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GUIDELINES FOR AUTONOMOUS CARGO SHIPS

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CONTENTS

PREFACE 1
CHAPTER 1 GENERAL 3
1.1 General requirements 3
1.2 Class notations 3
1.3 Definitions 4
1.4 Goal 4
1.5 Functional requirements 5
1.6 Performance standards 6
1.7 Risk analysis 6
1.8 Equivalent and alternative designs 6
CHAPTER 2 SITUATION AWARENESS 7
2.1 General requirements 7
2.2 Goal 7
2.3 Functional requirements 7
2.4 Equipment and performance requirements 10
2.5 Survey and tests 11
CHAPTER 3 NAVIGATION CONTROL 13
3.1 General requirements 13
3.2 Goal 13
3.3 Functional requirements 13
3.4 Design principle of the navigation control system 14
3.5 Anchoring and mooring control 15
3.6 Navigation control station on board 16
3.7 Data storage 17
3.8 Survey and tests 17
CHAPTER 4 MACHINERY INSTALLATIONS 19
4.1 General requirements 19
4.2 Goal 19
4.3 Functional requirements 19
4.4 Prescriptive requirements 20
4.5 Survey and tests 30
CHAPTER 5 MOORING AND ANCHORING 31
5.1 General requirements 31
5.2 Goal 31
5.3 Functional requirements of mooring system 31
5.4 Prescriptive requirements of mooring system 32
5.5 Functional requirements of anchoring system 32
5.6 Prescriptive requirements of anchoring system 33
5.7 Survey and tests 33
CHAPTER 6 ELECTRICAL INSTALLATIONS 35
6.1 General requirements 35
6.2 Goal 35

6.3 Functional requirements 35
6.4 Prescriptive requirements 35
6.5 Survey and tests 37
CHAPTER 7 COMMUNICATION AND SIGNAL EQUIPMENT 38
7.1 General requirements 38
7.2 Goal 38
7.3 Functional requirements 38
7.4 Equipment and requirements for communication 39
7.5 Equipment and requirements for signal 40
7.6 Survey and tests 41
CHAPTER 8 HULL CONSTRUCTION AND SAFETY 42
8.1 General requirements 42
8.2 Goal 42
8.3 Functional requirements 43
8.4 Prescriptive requirements 43
8.5 Survey and tests 49
CHAPTER 9 FIRE-FIGHTING 51
9.1 General requirements 51
9.2 Goal 51
9.3 Functional requirements 51
9.4 Probability of ignition 52
9.5 Detection and alarm 52
9.6 System monitoring and control 53
9.7 Containment of fire 54
9.8 Fire fighting 54
9.9 Structural integrity 55
9.10 Inert gas system 56
9.11 Alternative design and arrangement requirements 56
9.12 Survey and tests 56
CHAPTER 10 ENVIRONMENTAL PROTECTION 58
10.1 General requirements 58
10.2 Goal 58
10.3 Functional requirements 58
10.4 Prescriptive requirements 59
10.5 Survey and tests 61
CHAPTER 11 SHIP SECURITY 62
11.1 General requirements 62
11.2 Goal 62
11.3 Functional requirements 62
11.4 Prescriptive requirements 63
11.5 Survey and tests 63
CHAPTER 12 REMOTE OPERATION CENTER 65
12.1 General requirements 65
12.2 Goal 65

12.3 Functional requirements for the remote operation center 65
12.4 Arrangement of remote operation center 65
12.5 System design principle for remote operation center 66
12.6 Firefighting 66
12.7 Electric power supply 66
12.8 Environment of the remote operation center 67
12.9 Operation personnel in the remote operation center 67
12.10 Management requirements 67
12.11 Survey and tests 68
CHAPTER 13 CYBER SECURITY 69
13.1 General requirements 69
13.2 Goal 69
13.3 Technical requirements for cyber security 69
13.4 Surveys and tests 69
CHAPTER 14 SURVEY AND CERTIFICATION 71
14.1 General requirements 71
14.2 Maintenance of ship 71
14.3 Survey conditions 71
14.4 Plan approval 71
14.5 Survey during construction 71
14.6 Survey after construction 72
14.7 Certification of remote operation center 72

PREFACE

With the fast development and application of intelligent technologies, the automation of ships will become the inevitable trend of shipping development in the future.

As the development of current international maritime conventions, codes, rules and other technical standards is based on the prerequisite that the ship satisfies manning requirements of current conventions and regulations, they are not applicable to the development of automation in the future; and as a result, it is imperative to develop relevant technical standards applicable to the autonomous ship.

IMO has also fully realized the importance and urgency of autonomous ship legislation. In order to ensure the safe, secure and environmentally sound operation of Maritime Autonomous Surface Ships (MASS), the Maritime Safety Committee, at its 99th session, officially started the regulatory scoping exercise for the use of Maritime Autonomous Surface Ships (MASS). A framework for the regulatory scoping exercise has been established with preliminary definition of autonomous ship and autonomy degrees.

The autonomy degrees of MASS are as follows:

1. Ship with automated processes and decision support;
2. Remotely controlled ship with seafarers on board;
3. Remote controlled ship without seafarers on board;
4. Fully autonomous ship.

The autonomous ship will be developed progressively with a phased approach. With the improvement of ship's autonomy degrees, seafarers on board will gradually be replaced and the unmanned and autonomous navigation of ship will eventually be achieved. The Guidelines mainly cover technical requirements for achieving autonomy degrees 3 and 4 above.

Taking the principle of achieving an overall safety and environmental protection level at least the same as that provided in SOLAS, MARPOL, COLREG72 and STCW, and on the basis of risk analysis method, the Guidelines specify requirements for the construction of autonomous cargo ships, goal and functional requirements for ship systems as well as survey and test in accordance

with the GBS method, in order to provide basis for the design and construction of autonomous cargo ships and facilitate the test and development of autonomous ships.

The logic of specific implementation with regard to the risk analysis of autonomous cargo ships is as follows:

(1) classification of operational scenarios of ships: navigation at sea, entering and leaving port, berthing and unberthing, anchoring, cargo handling etc.;

(2) identification of risk incidents: collision, grounding, capsizing, structural loss, fire/explosion, loss of communication, power/electrical interruption, loss of control of direction, security threat (including cyber security), pollution, etc.;

(3) carrying out risk analysis: analyze the severity level of risk, by comparing with the criteria: "equivalent safety and environmental protection level of conventional ships", find the unacceptable risk encountered by the operation of autonomous ships;

(4) proposing control measures of risk incidents: propose corresponding risk control measures according to the risk analysis, and verify the feasibility of measures;

(5) developing goal and functional requirements for autonomous cargo ships: goal and functional requirements for perception, communication, decision making and operation of autonomous cargo ships are developed based on the result of risk analysis. The design requirements for the remote operation center and ship's systems are also proposed.

Goal-based standards (GBS) method is applied in the Guidelines. The contents of each chapter include goal, functional requirements, prescriptive requirements to achieve functions and survey and test requirements.

CHAPTER 1 GENERAL

1.1 General requirements

1.1.1 The Guidelines apply to the design and construction of autonomous sea-going steel cargo ships.

1.1.2 The Guidelines cover requirements for the prevention of ship's safety and environmental pollution accidents at sea.

1.1.3 Ship's safety level is at least the same as that generally required in the following conventions and/or regulations:

(1) International Convention for the Safety of Life at Sea (SOLAS);

(2) International Regulations for Preventing Collisions at Sea, 1972 (COLREG);

(3) International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW).

1.1.4 The following conventions and amendments relating thereto form technical requirements for environmental protection of the Guidelines:

(1) International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (2011 consolidated edition);

(2) International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004;

(3) International Convention on the Control of Harmful Anti-Fouling Systems on Ships, 2001;

(4) Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships, 2009.

1.1.5 In addition to the Guidelines, the autonomous ship is to satisfy the relevant requirements of the Administration of the flag State.

1.2 Class notations

1.2.1 At the request of the owner, where the ship's hull structure and system (including equipment) have been constructed with plan approval by and under the supervision of ISC and comply with the provisions of the Guidelines, the class notation **AS** may be assigned and appended to the ship type notation. For ships designed and constructed in accordance with the Common Structural Rules, the class notation **AS** is appended to the class notation CSR, e.g.:

Bulk carrier (CSR): □CSA Bulk Carrier; CSR; **AS**

Container ship: □CSA Container Ship; **AS**

1.2.2 The assignment, maintenance, suspension, cancellation and reinstatement of class notation of autonomous ships are to comply with the provisions of Section 9, Chapter 2, PART ONE of the Rules for Classification of Sea-going Steel Ships.

1.2.3 At the request of the owner, other types of class notations listed in the Rules for Classification of Sea-going Steel Ships may be assigned upon assessment by ISC.

1.3 Definitions

1.3.1 Terms used in the Guidelines are defined as follows:

(1) Autonomous cargo ship (hereinafter referred to as autonomous ship): a ship which, to a varying degree, can operate independent of human interaction.

(2) Autonomy: a ship and/or a shipboard system with control functions which can make decisions by itself and determine actions.

(3) Remote control: a control mode which controls and operates a ship and/or shipboard equipment and system from another location outside the ship.

(4) Remote operation center: a centralized space outside the ship capable of providing sufficient support and safeguards as well monitoring and controlling the ship.

1.4 Goal

1.4.1 The goal of the Guidelines is to achieve ship's safety and environmental protection in the following scenarios by defining goals, functional requirements, prescriptive requirements satisfying functional requirements and survey and test requirements for hull construction, ship's systems and remote operation center:

(1) navigation at sea;

(2) entering and leaving port;

(3) berthing/unberthing;

(4) anchoring;

(5) cargo operation.

1.5 Functional requirements

1.5.1 In order to achieve the goal of paragraph 1.4, the ship and its remote operation center are to satisfy the functional requirements of 1.5.2 to 1.5.4.

