



財團法人驗船中心

CR CLASSIFICATION SOCIETY

**GUIDELINES FOR HIGH VOLTAGE SHORE CONNECTION
SYSTEMS**

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Foreword

The risks of pollution and sustained environmental damage in ports all over the world is becoming more and more an issue. Since the number of auxiliary diesel engines on the ships has been increasing and causing more pollution in port and surrounding area. Therefore, how to reduce the pollution from the operating ship auxiliary diesel engine is getting more and more attention.

Ships and ports need to invest in new technology to reduce pollution and to be compliant with strict regulations which force ships that are in port to reduce their emissions.

Although many different strategies are applied in modern ports worldwide, the concept of shore powering the ships while at berth is attracting much attention, with significant both financial and scientific sources being directed towards the adaptation / implementation of shore connection technology. Shore connection technology is the only way that can cut all emissions from ships at berth.

High voltage shore connection (HVSC) is a system for supply of power from shore to ship at high voltage with the purpose of preventing atmospheric pollution due to the exhaust gas from generator engines on ships at berth. Instead of running on diesel power while at berth, HVSC equipped ships “plug in” to shore side electrical power.

HVSC is an international standard for Cold Ironing and was established by the joint efforts of IEC, ISO and IEEE. Therefore, HVSC is often referred to as Cold Ironing or Alternative Marine Power.

It is envisaged that the effect of increasingly stricter air emissions legislation implemented through mainly local air quality controls will see an increasing number of ships installing high voltage shore connection (HVSC) in the near future.

GUIDELINES FOR HIGH VOLTAGE SHORE CONNECTION SYSTEMS

CONTENT

Chapter 1	General Instructions.....	1
1.1	Application.....	1
1.2	Scope.....	1
1.3	Class Notation.....	1
1.4	Equivalency	1
1.5	Terminology.....	1
Chapter 2	Overview of High Voltage Shore Connection Systems	3
2.1	Schematic of High Voltage Shore Power Connection System	3
2.2	Block Diagram in the IEC Standard	3
Chapter 3	Surveys	6
3.1	Types of Survey	6
3.2	Period of Surveys.....	6
3.3	Periods of Surveys Carried out in Advance and Postponements of Surveys	6
3.4	Preparations for Surveys	7
3.5	Installation Survey	7
3.6	Special Survey	9
3.7	Annual Survey	9
Chapter 4	Requirements for High Voltage Shore Connection Systems.....	10
4.1	General Requirements for All Equipment.....	10
4.2	Requirements for Equipment	13
4.3	Compatibility Assessment.....	17
4.4	Maintenance Plan.....	18
4.5	Instruction Manual	18
Chapter 5	Fire Protection Construction and Fire Extinguishing System.....	20
5.1	General.....	20

Chapter 1 General Instructions

1.1 Application

The Guidelines for High Voltage Shore Connection Systems (hereinafter referred to as the Guidelines) specify requirements related to the design, provision and inspection of high voltage shore connection systems, which have been summarized referring to IEC/ISO/IEEE 80005-1 2019 "Utility connections in port – Part 1: High Voltage Shore Connection (HVSC) Systems – General requirements" (hereinafter referred to as the IEC standard) addresses the connection between ship and shore and the procedures for safe operation.

According to the IEC standard, high voltage shore connection systems are defined inclusive of shore side electric systems but shore side electric systems are not included in the Guidelines.

1.2 Scope

The Guidelines apply to ships that have shut down the on-board generators while at berth, and are supplied power only through high voltage shore connections.

1.3 Class Notation

For ships having high voltage shore connection systems which complies with the Guidelines, the class notation “**HVSCS**” will be assigned.

1.4 Equivalency

Even if the high voltage shore connection system does not comply with a part of the Guidelines, it may be treated as complying with the Guidelines if it is deemed to be equivalent to a system that complies with the Guidelines.

1.5 Terminology

1.5.1 Shore power

General name for electricity conveyed from shore power supply.

1.5.2 High voltage shore connection system (HVSC system)

A system on board ship that receives high voltage shore power. A high voltage shore connection system is designed to receive power from a high voltage shore supply system, and typically involving high voltage plugs, high voltage sockets, high voltage shore circuit breaker, step-down transformer (or isolation transformer), high voltage flexible cables, circuit breaker for incoming power, main switchboard and measuring instruments.

1.5.3 High voltage

For the purposes of the Guidelines, nominal voltage in the range above 1,000 V and up to and including 15 kV is considered the scope of rated voltage of the system.

1.5.4 Earthing method

This is a method of earthing the power supply system. Insulation (including earthing by Earthed Voltage Transformers (EVT)), neutral earthing, low-resistance earthing or high-resistance earthing, or circuit protection suitable for these earthing methods, such as, the availability of protection against over voltage, over current and single phase earth fault, should be consistent between ship and shore systems.

1.5.5 Cable management system

The cable management system is meant for controlling and monitoring high voltage flexible cables, and it includes cable connecting parts. Generally it consists of high voltage cable with plug enabling the cable to extend to the shore socket, cable reel, automatic tension control device and monitoring instruments.

