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■ *Section 1*
General

1.1 General

1.1.1 These optional requirements apply to the safety, reliability and availability of shipboard machinery, electrical and control engineering arrangements installed to permit continued operation of services by connection to an external electrical power supply in port. These requirements are additional to those applicable in other Parts of the Rules. Regular operation of ship's services from an external electrical power supply is often referred to as On-shore Power Supply, Cold Ironing, High Voltage Shore Connection or Alternative Marine Power.

1.1.2 These requirements are intended for application to the shipboard elements of designs where the connection(s) with external power supply arrangements are achieved by either extending ship cables from the ship to the external power supply connection points or by bringing external cables on board to connect to shipboard connection points. However, external equipment and machinery (including shore based transformers, circuit breakers, gantries, cables, connectors and control engineering arrangements) are not covered by classification or these requirements.

1.1.3 Compliance with these requirements is intended to assess the suitability of shipboard arrangements for the documented intended application and only addresses compatibility with external power supply arrangements that are suitable for connection to the installed ship arrangements.

1.1.4 Assessment of the overall compatibility and suitability of an external electrical power supply (including combined electrical and control engineering assessments, compliance with applicable regulations, operating practices and risk assessment, etc. as applicable) is necessary before connection and is the responsibility of the Owner. Elements of the overall assessment of compatibility will be required to be completed in advance to prepare for a ship visit to a port where it is intended to connect to an external power supply due to the need to involve competent and responsible parties.

1.2 Authorities and administrations

1.2.1 Additional requirements and/or restrictions may be imposed by the National Authority with which the ship is registered and/or by the appropriate Administration or Authorities within whose jurisdiction the ship is intended to operate and/or by the Owners or Authorities responsible for an external electrical power supply. Where such additional requirements are relevant, compliance is the responsibility of the Owner. If specifically requested, Lloyd's Register (hereinafter referred to as 'LR') may be able to provide a suitable statement of compliance.

1.2.2 Where additional requirements imposed by an Authority or Administration would result in a departure from the requirements of this Chapter, details demonstrating that safety, availability and reliability will not be adversely affected are to be submitted to LR for consideration.

1.3 Class notations

1.3.1 **OPS** 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.

1.4 Plans and information

1.4.1 Three copies of the plans and particulars in *Pt 7, Ch 13, 1.4 Plans and information 1.4.2 to Pt 7, Ch 13, 1.4 Plans and information 1.4.9* are to be submitted for consideration.

1.4.2 Operating Manuals that describe the intended methods of connection together with operating and monitoring instructions. Assessments of the external supplies that are to be connected to the ship together with the mooring and environmental conditions are to be included. Details of equipment and arrangements necessary to ensure safety when connecting, disconnecting, transferring electrical load, testing and operating are to be incorporated.

1.4.3 A Design Statement which details the Defined Operations. This statement is to include a description of the operating capability, functionality, limits and restrictions; in terms of:

- Connection Equipment, see *Pt 7, Ch 13, 1.6 Definitions 1.6.2*;
- Connection Equipment routes;
- mooring arrangements;
- environmental conditions including tidal and weather and, where applicable, electromagnetic conditions required to ensure compatibility or prevent damage caused by heating or sparking;
- Connection Equipment suitability for hazardous areas, see *Pt 7, Ch 13, 2.1 General requirements 2.1.4* and *Pt 6, Ch 2, 1.2 Documentation required for design review 1.2.6*
- arrangements for an external connection cable to be brought on board, where provided;
- Separation details, see *Pt 7, Ch 13, 3.2 Connection Equipment 3.2.7*;
- the rating of the arrangements;
- ratings and requirements for external power supplies, see *Pt 7, Ch 13, 3.1 General 3.1.10*; and
- the services to be supplied.

1.4.4 Arrangement plans of equipment, control stations, locations, routes to and from connections, openings and accesses and flexible or movable arrangements.

1.4.5 Operational and construction details of Connection Equipment, including any flexible or adjusting arrangements, including plugs and socket-outlets, see *Pt 7, Ch 13, 3.3 Connection cables, plugs and socket-outlets 3.3.4*.

1.4.6 Plans for control and electrical engineering arrangements required by *Pt 6, Ch 1 Control Engineering Systems* and *Pt 6, Ch 2 Electrical Engineering*, as applicable.

1.4.7 Details of type tests for Connection cables, plugs and socket-outlets required by *Pt 7, Ch 13, 3.3 Connection cables, plugs and socket-outlets 3.3.6*.

1.4.8 Details of supplementary arrangements required to protect equipment from exposure to moisture, condensation or temperatures outside their rating.

1.4.9 Schedule of testing at manufacturers' works, initial surveys and trials. The test schedules are to address the defined operations and are to include normal operations and failure conditions.

1.5 Additions and alterations

1.5.1 When an alteration or addition to the approved arrangements is proposed, including changes to the defined service profile, details are to be submitted for consideration.

1.6 Definitions

1.6.1 'Defined Operations' include the application, connection, electrical load transfer, in-service operation, failure response, disconnection and stowage of the connection to an external power supply.

1.6.2 'Connection Equipment' is the ship equipment used to connect permanently installed ship equipment with external electrical power supply connection points in accordance with the Design Statement. This includes, as applicable, flexible cables, plugs and socket-outlets, slip rings or other power conductors or control connections, and support and management measures for these connections. For the purposes of this Chapter, 'Connection Equipment' does not include external equipment, see *Pt 7, Ch 13, 1.1 General*.