1.5.2 The hull construction is to have:

(1) structural and watertight integrity sufficient to withstand the response of expected environmental and internal loads;

(2) sufficient subdivision and stability in intact and damage conditions;

(3) appropriate structural fire integrity corresponding to the fire risk of spaces and protection of system function.

1.5.3 Ship's systems are to have functions of perception, communication, decision making and operation etc., and make response satisfying the requirements for ship's design capability to the ship's expected environment (Table 1.1) and change of ship's condition (Table 1.2), and carry out automatic change-over to the autonomous control mode in case of unreliable communication environment after release of the ship.

Ship Environment **Table 1.1**

Environment	Description
Weather	Weather conditions, including wind, wave, current and swell, which lead to ship's excessive motion and affect ship manoeuvring
Visibility	Conditions affecting the effectiveness of environment perception, including fog, rain and dark night
Temperature	Temperature leading to structural icing and system freezing
Traffic volume	Other ships or objects existing in the vicinity of the ship
Restriction	Operation within SECA, ship reporting or other restrictive areas

Restriction on Ship's Condition **Table 1.2**

Limitation	Description
Propulsion	Reduction or loss of ship speed and/or manoeuvring capability
Sensor	Reduction or loss of sensor system capability
Communication	Reduction or loss of network and radio communication capability

1.5.4 The remote operation center is to have sufficient capabilities in terms of safety, electrical power, communication, security (including cyber security and management) and suitable environmental conditions, in order to carry out continuous monitoring, testing, remote control,

communication and emergency disposal to the ship or fleet.

1.6 Performance standards

1.6.1 The communication bandwidth is to be designed and tested with sufficient performance to support remote control.

1.6.2 UPS is to have the power supply capability of sending the information on ship position for at least 7 days continuously when the ship is out of control.

1.7 Risk analysis

1.7.1 For a ship applying for the class notion of autonomous cargo ship, risk analysis is to be carried out to the ship and its systems at the design stage in accordance with the practical operational demands of the ship. Design is to be carried out in accordance with the requirements of the Guidelines.

1.8 Equivalent and alternative designs

1.8.1 Where the hull construction and the design and arrangement of ship systems of autonomous ship fail to satisfy relevant requirements of the Guidelines, equivalent and alternative designs may be used, provided that they satisfies the goal and functional requirements of the Guidelines.

1.8.2 In case equivalent and alternative designs are used, assessment and approval are to be carried out in accordance with relevant requirements of ISC.

CHAPTER 2 SITUATION AWARENESS

2.1 General requirements

2.1.1 This Chapter specifies requirements for perceptive functions in each operational scenario specified in 1.4.1 of the Guidelines, the design of perceptive system and the inspection, testing and certification of relevant equipment of autonomous ships.

2.2 Goal

2.2.1 By means of perception and obtaining of the information on external environment and ship motion in operational scenarios specified in 1.4.1 of the Guidelines, provide information input for decision-making of autonomous or remote control operation during the process of navigation, entering and leaving ports, berthing and unberthing etc. of autonomous ships, in order to ensure the safety of navigation.

2.3 Functional requirements

2.3.1 The ship is to be capable of satisfying the requirements for situation awareness in 2.3.2 of this Chapter in all environmental conditions all the time.

2.3.2 The autonomous ship is to be capable of perceiving and obtaining the following environmental information:

(1) periodical obtaining of the short-term and long-term weather forecast data of the route, at least including:

① wind speed and direction;

② wave height and mean period;

③ swell height, direction and mean period;

④ current speed and direction;

⑤ tropical cyclone (or typhoon): maximum wind speed, gust speed, radius of moderate gale etc.;

⑥ extratropical cyclone: central pressure, moving path and speed, cold/warm front etc.;

⑦ warning of strong cold high pressure (cold wave and gale);

⑧ ice condition (where applicable).

(2) real-time perception of environmental and meteorological data during navigation, at least including:

① wind speed and direction;

② sea surface visibility.

(3) real-time perception of the information on the ship itself:

① information on position, speed and heading;

② ship motion response, at least including pitch and roll angle and the sway and heave acceleration;

③ bow, amidship and stern draught, port and starboard draught.

(4) obtain the real-time video picture in the horizontal direction of the ship at any time when necessary;

(5) continuously obtain the real-time video picture within an angle of view from right ahead to 112.5° on each side of the ship in the horizontal direction;

(6) timely obtain the data of electronic charts and information update related to the planned route;

(7) obtain AIS data of surface objects;

(8) real-time perception or obtaining of the information on other ships at sea as follows:

① perception of the information on approximate bearing of other ships within 12 nautical miles;

② perception of the position, motion direction, motion speed and actual distance of other ships within 6 nautical miles;

③ real-time perception of detailed information of other ships within 2 nautical miles, including position, motion direction, motion speed, size, actual distance and intersection angle with the ship itself;

④ real-time perception of information on signal lights, shapes, whistles, bells and gongs of other ships within at least 2 nautical miles; identification of ship's navigational condition described in COLREG;

(9) real-time perception of the information on position, size and distance of static obstacles above water within at least 2 nautical miles;

(10) real-time perception of position, size, distance and motion condition of mobile and floating objects on the water with a cross section of 6.317 m^2 and above within at least 1 nautical mile;

(11) real-time perception of the distance between the bow and stern and the shore as well as the angle between the ship and the shore;

(12) real-time perception of measured water depth of ship's position;

(13) obtaining of the information on tidal change of port and other relevant environmental information.

2.3.3 The information perceived and obtained by the ship in any operational scenario is to be transmitted to the navigation control system in real time and when necessary transmitted to the remote operation center in real time.①

2.3.4 When any unidentified floating object is detected in the navigation direction by the ship, an alarm message is to be sent to the remote operation center so as to obtain the operational instruction from the center.①

2.3.5 The equipment and components of situation awareness system are to be sufficiently reliable so as to minimize the failure probability. The situation awareness equipment is to be so equipped and arranged to ensure that the ship's perception capability is not affected or it can be restored as soon as possible in case of single point failure of equipment, to ensure the availability of equipment during operation of autonomous ships.

2.3.6 The situation awareness equipment is to have self-check and alarm functions, capable of providing continuous monitoring during the normal operation of equipment. When equipment failure is detected, it is to be capable of sending an alarm and failure message to the navigation control system and remote operation center and generating a record.

2.3.7 For situation awareness equipment provided with redundant arrangement, its change-over device is to have self-check and alarm functions in order to ensure the availability of the change-over function.

2.3.8 When the failure of situation awareness equipment of autonomous ships finally leads to the damage of perception capability of the ship during navigation, evaluations are to be carried out by navigation control system on whether the ship is to enter the safety mode and relevant conditions are to be reported to the remote operation center to ensure the safety of ship.

2.3.9 The power supply of situation awareness system and equipment is to meet relevant

① The communication protocol of environmental perception equipment and system interface is to satisfy IEC 61162 series standards or equivalent requirements.

requirements for power system of autonomous ships in 6.4.1 and 6.4.2 of the Guidelines.

2.3.10 Where the design or equipment selection related to the situation awareness system of autonomous ships fails to meet the requirements of this Chapter, alternative or equivalent design may be accepted by ISC, provided that any risk existing in the design of perception system in all scenarios is fully identified and analyzed by means of risk assessment method (e.g. FMEA), the risk elimination measure is proposed and the design of situation awareness system is improved upon verification.

2.4 Equipment and performance requirements

2.4.1 The autonomous ship is at least to be provided with the following situation awareness equipment:

(1) 2 marine radars with ARPA function;

(2) ship's automatic identification system (AIS);

(3) 2 different position, navigation and timing (PNT) systems;

(4) 2 sets of electronic chart display and information systems;

(5) 2 sets of independent gyro compasses;

(6) echo sounder;

(7) speed and distance measuring device;

(8) infrared camera;

(9) low-light camera;

(10) 2 sets of ship motion sensor;

(11) anemorumbometer;

(12) 2 sets of visibility sensors;

(13) close range detection equipment, e.g. laser radar;

(14) sound reception and recording system.

Situation awareness equipment specified in 2.4.1(1), (3), (4), (5), (10) and (12) is to satisfy the provision of 100% redundancy.

2.4.2 The measurement range, accuracy and delay of close range detection equipment are to satisfy the decision-making requirements for berthing. From at least 0.2 m to 200 m, continuous monitoring is to be achieved with measurement accuracy not less than 0.1 m and delay not

exceeding 0.1 s.

2.4.3 Two sets of radars are to have the function of identifying small targets, capable of identifying mobile and floating objects on the water with a cross section of 6.317 m^2 and above within 1 nautical mile.

2.4.4 The camera is to at least have a visual range of 6 nautical miles, including in severe weather such as dark night, rainstorm and heavy fog; meanwhile it is to be capable of maintaining the clearness and smoothness of acquired video picture in expected environmental conditions.

2.4.5 The installation and arrangement of camera are to be such that the field of vision of video picture of the autonomous ship meets the requirements in 2.3.2(4) and (5) of this Chapter and not inferior to the equivalent visibility requirements in SOLAS regulation V/22.

2.4.6 All situation awareness equipment is to be capable of real-time acquisition of data so as to meet the requirement for timely decision making.

2.4.7 Radar, ECDIS, AIS, gyro compass, position, navigation and timing (PNT) system, echo sounder and speed and distance measuring device required in paragraph 2.4.1 need to meet the performance requirements in SOLAS regulation V/18.

2.4.8 The working condition of equipment related to situation awareness is to meet the requirements of Section 2, Chapter 1, PART FOUR of the Rules for Classification of Sea-going Steel Ships.

2.4.9 The design, manufacture and installation of equipment related to situation awareness are to meet the requirements of Section 3, Chapter 1, PART FOUR of the Rules for Classification of Sea-going Steel Ships.

