations will be analysed thoroughly in the context of this chapter:

- **International Regulatory Framework**
  - SOLAS – International convention for the Safety of Life at Sea (SOLAS) 1974, as modified by the protocol of 1998 relating thereto.
  - MARPOL – International Convention for the Prevention of Pollution from Ships Annex VI, with limits on SOx and NOx emissions, Energy Efficiency and EAMs.
  - STCW – International Convention on standards of training, certification and watchkeeping for seafarers - Regulations III/6, III/2 related to the certificate of competency and Regulation B-III/2 OF STCW completed training.
- **European Regulatory Framework**
  - EU Alternative Fuel Infrastructure Directive – Directive 2014/94/EU on the deployment of alternative fuels infrastructure (3) part of the EU Clean Power for Transport package, Article 4, paragraphs 5 and 6.
  - Machinery Directive – Directive 2006/42/EC EU Machinery Directive – Directive 2006/42/EC - 1st Version 1989, new revised Directive since 29th December 2009.
  - Commission Delegated Regulation (EU) 2019/1745 (13.08.2019 – EU secondary regulation) supplementing and amending Directive 2014/94/EU of the European Parliament and the Council, as shore side electricity supply for inland waterway vessels and repealing Delegated Regulation (EU) 2018/674.
  - EU Port Services Regulation – Regulation (EU) 2017/352 of the European Parliament and of the Council of 15 February 2017 establishing a framework for the provision of port services and common rules on the financial transparency of ports.
  - EU Sulphur Directive – Directive 2016/802/EU, codifying Council Directive 1999/32/EC as regards the sulphur content of marine fuels, as amended by Directive 2012/33/EU.
  - Directive EU 2016/1629 laying down technical requirements for inland waterway vessels, amending Directive 2009/100/EC and repealing Directive 2006/87/EC.

2.2 Analysis of the Existing Regulatory Framework related to shore side electricity

In this sub-chapter, the aforementioned legislative framework at both international and European levels including the following conventions, guidelines, regulations and directives will be analyzed in detail to depict its relevance with legislative acts referring directly or indirectly to shipside

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installations for shore side electricity supply for vessels operating in the participating TEN-T core and comprehensive maritime ports of EALING Action.

2.2.1 International Regulatory Framework

As concerns the international regulatory framework, the following conventions and guidelines are related directly or indirectly to shipside installations for shore side electricity supply for vessels:

- **SOLAS – International Convention for the Safety of Life at Sea.** It includes requirements for ships engaged in international voyages that shall conform to SOLAS Chapter II-1, Part D Electrical Installations (Regulations 40-45). In particular, the electrical installations of ships are defined in these regulation of the SOLAS convention, provisions for the main source of electrical power and lightning systems for ships, emergency source of electrical power in passenger ships and cargo ships, supplementary emergency lightning for Ro-Ro passenger, starting arrangements for emergency generating sets, precautions against shock, fire and other hazards of electrical origin (paragraphs 10 and 11 of Regulation 45 apply to ships constructed on or after January 2007) are included.
- **MARPOL – International Convention for the Prevention of Pollution from Ships.** In Annex VI, limits on SOx and NOx emissions, Energy Efficiency and Emission Abatement Methods (EAMs) are regulated. Additionally, standard requirements for the adoption of cleaner fuels are being set. At port, Regulations 13 & 14 are foreseen in the EU additionally to the requirements set by MARPOL Annex VI while the Sulphur Directive adds the maximum limit of 0.10% Sulphur content in fuels, at berth.
- **STCW – International Convention on Standards of Training, Certification and Watchkeeping for Seafarers.** This Convention regulates training, certification and quantification processes for seafarers serving on board sea-going vessels, and defines minimum standards of competence for seafarers, especially important for competencies defined for the person in charge (electro-technical officers, chief/second engineer officers) for both High Voltage (HV) or Low Voltage (LV) systems. More specifically, Regulations III/6, III/2 related to the certificate of competency and Regulation B-III/2 of STCW completed training include related provisions. In particular, electro-technical officers holding a certificate of competency in accordance with the requirements of regulations III/6 of the STCW Convention. Additionally, chief engineer officers and second engineer officers on ships powered by main propulsion machinery of 3,000 kW propulsion power or more holding a certificate of competency in accordance with the requirements of regulations III/2 of the STCW Convention and who have completed training in accordance with section B-III/2 of the STCW Code.

2.2.2 European Regulatory Framework

Based on the fact that European Commission resulted in the characterization of Shore Side Electricity (SSE) as an important emission abatement method focusing strongly on the high potential of the use of SSE for the improvement of local air quality in ports and, in association with the improvement of life quality in the cities and areas surrounding ports, a number of EU Directives and Regulations have been issued. SSE in the EU context is characterized by a combination of work from 4 fundamental standpoints in developing an SSE framework for international shipping. The first related Legislative framework was Directive 2014/94/EC, part of the EU Clean Power for transport package, setting 31 December 2025 as the limit date for SSE infrastructure deployment on sea ports for serving adequately the vessels' needs, and the revised Alternative Fuels Infrastructure Regulation (AFIR), which includes new mandates for ports to have in place SSE infrastructure to supply passenger ships and containerships of above 5,000 GT, as of 1 January 2030. Concerning the demand side, the FuelEU Maritime Regulation includes specific provisions that will also promote the use of SSE in ports by the same ships, requiring them to be zero-emissions at berth as from 1 January 2030. To be more specific, as regards the European regulatory framework, the following directives and regulations are related directly or indirectly to shipside installations for shore side electricity supply for vessels:

- **EU Alternative Fuel Infrastructure Directive – Directive 2014/94/EU.** In **Article 4** of the Directive, **in the 5th paragraph**, it is stated that Member States shall ensure that the need for shore side electricity supply for inland waterway vessels and seagoing ships in maritime and inland ports is assessed in their national policy frameworks. Such SSE supply shall be installed as a priority in the ports of TEN-T Core Network, and in other ports, by 31 December 2025, unless there is no demand and the costs are disproportionate to the benefits, including environmental benefits.

  In the 6th paragraph of Article 4, it is stipulated that Member States shall ensure that SSE supply installations for maritime transport, deployed or renewed as from 18 November 2017, comply with the technical specifications set out in point 1.7 of Annex II. Annex II, which determines in point 1.7 the technical specifications for shore side electricity supply for seagoing ships, including the design, installation and testing of the systems, shall comply with the technical specifications of the IEC/ISO/IEEE 80005-1 standard.

- **EU Machinery Directive – Directive 2006/42/EC**. This EU Directive aims at harmonizing the health and safety requirements applicable to machinery on the basis of high-level protection of health and safety while ensuring the free circulation of machinery on the EU market. Applicable to SSE infrastructure equipment, in particular where automated systems are included in the design.

- **Commission Delegated Regulation (EU) 2019/1745 -** SSE supply for inland waterway vessels. This Delegated Regulation by EU Commission defines standards for SSE, compliance with

standard EN 15869-2 "Inland navigation vessels – Electrical shore connection, three phases current 400 V, up to 63 A, 50 Hz – Part 2: Onshore Unit, safety requirements".

- **EU Port Services Regulation – Regulation (EU) 2017/352** - Port services and common rules on the financial transparency of ports. In the context of the common rules on port services and ports' financial transparency, SSE is within the scope and applicability of this regulation, either inside the port area or on the waterway access to the port. Therefore, SSE is considered a bunkering service and is included in the minimum requirements for the provision of port services. More specifically, in the first and the second paragraphs of Article 4, it is stated that the managing body of the port or the competent authority may require providers of port services, including subcontractors, to comply with minimum requirements for the performance of the corresponding port service to the vessels calling at their ports. These minimum requirements related directly or indirectly to the SSE port services to vessels refer to the obligations of each port for the equipment needed to provide the relevant port service in normal and safe conditions and the capacity to maintain this equipment at the required level, for the availability of the relevant port service to all users, at all berths and without interruptions, day and night, throughout the year and for the compliance with local, national, Union and international environmental requirements.
- **EU Sulphur Directive – Directive 2016/802/EU.** This Directive is related to a reduction in the sulphur content of certain liquid fuels including reference to Shore-Power electricity as an alternative marine fuel without sulphur content for the energy needs of maritime vessels calling at EU ports.
- **Directive EU 2016/1629 – Establishment of requirements for inland waterway vessels.** This EU Directive includes references to technical requirements for Inland Navigation vessels and to Certificates for the Inland Navigation vessels. Inspection Processes of the Inland Navigation vessels are analyzed in detail. Reference is also made to Technical Requirements within CESNI Standard ES-TRIN 2021.2.3 Forthcoming Regulations

Considering that SSE facilities can serve maritime waterway transport as clean power supply, this can contribute to reducing the environmental impact of seagoing ships. Under the Fit for 55 package initiatives, ship operators of containerships and passenger ships need to comply with provisions to reduce emissions at berth. In this context, mandatory deployment targets should ensure that the maritime sector finds sufficient shore side electricity supply in TEN-T core and comprehensive maritime ports to comply with those requirements and therefore, the application of these targets to all TEN-T maritime ports should ensure the level playing field between ports. Long-term decarbonization strategies include the development in TEN-T maritime, in particular with a focus on deploying infrastructure for zero emission vessels.