■ Section 2 Essential features

2.1 General requirements

2.1.1 Connection equipment is to be designed to be compatible with ship mooring arrangements and the limits of acceptable forces, moments and deflections on correctly applied Connection Equipment resulting from the movement of the moored ship under normal operational circumstances is to be defined in the Design Statement.

2.1.2 Electrical and control engineering arrangements for operation with external electrical power supplies are to be in accordance with the requirements of *Pt 6, Ch 1 Control Engineering Systems* and *Pt 6, Ch 2 Electrical Engineering*, as applicable.

2.1.3 Connection to an external electrical power supply is not to adversely affect the availability of main, auxiliary or emergency machinery, including ship sources of electrical power to allow ship power to be restored. Details of arrangements provided to maintain availability (for example, pre-heating and lubrication and availability of starting, fuel, lubrication, air and auxiliary systems) are to be included in the Design Statement, see also *Pt 7, Ch 13, 4.5 Ship power restoration* and *Pt 7, Ch 13, 5.1 General 5.1.9*.

2.1.4 The permanent or temporary installation of electrical equipment in areas containing flammable gas or vapour and/or combustible dust, is to be minimised as far as is consistent with operational necessity and the provision of facilities enhancing the overall safety of the ship and connection to an external power supply. Where it is necessary to install electrical equipment in these areas, the arrangements are to be in accordance with the requirements of *Pt 6, Ch 2, 14 Electrical equipment for use in explosive gas atmospheres or in the presence of combustible dusts*. The suitability of electrical Connection Equipment for operation in areas containing flammable gas and/or vapour and/or combustible dust while in port is to be defined in the Design Statement and should, additionally, address the implications for Connection Equipment extended ashore, where applicable, and the suitability for operation in berths requiring extended, hazardous areas.

2.1.5 As far as practicable, Connection Equipment is to be located outside of areas where it could be damaged by inport activities under normal operational circumstances.

2.1.6 Consideration may be given to arrangements that are considered by LR to provide an equivalent level of safety. Evidence demonstrating compliance with IEC/ISO/IEEE 80005-1: *Electrical installations in ships – Special features: High-voltage shore connection systems*, or a relevant National Standard may be submitted for consideration of acceptability by LR.

■ Section 3 Electrical Connection

3.1 General

3.1.1 A connection cubicle is to be provided at a convenient location for the reception or extension of connection cable(s) for connection to the external electrical power supply connection points. The connection cubicle is to contain terminals for the connection cable(s) that can be isolated.

3.1.2 Power connections with external electrical power supply arrangements may be made with either suitable connections or by using socket-outlets and plugs in accordance with *Pt 7, Ch 13, 3.3 Connection cables, plugs and socket-outlets*.

3.1.3 Suitable cables, permanently fixed, are to be provided from the connection cubicle to the Connection Circuit-Breaker switchboard, with on-board overcurrent protection situated at or as close as is practicable to the connection cubicle. Connection Equipment to this overcurrent protection is to be installed in a manner such as to minimise the risk of short-circuit.

3.1.4 Where shipboard connection cables are extended to the external electrical power supply connection points, the connection cubicle is to be situated as close as practicable on board to the point where they are extended from the ship.

3.1.5 Means are to be provided to permit the quality of insulation between Connection Equipment conductors, and between the conductors and earth to be measured to verify suitability prior to the connection of an external power supply. The means of verifying satisfactory insulation quality of Connection Equipment in hazardous areas is to be addressed in the Operating Manuals, see *Pt 7, Ch 13, 1.4 Plans and information 1.4.2*.

3.1.6 An earth connection is to be provided for connecting the hull to an earth appropriate for the external electrical power supply which is being connected.

3.1.7 For high voltage connections, means are to be provided, as applicable to the design, to either:

- (a) permit termination of circuits used by external power supply equipment to monitor the continuity of the earth connection referred to in *Pt 7, Ch 13, 3.1 General 3.1.6*; or
- (b) monitor the continuity of the earth connection referred to in *Pt 7, Ch 13, 3.1 General 3.1.6*, see *Pt 7, Ch 13, 5.3 Emergency Shutdown 5.3.8*.

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

3.1.9 An indicator is to be provided at the Connection Circuit-Breaker switchboard, and at the connection cubicle if in a different location, in order to show when connections are energised.

3.1.10 Requirements for an external electrical power supply to be connected are to be defined in the Design Statement and this is to detail the following:

- connections, including control, alarm and safety systems and data communication links;
- Emergency Shutdown requirements, see *Pt 7, Ch 13, 5.3 Emergency Shutdown*;
- nominal voltage(s) or voltage range;
- nominal frequency or frequency range;
- number of phases and system of supply;
- rated current or apparent power;
- quality of power supply;
- reference to protection system design, including protection characteristics for the Connection Circuit-Breaker;
- maximum permitted prospective fault level;
- minimum supply apparent power or current capacity;
- earth fault limiting requirements for earthed high voltage connections;
- isolation and earthing; and
- supply requirements for lightning and surge protection, galvanic isolation of supply circuit from other ships, etc.

Required electrical characteristics are to address steady state, transient and fault conditions, as necessary.