1.5.6 Shore connection switchboard

Shore connection switchboard consists of shore connection circuit breakers, and is a switchboard installed close to the receiving point.

1.5.7 On-board receiving switchboard

The on-board receiving switchboard is generally a part of the on-board main switchboard. Shore power is supplied to this switchboard through the shore connection switchboard.

1.5.8 High voltage shore circuit breaker

Circuit breaker in the shore power receiving circuit provided in the shore connection switchboard.

1.5.9 Receiving point

Receiving point is a connection point for the high voltage flexible cable on the ship side.

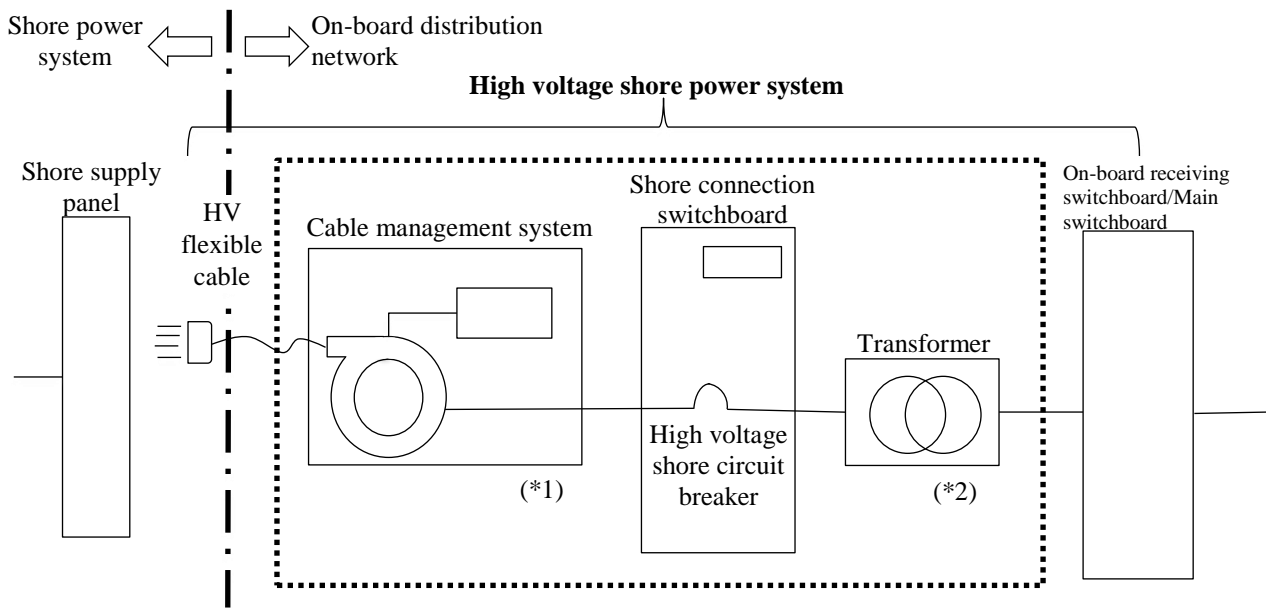
1.5.10 Supply point

Supply point is a connection point for the high voltage flexible cable on the shore side.

Chapter 2 Overview of High Voltage Shore Connection Systems

2.1 Schematic of High Voltage Shore Power Connection System

The Schematic of a high voltage shore connection system is as follows:



- (*1) This system may be provided on shore in some case.
- (*2) The transformer may be not necessary in some case.