As forthcoming regulation related directly or indirectly to shipside installations for SSE supply for vessels operating in the participating TEN-T core and comprehensive maritime ports of EALING

Action is considered the **Revised Alternative Fuel Infrastructure Directive.** This proposal for a new revised Alternative Fuels Infrastructure Regulation, COM (2021) 559 Final - 2021/0223(COD)/14.07.2021 constitutes the new regulation of the European Parliament and of the Council on the deployment of alternative fuels infrastructure and repealing Directive 2014/94/EU of the European Parliament and the Council and is consistent with the other policy initiatives of the Fit for 55 Package. This specific proposal acts in strong synergy with the revision of the proposal for a Regulation of the European Parliament and of the Council on the use of renewable and low-carbon fuels in maritime transport, FuelEU Maritime Directive for ensuring that sufficient shore side electricity supply is installed in ports to provide electricity while passenger ships (including Ro-Ro passenger ships, high speed passenger craft and cruise ships) and container vessels are at berth. By taking into consideration that for the case of passenger ships the different ship categories vary in their power demand characteristics while at berth, which leads to different investment needs at port, this needs to be combined with the different operational characteristics of ports, including layouts and terminals. For this reason, a further distinction is made on passenger ships compared to the FuelEU maritime initiative in identifying two categories: Ro-Ro passenger ships and high-speed passenger vessels and other passenger ships, notably cruise ships. This revised Alternative Fuel Infrastructure Directive is also in full accordance with the European Green Deal, which delivers on the clear requirement to oblige docked ships to use SSE and Sustainable, and the Smart Mobility Strategy, which boosts the uptake of zero emission vessels and renewable and low-carbon fuels in all modes transport and especially the European maritime transport, as a priority objective in the quest to make all transport modes including the maritime one more sustainable.

More specifically, in Article 9 of the new Alternative Fuels Infrastructure Regulation, COM (2021) 559 Final – 2021/0223(COD)/14.07.2021 of the European Parliament and of the Council on the deployment of alternative fuels infrastructure and repealing Directive 2014/94/EU, it is stipulated that specific targets for SSE supply in European maritime ports should be met and more requirements for the port services related to shore side electricity supply for vessels calling at them are included. This article explicitly states that Member States shall ensure a minimum SSE supply for seagoing container and passenger ships is provided in maritime ports.

Therefore, Member States shall take the necessary measures to ensure that by 1st January 2030, TEN-T core and TEN-T comprehensive maritime ports whose average annual number of port calls over the last three years by sea-going container ships above 5,000 gross tonnes, are above 50, are going to have sufficient shore side power output to meet at least 90% of that demand, as it is stated in point (a) of the first paragraph of Article 9 of this revised AFID Regulation. Additionally, in point (b) of the first paragraph of Article 9, it is stipulated that TEN-T core and TEN-T comprehensive maritime ports whose average annual number of port calls over the last three years by seagoing Ro-Ro passenger ships and high-speed passenger craft above 5,000 gross tonnes, is above 40, are going to have sufficient shore side power output to satisfy at least 90% of that demand. Last but not least, in point (c) of the first paragraph of Article 9, it is stated that TEN-T core and TEN-T

comprehensive maritime ports whose average annual number of port calls over the last three years by passenger ships other than Ro-Ro passenger ships and high-speed passenger craft above 5,000 gross tonnes, is above 25, are going to have sufficient shore side power output to meet at least 90% of that demand.

In addition to this, it should be noted that specific port calls that are included in the second paragraph of Article 9 shall not be taken into account for the determination of the number of port calls. In particular, port calls that are at berth for less than two hours, calculated on the hour of departure and arrival monitored per Article 14 of the proposal for Regulation COM(2021)562, are not included in the context of this Regulation. Moreover, port calls by ships that use zero-emission technologies, as specified in Annex III of the proposal for Regulation COM(2021)562 as well as unscheduled port calls for reasons of safety of saving life at sea, are not also included in the average number of port calls over the last three years related to the obligation of the TEN-T core and TEN-T comprehensive maritime ports for adequate shore side electricity services.

In the third paragraph of Article 9, it is clearly stated that where the maritime ports of the TEN-T core network and the TEN-T comprehensive network is located on an island which is not connected directly to the electricity grid, the measures of paragraph 1 of the article shall not apply, until such a connection has been completed or there is a sufficient locally generated capacity from clean energy sources. Therefore, until these prerequisites will be achieved, both TEN-T core and comprehensive maritime ports that are located on islands are not obliged to provide a minimum SSE supply for seagoing container and passenger ships in order to cover the future demand based on the average annual number of port calls over the last three years by seagoing container ships, Ro-Ro passenger ship, high-speed passenger craft and other passenger ships above 5,000 gross tonnes.

In addition, the forthcoming Carbon Intensity Indicator (CII) will indirectly contribute to adopting SSE infrastructures. Indeed, the CII is a rating system for ships that the IMO developed. This will be a mandatory measure under MARPOL Annex VI, which will come into force in 2023. The measure will impact all cargo, RoPax and cruise vessels above 5,000 gross tonnage (GT) and trading internationally. The CII determines the annual reduction factor needed to continuously improve the ship's operational carbon intensity within a specific rating level. The actual annual operational CII achieved will need to be documented and verified against the required annual operational CII.

This will then enable the operational carbon intensity rating to be determined on a scale of A, B, C, D or E, indicating a major superior, minor superior, moderate, minor inferior, or inferior performance level. The performance level will need to be recorded in the ship's Ship Energy Efficiency Management Plan (SEEMP). A ship rated D or E for three consecutive years will need to submit a corrective action plan to show how the required index rating (C or above) will be obtained.

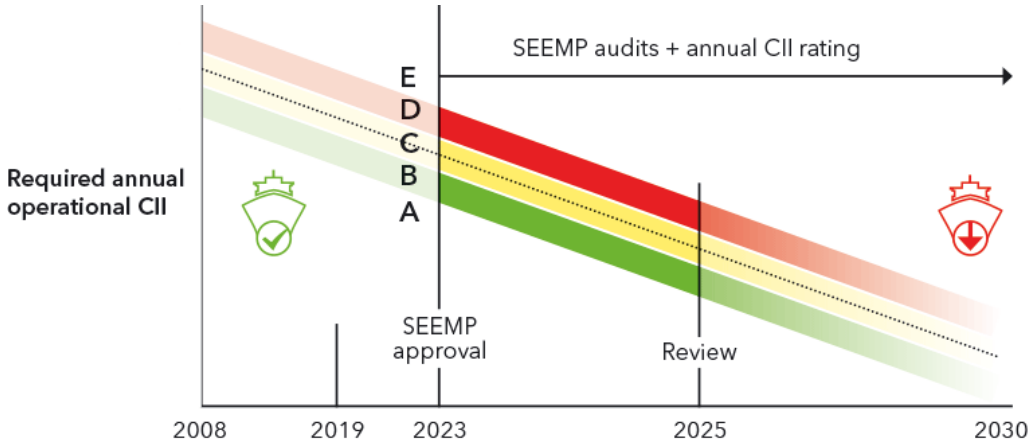

Figure 1: CII rating infographic (Source: www.dnv.com / CII – Carbon Intensity Indicator)

In the context of the forthcoming regulations related directly or indirectly to shipside installations for SSE for vessels operating in the participating TEN-T core and the comprehensive maritime ports of EALING Action are considered the national policy frameworks related to the development of Shore Side Electricity. As it is stated in paragraph 1 of Article 13 of the revised Alternative Fuel Infrastructure Directive, each Member State shall prepare and send to the Commission a draft national policy framework for the development of the market as regards alternative fuels in the transport sector and the deployment of the relevant infrastructure, which shall contain at least according to point (m) a deployment plan for alternative fuels infrastructure in maritime ports, in particular for electricity and hydrogen, for port services as defined in Regulation (EU) 2017/352 of the European Parliament and of the Council. In paragraph 4 of the Article 13, it is stipulated that Member States shall cooperate on the strategies to use alternative fuels such as shore side electricity and deployment of corresponding infrastructure such as SSE facilities and substations development in waterborne transport and the Commission will assist their cooperation process.

3 TECHNICAL & OPERATIONAL GUIDELINES/ STANDARDS – SHIPSIDE INSTALLATION AND REQUIREMENTS

3.1 Breakdown of the Existing Technical and Operational Guidelines/Standards related to Shore Side Electricity

This section gathers the main up-to-date references found regarding technical and operational guidelines and/or standards related to shore side electricity, with a focus on the ship's side, i.e., related to the ship. The references have been grouped into four categories:

1. Standards
2. European & International entities guidelines
3. Classification societies
4. Connection procedures at ports with SSE in operation

3.1.1 Standards

3.1.1.1 IEC/ISO/IEEE 80005

The reference standard regarding On Shore Power Supply (SSE), also called 'cold ironing' or AMP (Alternate Marine Power), is the IEC/ISO/IEEE 80005, Parts 1, 2 and 3. The standard was developed in close cooperation with the three associations, IEC, ISO and IEEE. Part 1 describes the general requirements for High Voltage Shore Connection (HVSC) systems. This part of the standard defines a high voltage system as an installation with a voltage above 1,000 Vac. The last version published of this standard is 2.0, dated March 2019. Part 2 describes the data communication interfaces and the procedures for establishing communication between the ship and shore. This standard is the 1.0 Edition, published in June 2016. Part 3 describes the general requirements for low voltage shore connection systems. The last version is not currently a standard, but a PAS (Publicly Available Specification, or pre-standard).

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IEC/ISO/IEEE 80005-1, High Voltage shore side electricity

Status	Published
Publication date	March 2019
Edition	2nd
Technical Committee	ISO/TC 8/SC 3. Piping and machinery
ICS (International Classification for Standards)	47.020.60 Electrical equipment of ships and of marine structures

The international standard ISO/IEC/IEEE 80005-1:2019 Utility connections in port – Part 1: High Voltage Shore Connection (HVSC) / Systems – General requirements (a more detailed successor of the withdrawn IEC/IEEE 80005-1:2012 standard) was published in March 2019 and addresses the connection between ship and shore, the procedures for safe operation and constitutes a technical revision of its predecessor.

This standard reviews "IEC/PAS 60092-510:2009 Electrical installations in ships – Special features – High Voltage Shore Connection Systems (HVSC-Systems)" and the above-mentioned first international standard.