3.1.11 A notice is to be provided at the connection cubicle referencing the Operating Manuals and Design Statement and advising of the requirement to ensure that external electrical power supplies satisfy the requirements of *Pt 7, Ch 13, 3.1 General 3.1.10* prior to connection. See *Pt 7, Ch 13, 1.1 General 1.1.4* for the conducting of the assessment of overall compatibility.

3.2 Connection Equipment

3.2.1 Connection Equipment support and management arrangements, including those for control engineering arrangements, are to be arranged not to apply damaging forces or tension to correctly applied equipment. Support arrangements are to ensure that the weight of connected cable is not borne by cable end terminations or connections, including those in plugs or socket-outlets.

3.2.2 Connection Equipment arrangements are to be such as not to coil or twist correctly applied equipment in a manner that would result in heating or physical tension beyond its rating during Defined Operations.

3.2.3 Where Connection Equipment passes through support or management arrangements or structural openings or is placed against structures, it is to be suitably protected against damage having regard to the Defined Operations.

3.2.4 Connection Equipment routes are not to reduce the effectiveness of openings required for the safety of the ship, for instance bulkhead or deck penetrations, watertight or fire doors.

3.2.5 Connection Equipment support and management arrangements are to be able to operate satisfactorily without damage during the Defined Operations.

3.2.6 Means are to be provided for Connection Equipment to be readily and safely adjusted in response to tidal changes, and other movements that could lead to damage or failure of connections, during the Defined Operations.

3.2.7 Connections with external electrical power supply arrangements are to be designed to prevent damage to the ship structure or Connection Equipment cable reels, cranes and/or gantries as a result of the connections separating in the event of the ship leaving a berth inadvertently or as a result of high cable tension for other reasons. Evidence of compliance with this requirement is to be included in the submission required by *Pt 7, Ch 13, 1.4 Plans and information 1.4.3* and is to identify

Connection Equipment (weak points) that will be damaged, if any, in the event of separation. Damage to connection cables, plugs and socket outlets or other identified equipment may be considered.

3.2.8 Connection Equipment cable reels, cranes and/or gantries used to manage, handle or adjust connection cables, plugs and/or socket-outlets, are to be designed and manufactured in accordance with applicable LR Rules or a marine standard acceptable to LR. A manufacturer's certificate verifying suitability for safe and effective operation for the Defined Operations and service profile is to be submitted.

3.2.9 The manufacturer's certificate referred to in *Pt 7, Ch 13, 3.2 Connection Equipment 3.2.8* is to be in the English language and include the following information:

- (a) Design and manufacturing standard(s) used.
- (b) Materials used for construction of key components and their sources.
- (c) Details of the quality control system applied during design, manufacture and testing.
- (d) Details of any existing type approval or type testing.
- (e) Details of installation and testing recommendations.

The manufacturer is to have a recognised quality management system certified by an IACS member or a Notified Body.

3.2.10 Connection cubicle and connection equipment locations are to have warning notices placed in prominent positions to indicate the presence of moving equipment, electricity and high voltage as applicable.

3.2.11 Effective means are to be provided to prevent the accumulation of moisture and condensation within equipment enclosures. Failure of heaters and/or ventilation fans provided to satisfy this requirement is to activate an alarm at a machinery control station that is attended while connected to an external power supply. The installation of open deck enclosures for high voltage connections is to be minimised to that required for the Defined Operations; a technical justification, including proposed degree of protection ratings, is to be included in the submission required by *Pt 7, Ch 13, 1.4 Plans and information 1.4.8*.

3.2.12 Connection Equipment support and management arrangements are to ensure that the correctly applied equipment is kept clear of areas where they may be exposed to moisture or temperatures outside their rating.

3.2.13 Arrangements are to be provided for stowage of on-board equipment when not in use such that equipment:

- will not be exposed to environmental conditions outside its rating;
- can be stowed, stored and removed without damage; and
- does not present a hazard during normal ship operation.

Adapters, extensions and parts dismantled after use are also to be provided with stowage arrangements.

3.3 Connection cables, plugs and socket-outlets

3.3.1 Plugs and socket-outlets for external electrical power supply connection points, including those for external control engineering arrangements, are to be designed constructed and tested in accordance with IEC 62613-1: *Plugs, socket-outlets and ship couplers for high-voltage shore connection systems (HVSC Systems) – Part 1: General requirements* or a relevant National Standard.

3.3.2 Plugs are to conform to applicable requirements that ensure compatibility with the intended socket-outlet type. Compatible plugs and socket-outlets are to be in accordance with 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* or a relevant National Standard.

3.3.3 Type tests are to be carried out on power connection plug and socket-outlets and cables, in accordance with IEC 62613-1: *Plugs, socket-outlets and ship couplers for high-voltage shore connection systems (HVSC Systems) – Part 1: General requirements* and Annex A.3 of the IEC/ISO/IEEE 80005-1:2012: *Electrical installations in ships – Special features: High-voltage shore connection systems respectively* or a relevant National Standard, to verify design suitability for the intended application described in the Design Statement. Type test reports are to be submitted that include details of the standards, the tests conducted and their order and the acceptance criteria. Alternative proposals may be submitted for consideration.

3.3.4 Power connection plugs and socket-outlets are to be assigned with ratings based on testing in accordance with IEC 62613-1: *Plugs, socket-outlets and ship couplers for high-voltage shore connection systems (HVSC Systems) – Part 1: General requirements* or a relevant National Standard. Details are to be provided in the submission required by *Pt 7, Ch 13, 1.4 Plans and information 1.4.5*.