Fig. 2-1
Schematic of High Voltage Shore Connection System

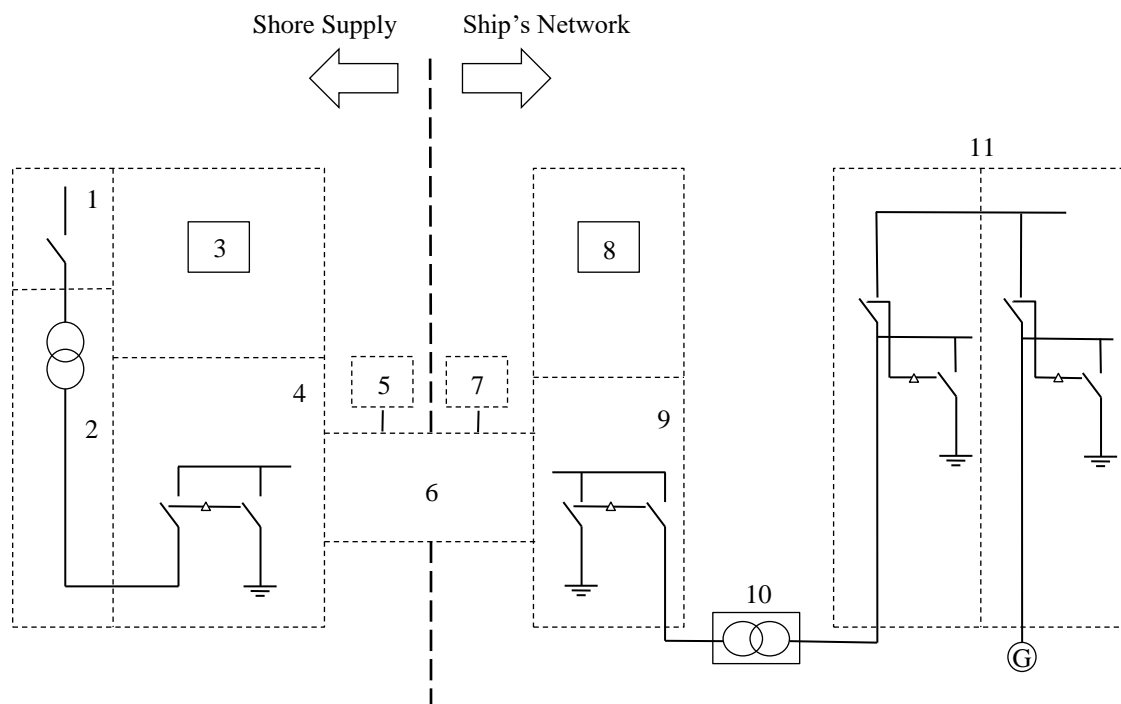
Shore power panel receives high voltage power supply from the shore distribution network of power plants, substations and so on, and distributes power to the ship. The voltage of shore power supplied to the ship is generally 6.6 kV or 11 kV as stipulated in the IEC standard. This high voltage power supply generally supplies power to the on-board power receiving switchboard through high voltage flexible cable arranged by the ship, the shore connection switchboard and the transformer.

The shore connection switchboard includes circuit breaker, earthing circuit and so on. The switchboard has the role of disconnecting power to the ship when an abnormality occurs in the on-board distribution system or on the shore side.

The role of the transformer is to step down the voltage to be distributed to the ship since the power supply supplied from shore is either 6.6 kV or 11 kV. The purpose may sometimes be isolation of power supply and adjustment of the earthing system. When the on-board distribution voltage is 6.6 kV or 11 kV, and the distribution system is matched with the shore side, the transformer may be omitted.

2.2 Block Diagram in the IEC Standard

The following is the Block diagram of high voltage shore power system shown in the IEC standard.



Key

- | | |
|-----------------------------------------------------|---------------------------------------------|
| 1. HV-Shore supply system | 7. Control |
| 2. Shore side transformer | 8. Ship protection relaying |
| 3. Shore side protection relaying | 9. Shore connection switchboard |
| 4. Shore side circuit breaker and earth switch | 10. On-board transformer (where applicable) |
| 5. Control | 11. On-board receiving switchboard |
| 6. Shore-to-ship connection and interface equipment | |

Fig. 2-2
Block Diagram of the HVSC System

The system may be split in two big blocks. The left side is the shore power supply system; it receives the shore power, and supplies it to the ship. The right side is the on-board distribution network.

The block number 1 is the High Voltage Shore Supply System contains high voltage power receiving circuit breaker. This block is the one that takes the electricity from the national grid, the generator of the port's energy or any other source of power, so it can be transformed and transferred to the ship that needs this energy.

Block number 2 contains the shore side transformer, besides the power-electronic conversion system, that converts the shore power voltage to the voltage to be supplied to the ship (generally 6.6 kV or 11 kV).

Block number 3 is the shore side protection relay circuit that controls protection devices in block number 4.

Block number 4 consists of the shore circuit breaker and earthing switch; it is a protection device that shuts down/handles abnormal current from shore power supply, earth fault current, and so on.

The switchboard in which equipment in the block number 1 to 4 are assembled corresponds to the shore power supply switchboard. It should be noted that equipment in block number 1 to 4 fall under the scope of the IEC standard, but do not fall under the scope of the Guidelines.

Block number 5 and block number 7 are the control circuit related to unwinding and winding the high voltage flexible cable.

Block number 6 is the high voltage flexible cable that supplies shore power to the ship; it has a built-in interface cable for exchanging information between shore and ship. This cable is generally provided by the ship side. It also includes the control circuit (block number 5 and 7) related to unwinding and winding the high voltage flexible cable.

The system in block number 5 to 7 corresponds to the cable management system in Fig. 2-1.

Block number 8 is the ship side protection relay circuit that controls protection devices in block number 9.

Block number 9 is the shore connection switchboard that receives power to the ship from the shore. It is installed as a fixed ship installation in a specific compartment or in a container, etc., and it facilitates changes in equipment.

The equipment in block number 8 and 9 correspond to the shore connection switchboard shown in Fig. 2-1.

Block number 10 is the ship side transformer which corresponds to the transformer shown in Fig. 2-1.

Block number 11 is the on-board receiving switchboard. It generally forms a part of the main switchboard. When it forms part of the main switchboard, the on-board generator is connected to this distribution board, and shore power is supplied for on-board loads through this distribution switchboard.

The switchboard in block number 11 corresponds to the on-board receiving switchboard/main switchboard shown in Fig. 2-1.