2.4.10 The electromagnetic compatibility of situation awareness equipment is to meet the requirements of SOLAS regulation V/17 and IMO resolution A.813(19).

2.4.11 The situation awareness equipment of autonomous ships needs to be subject to product approval and survey by ISC.

2.5 Survey and tests

2.5.1 At the ship plan approval stage, the following plans and documents are to be submitted to ISC for approval:

(1) scenario of operation of autonomous ships and explanation on corresponding environmental

perception plan, including the list of parameters of situation awareness system (for information);

(2) diagram of ship's situation awareness system;

(3) arrangement of ship's situation awareness system;

(4) analysis report on reliability of situation awareness system capability in typical incidents of operational scenario of autonomous ships;

(5) report on coping strategy after loss of situation awareness capability in operational scenario of autonomous ships;

(6) evaluation report on design risk of situation awareness system (where applicable);

(7) specification of situation awareness equipment (for information);

(8) mooring test program (situation awareness part);

(9) sea trial program (situation awareness part);

(10) fitting technique of situation awareness system and equipment;

(11) maintenance plan of situation awareness equipment;

(12) additional plans and documents found necessary to be submitted for examination or information during the review process.

2.5.2 At the product type approval/plan approval stage, the following plans and documents are to be submitted to ISC for approval:

(1) system design specification;

(2) hardware specification;

(3) system wiring diagram;

(4) user operating manual;

(5) equipment maintenance manual (for information);

(6) additional plans and documents found necessary to be submitted for examination or information during the review process.

2.5.3 The survey is to be carried out in accordance with the approved mooring test program and sea trial program, in order to fully verify the situation awareness function of autonomous ships.

CHAPTER 3 NAVIGATION CONTROL

3.1 General requirements

3.1.1 The provisions of this Chapter apply to navigation control of autonomous ships.

3.1.2 An equivalent plan may be used for the design of navigation control of autonomous ships subject to the agreement of ISC.

3.2 Goal

3.2.1 Ensure the safety of navigation of autonomous ships in all scenarios, mainly including:

(1) autonomous navigation; and

(2) remote-control operation at the remote operation center if feasible; and/or

(3) operation by a navigation officer at the onboard control station (if any) during entering and leaving port or berthing and unberthing.

3.3 Functional requirements

3.3.1 The navigation control system is to have the following functions:

(1) route design and optimization, specific technical requirements are given in 2.4 of ISC Rules for Intelligent Ships;

(2) carrying out comprehensive analysis and decision-making using information of situation awareness and the ship itself, carrying out control of the propulsion and manoeuvring system, mooring system etc. in accordance with pre-determined route and achieving autonomous navigation, anchor handling, berthing and unberthing;

(3) implementing collision prevention decisions and operations bases on information perceived and obtained and in accordance with the International Regulations for Preventing Collisions at Sea, 1972;

(4) accepting the operation request from and the condition information of systems such as machinery installations, electrical installations, hull construction and safety, communication and signal, fire safety and environmental protection, making corresponding decisions and controlling the safety and environmental protection of ship;

(5) accepting the instruction from the remote operation center to carry out operation of systems

onboard the ship;

(6) carrying out operation of entering and leaving port, berthing and unberthing through the shipboard control station (if any).

3.4 Design principle of the navigation control system

3.4.1 The navigation control system generally consists of operational modes of autonomous navigation, control of ship by accepting instructions from the remote operation center and control of ship by the onboard navigation bridge (if any) and carries out change-over in accordance with the following principles:

(1) the ship can be designed with autonomous operation or remote control or both functions during berthing and unberthing or entering and leaving port;

(2) the ship is to have autonomous navigation function during navigation at sea. The remote operation center can take over the control right from the ship if necessary. During the process of remote control, if the communication fails to meet the requirements for remote control, the ship will automatically switch back to autonomous navigation;

(3) where the ship is provided with a navigation control station, it can obtain the control right of ship subject to approval by the remote operation center. After the completion of control, the control right needs to be transferred back to the remote operation center.

3.4.2 The navigation control system generally has the functions of route design and optimization, propulsion control, automatic collision prevention, anchoring and mooring control, etc.

3.4.3 Each ship is at least to be provided with two sets of navigation control systems, either of which serves as the hot standby for the other. The navigation control system is to be so designed and arranged that it still can achieve autonomous navigation and accepting remote-control operation by the remote operation center in case of single failure of the whole system (only considering the failure of moving parts, not including fire in a single compartment or flooding of a single compartment below the waterline).

3.4.4 The navigation control system is to be connected to the situation awareness system, communication and signal system, machinery installations, anchoring and mooring system, electrical system, hull safety system, fire safety system, environmental protection system and security system through a redundant network (or equivalent measure).

3.4.5 When redundant system and equipment are connected to the navigation control system, the interfaces are to be independent from each other.

3.4.6 Upon receiving the failure of a connected system, the navigation control system is to be capable of analyzing the residual capacity of the ship to decide the control strategy at the next step.

3.4.7 The navigation control system is to be designed in accordance with the fail-safe principle and meanwhile provided with self-check function to obtain the failure information of connected systems.

3.4.8 The navigation control system is generally to have functions of automatic heading control or track control, receive the instruction from the remote operation center to carry out remote-control operation of each thruster and also carry out joint operation for multiple thrusters.

3.4.9 The automatic collision prevention system can carry out analysis and calculation to achieve automatic collision prevention based on the information of situation awareness.

3.4.10 The navigation control system is to be able to receive the optimized route speed from the remote operation center and achieve autonomous navigation. It may also be designed to automatically receive sea state information to carry out autonomous route design and optimization on board and autonomous navigation.

3.4.11 The navigation control system is to meet the applicable requirements of Chapter 2, PART SEVEN of the Rules for Classification of Sea-going Steel Ships.

3.5 Anchoring and mooring control

3.5.1 The mooring control is to satisfy the following requirements:

(1) evaluation on whether berthing, mooring and unberthing can be carried out in accordance with the signal and data detected and received on a real-time basis, the limitation of the ship’s manoeuvring capability (including navigation aided by external force) and the limitation of the mooring capability;

(2) a plan of berthing, mooring and unberthing is developed if the capability is sufficient as determined by the evaluation result;

(3) during the implementation of plan, environmental loads and hawser conditions are monitored on a real-time basis and if necessary, the plan should be adjusted;

(4) where the ship's safety condition cannot be maintained as determined by the control system, an alarm message is to be sent to the remote operation center.

3.5.2 The anchoring control is to satisfy the following requirements:

(1) evaluation on whether anchoring operation can be carried out in accordance with the signal and data detected and received on a real-time basis, and the limitation of the ship's anchoring capability;

(2) a plan of anchor handling is developed if the capability is sufficient as determined by the evaluation result;

(3) during the implementation of plan, environmental loads and chain cable conditions are monitored on a real-time basis and if necessary, the plan should be adjusted;

(4) in the anchoring condition, in case that it is judged by the control system that collision might be caused by the dragging of the anchor of the ship itself or other ships, the ship's manoeuvring system is to be started automatically to adjust the chain cable condition or sail away by hoisting/abandoning anchor;

(5) where the ship's safety condition cannot be maintained as determined by the control system, an alarm message is to be sent to the remote operation center.

3.6 Navigation control station on board

3.6.1 Autonomous ships may be provided with a simplified navigation control station, if necessary, to carry out pilot, entering and leaving ports, and berthing and unberthing operations.

3.6.2 The ship instruction information is to be indicated at the navigation control station, at least including heading information, rudder indicator, thruster speed, nautical chart information, radar information, etc.

3.6.3 The propulsion and manoeuvring systems are to be capable of manual control at the navigation control station. Such control can only be granted to the navigation control station with confirmation of the remote operation center.

3.6.4 The visibility of the navigation control station is to meet the applicable requirements of SOLAS regulation V/22 or it is achieved by equivalent means.

3.6.5 The navigation control station is to be provided with VHF installation for voice communication with other ships. The navigation control station is to be provided with relevant

communication terminals for voice communication with the remote operation center.

3.6.6 The navigation control station is to be provided with necessary personal life-saving appliances, including lifejackets, lifebuoys, etc.

3.6.7 Where the ship is provided with navigation control station, appropriate means of embarkation on and disembarkation from ships are to be provided, which are to be capable of being remotely controlled by the remote operation center and controlled by the navigation control station after the control is granted.

3.7 Data storage

3.7.1 The ship is to be provided with redundant data servers for the storage of information on condition and operation of the ship, equipment and system.

3.7.2 The capacity of each data server is to be such that at least the data generated by a single voyage but not less than 30 days can be stored. When the server capacity reaches its limit, the oldest data can be replaced by the latest data.

3.7.3 The data on the data server can be transmitted to the remote operation center according to the need.

3.8 Survey and tests

3.8.1 The following plans and documents are to be submitted to ISC for approval:

(1) diagram of navigation control system;

(2) arrangement of navigation control system;

(3) FMEA of navigation control system;

(4) line of sight of navigation control station (if any);

(5) diagram of equipment of navigation control station (if any);

(6) arrangement of equipment of navigation control station (if any);

(7) mooring test and sea trial program;

(8) rationale of navigation control system (for information).

3.8.2 The navigation control system (including its hardware and software) is to be approved by ISC.

3.8.3 The navigation control system is to be subject to the failure mode and effects analysis as

well as tests in accordance with approved mooring test and sea trial program, including tests of autonomous navigation and remote control.

CHAPTER 4 MACHINERY INSTALLATIONS

4.1 General requirements

4.1.1 The provisions of this Chapter apply to main propulsion machinery, manoeuvring machinery, auxiliary machinery installations, boilers, pressure vessels, pumping and piping systems, transmission gearing and automation system of autonomous ships.

4.1.2 Unless provided otherwise in this Chapter, machinery installations and automation systems of autonomous ships are to satisfy the applicable requirements of PARTs THREE and SEVEN of ISC Rules for Classification of Sea-going Steel Ships and Chapter 4 of the Rules for Intelligent Ships.