IEC/ISO/IEEE 80005-1:2019 describes high voltage shore connection (HVSC) systems, onboard the ship and on shore to supply the ship with electrical power from shore. This standard is applicable to the design, installation and testing of HVSC systems and addresses:

- HV shore distribution systems.
- Shore-to-ship connection and interface equipment.
- Transformers/reactors.
- Semiconductor/rotating convertors.
- Ship distribution systems.
- Control, monitoring, interlocking and power management systems.

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

In February 2022, a first amendment was added to this standard. A second amendment is under development by the date of submitting this deliverable.

Regarding the **ship side**, the standard addresses specifically the following issues that directly affect the electrical system configuration at the ship:

- The equipotential bonding between the ship's hull and the shore earthing system.

- The "ship's commissioning", or first call compatibility assessment before connection. This assessment shall be performed to verify the possibility of connecting the ship to a shore HV supply.
- Short-circuit current and compatibility with the shore.
- Operating voltages, phase rotation and frequencies.
- Ship-to-shore connection cables arrangement.
- Protection devices and circuit breakers.
- Connectors and connection/disconnection sequence.
- Onboard transformer, when required.
- Onboard switchboard connection point.
- Ship power restoration upon failure or disconnection.
- Load transfer means.
- Data communication between ship and shore, if any (also addressed in detail in 80005 - Part 2).

IEC/ISO/IEEE 80005-2, Communication Protocol

Status	Under review
Publication date	2016-06
Edition	1st
Technical Committee	ISO/TC 8/SC 3 Piping and machinery
ICS	47.020.60 Electrical equipment of ships and of marine structures

IEC/IEEE 80005-2:2016 Utility connections in port – Part 2: High and low voltage shore connection systems – Data communication for monitoring and control describes the data interfaces between shore and ships as well as step-by-step procedures for low and high voltage shore connection systems communication for non-emergency functions, where required. This standard specifies the interface descriptions and addresses the data type. In annex A this standard also specifies communication requirements on **cruise ships**. Application of this standard relates to annexes of IEC/ISO/IEEE 80005- 1.

This standard does not specify communication for emergency functions as described in IEC/ISO/IEEE 80005-1.

IEC/IEEE DIS 80005-3, Low Voltage shore side (typically less than 1 MVA)

Status	Under development
Publication date	-
Edition	1st
Technical Committee	ISO/TC 8/SC 3. Piping and machinery
ICS	47.020.60 Electrical equipment of ships and of marine structures

IEC/IEEE DIS 80005-3 Utility connections in port – Part 3: Low Voltage Shore Connection (LVSC) Systems – General requirements are being prepared and constitute a new version of IEC PAS 80005-3:2014. It is envisaged that it will be ratified by the end of 2023. The PAS (Publicly Available Specifications) document describes low voltage shore connection (LVSC) systems, on board the ship and on shore, to supply the ship with electrical power from shore. It is applicable to the design, installation and testing of LVSC and addresses:

- LV shore distribution systems.
- Shore-to-ship connection and interface equipment.
- Transformers/reactors.
- Semiconductor/rotating convertors.
- Ship distribution systems.
- Control, monitoring, interlocking and power management systems.

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

Regarding the **ship side**, the standard addresses very similar topics to Part 1, that directly affect the electrical system configuration at the ship:

- The equipotential bonding between the ship's hull and the shore earthing system.
- The "ship's commissioning", or first call compatibility assessment before connection. This assessment shall be performed to verify the possibility of connecting the ship to a shore HV supply.
- Short-circuit current and compatibility with the shore.
- Protection devices and circuit breakers.
- Operating voltages, phase rotation and frequencies.
- Ship-to-shore connection cables arrangement.
- Connectors and connection/disconnection sequence.

- Onboard transformer, when required.
- Onboard switchboard connection point.
- Ship power restoration upon failure or disconnection.
- Load transfer means.

3.1.1.2 IEC 60092, Electrical installations in ships

The standard, referenced inside the IEC/ISO/IEEE 80005, Parts 1 and 3, addresses electrical installations in ships. The following parts are referenced:

- IEC 60092-101, Electrical installations in ships - Part 101: Definitions and general requirements.
- IEC 60092-201, Electrical installations in ships - Part 201: System design – General.
- IEC 60092-301, Electrical installations in ships - Part 301: Equipment - Generators and motors.
- IEC 60092-401, Electrical installations in ships - Part 401: Installation and test of the completed installation.
- IEC 60092-502, Electrical installations in ships - Part 502: Tankers - Special features.
- IEC 60092-503, Electrical installations in ships - Part 503: Special features - AC supply systems with voltages in the range of above 1 kV up to and including 15 kV.
- IEC 60092-504, Electrical installations in ships - Part 504: Automation, control and instrumentation.

IEC 60092-101 Electrical installations in ships - Part 101: Definitions and general requirements

Status	Published (to be reviewed in 2022)
Publication date	2018-10
Edition	5.0
Technical Committee	IEC TC 18 - Electrical installations of ships and of mobile and fixed offshore units
ICS	01.040.47 - Shipbuilding and marine structures (Vocabularies) 47.020.60 - Electrical equipment of ships and marine structures

The 60092 series form a code of practical interpretation and amplification of the requirements of the International Convention for the Safety of Life at Sea, a guide for future regulations which may be prepared and a statement of practice for use by ship-owners, shipbuilders and appropriate organizations.

This fifth edition cancels and replaces the fourth edition published in 1994 and Amendment 1:1995 and constitutes a technical revision. It includes the following significant technical changes concerning the previous edition:

- The applicability of the standard has been changed to 1,000 V AC and 1,500 V DC
- The table for design temperature has been simplified
- The clause regarding power supply system characteristics has been rewritten
- Information regarding pollution degree has been added in the clause regarding clearance and creepage distances
- A clause regarding environmental impact has been added
- The clause regarding the classification test for materials has been deleted
- The annex regarding the flame-retardant test for cables has been deleted
- The annex regarding the test on bunched wires or cables under fire conditions has been deleted

3.1.1.3 IEC 61363-1, Electrical installations of ships and mobile and fixed offshore units

This standard is referenced inside IEC/ISO/IEEE 80005, Parts 1 and 3. Its Part 1 is titled "Procedures for calculating short-circuit currents in three-phase a.c.". A correct rating of the short-circuit current on board is critical for the operation and safety of the installation on shore.

3.1.1.4 IEC 62613, Plugs, socket-outlets and ship couplers for high-voltage shore connection systems (HVSC-Systems)

Parts 1 and 2 of this standard are referenced inside IEC/ISO/IEEE Part 1. These Parts are the following:

- IEC 62613-1, Plugs, socket-outlets and ship couplers for high-voltage shore connection systems (HVSC-Systems) - Part 1: General requirements
- IEC 62613-2, Plugs, socket-outlets and ship couplers for high-voltage shore connection systems (HVSC-Systems) - Part 2: Dimensional compatibility and interchangeability requirements for accessories to be used by various types of ships

3.1.2 European & International Entities' Guidelines

3.1.2.1 IMO

IMO SSE Guidelines – Interim Guidelines on Safe Operation of Onshore Power Supply (SSE) Service in Port for Ships engaged on international voyages

IMO is addressing the need for global standards for providing shoreside electrical power to a ship at berth while its main and auxiliary engines are turned off. In its 8th session (28 February – 4 March 2022), the IMO Sub-Committee on Ship Systems and Equipment (SSE) reviewed submissions related to the development of draft interim guidelines on the safe operation of onshore power supply service in port for ships engaged in international voyages. Those draft guidelines were finalized in SSE 7 (March 2020, no meeting in 2021). It invited relevant submissions to SSE 9 in 2023 with a view to finalization of the draft guidelines at that session.

3.1.2.2 IEEE - Institute of Electrical and Electronics Engineers

Besides collaborating in the development of standard 80005, the IEEE has an active role worldwide in working towards innovating, educating and standardizing the electrical and electronic development industry. It is best known for its development of standards such as IEEE 802.11. Other guides and standards related to the ships' electrical systems are the following:

- 1662-2008 - IEEE Guide for the Design and Application of Power Electronics in Electrical Power Systems on Ships. Published in 2009, this guide applies to power electronics components and systems on ships and similar applications. It summarizes current electrical engineering methods and practices for applying power electronics in electrical power systems on ships and describes analytical methods, preferred parameters, and performance characteristics from a common frame of reference for reliable integrated marine electrical power systems.
- IEEE 45.4-2018: IEEE Recommended Practice for Electrical Installations on Shipboard. It includes the following active standards, as described on its website:
    - 45.1-2017: IEEE Recommended Practice for Electrical Installations on Shipboard -- Design. Recommendations for the design of electrical power generation, distribution, propulsion, loads systems, and equipment on the merchant, commercial, and naval vessels.
    - 45.3-2015: IEEE Recommended Practice for Shipboard Electrical Installations -- Systems Engineering. Recommendations for systems engineering, design, and integration of electrical power systems at the total ship level from concept design through establishing the design baseline prior to detailed design.
    - 45.5-2014: IEEE Recommended Practice for Electrical Installations on Shipboard -- Safety Considerations. This recommended practice covers electrical safety considerations for shipboard electrical systems and equipment, including a review of fundamental concepts

pertaining to electrical safety and establishing electrical safety programs and work practices associated with the operation and maintenance of shipboard electrical power distribution systems.

- 45.6-2016: IEEE Recommended Practice for Electrical Installations on Shipboard --Electrical Testing. A consensus of recommended practices for system testing in marine electrical engineering applied specifically to vessels, shipboard systems, and equipment is provided.
- 45.7-2012: IEEE Recommended Practice for Electrical Installations on Shipboard -- AC Switchboards. Recommendations are provided for the design, selection, and installation of switchboards on merchant vessels with electrical apparatus for lighting, signaling, communication, power, and propulsion.
- 45.8-2016: IEEE Recommended Practice for Electrical Installations on Shipboard--Cable Systems. Recommendations are provided for the selection, application, and installation of electrical power, signal, control, data, and speciality marine cable systems on the shipboard.