Chapter 3 Surveys

3.1 Types of Survey

The high voltage shore connection system registered or intended to be registered is subjected to the following surveys:

3.1.1 Installation Survey

3.1.2 Surveys after installation

The types of surveys after installation are as follows:

- (a) Special Survey
- (b) Annual Survey
- (c) Occasional Survey

3.2 Period of Surveys

Surveys are to be carried out in accordance with the requirements given in 3.2.1 and 3.2.2 below.

3.2.1 Installation Survey is to be carried out at the time of application for registration.

3.2.2 Surveys after installation are to be carried out at periods given in (a) to (c) below.

- (a) Special Survey is to be carried out as specified in 1.6.4 in Part I of the Rules for the Construction and Classification of Steel Ships (hereinafter referred to as the Rules for steel ships).
- (b) Annual Survey is to be carried out as specified in 1.6.5 in Part I of the Rules for Steel Ships.
- (c) Occasional Survey is to be carried out at periods other than the period when Special Survey or Annual Survey is carried out, and it corresponds to any of (i) to (iii) below.
 - (i) When main parts of a system have been damaged, or when such a system is repaired or replaced
 - (ii) When any system is modified or changed
 - (iii) At other times when survey is deemed necessary.

3.3 Periods of Surveys Carried out in Advance and Postponements of Surveys

3.3.1 Periods for surveys carried out in advance

Periods of surveys carried out in advance are to be in accordance with the provisions of 1.6.4 (c), Part I of the Rules for Steel Ships.

3.3.2 Postponements of surveys

Postponements of surveys are to be in accordance with the provisions of 1.6.4 (d) in Part I of the Rules for Steel Ships.

3.4 Preparations for Surveys

3.4.1 The survey applicant shall make the necessary preparations so that survey can be carried out adequately according to the kind of survey to be received in respect of the survey items specified by the Surveyor if necessary, based on the inspection items and requirements established in the Rules. These preparations include preparations of equipment that can be easily and safely accessed as required for survey, equipment necessary for survey, certificates, inspection records, and also opening up of equipment, etc., removal of obstacles and cleaning. Survey equipment, measuring instruments and test instruments used for surveys, shall be identifiable individually, and shall be calibrated according to standards approved as appropriate by the Society.

3.4.2 When the survey applicant receives the survey, a person supervising the survey preparations and with knowledge of the inspection items shall be present during the survey, and shall extend the required assistance to the Surveyor during the survey.

3.4.3 If the necessary preparations for survey have not been made, the supervisor is not present or if there is possibility of a hazard, the Surveyor at his own discretion, can stop the survey.

3.4.4 If the results of the survey show that repairs are necessary, the Surveyor shall notify the applicant to that effect. Upon receiving such a notification, the applicant shall carry out repairs and have the repairs confirmed by the Surveyor.

3.5 Installation Survey

3.5.1 Drawings and documents

The following drawings and documents are to be submitted for approval prior to proceeding with the installation work.

- (a) One-line diagram showing shipboard elements related to high voltage shore connection systems
- (b) Documents related to the earthing arrangement of the power supply system and its adjustment method
- (c) Documents related to measuring and monitoring instruments and alarms
- (d) Short circuit current calculation of the ship related to shore supply system
- (e) Data associated with interface of protection devices related to each shore equipment
- (f) Electric load analysis
- (g) Data associated with design maximum earth fault current and rated capacity of high voltage shore connection systems
- (h) Outer dimensions and size, internal arrangement, and degree of protection of distribution switchboard, circuit breaker capacity, capacity of connecting sockets and drawings associated with receiving shore power
- (i) Data of construction, capacity, impedance and so on, of transformer
- (j) Cable specifications

- (k) Data associated with receiving power and interface related to connecting points of main switchboard and high voltage shore power
- (l) Data associated with control flow and automatic synchronizing in case uninterrupted power is transferred under parallel connection for a short duration
- (m) Interlocking data associated with safety during connection, isolation and disuse
- (n) Data associated with details of installation of cable management system
- (o) Drawings associated with arrangement of equipment and cable runs related to high voltage shore connection systems
- (p) Instruction manual

3.5.2 Tests at manufacturing plant

- (a) High voltage switchboard (shore connection switchboard and on-board receiving switchboard)
Tests required in 5.8 and 14.6.4 of Part VII of the Rules for Steel Ships shall be carried out in the presence of the Surveyor at the manufacturer's plant after completion of the ship's high voltage switchboard (shore connection switchboard and on-board receiving switchboard). In this case, the temperature rise test required by 5.8.1 in Part VII of the Rules for Steel Ships, may be omitted. If the on-board receiving switchboard is of low voltage (if the rated voltage is below 1 kV), all the tests required in 5.8 of Part VII of the Rules for Steel Ships shall be carried out but 14.6.4 of Part VII of the Rules for steel ships does not apply.
- (b) High voltage cable reel and slip rings
After completion, the tests below shall be carried out on the slip rings at the manufacturer's works. In principle, the test conditions shall be according to IEC 62271-200. For the second and later units of the same type, tests may be omitted except for the tests in (i) and (iii).
 - (i) Voltage withstand test
 - (ii) Impulse voltage withstand test
 - (iii) Insulation resistance measurement
 - (iv) Heat run test
 - (v) Short circuit withstand test
 - (vi) Arc test (if accessible in the charged condition)
- (c) Transformer
Transformer tests shall be carried out in the presence of the Surveyor according to 7.4 and 14.4 in Part VII of the Rules for Steel Ships.