3.3.5 Power connection plugs and socket-outlets are to be located to minimise the potential of arc flash hazards and suitable warning notices are to be provided at locations along Connection Equipment routes, including power connection plugs and socket-outlets operational locations.

3.3.6 Connection Equipment power cables are to be Type Approved in accordance with LR's *Type Approval System Test Specification Number 3* or, alternatively, surveyed by the Surveyors during manufacture and testing to assess compliance with *Pt 7, Ch 13, 3.3 Connection cables, plugs and socket-outlets 3.3.3* and application of an acceptable quality management system. Connection equipment cables are to be installed so as to minimise the risk of short-circuit when correctly applied.

3.4 Containers

3.4.1 Connection Equipment installed in removable containers is to satisfy the additional requirements of this sub- Section.

3.4.2 Containers are to be for the ship's exclusive use and are to be provided with a permanent notice indicating the ship name and IMO Ship Number.

3.4.3 Container locations are to be designated and identified in the plans required by *Pt 7, Ch 13, 1.4 Plans and information 1.4.4* and provided with fixings that are suitable for the Defined Operations. Procedures for container fixing, use and movement are to be included in the Operating Manuals.

3.4.4 The container type is to be a steel, closed type, weatherproof construction sufficient to prevent damage during expected use, for example during loading and unloading.

3.4.5 Measures necessary to prevent movement of the container when the container has electrical cables connected are to be provided.

3.4.6 Suitable protection is to be provided to prevent damage to Connection Equipment at the container entry points.

3.4.7 Suitable safe access is to be provided to the container for the Defined Operations, inspection and maintenance.

3.4.8 Container entry points are to be provided with suitable sealing arrangements to prevent the ingress of water into the container.

3.4.9 Containers are to be provided with effective means of ventilation. Where a container ventilation fan is provided, alarms are to be provided in accordance with *Pt 7, Ch 13, 3.2 Connection Equipment 3.2.11*.

3.5 High voltage in the presence of personnel

3.5.1 The Defined Operations are, as far as is practical, not to require personnel to be in the vicinity of high voltage equipment when it is energised.

3.5.2 For high voltage:

- (a) switchgear and controlgear assemblies;
- (b) cable reels, cranes and gantries; and
- (c) mounting enclosures for socket-outlets used to connect flexible cables to fixed connections;

arrangements are to be made to protect personnel in the event of gases, arc flash or vapours escaping under pressure as the result of arcing due to an internal fault. Where the Defined Operations require personnel to be in the vicinity of such equipment when it is energised, this may be achieved by an assembly that has been tested in accordance with Annex A of IEC 62271-200 and qualified for classification IAC (internal arc classification), or equivalent.

■ *Section 4* **Electrical System**

4.1 Electrical Load Transfer

4.1.1 'Dead transfer' arrangements are to be provided that permit transfer between operation using ship sources of electrical power and an external electrical power supply by disconnecting one from the ship distribution system and then connecting the other to the dead system.

4.1.2 Additional arrangements for connecting ship sources of electrical power and an external electrical power supply in parallel temporarily to transfer load from one to the other only are permitted, provided these are in accordance with *Pt 7, Ch 13, 4.1 Electrical Load Transfer 4.1.3 to Pt 7, Ch 13, 4.1 Electrical Load Transfer 4.1.9*.

4.1.3 Means to automatically synchronise a ship source of electrical power with an external electrical power supply and connect them in parallel for load transfer when requested by operating staff are to be provided.

4.1.4 Means to automatically transfer load between a ship source of electrical power and an external electrical power supply following their connection in parallel, are to be provided. The load transfer is to be completed in as short a time as practicable without causing machinery or equipment failure or operation of protective devices and this time is to be used as the basis for defining the Transfer Time Limit required by *Pt 7, Ch 13, 4.1 Electrical Load Transfer 4.1.5*.

4.1.5 When transferring of load between ship sources of electrical power and an external electrical power supply exceeds a defined Transfer Time Limit then, arrangements are to be such that:

- the transfer is aborted;
- load is removed from the ship sources of electrical power or external electrical power supply that was intended to take the load; and then
- the Connection Circuit-Breaker is opened.

An alarm is to be provided at a machinery control station that is attended when connected to an external electrical power supply when the Transfer Time Limit is exceeded and is to indicate the return to previous operating conditions.

4.1.6 The Transfer Time Limit referred to in *Pt 7, Ch 13, 4.1 Electrical Load Transfer 4.1.5* may be adjustable to match the ability of an external electrical power supply to accept and shed load. Setting of the Transfer Time Limit is to be demonstrated to the attending Surveyor at Surveys and Trials, see *Pt 7, Ch 13, 6.1 General*.

4.1.7 An external power supply may only be connected in parallel with a single ship source of electrical power. Arrangements are to be provided to ensure that this requirement is satisfied before and during parallel connection. Details of alternative proposals may be submitted for consideration.

4.1.8 Arrangements provided to adjust ship sources of electrical power to allow connection in parallel and transfer of load are not to cause machinery or equipment failure, operation of protective devices or damage under normal conditions or in the event of a failure.

4.1.9 Where load reductions are required to transfer load they are not to result in loss of essential services or the loss of availability of emergency services. Means are to be provided to readily make necessary load reductions and re-instate supplies following transfer.