3.1.2.3 EMSA

The European Maritime Safety Agency (EMSA) published its "Guidance on Shore side Electricity (SSE) for Port Authorities and Administrations" in July 2022. The guide covers shore side electricity supply infrastructure with a focus on SSE, but it also includes Shore side Battery Charging (SBC), i.e., on-shore infrastructure to charge batteries onboard a ship, and Shore side Power Banks (SPB), i.e., the deployment of battery banks along the SSE infrastructure.

The guide is divided into two main documents: Part 1 on Equipment and Technology and Part 2 on Planning, Operations and Safety.

3.1.2.4 CENELEC

The European Electrotechnical Committee for Standardization (CENELEC) is one of three European Standardization Organizations (together with CEN and ETSI) that have been officially recognized by the European Union and by the European Free Trade Association (EFTA) as being responsible for developing and defining voluntary standards at European level.

CENELEC published in 2015 the Harmonization Document (HD) 60364-7-730:2016, titled "Low-voltage electrical installations - Part 7-730: Requirements for special installations or locations - Onshore units of electrical shore connections for inland navigation vessels. "Although not specifically addressed for seagoing vessels, it might be relevant for this analysis, regarding SSE at low voltage levels. For instance, an article in 2017 from the Institution of Engineering and Technology (IET) indicates that the HD "recognises that there is an additional risk of electrolytic

corrosion resulting from circulating galvanic currents in the protective conductor from the shore supply to a vessel"[1].

3.1.2.5 IET

The IET (Institution of Engineering and Technology) co-publishes BS 7671 Wiring Regulations with the BSI (British Standards Institution) and has expert knowledge and experience in producing high-level Codes of Practice and guidance. The IET Wiring Regulations is currently in its 18th Edition. BS 7671:2018+A2:2022 was published in March 2022 and came into effect on 28 March 2022.

Regarding ship electrical systems, the IET and BSI jointly publish BS 8450:2006 Code of Practice for Installation of Electrical and Electronic Equipment in Ships, and the IET provides the secretariat for the national committee JPEL/18 (electrical installations of ships and mobile and fixed offshore units). This Code of Practice is, according to the definition given by the IET, "written for those involved in the design, installation and maintenance of electrical equipment for the generation, storage, conversion, distribution and utilisation of electrical energy for all purposes in ships of all descriptions (excluding warships)."

It is also interesting to mention the Code of Practice: Cyber Security for Ships, published by the IET in 2017. The document, available free of charge, provides, in its own words, "actionable good practice advice" on areas such as:

- Developing a Cyber Security Assessment and Plan
- Devising the most appropriate mitigation measures
- Having the correct structures, roles, responsibilities and processes in place
- Handling security breaches and incidents
- Highlighting the key national and international standards and regulations that must be reviewed and followed."

Cybersecurity is key for the integrity of the shore connection system, not only onboard. Given that a communication link is established with the shore, there is a potential risk of cyber intrusion or attack, that, by gaining access to the ship SCADA, may take remote control of the electrical systems onboard.

[1] https://electrical.theiet.org/wiring-matters/years/2017/64-march-2017/section-730-onshore-units-of-electrical-shore-connections-for-inland-navigation-vessels/

3.1.3 Classification Societies

A ship classification society is a non-governmental organization that establishes and maintains technical standards for the construction and operation of ships and offshore structures. Classification societies certify that the construction of a vessel complies with relevant standards and carry out regular surveys in service to ensure continuing compliance with the standards. Classification societies may act as Recognized Organizations (RO) on behalf of Flag Administrations. Currently, more than 50 organizations describe their activities as including marine classification, eleven of which are members of the **International Association of Classification Society (IACS).**

Dedicated to safe ships and clean seas, IACS makes a unique contribution to maritime safety and regulation through technical support, compliance verification and research and development. More than 90 % of the world's cargo-carrying tonnage is covered by the classification design, construction and through-life compliance rules and standards set by the eleven Member Societies of IACS.

IACS is a not-for-profit membership organization of classification societies that establishes minimum technical standards and requirements that address maritime safety and environmental protection and ensures consistent application. It carries out this responsibility through its panels, expert groups and project teams and provides a Quality System Certification Scheme (QSCS) that its Members comply with, as an assurance of professional integrity and maintenance of high professional standards, IACS is recognized as the principal technical advisor of IMO, and it in fact provides feedback on the interim guidelines on the safe operation of Shore Side Electricity service in port for ships engaged on international voyages, being prepared by IMO.

The eleven classification societies that belong to IACS are the following: ABS, Bureau Veritas, CCS, CRS, DNV, IR CLASS, KR, Lloyd's Register, ClassNK, PRS and RINA. Out of the eleven IACS members, the following five and their guidelines were referred to in the EALING Activity 2 questionnaire:

Table 1: List of Classification Societies' documentation related to SSE

Guidelines	Classification Society	link
High Voltage Shore Connection	American Bureau of Shipping (ABS)	https://ww2.eagle.org/content/dam/eagle/rules-and-guides/current/conventional_ocean_service/182_highvoltage_2021/hvsc-guide-july21.pdf

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High-Voltage Shore Connection System	Bureau Veritas (BV)	https://erules.veristar.com/dy/data/bv/pdf/557-NR_2010-01.pdf
Guidelines for High-Voltage Shore Connection System	Nippon Kaiji Kyokai (ClassNK)	https://www.classnk.or.jp/account/en/Rules_Guidance/ssl/guidelines.aspx
Electrical Shore Connections – Shore Power	Det Norske Veritas (DNV)	https://rules.dnv.com/docs/pdf/DNV/RU-SHIP/2021-07/DNV-RU-SHIP-Pt6Ch7.pdf
Lloyd's Register Rules and Regulations for the Classification of Ships	Lloyd's Register	https://www.lr.org/en/rules-and-regulations-for-the-classification-of-ships/

It is also worth mentioning the works done by RINA related to SSE, such as adding an additional HVSC class notation for the **Rules for the Classification of Ships**.

The IACS also publishes the Unified Requirements, or "adopted resolutions on matters directly connected to or covered by specific Rule requirements and practices of classification societies and the general philosophy on which the rules and practices of classification societies are established." One of these Unified Requirements is **UR E: Electrical and electronic installations**, which includes, among other, UR E11 (Unified Requirements for systems with voltages above 1 kV up to 15 kV), UR E24 (Harmonic Distortion for Ship Electrical Distribution Systems including Harmonic Filters), UR E26 (Cyber resilience of ships) and UR E27 (Cyber resilience of on-board systems and equipment).

3.1.4 Connection Protocols at Ports

This section is intended to be informative. The following is a description, by way of example of operation, of the SSE connection and disconnection procedures currently practised at the Port of Los Angeles, information on which is available to the public.

The Port of Los Angeles (POLA) deployed the first high voltage SSE facilities for container vessels at Berth 100 of the West Basin Container Terminal in 2004. The number of installations has been growing since, with the objective of providing SSE to all its container terminals. In 2020, the port reached 79 SSE vaults. The Port was an active participant in the development of the IEC/ISO/IEEE 80005-1 international standard, and all its shoreside installations currently meet the standard

requirements. POLA's web site publishes a number of documents for vessels willing to connect to SSE at the port, describing the process to be followed. These documents are the following:

- A document with general guidelines. It states that the process will be coordinated between a Person In Charge (PIC) at the port and a PIC at the ship. The service is described as a "HVSC Power Transfer Conference'' between the two PICs. A form is facilitated that has to be reviewed and signed by the two of them. It also gives general requirements on voltage and frequency levels and other electrical parameters and informs about the electricity rate and how it will be charged. It also indicates how to order an HVSC service. It is requested by e-mail, 72 hours prior to the ship's arrival.
- The e-mail scheduling request is a form that has to be e-mailed by the ship, indicating the IMO of the vessel, berth and terminal, and the date and time of connection and disconnection. The ship also has to answer two questions: whether it has previously connected to an SSE facility at POLA or not, and whether it has connected successfully to an SSE facility within the last 12 months. If the answer to this last question is no, the ship will need an additional POLA shore safety verification, estimated in 1 hour of duration.
- The system safety verification is a checklist to be completed for those cases of ships that have not connected successfully to an SSE facility within the last 12 months. It includes some tests such as insulation resistance of the cables and a visual inspection, and has to be signed by both PICs.
- The pre-power transfer conference is another checklist document used to verify that the system onboard is ready for an HVSC connection to the POLA SSE facilities. It must be signed by both PICs, ship and port.
- The HVSC connection procedure describes the steps to be followed by all the personnel involved, either onboard and on shore, to perform the SSE connection. It starts with a safety check of the electrical system at the terminal, and the review and signature of all the previous documents. Following, the ship PIC will, in the case of container ships, lower the cables to the connection pit and proceed to connection. The POLA PIC will monitor the connection; however, it is the ship's PIC (or designee) one in charge of plugging. Once the cables are connected, the ship's PIC provides the Kirk keys to the POLA PIC and removes the lock from the ground switch. The POLA PIC will then proceed with the sequence to verify the connections on shore and close the breaker at the substation to supply power to the ship.
- The HVSC disconnection procedure starts at the ship, with the ship's PIC opening the shore breaker remotely; then, the POLA PIC will start the process to de-energize the SSE substation. Finally, the ship's PIC disconnects the cables from the plug at the shore.

3.2 Analysis of the Existing Technical and Operational Guidelines/Standards related to Shore Side Electricity

This section analyzes the technical and operational guidelines and/or standards previously identified in Section 3.1, focusing on the ship's side. Only relevant technical and operational guidelines and/or standards will be deeper analyzed in this Section.