4.1.3 Where the propulsion system of autonomous ships satisfies the provisions of Chapter 14, PART EIGHT of ISC Rules for Classification of Sea-going Steel Ships, a corresponding notation may be assigned.

4.2 Goal

4.2.1 Provide timely, effective, continuous and reliable power to the ship in anticipated conditions and in emergency.

4.3 Functional requirements

4.3.1 In order to achieve the goal specified in 4.2.1, machinery installations and automation systems of autonomous ships are to have the following functions:

(1) providing safe, reliable and continuous propulsion power for the navigation of ship;

(2) providing safe, reliable and continuous manoeuvring power for the directional control of navigation;

(3) receiving, executing and responding to the instructions from the navigation control system;

(4) giving feedback on the running condition to the navigation control system and sending report on any abnormal condition of system to the remote operation center;

(5) conducting autonomous operation required for executing the instructions and remote operation of essential equipment by means of the remote operation center;

(6) carrying out real time monitoring of the working condition of equipment and system related to

propulsion and manoeuvring, and self-health management based on condition monitoring;

(7) adopting effective measures to prevent the risk of flooding of engine room.

4.4 Prescriptive requirements

4.4.1 General requirements

4.4.1.1 The safety, reliability and availability of machinery installations and systems of autonomous ships are not to be lower than the level of a manned ship.

4.4.1.2 The design, arrangement and maintenance of all machinery installations and systems are to be suitable for the special operational and running mode of autonomous ships, in order to ensure continuous operation in all anticipated operating conditions.

4.4.1.3 Machinery installations and systems are to be provided with automatic control system capable of automatic operation and running in accordance with the instructions or needs of ship navigation, manoeuvring and cargo management. Means are to be provided to ensure that effective operation and control of essential equipment can be carried out at the remote operation center in case of failure of the automatic control system.

4.4.1.4 The running status, monitoring parameters etc. of machinery installations and systems are to be indicated at the remote operation center.

4.4.1.5 Appropriate control and operational conditions are to be provided on board to facilitate installation and commissioning, testing and verification, maintenance and repair of machinery installations and systems on board.

4.4.1.6 The setting of authority for various control modes of machinery installations and systems is to be suitable for the needs of ship’s operational scenarios.

4.4.1.7 Emergency operational functions such as emergency stopping/boiler shutdown/cutting off/shutting down specified in ISC Rules for Classification of Sea-going Steel Ships are to be realized at the remote operation center.

4.4.1.8 Effective means of communication are to be provided between the control system of engine room machinery installations and ship’s navigation control system and the remote operation center, in order to ensure that timely, effective and reliable data and information transmission can be carried out between each other.

4.4.2 Machinery piping system, oil tanker piping system, ship's piping and ventilation system

4.4.2.1 In addition to the following provisions, machinery piping system, oil tanker piping system, ship's piping and ventilation system of autonomous ships are also to satisfy the applicable requirements of Chapters 2 to 5, PART THREE of ISC Rules for Classification of Sea-going Steel Ships:

(1) Fuel oil supply piping system, lubricating oil piping system, hydraulic transmission piping system, cooling water piping system and compressed air piping system (including driving system of automatic/remote control valves fitted to the piping system) serving the single main engine propulsion system are to be duplicated, unless it is demonstrated by the failure mode and effects analysis that a single failure will not lead to the total failure of the propulsion system. Where two or more main engines are provided and each engine is fitted with separate fuel oil supply piping system, lubricating oil piping system, hydraulic transmission piping system (if any), cooling water piping system and compressed air piping system, additional piping systems common to and readily available to multiple engines may be provided.

(2) For piping systems serving the main propulsion and ship's manoeuvring machinery equipment, effective measures are to be adopted to reduce the risk of leakage of piping, in order to reduce insofar as practicable the action of engine room safety and protection system due to leakage during the operation of ship.

(3) Pumps, valves and closing appliances of air vents related to automatic operation and running are to be capable of automatic operation in accordance with procedures and remote operation by the remote operation center.

(4) For automatic/remote control valves and closing appliances of air vents provided for oil tanker piping system, ship's piping and ventilation systems, their driving systems are to be redundant.

(5) Machinery installations such as diesel engines and boilers are to be capable of carrying out fuel oil change-over and recording automatically in accordance with procedures.

(6) Valves fitted in order to satisfy subdivision and watertight requirements in accordance with 2.8.1.3, Chapter 2, PART THREE of ISC Rules for Classification of Sea-going Steel Ships are to be automatically operated in accordance with procedures.

(7) Ballast water and bilge systems required by 3.12.4.1, Chapter 3, PART THREE of the Rules

for Classification of Sea-going Steel Ships are to be automatically operated in accordance with procedures.

(8) For all tanks, cofferdams and pipe tunnels as well as the bilges or bilge wells, the liquid level is to be monitored and the start/stop and on/off of pumps and valves of relevant systems are to be controlled automatically in accordance with procedures.

(9) Oil fuel transfer pumps, oil fuel unit pumps, lubricating oil service pumps, thermal oil circulating pumps, oil separators (purifiers), forced and induced draught fans for engine room ventilation, closing appliances of air vents and means of control required by SOLAS regulation II-2/4.2.2.3.4 are to be automatically controlled or remotely controlled by remote operation center in accordance with procedures based on engine room fire detection and monitoring information.

(10) Tanks provided with means for draining in accordance with ISC Rules for Classification of Sea-going Steel Ships are to be automatically drained in accordance with procedures or monitoring results.

(11) Self-cleaning filters are to be used. Their working conditions are to be monitored.

(12) Condensate water tanks of boilers are to be provided with means for monitoring oil fuel leakage. In case any leakage is detected, feedback is to be given to the remote operation center timely for making decisions on repair.

4.4.3 Boilers and pressure vessels

4.4.3.1 In addition to the following provisions, boilers and pressure vessels are also to satisfy the applicable requirements of Chapter 6, PART THREE of ISC Rules for Classification of Sea-going Steel Ships:

(1) Boilers are to be provided with automatic control systems and operated and controlled through the remote operation center.

(2) Boilers are to be provided with means for automatic blow-off, which is to be carried out in accordance with procedures or monitoring information.

(3) Air which might accumulate at the top of the boiler or drum is to be automatically discharged in accordance with procedures or monitoring information.

(4) The feed water quality of boilers is to be monitored and water quality is automatically controlled in accordance with procedures.

(5) The liquid level (where applicable) and pressure of pressure vessels are to be monitored.

(6) scum ,water and oil which might accumulate inside the pressure vessel (including air bottle) during use are to be automatically discharged in accordance with procedures or monitoring information.

(7) Means for relief used for over-pressure protection of pressure vessels are to be automatically reset after drainage due to over pressure.

(8) Condition monitoring and fitness assessment are to be carried out in accordance with 4.4.8 of this Chapter in order to effectively manage the fitness of boilers/pressure vessels.

4.4.4 Diesel engines

4.4.4.1 In addition to the following provisions, diesel engines are also to satisfy the applicable requirements of Chapter 9, PART THREE of ISC Rules for Classification of Sea-going Steel Ships:

(1) Diesel engines are to be provided with automatic control systems, automatically operated and run in accordance with the instructions of ship's navigation control system and remotely controlled through the remote operation center.

(2) The speed (including restricted speed range) and ahead/astern direction (if it can be reversed) of main engines are to be indicated at the remote operation center.

(3) Means for relief used for over-pressure protection of diesel engines are to be automatically reset after drainage due to over pressure.

(4) The operation of diesel engines, fuel change-over and operational conditions are to be automatically recorded, with output of relevant records and reports when needed by examination/survey.

(5) For diesel engines for main propulsion and generators, condition monitoring and fitness assessment are to be carried out in accordance with 4.4.8 of this Chapter in order to effectively manage the fitness of diesel engines.

4.4.5 Shafting and transmission gearing

4.4.5.1 In addition to the following provisions, gears are also to satisfy the applicable requirements of Chapter 10, PART THREE of ISC Rules for Classification of Sea-going Steel

Ships:

(1) Operations such as gear engagement and disengagement are to be automatically conducted in accordance with instructions and remotely controlled through the remote operation center. The condition of gear engagement/disengagement is to be indicated at the remote control position of the remote operation center. Emergency mechanical means are to be remotely controlled at the remote operation center to ensure that the ship can run at a reasonable speed in the event of failure of hydraulic control systems.

(2) Lubricating oil temperature and pressure in the pressure lubricating oil systems, pressure of hydraulic oil (if any) and oil level of the oil sump of splash lubrication are to be monitored, which can be indicated at the remote operation center.

(3) Filters fitted in in the pressure lubricating oil system are to be self-cleaning filters and their working conditions are to be monitored.

(4) For reversible gearing, the directions of ahead and astern running are to be indicated at the remote control position of the remote operation center.

(5) For transmission gearing, condition monitoring and fitness assessment are to be carried out in accordance with 4.4.8 of this Chapter in order to effectively manage the fitness of transmission gearing.

4.4.5.2 In addition to the following provisions, shafting and propellers are also to satisfy the applicable requirements of Chapters 11 and 12, PART THREE of ISC Rules for Classification of Sea-going Steel Ships:

(1) Clutches, hydraulic transmission arrangements of shafting, controllable pitch propellers, Z propulsion arrangements and transverse propulsion arrangements are to be automatically operated in accordance with instructions and remotely controlled through the remote operation center.

(2) Parameters necessary for the remote operation of the above transmission gearing and propulsion plants are to be indicated at the remote control position of the remote operation center, e.g. speed and rotation direction of propellers, clutching /declutching and astern/ahead direction (if any) of the clutches, pitch angle (controllable pitch propeller), lubricating oil/hydraulic oil pressure.