4.2 Capacity

4.2.1 Arrangements for operating from external supplies are to be sufficiently rated to supply the following:

- essential services normally required in port;
- emergency services;
- services required to ensure ready availability of non-operating main and auxiliary machinery;
- services required to prevent damage to cargo or stores; and
- the services required for the Defined Operations.

The schedule of loads required by *Pt 6, Ch 2, 1.3 Documentation required for supporting evidence 1.3.3* is to incorporate operation when connected to an external electrical power supply.

4.2.2 The maximum electrical step load switched on or off is not to cause the power supply quality to exceed the parameters given in *Pt 6, Ch 2, 1.8 Quality of power supplies* or failure when connected to an external electrical power supply in accordance with the defined requirements, see *Pt 7, Ch 13, 3.1 General 3.1.10*.

4.2.3 Consideration is to be given to providing means to inhibit automatically the connection of large motors, or the connection of other large loads, that the arrangements are not rated to supply when connected to an external electrical power supply having the defined minimum apparent power or current capacity, see *Pt 7, Ch 13, 3.1 General 3.1.10* and *Pt 6, Ch 2, 6.9 Load management 6.9.4*.

4.3 Protection

4.3.1 Where an external electrical power supply is not arranged to operate in parallel with ship sources of electrical power, the connection to the external electrical power supply is to be provided with a Connection Circuit-Breaker arranged to open simultaneously, in the event of short-circuit, overload or undervoltage, all insulated poles.

4.3.2 Where an external electrical power supply is arranged to operate in parallel with ship sources of electrical power during load transfer, the connection to the external electrical power supply is to be provided with a Connection Circuit-Breaker arranged to open simultaneously, in the event of a short-circuit, an overload or an undervoltage, all insulated poles. This circuit-breaker is to be provided with reverse power protection with time delay, selected or set within the limits of 2 per cent to 15 per cent of full load to a value fixed in accordance with the rating defined in the Design Statement; a fall of 50 per cent in the applied voltage is not to render the reverse power mechanism inoperative, although it may alter the amount of reverse power required to open the circuit breaker.

4.3.3 The electrical system, including short-circuit protective device rating, is to be suitable for the highest prospective fault level at the point of installation. The short-circuit current calculations required by *Pt 6, Ch 2, 1.2 Documentation required for design review 1.2.6* are to identify the system state that would result in the highest prospective fault level. The highest prospective fault level may occur during parallel connection with an external power supply and the resulting combination of:

- (a) ship sources of electrical power, taking into account *Pt 7, Ch 13, 4.1 Electrical Load Transfer 4.1.7*; and
- (b) an external electrical power supply having the defined maximum permitted prospective fault level, see *Pt 7, Ch 13, 4.1 Electrical Load Transfer 4.1.7*.

Details of alternative proposals may be submitted for consideration.

4.3.4 The connection circuit is to be arranged such that contamination due to the products of arcing as a result of a fault in the Connection Circuit-Breaker enclosure on the external power supply side will not result in essential or emergency services not being available when supplied by ship sources of electrical power.

4.3.5 Initial connection of an external electrical power supply to the ship switchboards or converter equipment to connect to ship loads is to be arranged to be made by closing of the Connection Circuit-Breaker only.

4.3.6 Converter equipment used to connect an external electrical power supply to the ship electrical system is to ensure that a supply that would result in damage is not applied to the connected ship electrical systems in the event of a failure.

4.3.7 The voltage and time delay settings of the Connection Circuit-Breaker undervoltage release mechanism(s) are to be selected to ensure that the discriminative action required by *Pt 6, Ch 2, 6.1 General 6.1.1* is maintained.

4.3.8 Means are to be provided to prevent closure of the Connection Circuit-Breaker when a connected external electrical power supply has a different phase rotation or has a voltage or frequency that does not match the ship electrical system rating within the tolerances defined by *Pt 6, Ch 2, 1.8 Quality of power supplies 1.8.2* or *Pt 6, Ch 2, 1.8 Quality of power supplies 1.8.4*. Signals are to be provided, where necessary, to allow comparison with ship electrical system characteristics.

4.3.9 Connection power circuits are to be provided with protection against earth faults in accordance with *Pt 6, Ch 2, 6.4 Protection against earth faults*.

4.4 Interlocking and synchronising arrangements

4.4.1 External electrical power supply connections are to be provided with instruments and devices on board equivalent to those required for alternating current generators by *Pt 6, Ch 2, 7.11 Instruments for alternating current generators 7.11.1* where synchronising is not provided, or by *Pt 6, Ch 2, 7.11 Instruments for alternating current generators 7.11.2* to *Pt 6, Ch 2, 7.11 Instruments for alternating current generators 7.11.3* where synchronising for load transfer is provided. See also *Pt 6, Ch 2, 7.11 Instruments for alternating current generators* and *Pt 6, Ch 2, 7.12 Instrument scales*.

4.4.2 Means are to be provided to ensure that a source of electrical power or electrical power supply can only be connected to other live parts when synchronised. See also *Pt 7, Ch 13, 4.1 Electrical Load Transfer 4.1.2* for temporary parallel connection for load transfer.

4.4.3 The arrangements are to prevent Connection Equipment power conductors being made live by connecting to the ship electrical system.

4.4.4 The simultaneous connection of a ship source of electrical power and external electrical power supply to the same dead part of the electrical system is to be prevented.

4.4.5 For high-voltage connections, suitable means are to be provided to earth the connection power circuit so that it is discharged and so maintained that it is safe to touch.