1. Standards
2. European & International entities' guidelines
3. Classification societies

3.2.1 Standards

3.2.1.1 IEC/ISO/IEEE 80005-1, High voltage shore connection (HVSC) systems – General requirements

(Note: As stated in Section 3.1, the reference standard regarding the SSE is the IEC/ISO/IEEE 80005, Parts 1, 2, and 3. Since Part 3 is not currently a standard, it will not be analyzed in this section.)

The international standard ISO/IEC/IEEE 80005-1:2019 Utility connections in port – Part 1: High Voltage Shore Connection (HVSC) / Systems – General requirements address the ship equipment' requirements to perform the connection between the ship and the shore at its Section 8.

The section contains the following subsections:

- Ship electrical distribution system protection: within this sub-section, the requirements regarding short-circuit protection, earth fault protection, monitoring, and alarm are addressed.
- Shore connection switchboard: the shore connection switchboard shall include a circuit-breaker to protect the ship's electrical equipment downstream and shall be located asclose as possible to the receiving point. Moreover, it shall be designed in accordance with the IEC 62271-200, service continuity LSC1 (see figure 1).
- Onboard transformer: within this subsection, the requirements regarding the onboard transformer design are provided (if required).
- Onboard receiving switchboard connection point: the onboard receiving switchboard connection point is normally a part of the main switchboard. In this subsection the following topics are analyzed:

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- Circuit-breaker short-circuit breaking capacity (in accordance with IEC 61363-1) and earthing switch making capacity
- Instrumentation to be required
- Protections to be required
- Operations of the circuit-breaker

- Ship power restoration: it describes the procedure to be followed in order to restore the main source of electrical power in case of the connected HVSC supply failure.

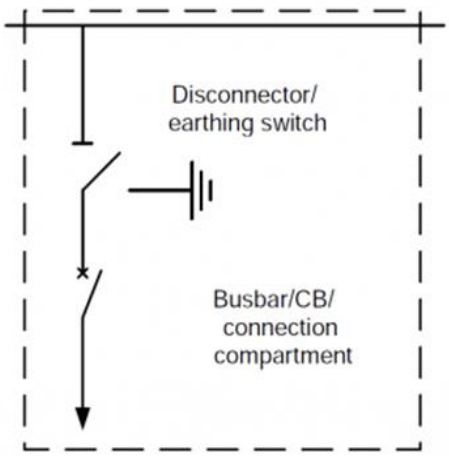

Figure 2: Loss of Service Continuity LSC1 functional diagram. Each of these sub-sections provide the technical prescriptions and requirements in order to ensure the correct connection between the ship and the shore in a safe condition (Source: https://global.abb/group/en)

In addition, Annexes B-F provide additional requirement for different types of ships as follows:

- Annex B: Additional requirements for Roll-on Roll-off (Ro-Ro) cargo ships and Ro-Ro passenger ships.
- Annex C: Additional requirements for cruise ships.
- Annex D: Additional requirements for container ships.
- Annex E: Additional requirements of liquefied natural gas carriers (LNGC).
- Annex F: Additional requirements for tankers.

3.2.1.2 IEC/ISO/IEEE 80005-2, Communication Protocol

The international standard IEC/IEEE 80005-2:2016 Utility connections in port – Part 2: High and low voltage shore connection systems – Data communication for monitoring and control describes the data interfaces between shore and ships as well as step-by-step procedures for low and high voltage shore connection systems communication for non-emergency functions, where required.

The standard defines the physical layer, the communication protocol and the IP-address to be used during the connection between the ship and the shore.

Moreover, Sections 5 to 8 deal with the following topics:

- Section 5 provides the shore interface data packet description
- Section 6 focuses on the ship interface data packet description. This section defines the data packet structure to be provided to the shore by the ship interface. The ship information and status are mapped in different registers where each bit has a specific meaning as follows:
    - Register 0: Version number in order to check the compatibility of the ship side
    - Register 1: Ship communication fault detection register
    - Register 2: The basic operation modes indicate in which procedure and state the ship side is actually working. Only one mode out of the basic modes may be active at the same time
    - Register 3: The synchronization operation mode indicates for which type of synchronization the ship side is prepared according to its choice. Only one mode out of the synchronization modes may be active at the same time
    - Register 5: Ship Alarm Circuit Breaker Protection
    - Register 9: The information block status of switches shows the state of all involved circuit breakers, earthing and auxiliary switches
    - Register 10: Ship commands are used to send requests to the shore side
    - Register 12: General Ship status and diagnostic data block includes summary signals and overall signals for the complete system
    - Register 14: The following data block includes signals for the sub-procedure choice droop values
    - Register 16: The following data block includes signals for the sub procedure Start of Power
    - Register 17: The following data block includes signals for the shore indicating which work step is actually active within the cable test procedure
    - Register 18: This data block includes signals for the sub procedure Synchronization, the Procedure Stop, and for additional status and diagnostic
    - Registers 20-24: This data block includes the characteristic values from the ship, which are required for the start up procedure
    - Registers 26-27: This data block includes information for a static frequency converter to adapt frequency and voltage droop
    - Registers 32-105: The ship start-up data are available for logging and identifying the ship
- Section 7 describes in detail the start-up procedure to follow in order to synchronize the ship network to the shore one. The start-up procedure is to initialize the power connection to the ship. General, technical and safety information are exchanged during this procedure. The procedure shall be executed sequentially and shall be stopped and restarted if the transfer time limit is exceeded or a safety shut-down is activated. In this section, the data flow is illustrated

as follows:

- Initialize the start-up procedure in order to assess all the preliminary conditions to be fulfilled.
- Choice droop values.
- Choice power and synchronize mode.
- Start of power.
- Optional cable test.
- Synchronizing.

- Section 8, finally, deals with the stop procedure to disconnect the ship network to the shore one. Anytime the ship may initialize a controlled shutdown of the Shore Side Electricity. To initialize the stop procedure, the ship shall send the **Ship Co Stop Shore Power** command.

3.2.1.3 IEC 60092, Electrical installations in ships

As mentioned in the previous section, this series of standards addresses electrical installations in ships. The following parts are referenced:

- IEC 60092-101, Electrical installations in ships - Part 101: Definitions and general requirements.
- IEC 60092-201, Electrical installations in ships - Part 201: System design – General.
- IEC 60092-301, Electrical installations in ships - Part 301: Equipment - Generators and motors.
- IEC 60092-401, Electrical installations in ships - Part 401: Installation and test of the completed installation.
- IEC 60092-502, Electrical installations in ships - Part 502: Tankers - Special features..
- IEC 60092-503, Electrical installations in ships - Part 503: Special features - AC supply systems with voltages in the range of above 1 kV up to and including 15 kV.
- IEC 60092-504, Electrical installations in ships - Part 504: Automation, control and instrumentation.

Only the IEC 60092-201, Electrical installations in ships - Part 201: System design - General addresses shore connection requirements in section 9.8. In detail, section 9.8.1 deals with the shore connection during docking, while section 9.8.2 is referred to the shore connection during port stay.

3.2.1.4 Shore connections during docking

Consideration should be given to the voltage and the frequency of the shore supplies, which might be connected to the voltage and the frequency for the ship's system and to the effect that a different voltage and/or frequency may have on the performance of electrical equipment.

Table 2 gives the maximum voltages allowed and the recommended values of nominal voltages and frequencies for the ship's service systems of supply.

Table 2: AC voltages and frequencies for ship's service systems of supply (IEEC 60092-201)

Application	Nominal voltages V	Nominal frequencies HZ		Maximum voltage V
1 Power, heating and cooking equipment securely fixed and permanently connected.	Three-phase	Three-phase	Three-phase	Three-phase
	115		60	1 000
Socket-outlet supplying equipment, which is earthed either permanently by its fixing or by a specific connection which incorporates an earth-continuity conductor of a size in accordance with IEC 60092-401:	230	50	60	1 000
	400	50	-	1 000
	440	-	60	1 000
	690[a]	50	60	1 000
	3 000[a]/3 300[a]	50	60	15 000
	6 000[a]/6 600[a]	50	60	15 000
	10 000[a]/11 000[a]	50	60	
	24 kV[b]	50	60	
	36 kV[b]	50	60	
	Single-phase	Single-phase	Single-phase	Single-phase
	115	-	60	500
	230	50	60	500
2 Fixed lighting including outlets for purposes not mentioned in items 1 and 3 but intended for apparatus with reinforced or double insulation or connected by a flexible cord or cable incorporating an earth-continuity conductor of a size in accordance with IEC 60092-401	Single-phase	Single-phase	Single-phase	Single-phase
	115	-	60	250
	230	50	60	250
3 Socket-outlets for use where extra precautions against shock are necessary:	Single-phase	Single-phase	Single-phase	Single-phase
	24	50	60	55
supplied with or without the use of isolating transformers	115	-	60	250
	230	50	60	250
where a safety isolating-transformer is used supplying one consuming device only				
Both wires of such systems should be insulated from earth.				
4 Instrumentation and control	Single-phase	Single-phase	Single-phase	Single-phase
	24	50	60	55
	48	50	60	55
	115	-	60	250
	230	50	60	250

NOTE 1 For limited distribution in excess of 1 000 V, see IEC 60092-503.

NOTE 2 For tankers, see also IEC 60092-502.

[a] For power only.

[b] Implementing 24 kV and 36 kV in IEC 60092-503 is under consideration.

Where arrangements are made for the supply of electricity from a source on shore or elsewhere, a suitable termination point shall be installed on the ship for the convenient reception of the flexible cable from the external source. Fixed cables of adequate rating shall be provided between the termination point and the main or emergency switchboard.

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An earth terminal shall be provided for connecting the hull to appropriate earth. The risk of accelerated corrosion shall be considered.

The shore connection shall be provided with an indicator at the main or emergency switchboard in order to show when the cable is energized.

Means shall be provided for checking the polarity (for DC) or the phase sequence (for three-phase AC) of the incoming supply in relation to the ship's system.