(3) Emergency mechanical means are to be remotely controlled at the remote operation center to ensure that the ship can run at a reasonable speed in the event of failure of hydraulic control

systems.

(4) Filters fitted in in the lubricating oil/hydraulic oil systems are to be capable of being cleaned automatically in accordance with procedures.

(5) For shafting, condition monitoring and fitness assessment are to be carried out in accordance with 4.4.8 of this Chapter in order to effectively manage the fitness of shafting.

4.4.6 Steering gear

4.4.6.1 In addition to the following provisions, the steering gear of autonomous ships is also to satisfy the applicable requirements of Chapter 13, PART THREE of ISC Rules for Classification of Sea-going Steel Ships:

(1) all steering gear or steering arrangements are to be operated by power and can work automatically in accordance with the instructions of ship's navigation control system;

(2) a single failure is to be automatically isolated so that the steering capability can be maintained or quickly regained without manual intervention;

(3) the safety valve of hydraulic system is to be reset by itself after lifting without any need of change, so that the normal working condition of system can be maintained;

(4) self-cleaning filter or multi-connected filters with a controllable period of cleaning and maintenance are to be used in the hydraulic system;

(5) gas that might enter the hydraulic system is to be automatically drained from the system;

(6) in case of low oil level due to normal loss of the hydraulic system, oil is to be automatically re-filled;

(7) all steering gear (including main and auxiliary steering gear) is to be remotely controlled at the remote operation center. For this purpose, all monitoring and alarm items are to be real-time transmitted to the remote operation center;

(8) accessibility and space, for the purposes of maintenance, inspection and repair of equipment, are to be provided in steering gear room;

(9) the effectiveness of autonomous operational mode of steering gear is to be confirmed by test.

4.4.7 Monitoring, alarm and control

4.4.7.1 In addition to the following provisions, the monitoring, alarm and control system and the

safety system of machinery installations of autonomous ships are also to satisfy the applicable requirements of Chapters 1 to 3, PART SEVEN of ISC Rules for Classification of Sea-going Steel Ships:

(1) the safety of autonomous control system of autonomous ships is to be not less as that of the ships with machinery spaces being attended. Means are to be provided to ensure that essential equipment can be remotely controlled effectively from the remote operation center in case of failure of the autonomous control systems;

(2) the means of control of machinery installations and systems of autonomous ships generally consist of autonomous control and remote control by the remote operation center. In normal operational conditions, the authority of remote control by the remote operation center is to be set at the highest level and the authority of other means of control is under the jurisdiction of the remote operation center. Where the communication condition is not sufficient to support the remote control by the remote operation center, autonomous control is to be the preferred mode of control;

(3) the remote operation center is generally to satisfy the requirements in the rules applicable to the monitoring, alarm and control of bridge control stations;

(4) all machinery and electrical installations essential for the safe operation of the ship are, in the case of failure in or out-of-action of any part of autonomous control system including failure of power supply, to be capable of:

① sending out alarm signals to the remote operation center;

② putting the back-up arrangements into service in time for recovering normal operation; or

③ transferring to remote control at the remote operation center, and the transfer of control is not to seriously affect the operating conditions of the machinery and electrical equipment;

(5) for machinery piping systems which are duplicated and can be operated independently, their monitoring, alarm and control systems as well as power sources are also to be independent from each other. Any common part is to be redundant in order to effectively isolate a single failure;

(6) for a single ship’s piping systems, the monitoring, alarm and control systems (including sensors, controls, cables etc.) and power sources (including electrical power, gas source of pneumatic system, pressure relief valve, filter and dryer, hydraulic pump of hydraulic power system, solenoid valve etc.) are to be designed in redundancy. Any single failure will not lead to

the failure of the whole system;

(7) in addition to starting standby pump, mode c protective action of the safety system may also start the standby system;

(8) after the occurrence of mode a protective action of the safety system, relevant equipment can generally be re-started after being reset by the remote operation center. Where it is designed with automatic reset, it is to be ensured that relevant machinery installations will not be damaged due to such function;

(9) the self-check scope and extent of the monitoring, alarm and control system and the safety system are to take into account the factor of autonomous operation and match the maintenance plan;

(10) the automatic monitoring items required in applicable rules are to give a single alarm and/or indication at the remote operation center;

(11) for the monitoring, alarm and control system and the safety system, the authority of adjusting the setting value is to be strictly controlled and managed;

(12) the alarm system is to be capable of blockading meaningless signals intelligently during certain processes;

(13) the overriding function is to be implemented autonomously by the autonomous ship in accordance with the needs of marine environment, e.g. overriding operation of main engines for the purpose of collision prevention;

(14) valves for controlling the flooding due to damage are to be capable of being closed automatically in accordance with the instructions.

4.4.8 Intelligent machinery system

4.4.8.1 In addition to the following provisions, the intelligent machinery system is also to satisfy the applicable requirements of Chapter 4 of ISC Rules for Intelligent Ships.

(1) the autonomous ship is to be provided with an intelligent machinery system, carrying out condition monitoring and fitness management of main propulsion machinery, auxiliary machinery installations, boilers and machinery piping systems in the engine room. A feasible maintenance and examination plan is developed by taking into account factors such as the arrangement of ship’s route/voyage and berthing duration;

(2) in addition to the monitoring scope specified in 4.1.5, 4.1.6 and 4.1.7 of Chapter 4 of ISC Rules for Intelligent Ships, consideration is also to be given to condition monitoring and health management of the following machinery installations and systems in the engine room:

① auxiliary systems, at least including:

(a) fuel processing/supply systems, e.g. oil separators, pumps, heat exchangers, filters etc.;

(b) lubricating oil supply systems, e.g. lubricating oil pump, heat exchangers, filters etc.;

(c) air intake/scavenge systems, e.g. air coolers, auxiliary fans (if any) etc.;

(d) cooling systems, e.g. cooling pumps, heat exchangers, filters etc.;

(e) hydraulic systems, e.g. hydraulic oil pumps, filters etc.;

(f) starting/control air systems, e.g. compressors, filters;

(g) boiler feed water, blow-off and condensate water systems, e.g. pumps, condensate water tanks etc.;

② boilers, at least including the following components/performance:

(a) combustion state of combustion chamber;

(b) combustion units, e.g. fuel oil nozzles, fans etc.;

(c) feed water quality;

③ emission after treatment devices, at least including:

(a) reactors;

(b) pumps;

(c) filters;

(d) fans (if any);

④ ballast water management systems, at least including:

(a) pumps;

(b) filters;

(3) the intelligent machinery system is to have the function of automatically recording various operation and action response of machinery installations and systems in the engine room in accordance with procedures and plans, at least including:

① various records and test results related to sea trial, test and verification;

② various instructions from ship's navigation control system and remote operation center;

③ all action response after the instruction is received by machinery installations and relevant auxiliary systems in the engine room;

④ engine room alarm and safety protection action;

⑤ various emergency operation;

⑥ operational records specified by regulations, e.g. low sulphur fuel oil change-over, oil fuel /gas fuel change-over, starting and stopping of exhaust gas after treatment devices (e.g. exhaust gas cleaning (EGC) system, selective catalytic reduction (SCR) system), starting and stopping of EGR system of diesel engines, starting and stopping of oil water separators, operation of incinerators etc.;

⑦ maintenance and repair records (manually entered into the system after completion);

(4) the intelligent machinery system is to have the function of automatic reporting, automatic output of various records and reports in accordance with procedures and plans and sending feedback to the remote operation center.

4.4.9 Protection against flooding

4.4.9.1 In addition to the following provisions, protection against flooding of engine room of autonomous ships is also to satisfy the applicable requirements of ISC Rules for Classification of Sea-going Steel Ships:

(1) any valve serving a sea inlet, a discharge below the waterline or a bilge injection system, for controlling flooding upon damage is to be automatically closed in case of alarm of water level as specified in 3.9.2.1 and 3.9.2.2 of PART SEVEN of ISC Rules for Classification of Sea-going Steel Ships;

(2) bilge pumps are to be operated automatically in accordance with specified procedures. The operational conditions of bilge pumps are to be indicated at the remote operation center. In case the influx of liquid is greater than the pump capacity or the pump is operating more frequently than would normally be expected, timely feedback is to be sent to the remote operation center for making decisions on repair.

4.4.10 Procedures and plans

4.4.10.1 Detailed control and operational procedures (including control logic, functional block

diagram etc.) are to be developed by taking into account various control and operational modes of machinery installations and systems of engine room.

4.4.10.2 Detailed examination procedures and plans are to be developed. Main working parameters, operational status of machinery installations and various records and reports are to be periodically examined by watchkeepers at the remote operation center.

4.4.10.3 Corresponding emergency procedures are to be developed with regard to any failure that might occur during the operation and use of machinery installations and systems.

4.5 Survey and tests

4.5.1 In addition to the provisions of ISC Rules for Classification of Sea-going Steel Ships and Rules for Intelligent Ships, the following plans and documents are also to be submitted:

(1) intelligent machinery system diagram;

(2) arrangement of primary equipment of intelligent machinery system;

(3) function, operation and maintenance instructions of intelligent machinery system;

(4) procedures and plans, at least including:

① control and operational procedures and plans of machinery installations and systems;

② inspection procedures and plans of machinery installations and systems;

③ emergency operational procedures.

4.5.2 The effectiveness of communication function between the automatic control system of engine room machinery installations and systems, ship's autonomous navigation control system and the remote operation center is to be verified at the ship's mooring test and sea trial.

4.5.3 The effectiveness of the automatic control of engine room machinery installations and systems, remote control of the remote operation center, emergency control and shipboard control function is to be verified at the ship's mooring test and sea trial.

4.5.4 The effectiveness of functions of condition monitoring and fitness management, automatic recording and reporting of intelligent machinery system is to be verified on real ships.