4.4.6 Means provided to connect a connection power circuit to earth are to be arranged such that the circuit may only be earthed when it is isolated.

4.4.7 Interlocking arrangements are to be provided to prevent the connection of a high-voltage external power supply to a switchboard connected to earth using the means required by *Pt 6, Ch 2, 7.8 Earthing of high-voltage switchboards*.

4.5 Ship power restoration

4.5.1 When the ship main source of electrical power is shutdown and failure of the connected external electrical power supply occurs, the Connection Circuit-Breaker is to be arranged to automatically open followed by:

- (a) connection of the emergency source of electrical power to emergency services in accordance with *Pt 6, Ch 2, 3.3 Emergency source of electrical power in passenger ships 3.3.1* or *Pt 6, Ch 2, 3.4 Emergency source of electrical power in cargo ships 3.4.1* as applicable; and
- (b) automatic connection of the transitional source of electrical power to emergency services in accordance with *Pt 6, Ch 2, 3.3 Emergency source of electrical power in passenger ships 3.3.1* or *Pt 6, Ch 2, 3.4 Emergency source of electrical power in cargo ships 3.4.1* as applicable; and
- (c) automatic starting and connecting to the main switchboard of the main source of electrical power and automatic sequential restarting of essential services, in as short a time as is practicable. See also *Pt 7, Ch 13, 2.1 General requirements 2.1.3* and *Pt 6, Ch 2, 2.2 Number and rating of generators and converting equipment 2.2.3*.

Failures include loss of power, disconnection, phase failure and quality of supply outside the tolerances given in *Pt 6, Ch 2, 1.8 Quality of power supplies 1.8.2* or *Pt 6, Ch 2, 1.8 Quality of power supplies 1.8.4*.

4.5.2 An alarm is to be provided at a machinery control station that is attended when connected to an external electrical power supply to indicate activation of the automatic power supply failure response required by *Pt 7, Ch 13, 4.5 Ship power restoration 4.5.1*. The alarm is to indicate the failure that caused the activation.

4.5.3 The automatic power supply failure response required by *Pt 7, Ch 13, 4.5 Ship power restoration 4.5.1* is to be inhibited during the 'dead transfer' required by *Pt 7, Ch 13, 4.1 Electrical Load Transfer 4.1.1* but arrangements are to permit personnel to readily revert to operation from ship sources of electrical power if the 'dead transfer' to the external electrical power supply is not completed.

■ Section 5 Control and monitoring

5.1 General

5.1.1 Control engineering arrangements are to be in accordance with *Pt 6, Ch 1 Control Engineering Systems*, as applicable. The connection of, and the electrical load transfer to and from, an external electrical power supply are only to be controlled on board using shipboard arrangements.

5.1.2 External control of ship equipment may only be provided when in accordance with *Pt 7, Ch 13, 5.1 General 5.1.5*. Otherwise, external arrangements may be used to send requests for action to ship personnel for consideration.

5.1.3 Integration or connection with external, control, alarm and safety systems is to be 'fail-safe'.

5.1.4 The effects of failure of control, alarm and safety system and data communication link connections are to be documented along with resulting failure responses in the submission required by *Pt 7, Ch 13, 1.4 Plans and information 1.4.6*.

5.1.5 Details of proposals that would involve external control of ship equipment to respond to potentially hazardous situations detected externally are to be submitted for consideration. Provided that the arrangements are considered to be in accordance with the provisions of an acceptable and relevant standard, the following external control functions may be permitted:

- initiation of load reductions;
- initiation of electrical load transfer to ship sources of electrical power; and
- initiation of Emergency Shutdown.

5.1.6 The connection power circuit is to be isolated, and for high-voltage connections connected to earth so that it is discharged and so maintained that it is safe to touch, until the connections necessary for safe and effective operation are correctly established, including control, alarm and safety system and data communication link connections.

5.1.7 Following the correct establishment of the necessary connections in accordance with *Pt 7, Ch 13, 5.1 General 5.1.6*:

- where applicable, the connection power circuit may be disconnected from earth; and arranged such that only then
- may the request to make the external power supply connection points live described in *Pt 7, Ch 13, 5.1 General 5.1.8* be sent.

5.1.8 Ship control system arrangements are to be provided to request the external electrical power supply conductors to be:

- where applicable, disconnected from earth; and then
- made live up to the connection points.

5.1.9 An alarm is to be provided at a machinery control station that is attended when connected to an external electrical power supply upon failure of arrangements required to maintain ready availability in accordance with *Pt 7, Ch 13, 2.1 General requirements 2.1.3* (for example pre-heating).

5.1.10 Additional alarms with their associated safeguards are indicated in *Table 13.5.1 Additional alarms and associated safeguards*. These are in addition to those required by other Parts of the Rules.

5.1.11 Means are to be provided to allow testing of control, alarm and safety system connections with external arrangements, including operation of Emergency Shutdown facilities, before electrical connection to an external power supply.

5.1.12 If, depending upon the in-port shipboard work organisation, no machinery control stations are continuously attended while connected to an external power supply, then alarm transfer arrangements that activate an audible indication to warn relevant duty personnel of alarm initiation may be accepted. An audible warning from any portable devices is to be provided in the event of loss of the wireless link.