At the connection box, a notice shall be provided giving full information on the system of supply and the nominal voltage (and frequency if AC), the short circuit capacity of the ship's electrical plant of the ship's system and the procedure for carrying out the connection.

Provision shall be made for attaching the trailing cables to the framework so that mechanical stress is not applied to the electrical terminals.

Any transformer used for shore connection shall be of the double-wound type.

3.2.1.5 Shore connections during the stay in port

Requirements for shore connections are given in IEC/ISO/IEEE 80005 (all parts).

3.2.2 European & International Entities' Guidelines

3.2.2.1 IEEE - Institute of Electrical and Electronics Engineers

Beyond the previous described 80005 standards, IEEE has not particular prescriptions for the ship-side SSE installation.

3.2.2.2 EMSA

The European Maritime Safety Agency (EMSA) published its "Guidance on Shore side Electricity (SSE) for Port Authorities and Administrations" in July, 2022. The guide is divided into two main documents: Part 1 on Equipment and Technology and Part 2 on Planning, Operations and Safety.

Even though the guide is mainly based on the IEC/ISO/IEEE 80005 standard, it is worth highlighting specific issues mentioned in it concerning the ship side. In Part 2 (Planning, Operations and Safety), the following can be found:

- The guide highlights the importance of knowing the transient responses at the ship, in terms of frequency and voltage.

- The **earthing system** used by the ship ensures an adequate equipotential bonding with the shore. As a function of the ship type, the earthing can be of high or low resistance, or unearthed. The **neutral earthing resistor** value is also critical for the SSE system design, and may vary as a function of the ship's type.
- The **Emergency Shutdown Systems** (ESD) for SSE on the ship's side, which are defined in the guide for each type of ship.
- The need to have a **Receiving Ship Operator** (RSO) on board the ship. responsible for the SSE connection from the ship side.
- The need to have access to good operational **demand profiles of the ships**, in order to properly size the SSE facility on the shore side. A **power demand estimate** of all the ships calling, including peak power values, is key for the assessment of the SSE facilities that need to be deployed.
- Once in operation, the guide indicates the need to implement accurate **demand forecast models** that allow an optimized energy and power management at port or terminal level.
- **Safety and security** issues on board the ship regarding the SSE system and the connection with shore, per type of ship.
- The challenges to **retrofit** existing types of vessels with SSE, specifically chemical and oil tankers, and LNG carriers.
- The connection and disconnection procedures, especially the **synchronization** process of SSE with the generators onboard.
- The **tests and verification procedures** (and subsequent **certifications**) that need to be done on the ship's SSE facility, classified in three different types:
    - Compatibility assessment before connection.
    - Integration tests.
    - Routine tests.

3.2.3 Classification societies

3.2.3.1 Det Norske Veritas (DNV)

DNV-RU-SHIP Pt.6 Ch.7 Sec.5 Electrical shore connections - Shore power (Jul, 2022)

Additional class notation Shore power provides requirements for the design of electrical shore connections, the ship side installation of necessary equipment and the verification of the installations.

The additional class notation Shore power applies to vessels utilizing electrical shore connections while in port and is mandatory for vessels with high voltage shore connections and low voltage shore connections with power ratings greater than or equal to 1 MVA. This is applicable for shore power supplying the distribution grid and/or charging electrical energy storage systems onboard the vessel.

The system design comprises the following aspects:

- system functionality of the electrical shore connection as a total system. In addition, requirements for circuit breakers, earthing switches and protective functions are given
- control systems and control system interface between the shore and the vessel. Requirements are given for necessary functionality. However, the physical installations on shore are not covered by these rules
- ship side electrical equipment and installations. However, only specific requirements related to electrical shore connections are given. Generally, equipment and installations shall comply with relevant parts of Pt.4 Ch.8.

Operational characteristics and requirements with respect to power availability during loading and unloading are not within the scope of these rules.

Shore side electrical equipment and installations, apart from the functional requirements to the installation, are governed by national regulations. The additional class notation Shore power is not intended for shore connections used during service and maintenance docking. The requirements for those shore connections are covered by Pt.4 Ch.8.

3.2.3.2 American Bureau of Shipping (ABS)

Guide for High Voltage Shore Connection (Jul, 2021)

A vessel with a high voltage shore connection installation found to comply with the requirements in the Guide will be assigned the classification notation HVSC.

A vessel that has been designed for future installation of a high voltage shore connection is eligible for the optional notation HVSC-Ready. The system and equipment do not need to be installed to be eligible for this notation.

In Section 7.3, the following prescriptions are provided regarding the grounding system. Indeed, arrangements are to be provided so that when the shore connection is established, the resulting system grounding onboard is to be compatible with the vessel's original electrical system grounding philosophy (for instance, the shipboard ungrounded power distribution system is to remain ungrounded, or the shipboard high impedance grounding system is to remain high impedance grounded within the design grounding impedance values). Ground fault detection and

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protection is to remain available after the shore connection has been established. Examples are shown in the figures below.

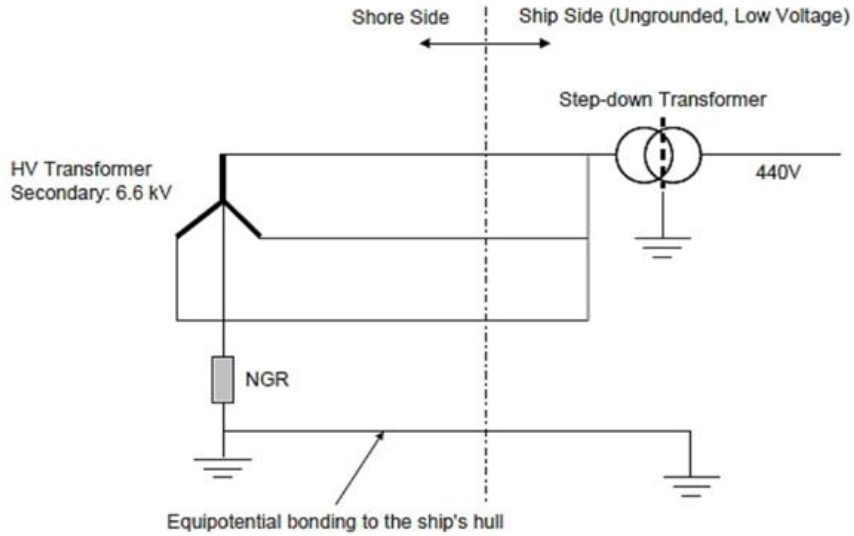

Figure 3: Example for Ungrounded LV Ship's System (Source: ABS - Guide for High Voltage Shore Connection)

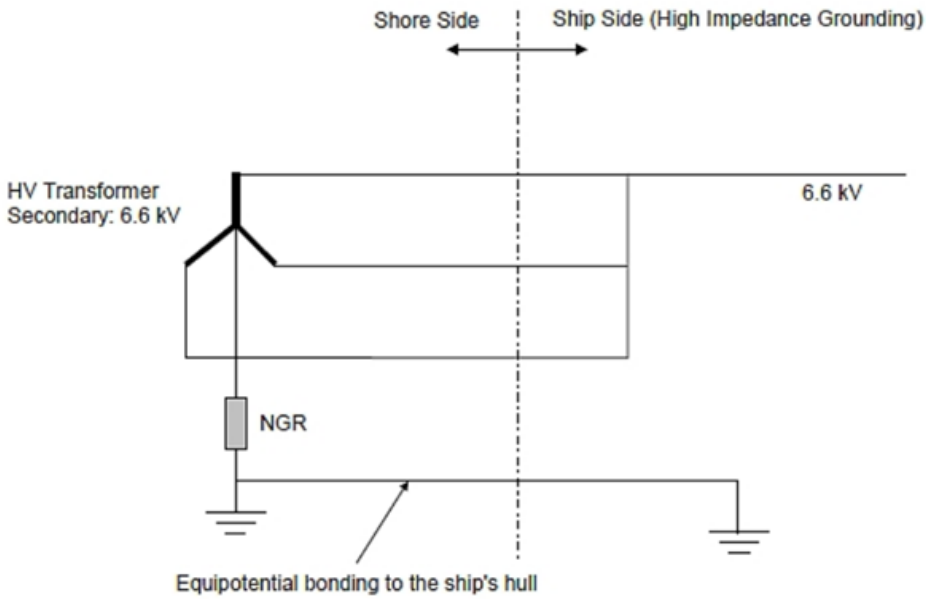

Figure 4: Example for Grounded HV Ship's System (where NGR Value is Compatible with the Ship's Design Ground Current Range, Otherwise 1:1 Isolation Transformer may be Required) (Source: ABS - Guide for High Voltage Shore Connection)

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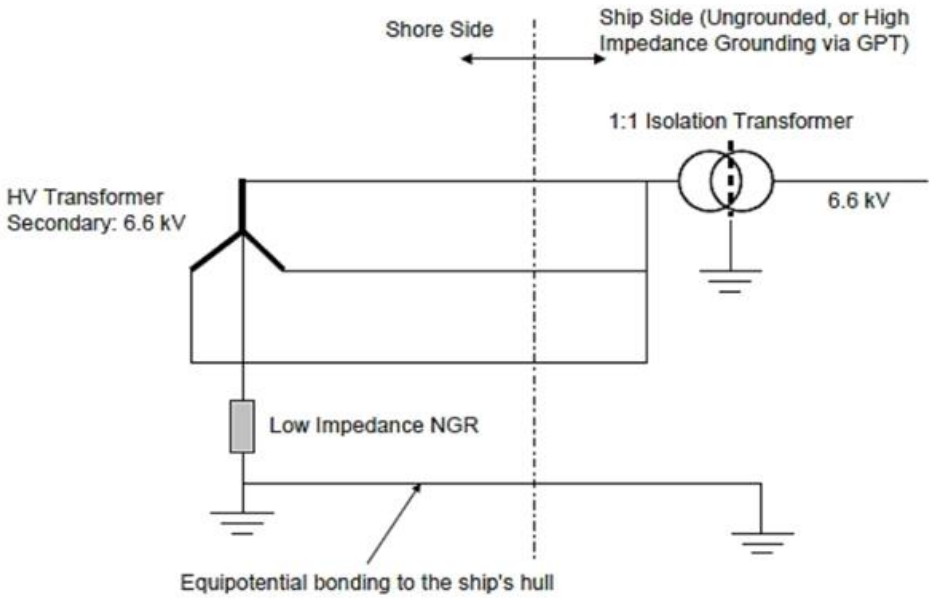