4.5.5 The effectiveness of implementing the condition-based maintenance of machinery installations and systems is to be evaluated at the first annual survey after the ship is put into service. The ship is allowed to continue its service upon satisfactory evaluation.

CHAPTER 5 MOORING AND ANCHORING

5.1 General requirements

5.1.1 This Chapter applies to the mode of mooring using mooring lines and mode of anchoring using anchor and chain.

5.1.2 When the ship adopts other mooring modes and mooring equipment different from that described in this Chapter, the risk assessment of mooring and anchoring systems is to be carried out so as to meet the goal set out in this Chapter.

5.1.3 The design and construction of the mooring and anchoring equipment of the ship and its supporting structure are to comply with the applicable provisions of Chapter 3, PART TWO of ISC Rules for Classification of Sea-going Steel Ships.

5.1.4 Ship's mooring and anchoring equipment is to be controlled and operated by personnel boarding the ship when needed.

5.2 Goal

5.2.1 The goal of this Chapter is to ensure that the ship can safely complete the berthing and departing at the dock or dropping and weighing anchor at the anchorage, and that it can be effectively fastened to the preset position.

5.3 Functional requirements of mooring system

5.3.1 Under the condition of remote control, the ship itself or with the navigation aids of external forces can realize berthing and departing.

5.3.2 When the ship berths and departs autonomously, the ship is to have sufficient power and maneuvering ability and can safely berth and depart under permitted environmental conditions.

5.3.3 The mooring control system is to comply with the requirements of 3.5 of Chapter 3.

5.3.4 The mooring equipment is to effectively keep the ship at preset position under permitted environmental conditions.

5.3.5 The ship is to have the function of mooring line delivery and recovery.

5.3.6 The mooring line pulling force condition can be monitored and adjusted.

5.3.7 To make sure that the remote operation center is able to implement the function of monitoring and communication for the dock.

5.4 Prescriptive requirements of mooring system

5.4.1 The ship mooring arrangement, the number of mooring cables and the breaking strength are to be determined according to the size of the ship, the layout of expected mooring dock and the environmental conditions. Mooring arrangement of each side of the ship is to be able to make sure the ship can be moored safely.

5.4.2 Each mooring cable is to be fixed to a separate mooring winch, and the mooring cable between the winch and chock is to be guaranteed not to change direction as much as possible. A closed guide device is to be used for changing direction.

5.4.3 The mooring winch could be controlled automatically by the navigation control system and remotely controlled. The mooring winch is to haul and release the mooring line, brake and open and close the clutch automatically or according to the instruction. The mooring winch is to monitor the mooring line tension, the speed of hauling and releasing mooring line, and feed back to the navigation control system and the remote operation center in real time.

5.4.4 A mooring line delivery device is to be provided so as to effectively deliver the mooring line (or connection line) to the dock for connection and recover it after disconnection.

5.4.5 In order to cooperate with the tugboat, strong points (such as mooring bollards) are to be provided in the middle and two sides of the bow and stern. The strong points are to be fixed to the towing lines and the breaking strength of the towing lines is not to exceed the safe working load of the strong point. A line delivery device is to be provided so as to effectively deliver the free end of towing line (to be equipped with rigging) to the tugboat for connection and recover it after disconnection.

5.4.6 All line delivery devices are to be automatically controlled by the navigation control system and remotely controlled.

5.4.7 The monitoring and communication systems on board are to meet the monitoring and communication needs of berthing, departing and mooring of the ship, such as dock connection and disconnection, tug aid and make sure all the equipment is disconnect when departing etc.

5.5 Functional requirements of anchoring system

5.5.1 The anchor handling operations can be carried out under the condition of remote control.

5.5.2 When the ship is anchoring autonomously, the anchor handling operations can be safely carried out under the permitted environment conditions.

5.5.3 The anchoring control system is to comply with the requirements of 3.5 of Chapter 3.

5.5.4 The anchoring system is to effectively keep the ship at preset position under permitted environmental conditions.

5.5.5 The release length, speed and tension of the anchor chain are to be monitored.

5.5.6 The anchoring system is to be able to receive the information of anchorage and anchor position, to make sure that the remote operation center can monitor the surroundings of the anchorage, and send alarm to remote operation center in emergency.

5.6 Prescriptive requirements of anchoring system

5.6.1 The provision of anchors and chains is to comply with the applicable provisions of Section 2, Chapter 3, PART TWO of ISC Rules for Classification of Sea-going Steel Ships.

5.6.2 The windlass should be operated remotely. The windlass is to automatically haul and release the chain, brake, open and close clutch according to the instruction. The windlass is to monitor the release length, speed and tension of anchor chain, and feed back to the navigation control system and the remote operation center.

5.6.3 The stopper, anchor chain flush device and anchor chain water discharge device, anchor and anchor chain holding (at sea) device are to operate remotely.

5.6.4 In case of emergency, such as other ship is dragging anchor, the autonomous ship has the risk of collision and the anchor chain cannot be recovered, the chain releasing device is to be remotely controlled.

5.6.5 The communicate system on board is to be able to receive the information of anchorage and anchor position, the monitoring and alarm systems on board are to meet the monitoring and alarm needs of anchoring, such as the ship anchor dragging, passing ships, chain direction, etc.

5.7 Survey and tests

5.7.1 The following drawings and documents are to be submitted to ISC for approval:

(1) mooring arrangement plan;

(2) anchoring arrangement plan;

(3) support structure detail plan for mooring equipment (winch, cable delivery device, chocks, etc.), anchoring equipment (windlass, stopper, etc.), strong point for towing;

(4) control system plan.

5.7.2 The deck machinery (including the windlass, mooring winch, etc.) is to also verify the implementation of its control functions except for complying with the applicable requirements of ISC Guidelines for Inspection of Marine Products.

5.7.3 In addition to the test and verification requirements set out in the Rules for Classification of Sea-going Steel Ships, mooring and anchoring systems are to be tested after installation in accordance with the system test and verification plan.

CHAPTER 6 ELECTRICAL INSTALLATIONS

6.1 General requirements

6.1.1 This Chapter specifies the requirements for the electrical installations of autonomous ships.

6.1.2 Equivalent plan may be used for the design of electrical installations of autonomous ships subject to the agreement of ISC.

6.2 Goal

6.2.1 Continuous and reliable power supply is guaranteed so as to ensure the safety of the ship and to avoid the electrical hazards.

6.3 Functional requirements

6.3.1 In all working conditions, the system can automatically provide continuous and reliable power supply to equipment which is necessary for the operation and safety of autonomous ships.

6.3.2 The function of autonomous control and remote control is to be available.

6.4 Prescriptive requirements

6.4.1 A power system is to be arranged to provide continuous power supply for shipborne systems.

6.4.1.1 The power system includes the prime mover, generator, transformer, frequency converter, switchboard, control gear, uninterruptible power supply, cables, automation and auxiliary system serving the above equipment.

6.4.2 The power system is to have redundancy arrangement, in case of any single failure for the power system which causes black out of the ship, the standby system is to be able to start automatically and supply power to essential equipment, so as to restore or maintain functions of each system, and the following requirements are to be met:

(1) essential equipment means the equipment necessary for maintaining the autonomous navigation, steering and other safety function of autonomous ships, any single failure of the power system is not to result in loss of the function concurrently;

(2) the scope of a single failure includes any active components and systems belonging to or

serving the power system, but does not include static component failures, fire or flooding in a single compartment;

(3) the power system is to have sufficient capacity to satisfy the power supply demand under normal and failure conditions.

6.4.3 Under various working conditions, the energy for starting and controlling of the power system is to be equipped with automatic charging function, and such energy system is to meet the same redundancy requirements as those for the power system.

6.4.4 When the power supply system needs to rely on other auxiliary systems in order to be available in the standby mode, the function is to be automatically controlled. At the same time, such function needs to have self-diagnosis function to determine whether the power supply system can be automatically started and supply the relevant equipment. The diagnostic function needs to check the running status, the most likely failures mode and the mode of equipment.

6.4.5 The power management system is to be able to automatically start and stop the power supply according to the load demand and operation mode of autonomous ships in order to maintain sufficient reserve power in all working conditions.

6.4.6 The power management system is to have redundant arrangement. In case of any single failure of the control system, the system is to be designed to be fail-safe and the necessary automatic function can still be maintained.

6.4.7 The remote control and monitoring are to meet the following requirements:

(1) the power grid’s parameters of the autonomous ship and the status of the electrical equipment serving essential equipment are to be monitored by the remote operation center, the priority and monitoring intervals are to be determined according to the importance;

(2) the electrical system for power system and other essential system are to be equipped with the functions of autonomous control and remote control by the remote operation center. The function of remote control is to include at least the start/stop of the generator sets, parallel running, breaker control, motor start/stop of motors, mode selection, etc.;

(3) if necessary, the remote control function is to be able to override the autonomous control in order to control the same device. The autonomous and remote controls are to be mutually independent of each other.

6.4.8 If arranged, the change-over, sequential startup and standby startup function for essential

equipment needs to be arranged with sufficient self-diagnostic capability.

6.4.9 The control system serving shipborne systems is to be supplied by the uninterruptible power supply. The corresponding uninterruptible power supply needs to meet the same redundancy requirement as for the equipment being served, and the required uninterruptible power supply is to be the on-line UPS type and be equipped with the automatic by-pass function.

6.4.10 In addition to the special provisions of this Chapter, the ship's electrical installations need to comply with applicable requirements of PART FOUR of ISC Rules for Classification of Sea-going Steel Ships.

6.5 Survey and tests

6.5.1 The following drawings and documents are to be submitted to ISC for approval:

(1) electrical operation and design philosophy, describing how electrical system work under various working conditions and modes. The working condition should include normal and fault conditions, the scene should include at least the initial starting, sea going, anchorage, entering and leaving the port, docking and undocking, loading and unloading cargo, etc.;

(2) system risk assessment and test report, analyzing the influence on redundancy in electrical system and the influence on the shipborne system in case of the single failure;

(3) applicable drawing under Chapters 1 and 3, PART FOUR of ISC Rules for Classification of Sea-going Steel Ships.