3.5.3 Tests at the shipyard

- (a) Shore connection switchboard and on-board receiving switchboard
After on-board installation, the insulation resistance measurement of the shore connection switchboard and the on-board receiving switchboard shall be carried out in the presence of the Surveyor.
- (b) Cable tests after installation

Voltage withstand test of cables shall be carried out according to 14.7.2 (f) in Part VII of the Rules for Steel Ships, in the presence of the Surveyor.

3.6 Special Survey

The following tests shall be carried out in the presence of the Surveyor:

- (a) General examination
- (b) Insulation resistance measurement
- (c) Voltage withstand test of cable (Test method shall be according to 14.7.2 (f) in Part VII of the Rules for Steel Ships. If the shore connection equipment has been used or voltage withstand test has been carried out within 30 months, this test may be omitted.)

3.7 Annual Survey

The following tests shall be carried out in the presence of the Surveyor:

- (a) General examination
- (b) Insulation resistance measurement (If the shore connection equipment has been used or insulation resistance measurement has been carried out within 30 months, this test may be omitted.)
- (c) Voltage withstand test of cable (Test method shall be according to 14.7.2 (f) in Part VII of the Rules for Steel Ships. If the shore connection equipment has been used or voltage withstand test has been carried out within 30 months, this test may be omitted.)

Chapter 4 Requirements for High Voltage Shore Connection Systems

High voltage shore connection systems are to comply with the requirements of this chapter. However, if the results of the compatibility assessment prescribed in 4.3 of this chapter show that compliance with a part of the requirements is impractical or impossible, compliance with this requirement may be exempted. In this case, when there is a need to change the equipment on the ship side based on the change of equipment on the shore side or on the requirement, quick countermeasures should be taken under the responsibility of the operator.

4.1 General Requirements for All Equipment

4.1.1 Arrangement of equipment

- (a) High voltage shore connection system shall be installed in access controlled spaces.
- (b) High voltage shore connection system shall not be installed in hazardous spaces.
- (c) Shore connection switchboard shall be installed in a space protected from exposure.
- (d) Shore connection switchboard shall be installed as close as possible to the receiving point. The distance between the supply point and the receiving point shall be as short as possible.
- (e) Adequate space shall be provided around the shore connection switchboard to enable the operator to perform connection and disconnection operations.

4.1.2 Means to confirm compatibility with shore power

Locations for controlling high voltage shore circuit breaker (e.g., in the engine control room) shall be provided with means to confirm status of shore power (for instance, voltage, frequency, phase sequence, etc.)

4.1.3 Capacity

High voltage shore power equipment shall have adequate capacity to supply power for the following: (For this purpose, loads on ship side may be limited beforehand when power is supplied from shore side).

- (a) Normal loads required at berth
- (b) Emergency loads (may be limited to load used while ship is berthed)
- (c) Loads required for ship operation while at berth.

4.1.4 Earthing

(a) Equipotential bonding

Equipment for equipotential bonding between ship and shore shall be provided. For this equipment, interlock shall be provided so that high voltage shore circuit cannot be connected until equipotential bonding is established. Cable used in equipotential bonding (equipotential bonding cable) may be integrated with high voltage flexible cable. When the equipotential bonding cable is intended to allow earth fault current to flow, the cross section area of the said cable shall be adequate to withstand the designed maximum earth fault current.

4.1 General Requirements for All Equipment

(b) Safe interlock for equipotential bonding

Means for interlocking shall be provided such that connection with high voltage shore supply is automatically cut off when equipotential bonding is lost.

(c) Compatibility with system earthing

When establishing high voltage shore connection, consideration shall be given to providing an earthing arrangement that is compatible with the earthing arrangement specific to the ship (for instance, in case of isolated neutral system, the isolated neutral condition shall be maintained and in the high resistance earthing condition, high resistance earthing condition shall be maintained). Functions for detecting and protecting earthing shall be capable of being used continually even during high voltage shore connection.

4.1.5 Rated voltage

Rated voltage of electric equipment shall be appropriate for the earthing system.

4.1.6 Capacity to withstand short circuit current

Under the conditions indicated below, the prospective short circuit current at all points in the on-board distribution system shall not exceed the short circuit capacity of the circuit breaker. The circuit breaker shall be selected/set such that the short circuit current supplied to the shore power supply switchboard from the on-board distribution system shall be limited less than 16 kA (less than 25 kA in case of passenger ships and LNG carriers).