Figure 5: Example for Ungrounded Ship's System (e.g., Oil Carriers and Gas Carriers) (Source: ABS - Guide for High Voltage Shore Connection)

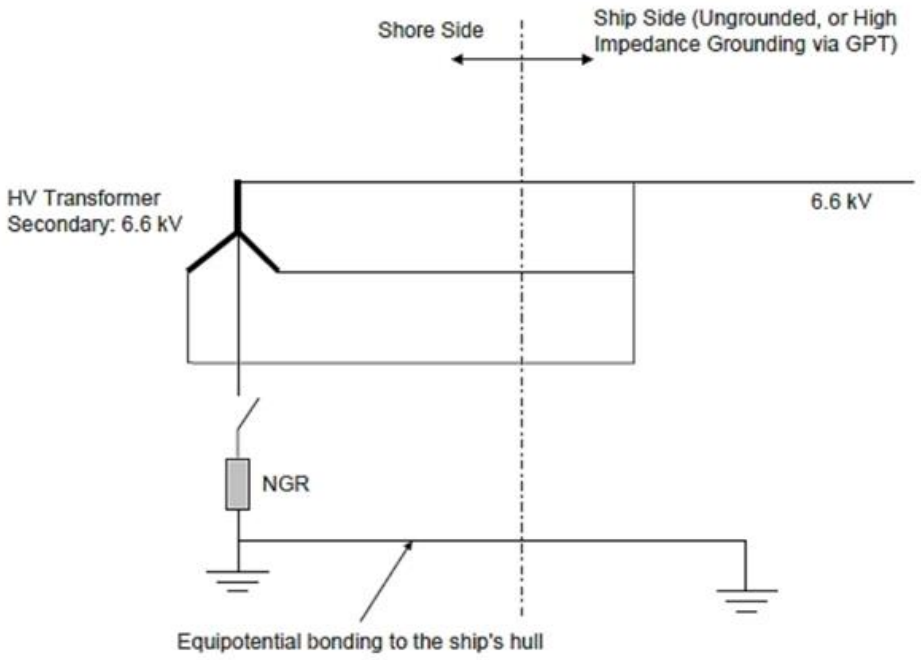

Figure 6: Example of Ungrounded Ship's System where Shoreside Option for Ungrounded Neutral is Available (e.g., Oil Carriers and Gas Carriers) (Source: ABS - Guide for High Voltage Shore Connection)

Electrical equipment is to be constructed of durable, flame-retardant, moisture-resistant materials, which are not subject to deterioration in the marine environment and at the temperatures to which it is likely to be exposed.

Section 8.6 contains a prescription for the design of the onboard receiving switchboard. Indeed, the HV onboard receiving switchboard is to be designed, manufactured and tested in accordance with a recognized standard such as IEC 62271-200.

Moreover, the receiving switchboard is to be equipped with the following:

- Voltmeter(s), all three phases, for the shore power and the shipboard power.
- Phase rotation indicator for the shore power.
- Frequency meter(s) for the shore power and the shipboard power.
- Ammeter for the shore power, all three phases.
- Synchronizing device, see 1/7.9.1.
- Short-circuit protection.
- Overcurrent protection.
- Earth-fault detection.

Thus, the circuit breaker has to fulfill the following requirements:

- The rated short-circuit making capacity of the circuit breaker is not to be less than the prospective peak value of the short-circuit current.
- The rated short-circuit breaking capacity of the circuit breaker is not to be less than the maximum prospective symmetrical short-circuit current.

3.2.3.3 Bureau Veritas (BV)

NR557 High-Voltage Shore Connection Systems (HVSC) (Jan 2010)

Section 4 contains the requirements for the HVSC ship installation. Permanently fixed cables are to be provided between the shore connection switchboard and the ship-receiving switchboard connection point.

An earth connection is to be provided for connecting the hull to earth appropriate for external electrical power.

Arrangements are to be provided to check the insulation between Connection Equipment conductors and between the conductors and the earth before an external power supply is connected.

Means are to be provided for checking the phase sequence of the incoming supply.

An indicator is to be provided at the Shore Connection switchboard, and at the main switchboard, in order to show when connections are energized.

The shore connection switchboard is to be located onboard the vessel in a dry space close to the connection point, for the reception and/or extension of the ship to shore connection cable. The degree of protection is to be in accordance with UR E11.

The switchboard is to be tested in accordance with the internal arc classification (IAC) procedure in IEC 60271-200 Annex A, Accessibility class A, or the access to the room shall be prevented if the switchboard is energized.

Moreover, the ship-receiving switchboard is to be equipped with the following protections and alarms:

- Short-circuit: tripping with alarm.
- Overcurrent in two steps: alarm and tripping with alarm.
- Earth fault: alarm and tripping if required by the type of isolation system used.
- Over / under voltage in two steps: alarm and tripping with alarm.
- Over / under frequency in two steps: alarm and tripping with alarm.
- Reverse power: tripping with alarm.
- Directional overcurrent: tripping with alarm.

3.2.3.4 Lloyd's Register (LR)

Lloyd's Register Rules and Regulations for the Classification of Ships (Jul 2020)

The document deals with the High-Voltage Shore Connection Systems (HVSC) in the Part 7, Chapter 13 named "On-shore Power Supplies".

SSE machinery class notation may be assigned where machinery, electrical and control engineering arrangements installed onboard to permit continued operation of services by connection to an external electrical power supply are assessed and found to comply with the requirements of this Chapter.

Part 7, Chapter 13, Section 3 describes the general requirements for the electrical connection. The first subsection gives a general prescription, the second describes the required connection equipment, the third the connection cables, plugs and socket-outlets, and the fourth deals with the connection equipment installed in removable containers.

Section 4 deals with the following electrical system aspects: requirements for the electrical load transfer, the oh-shore power supply capacity, the electric protection, the interlocking and synchronizing arrangements, and the ship power restoration.

Section 5 describes the control and monitoring requirements, the connection equipment for control and monitoring, and the emergency shutdown procedure.

3.2.3.5 RINA

Rules for the Classification of Ships (Jul 2022)

The additional class notations HVSC-NB and HVSC are assigned to ships fitted with high voltage shore connection systems complying with the requirements given in Part F, Chapter 13, Section 15.

Section 15.2 describes general requirements for both ship's and shore systems, such as: equipotential bonding, compatibility, failures, location, prescription for short-circuit calculation and electrical load analysis, and emergency shutdown and emergency stop.

Section 15.3 deals with the ship requirements regarding the instrumentation and protection, the system separation, the power switchboard, the Load transfer via temporary parallel operation, and the communication means.

3.3 Forthcoming Guidelines/Standards

- IEC/ISO/IEEE 80005 series of standards are developed by the Joint Working Group 28 (JWG 28)
- IEC/ISO/IEEE 80005-1 referring to High Voltage Shore Connection (HVSC) is always under development. New amendments are under way.
- IEC/ISO/IEEE 80005-2, referring to communication systems of Shore connection facilities, is of limited interest even for cruise ship applications for which it has been initially developed.
- IEC/ISO/IEEE 80005-3 referring to Low Voltage Shore Connection (LVSC) is still under development (with the previous edition being inactive). The draft has been prepared and submitted for approval by all three IEC, ISO and IEEE standardization committees. It is anticipated to be approved by the end of 2023 and become active within 2024.
- Within 2022 a new effort was launched within JWG28 dealing with Development of Direct Current shore connection dedicated, in particular to supplying DC electric power to ships with their main power sources being batteries. The corresponding sub-Working Group has identified targets and objectives; currently, a draft is under preparation. It is likely that this new standard will be named as IEC/ISO/IEEE 80005-4.

IEEE, on its own, developed a series of standards related to SSE, namely IEEE 45.1-45.8 dedicated to shipboard electrical installations. The Working Groups dealing with IEEE 45 amendments, comprise members of the Marine Systems Coordinating Committee (IEEE/MSCC). The most appropriately close-to-shore connection is IEEE 45.1 which is in amendment phase. The IEEE Working Group 45.1 is anticipated to submit the finalized draft within 2023, while the amended document become active within 2024.

4 IDENTIFICATION OF CHALLENGES

The review of guidelines, regulations, directives and standards allows for identifying some potential gaps or challenges that will need to be addressed by the appropriate stakeholders. On the other hand, also some overlaps may be found among different regulations covering the same topics. Specific issues found by means of the analysis performed for this report are described in the following subsections.

4.1 Lack of information

Regarding information on SSE infrastructure, technical arrangements upon shore and ship connection seem to be detailed enough in the standard IEC/ISO/IEEE 80005 and the Classification Societies' Guides. There are, however, other aspects to be considered, where more work should be done to improve standardization of infrastructure and procedures.

One issue mentioned by the EMSA Guidance, for instance, is an adequate assessment of the SSE demand, to properly size the infrastructure. This means that maybe more information is needed regarding the main auxiliary energy consumption sources of berthed vessels, by type, size and/or other characteristics. A close collaboration would be needed among the different stakeholders for this.

Another critical issue is the location of the SSE connector on board. It seems that, besides some hints, there is neither a general norm nor standard for the receiving switchboard to be placed. More information or guidelines, therefore, are needed in this sense.