6.5.2 Survey requirements:

(1) verification of the automatic functionality of power system supplying each system under various working conditions and modes;

(2) change-over between autonomous control and remote control, including the verification of independence;

(3) failure test simulated in accordance with the system risk assessment report;

(4) applicable tests under Chapters 1 and 3, PART FOUR of ISC Rules for Classification of Sea-going Steel Ships.

CHAPTER 7 COMMUNICATION AND SIGNAL EQUIPMENT

7.1 General requirements

7.1.1 This Chapter applies to the external communication and signal equipment of autonomous ships and the signal equipment complying with IMO International Regulations for Preventing Collisions at Sea, 1972.

7.1.2 Equivalent plan may be used for the design of communication and signal equipment of autonomous ships subject to the agreement of ISC.

7.2 Goal

7.2.1 The arrangement of ship communication equipment should be such that effective voice and data communication with the dock, nearby ships, VTS center, search and rescue center and owner via the remote operation center can be achieved automatically throughout the voyage. It is to be equipped with enough bandwidth.

7.2.2 When the ship is provided with the pilot control station, the communication equipment should be able to realize the voice communication between the remote operation center and the pilot control station. At the same time, it can realize the voice communication between the pilot control station and the surrounding docks, VTS center.

7.2.3 The signal equipment of the autonomous ship should be able to operate automatically or remotely controlled by the remote operation center, and give the audible, visual and shape signals according to IMO International Regulations for Preventing Collisions at Sea, 1972.

7.3 Functional requirements

7.3.1 The communication function of each autonomous ship is to comply with the following requirements:

(1) at each sea area of the entire route, at least two separate independent devices with bandwidth and speed satisfying autonomous or remote control are to set up the voice and data communication link and can also realize the ship-to-shore distress alarm;

(2) sending ship-to-shore and ship-to-ship distress alarm signals;

(3) sending and receiving the search and rescue coordination communication;

(4) sending and receiving the live communication;

(5) sending the search and rescue location signal;

(6) sending and receiving the marine safety information;

(7) sending and receiving the common radio communication to a coastal radio system or network;

(8) sending and receiving the ship-to-ship communication.

7.3.2 Each autonomous vessel should be able to display the light information and give an audible signal according to the ship's condition in accordance with the requirements of IMO International Regulations for Preventing Collisions at Sea, 1972.

7.4 Equipment and requirements for communication

7.4.1 Each autonomous vessel is to be provided with at least the following communication equipment suitable to the navigation area:

(1) one satellite ship station or equivalent device with voice communication and internet data communication;

(2) one V-SAT ship station or equivalent device with internet data communication;

(3) two VHF radio units;

(4) one satellite position-indicating radio beacon;

(5) one Maritime safety information receiving device;

(6) LRIT equipment.

7.4.2 The communication equipment is to meet the applicable requirements of performance standards adopted by IMO. V-sat is to meet the requirements of marine environmental conditions and comply with the recognized international or national standards;

7.4.3 The states of all communication equipment are to be transferred to the remote operation center and be remotely controlled by the remote operation center;

7.4.4 The satellite position-indicating radio beacon should be able to automatically release and start up when the ship sinks.

7.4.5 When the ship sends a distress alarm, the alarm signal should include the location information of the ship.

7.4.6 The communication equipment is to be supplied by two sources of electrical power from different sections of main switchboards, and to realize automatic change-over in the event of

failure of one power supply. In addition, the communication equipment is to be equipped with a dedicated standby power which provides an hour of power supply.

7.4.7 The installation position of communication equipment is to be fit for the function of equipment and is to be installed outside the engine room.

7.5 Equipment and requirements for signal

7.5.1 Each autonomous vessel is to be provided with the following equipment in accordance with the requirements of IMO International Regulations for Preventing Collisions at Sea, 1972:

(1) mast light, to be equipped with the range light for ships of 50m or more in length.

(2) port and starboard light;

(3) tail light;

(4) command light;

(5) anchor light;

(6) whistle;

(7) bell;

(8) gong;

(9) shape;

(10) dedicated signals of the autonomous ship to show that the ship is in autonomous navigation condition.

7.5.2 The mast light, side light and tail light are to be provided with two sets of lighting fittings or double filament lighting fittings.

7.5.3 The bell and gong can be realized electronically and the shape signal can be electrically controlled.

7.5.4 Each signal equipment is to be supplied by the independent branch of the signal equipment control board. The signal equipment control board is to be supplied by two sources of electrical power from different sections of main switchboards, and to realize automatic change-over in the event of failure of one power supply.

7.5.5 The states of all signal equipment are to be transferred to the remote operation center and can autonomously operate or be remotely controlled by the remote operation center.

7.5.6 The performance of signal equipment is to comply with the technical requirements of IMO

International Regulations for Preventing Collisions at Sea, 1972 and adapts to the environmental conditions of the ship.

7.5.7 When the ship passes through a special channel such as a canal, it is to be equipped with a specified signal according to the requirements of the canal authority or port State authority. The signal light is to be operated remotely from the remote operation center.

7.5.8 The arrangement of the signal light is to comply with IMO International Regulations for Preventing Collisions at Sea, 1972 and relevant administrations.

7.6 Survey and tests

7.6.1 The following drawings and documents are to be submitted to ISC for approval:

(1) communication equipment system plan;

(2) signal equipment system plan;

(3) communication equipment arrangement plan;

(4) signal equipment arrangement plan.

7.6.2 The communication equipment and signal equipment are to be approved by ISC.

7.6.3 In the construction survey, the power supply, function and independence of the equipment are to be inspected and tested.

CHAPTER 8 HULL CONSTRUCTION AND SAFETY

8.1 General requirements

8.1.1 This Chapter applies to hull construction and related hull safety systems of autonomous steel ships.

8.1.2 This Chapter specifies technical requirements for load lines, subdivision and stability and hull structures of ships, as well as requirements for design, survey and tests of hull safety systems.

8.1.3 The hull safety system is an analysis, decision-making and control system that can automatically detect information related to the hull and cargo safety, carry out data transformation and storage, real-time monitoring and safety evaluation, analyze and deal with the anomalies, form operation instructions and send them to the related systems or equipment to implement automatic operation.

8.1.4 Unless specified otherwise by this Chapter, ship's load lines, subdivision and stability, and hull structures are to comply with the applicable requirements of the International Convention for the Safety of Life at Sea, 1974, as amended (hereinafter referred to as SOLAS), Amendments to Annex B to the Protocol of 1988 relating to the International Convention on Load Lines, 1966 (resolution MSC.143(77))(hereinafter referred to as ICLL), and ISC Rules for Classification of Sea-going Steel Ships and Rules for Materials and Welding.

8.1.5 When applying this Chapter, equivalent or alternative measures may be taken in the following cases:

(1) ships of novel characteristics;

(2) ships with novel hull construction, including structural forms, arrangements, materials, etc.;

(3) novel hull perception systems and related installations;

(4) others.

8.1.6 Where equivalent or alternative measures are taken, the following requirements are to be complied with so that the safety goals, functional requirements and safety level of hull construction are equivalent to the requirements of the Guidelines:

(1) for the calculation methodology, evaluation criteria, material, survey and test methods required by this Chapter, capable of providing verification basis such as theories and tests that are proved to provide a safety level equivalent to that specified in this Chapter;

(2) for those unspecified by this Chapter, if it can be proved that the safety goal and level of the solution are equivalent to those specified in the Guidelines.

8.2 Goal

8.2.1 Hull construction is to have sufficient integrity, subdivision and stability, structural strength, and the hull safety system is to ensure continuous effective operation and that the ship is controlled within the designed capacity of stability and strength in various operation scenarios.

8.3 Functional requirements

8.3.1 To achieve the goal specified in 8.2.1, hull construction and the relevant hull safety system are to comply with the functional requirements specified in 8.3.2 and 8.3.3.

8.3.2 Hull construction is to have the following functions:

(1) the hull is to have sufficient freeboard and bow height;

(2) the hull is to have sufficient stability corresponding to the marked freeboard;

(3) the hull structure is to be designed for service life of 25 years, to satisfy expected structural strength in operation and environment conditions, including global strength and local strength in failure modes such as yield, buckling, fatigue, and to have appropriate safety allowance;

(4) the hull structure is to have good corrosion protection capabilities;

(5) the hull construction is to provide safe conditions for ship inspection, maintenance and surveyors.

8.3.3 The hull safety system is to have the following functions:

(1) automatically adjusting ballast water according to the loading and unloading sequence;

(2) automatically calculating stability according to the changes in loading, giving early warning and adjusting operation instructions;

(3) carrying out real-time monitoring of structure conditions (stress, temperature), giving early warning and adjusting operation instructions;

(4) carrying out real-time monitoring of cargo hold conditions (temperature, cargo), giving alarms, evaluating impacts, and taking corresponding measures;

(5) monitoring opening and closing of cargo hold hatch covers, watertight doors and watertight small hatch covers, and ensuring they are closed during navigation;

(6) monitoring watertight spaces water ingress and water level, giving alarms and operation instructions.

8.4 Prescriptive requirements

8.4.1 Load lines, subdivision and stability

8.4.1.1 To satisfy the functional requirements in 8.3.2(1) and (2), the following requirements are to be complied with in addition to those specified in 8.4.1.2, 8.4.1.3 and 8.4.1.4:

(1) applicable requirements of Annex I of ICLL;

(2) applicable requirements of Part B, B-1 ~ B-4 of Chapter II-1 of SOLAS on cargo ships;

(3) applicable requirements of Chapter VI of SOLAS;

(4) for bulk carriers: applicable requirements of Chapter XII of SOLAS;

(5) applicable requirements of Annex I of MARPOL.