(a) Before shore connection

(b) During short-time parallel connection of shore power and on-board generator

(c) After shore connection

4.1.7 Coordination of protection devices

(a) Circuit breakers used in shore connection shall be coordinated with circuit breakers for generator as far as possible so that a blackout does not occur even a short circuit occurs in the high voltage shore connection system during parallel connection with shore power and on-board generator.

(b) The circuit breaker in the on-board distribution system shall be coordinated as far as possible with the circuit breaker for shore connection so that shore power is supplied continuously to other circuits in the on-board distribution system even if short circuit occurs in the on-board distribution system while power is supplied from shore.

4.1.8 Load transfer

(a) Load transfer by short time parallel connection

In ships where short time parallel connection of on-board generator and shore power is performed so that on-board power and shore power can be transferred without a blackout, the following requirements shall be complied with:

- (i) The shore power voltage shall be within the range of regulation of the automatic voltage regulator of the on-board generator.
- (ii) Automatic synchronizing means shall be provided.
- (iii) Automatic load transfer means shall be provided.

(b) Load transfer via blackout

In ships performing load transfer via blackout, interlocking means shall be provided so that the high voltage shore power circuit breaker activates only in the no voltage condition. Interlocking means shall be provided so that shore power and on-board power are not switched on simultaneously onto a dead switchboard.

4.1.9 Restoration after an accident

When shore power is lost, on-board power required for safety operations shall be automatically restored. The detailed flow shall be indicated in the instruction manual.

4.1.10 Emergency shutdown equipment

- (a) Emergency shutdown equipment shall be provided that operate because of the factors given below. Note that during emergency shutdown, high voltage shore circuit breaker shall be opened immediately.
 - (i) Loss of equipotential bonding
 - (ii) Over tension of the high voltage flexible cable or inadequacy of remaining cable with an automatic tension control device
 - (iii) Loss in the shore connection safety circuit
 - (iv) Activation of emergency stop buttonAll pull-out operations of high voltage plugs in the charged condition (pilot contact is assumed to be disconnected before disconnecting each phase contact; emergency shutdown may be initiated by pilot contact).
- (b) Emergency stop switch for initiating emergency shutdown shall be installed at the following locations: The emergency stop switch shall be installed in an easily visible position, prevent operational errors, and shall be reset manually.
 - (i) Remote control location for controlling circuit breaker (if it exists)
 - (ii) Control location for automatic tension control device having cable management system
 - (iii) Above shore connection switchboard
 - (iv) May be provided at other locations deemed necessary.
- (c) After emergency shutdown, on-board power supply shall be automatically restored.

4.1.11 High frequency waves

When convertor is provided in the shore connection equipment to acquire the required voltage or frequency, the total harmonic distortion (THD) of the convertor shall be within 5% in the all operating load ranges.

4.1.12 Monitoring and alarms

The monitoring and alarm devices given below shall be provided at the control location of high voltage shore connection circuit breakers. Moreover, if considered necessary, these devices shall also be provided at locations manned by crew.

- (a) Remaining cable is inadequate when tension in the high voltage flexible cable is excessive or there is an automatic tension control device
- (b) Shore power loss
- (c) Automatic emergency shutdown
- (d) Manual emergency shutdown

- (e) Safety device activation alarm (for example, overcurrent, earth fault)

4.2 Requirements for Equipment

4.2.1 General

Electric equipment shall be made of durable, flame-retardant, and moisture-proof materials; these equipment shall withstand marine environments, such as temperature. The degree of protection of equipment shall be according to 1.11 and 14.2.2 in Part VII of the Rules for Steel Ships.

4.2.2 Preventing condensation

Means to prevent condensation shall be provided if there is a risk of damage of insulation due to condensation of moisture.

4.2.3 Air gap clearance

The air gap clearance of conducting parts in high voltage electric equipment shall be according to 14.2.3 (a) in Part VII of the Rules for Steel Ships.

4.2.4 Creepage distance

The creepage distance of high voltage electric equipment shall be adequate for the rated voltage. Tracking index in the condensation condition of insulation materials according to IEC 60112, or transient over voltage during an accident when circuit breaker is activated, shall also be considered.

4.2.5 Shore connection switchboard

(a) Construction

The shore connection switchboard shall conform to the provisions of IEC 62271-200.

(b) Circuit breaker

- (i) Circuit breaker shall be installed in the shore connection switchboard to protect the high voltage cable to the on-board receiving switchboard.
- (ii) Low voltage protector (LVP) shall be provided in the high voltage shore circuit breaker.
- (iii) The rated short circuit making current of the high voltage shore circuit breaker shall be greater than the maximum prospective short circuit current (maximum peak value).
- (iv) The rated breaking capacity of the high voltage shore circuit breaker shall be greater than the maximum prospective short circuit current (rms value).

(c) Instrumentation and protection devices

The instrumentation listed below shall be provided in the shore connection switchboard. Backup power supply for operation of at least 30 minutes shall be provided for the protection devices. In the event of a breakdown of this backup power supply, alarm shall be given in the machinery control room.