Finally, there is a lack of specifications and definitions regarding the verification or compatibility tests, i.e., the compatibility test to be done the first time a vessel is connected to an SSE facility, as described by the IEC 80005. Specific questions that would need to be harmonized and detailed are: "how is the test done?", "What is to be done and by whom?", "Is it costly?", "Is it time consuming?", "How many tests are needed?"

4.2 Overlaps

Regarding regulations and guidelines, some overlaps could be found when analyzing the documents from the perspective of the specific topics or subjects they address. Two topics have been identified that might be addressed differently in the SSE Directives, standards and guidelines:

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1. **Technical specifications for SSE electrical infrastructure on board the ship.** Besides the widely known and relevant standard IEC/ISO/IEEE 80005, other documents have been found that approach the same objectives, however for different kinds of vessels i.e., inland ones. This is the case of the CENELEC Harmonization Document (HD) 60364-7-730:2016, titled "Low-voltage electrical installations - Part 7-730: Requirements for special installations or locations - Onshore units of electrical shore connections for inland navigation vessels", or the European standard EN 15869: "Inland navigation vessels - Electrical shore connection, three-phase current 400 V, up to 63 A, 50 Hz". A further review should be made to find out whether there might be an overlap in technical characteristics for the SSE infrastructure or not, and to what extent. It could also be a good opportunity to discriminate what would be the differences on technical requirements of an SSE connection between seagoing and inland vessels, if any.

2. **Safety and occupational hazards prevention.** A specific mention of the safety of operation, and the subsequent need for qualified, certified operators can be found in different documents and Directives. For instance, besides the IEC/ISO/IEEE 80005, explicit mention to these issues can be found in three EU Directives: EU Alternative Fuel Infrastructure Directive – Directive 2014/94/EU, that references to the IEC/ISO/IEEE 80005 standard requirements, including verification tests and connection procedures; the EU Machinery Directive – Directive 2006/42/EC, that aims at harmonizing the health and safety requirements applicable to machinery on the basis of a high level protection of health and safety; and the EU Port Services Regulation – Regulation (EU) 2017/352, that considers SSE as a bunkering service and refers to the obligations of each port for the equipment needed to provide the relevant port service in normal and safe conditions and the capacity to maintain this equipment at the required level. The IMO is also specifically addressing this subject at an international level, with the "Interim Guidelines on Safe Operation of Onshore Power Supply (SSE) Service in Port for Ships engaged on international voyages". All these mentioned documents include safety measures in their requirements, and probably a study in detail should be made to identify overlaps.

4.3 Harmonization guidelines

At the EU level, The European Maritime Safety Agency (EMSA), with its "Guidance on Shore side Electricity (SSE) for Port Authorities and Administrations" has provided a harmonizing effort that covers the deployment of the infrastructure from the demand assessment study. This Guidance includes, as commented, specific mentions to the ship's side in its Part 2 (Planning, Operations and Safety).

Directly related to operations and safety, one key aspect to be sought and harmonized is the certification of qualified SSE operators, critical for safe operation, either on shore and at the ship. As seen in the previous subsection, mentions of a safe operation can be found throughout the different Directives, guidelines and standards. This is also one of the recommendations in the EALING project's Activity 1 – Milestone 6: "Final recommendations for a harmonized framework on SSE in EU ports". Harmonization is needed to define good and quality-proven certification tests and procedures.

Regarding classification, the label of SSE-Ready should be harmonized for any kind of ship, in any part of the world this certification process is done. This may imply, if not already existing, unique rules of classification for SSE systems on board, at least within the IACS. Moreover, harmonization should start with the label itself: how to call it (e.g. HVSC ready? SSE ready?) and what is covered by it (e.g. is the SSE already installed? Is it in operation?). In fact, different labels could be set, for different phases of SSE deployment at the ship.

4.4 Technical challenges

Regarding the identification of technical challenges, one of the main challenges with implementing SSE had been that different ships of different sizes and functions use different operating voltages and frequencies, which are often different to the electrical characteristics of the grid of the port facility. This was frequently one of the main deciding factors cited in feasibility studies for ports and shipping companies which prevented them from adopting the technology. Besides the operating voltage and frequencies, also the different system architectures have a huge impact on the feasibility of the SSE connection. Indeed, the two most critical issues in connecting the vessels' electrical systems to the port main grid are related to the power quality and safety issues, which are strictly connected to the power system architecture of both port and ship side.

The EMSA "Guidance on Shore side Electricity (SSE) for Port Authorities and Administrations" Part 2 (Planning, Operations and Safety) correctly addresses the main issues related to the ship side (operational and electrical). The guide highlights the importance of knowing what the transient responses are at the ship, in terms of frequency and voltage. Indeed, the main switchboard breakers relays are carefully set in accordance with the different ship operational configurations (e.g., two or three diesel gen-sets online). The connection of the SSE feeder requires the reconfiguration of the protection and control relay with open/close control and tripping function for the typical equipment protection such as overload, short circuit, voltage, and frequency in order to implement grid selectivity. A wrong set of those parameters can result in power system blackout with possibly harmful consequences for the safety onboard.

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Moreover, the earthing system used by the ship shall ensure an adequate equipotential bonding with the shore. As a function of the ship type, the earthing can be of high or low resistance, or unearthed. The neutral earthing resistor value is also critical for the SSE system design and may vary as a function of the ship's type. This will ensure electrical safety for the passengers/personnel during port stay and SSE operation. There must be a deeper understanding of the ship network configuration as well as the port network because this will have a huge impact on the issues related to indirect contact with the electrical equipment.

The connection and disconnection procedures need to be agreed and detailed with each port, especially the synchronization process of SSE with the generators onboard. The Power Management System (PMS) should correctly handle the synchronization operation and the load transfer from the onboard diesel gen-sets to the SSE avoiding undesired blackouts. In addition, the PMS should be aware of all the technical limitations of the equipment, both in steady state and transient response. The capability of gen-sets and/of power electronics equipment should be mapped in order to avoid operating conditions that can exceed the capability curve for both active and reactive power.

Several tests and verification procedures (and subsequent certifications) need to be done to prove the feasibility of the SSE connection, such as but not limited to:

- Simulation of steady-state operation of the network in different scenarios
- Simulation of transition between different configurations of the network
- Stability under dynamic conditions
- Simulation of transient, following generation or load equipment failure
- Simulation of the electrical fault in the system (short circuit)

Last but not least, one of the main technical challenges is related to the position of the SSE connection point on the ship's side. Different ships are designed in different ways; therefore, the main switchboards can be located in a different position (both in length and in height) onboard according to the shipyard's best construction practice.

Moreover, the SSE connection point on the ship's side depends on the onboard space availability in refitting projects and therefore, each shipowner can refit the most suitable room according to their need. This will result in a technical challenge in the design of the port infrastructure to successfully connect the ship.

5 CONCLUSIONS

The present document has identified some possible overlaps; also some specific topics that should be further developed; some challenges not yet completely unveiled; and some issues, finally, where harmonization, or at least a check review, is needed, all of this regarding SSE infrastructure and operations at the ship's side.

Therefore, the next steps are to provide a set of suggestions and recommendations towards harmonising the SSE infrastructure at the ship's side. These recommendations will be described in the **Deliverable D2.2** of the EALING Project.

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Marta Nácher (mnacher@fundacion.valenciaport.com)

Valencia, 31 January 2023

Subject: EALING – European flagship action for cold ironing in ports, Action number 2019-EU-TM-0234-S. Means of verification of *Milestone 10.- Analysis of the standards relevant to shipside installation for shore side electricity supply for the vessels operating in the ports of the consortium completed.*

Dear EALING Action Coordinator,

I, Rocío García, as member of the Steering Committee, approve the contents of the report *Analysis of the standards relevant to shipside installation for shore side electricity supply for the vessels operating in the ports of the consortium*.

Yours sincerely,

Rocío García
Fundación Valenciaport

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Genoa, 31 January 2023

Subject: EALING – European flagship action for cold ironing in ports, Action number 2019-EU-TM-0234-S. Means of verification of *Milestone 10.- Analysis of the standards relevant to shipside installation for shore side electricity supply for the vessels operating in the ports of the consortium completed.*

Dear EALING Action Coordinator,

I, Alexio Picco, as member of the Steering Committee, approve the contents of the report *Analysis of the standards relevant to shipside installation for shore side electricity supply for the vessels operating in the ports of the consortium*.

Yours sincerely,

Alexio Picco

Circle S.p.A.

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Athens, 31 January 2023

Subject: EALING – European flagship action for cold ironing in ports, Action number 2019-EU-TM-0234-S. Means of verification of *Milestone 10.- Analysis of the standards relevant to shipside installation for shore side electricity supply for the vessels operating in the ports of the consortium completed.*

Dear EALING Action Coordinator,

I, Lambros Nakos, as member of the Steering Committee, approve the contents of the report *Analysis of the standards relevant to shipside installation for shore side electricity supply for the vessels operating in the ports of the consortium*.

Yours sincerely,

Lambros Nakos
Hydrus Engineering S.A.

ocean finance

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Subject: EALING – European flagship action for cold ironing in ports, Action number 2019-EU-TM-0234-S. Means of verification of *Milestone 10.- Analysis of the standards relevant to shipside installation for shore side electricity supply for the vessels operating in the ports of the consortium completed.*

Dear EALING Action Coordinator,

I, Panayotis Zacharioudakis, as member of the Steering Committee, approve the contents of the report *Analysis of the standards relevant to shipside installation for shore side electricity supply for the vessels operating in the ports of the consortium*.

Yours sincerely,

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Dear EALING Action Coordinator,

I, Stefanos Dallas, as member of the Steering Committee, approve the contents of the report *Analysis of the standards relevant to shipside installation for shore side electricity supply for the vessels operating in the ports of the consortium.*

Yours sincerely,

Dr. Stefanos Dallas
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