5.2 Connection Equipment control and monitoring

5.2.1 Connection Equipment is to be capable of unattended operation under normal operating conditions after correct application of the connection. Remote indication of active ship equipment faults at a machinery control station that is attended when connected to an external electrical power supply is to be provided. Details of arrangements that involve periodic attendance to inspect and adjust Connection Equipment may be submitted for consideration.

5.2.2 A control station is to be provided locally to Connection Equipment cable reel, cranes and gantries that permits identification of faults and permits safe and effective supervision and control of this equipment in the foreseeable environmental conditions.

5.2.3 A fixed means of two-way voice communication with a machinery control station that is attended when connected to an external electrical power supply is to be provided at the control station required by *Pt 7, Ch 13, 5.2 Connection Equipment control and monitoring 5.2.2*.

Table 13.5.1 Additional alarms and associated safeguards

Item	Alarm	Note
Presence of voltage on connections		Indicators in accordance with <i>Pt 7, Ch 13, 3.1 General 3.1.9</i> .
Transfer of load	Time limit exceeded	Return to previous operating state to be indicated, see <i>Pt 7, Ch 13, 4.1 Electrical Load Transfer 4.1.5</i> .
Ship power restoration	Activation	See <i>Pt 7, Ch 13, 4.5 Ship power restoration 4.5.2</i> .
Arrangements to ensure main and auxiliary machinery availability	Failure	When shut down. See <i>Pt 7, Ch 13, 5.1 General 5.1.9</i> .
Applied connection equipment status	Changed	Indication to be provided also. See <i>Pt 7, Ch 13, 5.2 Connection Equipment control and monitoring 5.2.4</i> and <i>Pt 7, Ch 13, 5.2 Connection Equipment control and monitoring 5.2.5</i> .
Connection equipment	Close proximity to water level	See <i>Pt 7, Ch 13, 5.2 Connection Equipment control and monitoring 5.2.6</i>

Heaters and/or ventilation fans	Failure	See Pt 7, Ch 13, 3.2 Connection Equipment 3.2.11 and Pt 7, Ch 13, 3.4 Containers 3.4.9
Connection equipment tension	High	Emergency Shut-Down to be activated. See Pt 7, Ch 13, 5.3 Emergency Shutdown 5.3.11.
Plug connectors	Withdrawal	
Earth connection, if required. See Pt 7, Ch 13, 5.3 Emergency Shutdown 5.3.9	Loss of continuity	
Manual disconnection	Activation	
Plug and socket-outlet, if required. See Pt 7, Ch 13, 5.3 Emergency Shutdown 5.3.6	Not in locked position	
Switchgear enclosure mounted socket-outlets	Arc fault detection	

5.2.4 The control station required by Pt 7, Ch 13, 5.2 Connection Equipment control and monitoring 5.2.2 is to be provided with a means for operators to:

- select manual control; or
- lock equipment in position; or
- where provided, select automatic adjustment.

This status is to be indicated remotely at a machinery control station that is attended when connected to an external electrical power supply.

5.2.5 When the equipment status selection referred to in Pt 7, Ch 13, 5.2 Connection Equipment control and monitoring 5.2.4 is changed whilst an external electrical power supply is connected, an alarm is to be activated at a machinery control station that is attended when connected to an external electrical power supply.

5.2.6 Where correctly applied connection equipment is not protected from submersion in the water between the ship and shore (e.g. submersible equipment, equipment routing or slack cable prevention by torque control), an alarm is to be provided at a machinery control station that is attended when connected to an external electrical power supply when Connection Equipment approaches a situation where it may be submerged in the water between the ship and shore, for instance due to tidal changes. The time between alarm initiation and possible exposure to this water is to be sufficient to allow the equipment to be attended and adjusted prior to exposure to water.

5.3 Emergency Shutdown

5.3.1 The requirements of this sub-Section apply to arrangements for the emergency disconnection of live electrical power from the connection to an external electrical power supply.

5.3.2 Emergency Shutdown facilities are to be provided that, when activated, will instantaneously:

- isolate the connection from ship electrical power supplies; and
- request isolation of the external electrical power supply connection points.

5.3.3 High-voltage Connection Equipment is to be either:

- provided with permanent arrangements for manual discharging and routed to prevent personnel access to live connection cables and connection points by barriers and/or adequate distance(s) under expected operating conditions; or
- automatically discharged so that it is safe to touch with immediate initiation of switching device closure following the isolation from ship and shore electrical power supplies required by Pt 7, Ch 13, 5.3 Emergency Shutdown 5.3.2.

5.3.4 For ships that are intended to connect in ports where Connection Equipment may move into a hazardous area associated with the terminal or port area as a result of the ship inadvertently leaving the berthed position (slipping/ breaking of moorings, etc.), this condition is to be included in the Design Statement. The arrangements are to comply with Pt 7, Ch 13, 5.3 Emergency Shutdown 5.3.3 and, additionally, other electrically powered connection equipment that is not intrinsically safe is to be arranged for automatic isolation.

5.3.5 Means are to be provided to detect or predict tension in the external electrical power supply connection cable that activate the Emergency Shutdown facilities described in Pt 7, Ch 13, 5.3 Emergency Shutdown 5.3.2 before damage occurs.

Where alternative arrangements to tension detection are proposed (automatic break-away release, connectors with shear bolts and pilot lines, connection with ship/shore Emergency Shutdown system, etc.), details are to be submitted for consideration.