- (i) Voltmeter (that can measure voltage in each phase)
- (ii) Short circuit protection device (open circuit and alarm)
- (iii) Overload protection device (open circuit and alarm)
- (iv) Earth fault detector
- (v) Unbalance protection device (for multiple connections)

4.2.6 On-board receiving switchboard

(a) Construction

On-board receiving switchboard shall conform to IEC 62271-200, except when low voltage is received (less than 1 kV) through a transformer.

(b) Instrumentation and protection devices

(i) For load transfer via short term parallel connection, the following instrumentation and protection devices shall be provided in the on-board receiving switchboard:

- (1) 2 sets of voltmeters (for on-board power and shore power)
- (2) Phase sequence indicator for shore power
- (3) 2 sets of frequency meters (for on-board power and shore power)
- (4) Ammeter for shore power (for all three phases)
- (5) Synchronizing device
- (6) Short circuit protection device (open circuit and alarm)
- (7) Overcurrent protection device (open circuit and alarm)
- (8) Overcurrent alarm
- (9) Earth fault detection (alarm and insulation system connection, and open circuit if required)
- (10) Over-voltage/ low voltage protection device (open circuit and alarm)
- (11) Over-voltage/ low voltage alarm
- (12) High/ low frequency protection device (open circuit and alarm)
- (13) High/ low frequency alarm
- (14) Reverse power protection device (open circuit and alarm)
- (15) Phase sequence protection device (alarm and interlock)

(ii) For load transfer via blackout, the following instrumentation and protection devices shall be provided in the on-board receiving switchboard:

- (1) Voltmeter
- (2) Frequency meter
- (3) Ammeter (for all three phases)
- (4) Short circuit protection device (open circuit and alarm)
- (5) Over current protection device (open circuit and alarm)
- (6) Overcurrent alarm
- (7) Over-voltage/ low voltage protection device (open circuit and alarm)
- (8) Over-voltage/ low voltage alarm
- (9) High/ low frequency protection device (open circuit and alarm)
- (10) High/ low frequency alarm
- (11) Phase sequence protection device (alarm and interlock)

(c) Circuit breaker

(i) The rated short circuit making current of the circuit breaker shall be greater than the maximum prospective short circuit current (maximum peak value).

(ii) The rated breaking capacity of the circuit breaker shall be greater than the maximum prospective short circuit current (rms value).

(iii) Interlocking means shall be provided for the circuit so that the circuit breaker cannot be closed in the following conditions:

- (1) One of the earthing switches is closed (shore side, ship side or both)
- (2) The pilot connection circuit is not established
- (3) The emergency shutoff facilities are activated

- (4) Abnormality such as effect of controller (shore side/ship side) or self-monitoring function (alarm/safety device) on safe connection is detected
- (5) Ship-shore communication system (if it exists) is not working
- (6) High voltage power is not being supplied
- (7) Equipotential bonding is not established
- (8) Earth fault condition is detected in on-board distribution system

4.2.7 Cable management system

The cable management system shall prevent the tension limits of the cable from being exceeded during cable extension or retraction.

4.2.8 High voltage plug and socket

- (a) High voltage plug (limited to ship-shore connections) and high voltage shore circuit breaker shall be provided with interlocking means so that high voltage plug can be pulled out only after the circuit breaker is open. This interlocking means may be realized through appropriate construction of high voltage plug and socket.
- (b) High voltage plug and socket shall be protected from dust, humidity and condensation when not in use. Degree of protection provided by enclosures for high voltage plug and socket shall comply at least with IP66 rating.
- (c) High voltage plug and socket shall be provided with interlocking means so that plug can be pulled out or inserted only when the earthing switch is closed. However, high voltage plug and socket other than for ship-shore connections need not be provided with interlocking means provided that safety measures are adopted during removal (such as automatic opening of circuit breaker, device for discharging residual charge, earthing device).
- (d) High voltage plug and socket shall be protected so that internal fault shall not cause harm to personnel.
- (e) When inserting the high voltage plug, the earthing connection unit shall be connected before connecting the conducting pin.
- (f) Pilot contact shall be provided in all high voltage plugs to maintain safe circuits. At least three pilot contacts are required in a single phase plug. When two or more cables are laid, interlock shall not be removed until all the cables are connected.
- (g) While high voltage shore circuit breakers are open, the high voltage flexible cable conductor shall be maintained in the earthed condition manually or automatically. The pilot contact assembled in the high voltage plug and socket may be used for this interlocking application.
- (h) Connection shall be made according to the following procedure:
 - (i) Connection
 - (1) Earthing connection
 - (2) Power circuit connection
 - (3) Pilot connection
 - (ii) Isolation
 - (1) Isolation of pilot connection
Shall be isolated before the required protection performance is lost.

- (2) Isolation of power circuit
- (3) Isolation of earthing circuit

- (i) In principle, all the electrical and mechanical specifications of the high voltage plug and socket shall be according to IEC 62613-1 and -2; however, if the specifications on the shore side are different, then those specifications may be applied.
- (j) The connection of the high voltage plug and socket shall be supported such that the cable weight does not fall on it.