5.3.6 To detect and react to the withdrawal of plugs from socket-outlets while power supply connections are live, the Emergency Shutdown facilities described in *Pt 7, Ch 13, 5.3 Emergency Shutdown 5.3.2* are to be activated before the necessary degree of protection is no longer achieved or power connections are broken by the removal of a plug from a connected socket-outlet, including in-line connections.

5.3.7 For high-voltage connection points on board where the means of locking together plugs and socket-outlets required by *Pt 7, Ch 13, 3.3 Connection cables, plugs and socket-outlets 3.3.4* are not interlocked to prevent removal from the locked position when the Connection Equipment power connections are not discharged so that they are safe to touch, the Emergency Shutdown facilities described in *Pt 7, Ch 13, 5.3 Emergency Shutdown 5.3.2* are to be activated when connected plugs are moved from the locked position. Consideration may be given to relaxing this requirement when evidence is submitted which demonstrates that appropriate controls and procedures acceptable to LR are in place to control personnel access plugs and socket-outlets.

5.3.8 Where connection power plugs are connected to socket-outlets mounted on a switchgear enclosure, arrangements are to be provided to activate the Emergency Shutdown facilities described in *Pt 7, Ch 13, 5.3 Emergency Shutdown 5.3.2* in as short a time as practicable in the event of an arc occurring in the enclosure at the rear of the socket-outlets.

5.3.9 Where *Pt 7, Ch 13, 3.1 General 3.1.7* applies, the Emergency Shutdown facilities described in *Pt 7, Ch 13, 5.3 Emergency Shutdown 5.3.2* are to be activated in the event of loss of earth connection continuity being detected.

5.3.10 Means to manually activate the Emergency Shutdown facilities described in *Pt 7, Ch 13, 5.3 Emergency Shutdown 5.3.2* are to be provided at:

- a machinery control station that is attended when connected to an external electrical power supply;
- in close proximity to the connection cubicle; and
- at the switchboard where the fixed cable from the shore connection cubicle are received.

Additional manual activation facilities may also be provided at other locations where it is considered necessary. The means of activation are to be visible and prominent, prevent inadvertent operation and require a manual action to reset.

5.3.11 An alarm to indicate activation of the Emergency Shutdown is to be provided at a machinery control station that is attended when connected to an external electrical power supply. The alarm is to indicate the cause of the activation. For power supply restoration, see *Pt 7, Ch 13, 4.5 Ship power restoration 4.5.1* to *Pt 7, Ch 13, 4.5 Ship power restoration 4.5.3*.

■ Section 6 Testing, trials and surveys

6.1 General

6.1.1 The testing and trials required by *Pt 7, Ch 13, 6.1 General 6.1.2* to *Pt 7, Ch 13, 6.1 General 6.1.5* are to be successfully completed to the Surveyor's satisfaction before **OPS** notation may be assigned. Where appropriate test facilities cannot be provided, trials are likely to require the additional co-operation of a port facility with a suitable external electrical power supply and the ability to operate the defined services to be supplied during these trials and allow the testing described to be conducted.

6.1.2 Electrical and control engineering equipment is to be surveyed at manufacturer's works and undergo survey and operational trials on board in accordance with the approved test schedules and applicable testing requirements in *Pt 6, Ch 1 Control Engineering Systems* and *Pt 6, Ch 2 Electrical Engineering*.

6.1.3 In addition to *Pt 7, Ch 13, 6.1 General 6.1.2*, the following Connection Equipment, where applicable, is to be surveyed by the Surveyors during manufacture and testing:

- filters;
- converters; and
- slip ring assemblies.

6.1.4 Cable reels, cranes and/or gantry drives for Connection Equipment are to be surveyed and tested in accordance with applicable LR Rules and *Pt 7, Ch 13, 3.2 Connection Equipment 3.2.9*.

6.1.5 Trials are to be conducted when connected to a compatible external electrical power supply in accordance with *Pt 7, Ch 13, 3.1 General 3.1.10* to demonstrate to the attending Surveyor that the Rules have been complied with in respect of:

- (a) operation of connection management arrangements;
- (b) trials on cable lifting appliances (for example cable reels or cranes) are to be conducted that demonstrate suitability for the maximum mechanical load and duty required by the Defined Operations within the service profile contained in the Design Statement, including connection of extensions or adapters;
- (c) satisfactory performance of the connection and Connection Equipment throughout the Defined Operations, including a run with the defined services to be supplied operational;
- (d) temperature of electrical joints, connections, circuitbreakers and fuses;
- (e) the operation of electrical load transfer arrangements (including Transfer Time Limit setting), electrical system protection and interlocking devices, Emergency Shutdown arrangements and other safety devices and ship power restoration;
- (f) where acceptable type-test evidence is not submitted, connection break-away, see *Pt 7, Ch 13, 3.2 Connection Equipment 3.2.7*;
- (g) voltage regulation when the maximum load is suddenly thrown off and when starting the largest motor connected to the system;
- (h) where more than one external power supply connection can be operated in parallel, satisfactory load sharing at loads up to normal working load; and
- (i) voltage drop is to be measured, where necessary, to verify that this is not in excess of that specified in *Pt 6, Ch 2, 1.8 Quality of power supplies*.

6.1.6 Arrangements are to be:

- examined at Annual Survey; and
- examined and functionally tested whilst connected to an external electrical power supply during the Complete Surveys of machinery or, where this is not practical, within 12 months of the due date of the Complete Surveys of machinery.

This is to include examination of Connection Equipment.