4.2.9 Transformer

- (a) A transformer when installed shall comply with chapter 7 and 14 in Part VII of the Rules for of Steel Ships. The current of high frequency harmonics shall be considered when deciding the rated capacity of the transformer.
- (b) Protection of transformer
The transformer shall be protected from short circuits and overloads. Time and current shall be considered when setting the values for overload protection according to the thermal capacity of the transformer.
- (c) Shore system and shipboard distribution system shall be separated by an insulating transformer. An on-board transformer may not be required if the earthing arrangement for neutral is the same on ship and shore and an insulating transformer is provided on shore.
- (d) If necessary, procedures shall be established for reducing the transformer inrush current, inhibiting the start of large capacity electric motor, inhibiting connection to large capacity loads, and so on.
- (e) Primary and secondary windings of the transformer shall be separate. Secondary winding shall be star configuration.
- (f) The neutral point of a transformer shall be connected according to the earthing arrangement used in the main distribution system.
- (g) If the transformer is connected to a low voltage distribution system, insulated winding shall be provided between the high voltage and low voltage systems.

4.2.10 High voltage cable

Fixed high voltage cable installed on-board shall comply with the provisions of IEC 60092-353 and -354. High voltage cables that are not fixed installations (i.e. high voltage flexible cable) shall comply with standards deemed appropriate by the Society.

4.2.11 Laying high voltage cables

- (a) If it is unavoidable to pass high voltage cable through accommodation space, fully closed cable run shall be used.
- (b) High voltage cables are not to be installed in the same cable tray as low voltage cables below 1 kV.

- (c) When high voltage cable is installed in a cable tray or equivalent, the cable shall have continuous metal sheathing or armor, which shall be effectively earthed. If this is not possible, the entire length of the high voltage cable shall be covered effectively by earthed metallic case.
- (d) High voltage cables shall be appropriately marked so that they can be easily identified.

4.2.12 Storage

High voltage shore power associated equipment that are removable and that are not in use, shall be stored in a dry space where they cannot sustain damage. Special precautions shall be adopted to protect the internal parts of high voltage plug and socket from dust, humidity and condensation.

4.3 Compatibility Assessment

4.3.1 Compatibility assessment related to the items below shall be performed to confirm the consistency with shore power systems before receiving high voltage shore power.

- (a) Consistency with the IEC standard and differences
- (b) Minimum and maximum prospective short circuit current
- (c) Rated capacity of shore power, ship-shore connections and shipside connections
- (d) Coefficients such as derating coefficient (if it exists) due to multilayer winding of cable
- (e) Acceptable voltage variations in the range of loads from no-loads to maximum loads of on-board distribution switchboard
- (f) Response to stable condition and temporary on-board demand loads during supply of high voltage shore power, and stepwise load variation in high voltage shore power
- (g) System study and calculations
- (h) Validation of impulse withstand capability
- (i) Compatibility with ship-shore control voltage
- (j) Compatibility with communication link
- (k) Validation of compatibility with distribution system (neutral point earth, etc.)
- (l) Shipside earth fault protection, monitoring and alarm functions during high voltage shore power connections
- (m) Adequate cable length
- (n) Compatibility with safety circuits

- (o) Overall distortion factor
- (p) Study documents, if hazardous space exists
- (q) Considerations for method of reducing overload current when connected to high voltage shore supply, inhibiting start of large capacity electric motor with possibility of abnormality or overload occurrence, or automatic load reduction
- (r) Protection from electrochemical corrosion due to equipotential bonding
- (s) Control circuit connection requirements for load transfer parallel connection
- (t) Monitoring equipotential bonding

4.4 Maintenance Plan

Weekly inspection and maintenance plan for high voltage shore supply systems shall be established. Maintenance plan shall be included in the instruction manual.

4.5 Instruction Manual

4.5.1 The instruction manual for high voltage shore supply system shall be stored at an easily accessible location for the operator.

4.5.2 The instruction manual shall include at least the following:

- (a) Operator qualification requirements
- (b) Conformity assessment method for shore power connection including acceptable voltage variations, frequency, accurate phase rotation, shore-side impedance for prospective short circuit current assessment, neutral point earthing arrangement for conformity assessment of earthing method.
- (c) Operating procedure for actions to be taken when the shore power supply is incompatible with on-board equipment
- (d) Stepwise instructions from the establishment of shore power connection to its isolation, including equipotential bonding
- (e) Procedure for transmitting “permission to switch on” shore-side circuit breaker in high voltage shore connection systems
- (f) Emergency shutdown procedure
- (g) Procedure for restoration from fault condition
- (h) Storage of equipment associated with high voltage shore connection system

- (i) Maintenance plan for high voltage shore connection system

Chapter 5 Fire Protection Construction and Fire Extinguishing System

5.1 General

At least fire protection construction and fire extinguishing system required for “Other machinery spaces” in Part IX of the Rules for Steel Ships shall be complied with in spaces where high voltage shore connection systems are installed (excluding spaces where on-board receiving switchboards are installed).

Fire protection construction and fire extinguishing systems for machinery and equipment installed directly in exposed parts shall be as deemed appropriate by the Society.