8.4.1.2 To satisfy the functional requirements in 8.3.2(1), the following provisions are still to be complied with:

(1) when applying the requirements of ICLL regulation I/27(14)(b), autonomous ships are to

comply with the requirements of ICLL regulation I/39;

(2) where it is anticipated that personnel will be onboard for a short period due to emergency, mandatory piloting, etc., the open deck where personnel are anticipated to have access to or any spaces the entry of which is anticipated for essential operations are to be provided with appropriate personnel protective measures (i.e. guardrails, bulwarks and/or other safe means of access) according to ICLL regulation I/25;

(3) when applying the requirements of ICLL regulation I/10, the approved Loading Manuel, including stability and structural strength information, is to be shown electronically onboard and the written information is to be kept in the remote operation center;

(4) the leakage detected by the leakage detection device mentioned in ICLL regulation I/21(4) is to be indicated in the remote operation center, and the screw-down valve controlling drainage is to operate automatically according to the prescribed procedures;

(5) when applying ICLL regulation I/22:

① paragraph(1)(b) and (1)(c) may not be applied;

② the automatic non-return valve with a positive means of closing it from a position above the freeboard deck mentioned in paragraph(1)(a) is to operate automatically according to the prescribed procedures and be remotely operated by the remote operation center; the status of opening/closing of the valve is to be indicated in the remote operation center;

③ the locally operated positive closing valve at the shell mentioned in paragraph(1)(d) is to operate automatically according to the prescribed procedures and be remotely operated by the remote operation center;

④ the individual screw-down valve operated from the deck mentioned in paragraph(1)(f) is to operate automatically according to the prescribed procedures and be remotely operated by the remote operation center;

⑤ paragraph(3) is implemented as follows: in machinery spaces of autonomous ships, main and auxiliary sea inlets and discharges in connection with the operation of machinery are to operated automatically according to the prescribed procedures and are to be remotely operable by the remote operation center; the opening/closing of the valve is to be indicated in the remote operation center;

(6) When applying ICLL regulation I/22-1, autonomous ships are not to be provided with garbage chutes; all garbage that may be generated, including food, is prohibited from being discharged into sea.

8.4.1.3 To satisfy the functional requirements in paragraph 8.3.2(2), the following provisions are to be complied with:

(1) when applying Chapter II-1 of SOLAS, the approved stability information mentioned in regulations 5 and 5-1 and the approved damage control plan and damage control information mentioned in regulation 19 are to be shown electronically onboard and the written information is

to be kept in the remote operation center;

(2) the as-built construction drawings mentioned in SOLAS regulation II-1/3-7 are to be shown electronically onboard;

(3) for ships to which SOLAS regulation II-1/3-10 is applicable, where the construction drawings are not kept onboard, they are to be shown electronically onboard;

(4) all openings (including cargo hold covers; internal and external doors, windows, small hatch covers; scuttles; other openings on the shell, excluding closing appliances of the ventilation system), if fitted, are to be provided with automatic control systems which can automatically operate according to ship's navigation, maneuvering, cargo management orders and demands, and means are to be provided to ensure that when automatic control systems fail, essential equipment can be effectively operated and controlled through remote control by the remote operation center. These openings are to be closed automatically before the ship leaves port and they are not to be opened before the ship arrives at the next port;

(5) the screw-down valve mentioned in SOLAS regulation II-1/12 and the controls to equalization devices are to be automatically operable according to the prescribed procedures and are to be remotely operable by the remote operation center;

(6) all detection and alarm devices (e.g. cargo hold water level detectors in regulation II-1/25; bilge well high water level alarms in regulation XII/9; and water level detectors and alarms fitted in cargo holds, ballast tanks forward of the collision bulkhead and any dry or void space, any part of which extends forward of the foremost cargo hold in regulation XII/12) are to be automatically operable according to the prescribed procedures and the alarm information is to be indicated in the remote operation center.

8.4.1.4 To satisfy the functional requirements in 8.3.2(5) above, the requirements of 14.3.1 of Chapter 14 are to be complied with.

8.4.2 Hull structure

8.4.2.1 To satisfy the functional requirements for hull structure in 8.3.2(3) and (4), applicable requirements in PART TWO Hull or PART NINE of ISC Rules for Classification of Sea-going Steel Ships as well as Rules for Materials and Welding are to be complied with in addition to the following provisions:

(1) the hull structure is to be designed according to the environmental conditions of the intended navigation areas and their corresponding long-term sea condition scatter diagrams;

(2) the structures in key areas are to be appropriately strengthened in design and requirements for construction in ISC Guidelines for Construction Monitoring of Hull structures.

8.4.2.2 When applying the rules mentioned in 8.4.2.1, the following principles are to be considered based on the characteristics of autonomous ships:

(1) structural arrangements concerning personnel passage, such as manholes, passages, may be submitted to ISC for special consideration according to the design requirements of specific ships;

(2) requirements concerning crew's cabin, accommodation, recreation, potable water, the International Labor Organization (ILO), training and drills need not be considered.

8.4.3 Hull safety system

8.4.3.1 To satisfy the functional requirements in 8.3.3, the provisions in 8.4.3.2 to 8.4.3.8 are to be complied with.

8.4.3.2 The following data can be perceived and obtained from the scenarios mentioned in Chapter 2 of the Guidelines:

(1) sea environment data, e.g. wind force, wind direction, wave;

(2) ship navigation parameters, e.g. course, speed;

(3) ship motion data, motion and acceleration in six degrees of freedom;

(4) hull floating condition, including draught of bow, midship and stern (port and starboard).

8.4.3.3 The following data can be perceived:

(1) watertight integrity

① The opening and closing status of watertight doors and watertight small hatch covers, if applicable;

② water ingress and condition of watertight spaces, e.g. cargo hold water level, bilge well water level, forepeak tank water level, bow hold or void space water level;

(2) hull structure

① the longitudinal strength of the hull structure(L>250 m);

② stress in the key structural areas(L>250 m);

③ temperature of the structural members, where applicable;

④ bow slamming pressure (applicable ship types);

(3) ballast system

① water level of the ballast tanks;

(4) cargo system

① loading sequence and loading volume of cargo hold, where applicable;

② cargo hold environment conditions, where applicable, such as temperature, humidity, pressure;

③ hazardous gases in the cargo hold, where applicable, considering redundancy;

④ cargo conditions, where applicable, e.g. cargo movements, liquefaction of ores, considering redundancy;

⑤ conditions of cargo hold hatch covers, where applicable, such as open or closed, watertight, hatch trackway, considering redundancy;

⑥ cargo securing conditions, where applicable, such as stress of the lashing system, considering redundancy;

⑦ cargo containment and loading and unloading systems of cargo tankers, where applicable,

such as stress, temperature, considering redundancy;

(5) relevant data may be added or redundancy may be considered according to the actual conditions and safety needs of the ship.

8.4.3.4 The perceived data mentioned in 8.4.3.3 above are to be able to be transmitted to and kept in the navigation control system.

8.4.3.5 The hull safety system is to realize information transmission such as instruction orders, data, alarm with the following systems and equipment:

(1) navigation control system;

(2) remote operation center;

(3) hatch cover operation appliances;

(4) watertight door and watertight small hatch cover operation appliances;

(5) docks;

(6) communication requirements for relevant systems or equipment may be added according to the actual conditions and safety needs of the ship.

8.4.3.6 Analysis and decision-making are to comply with the following provisions:

(1) data related to calculations and criteria of stability and structural strength are to be included, such as the Loading Manual (including stability information), the loading instrument (stability software type 3), loading and unloading sequence, sequential ballast water exchange, to realize the functions of the information;

(2) the damage control function specified in SOLAS regulation II-1/19 is to be realized;

(3) analysis and decision making is to be capable of sending the loading and unloading sequence (self-developed or provided by the remote operation center) to the dock and send ballast water instruction orders to the navigation control system according to the loading and unloading sequence to carry out the corresponding ballast water adjustment so that the ship's stability, floating condition and longitudinal strength are maintained in the normal range;

(4) before the ship leaves the port, the hull safety system is to be able to:

① carry out self-inspection of the whole system;

② check the opening/closing condition of all cargo hold hatch covers, watertight doors, watertight small hatch covers to ensure that they are closed before the ship leaves the port;

③ check whether the hatch trackway is in order;

④ give an alarm to the navigation control system and remote operation center in case of malfunction or abnormality;

(5) during navigation, cargo loading and unloading at docks and mooring, the hull safety system is to be able to:

① carry out ship stability calculation and give safety criteria. In case of abnormality, give an alarm and send operation request to the navigation control system in a timely manner, adjust ballast water, course, speed or adjust cargo loading and unloading so as to ensure that the ship stability is in safe condition;

② monitor the hull's longitudinal strength and safety criteria. In case of abnormality, give an alarm and send operation request to the navigation control system in a timely manner, adjust ballast water, course, speed or adjust cargo loading and unloading so as to ensure that the hull's longitudinal strength is in safe condition;

③ monitor the hull's local strength (including key structural areas) and safety criteria. In case of abnormality, give an alarm and send operation request to the navigation control system in a timely manner, adjust ballast water, course, speed or adjust cargo loading and unloading so as to ensure that the hull's local strength is in safe condition;

④ monitor whether watertight spaces are flooded and the water level. When the water level is higher than the warning level, give an alarm and send operation request to the navigation control system in a timely manner, initiate drainage so as to ensure that the water level is below the warning level;

⑤ send a cargo loading sequence error alarm to the dock and report to the remote operation center where necessary to let the remote operation center make decisions and control the process when the loading and unloading sequence monitored is not consistent with the loading and unloading sequence list;

⑥ give an alarm to the remote operation center where applicable to let the remote operation center make decisions and control the process when the cargo moves or ores liquefies;

⑦ transmit to the relevant fire-fighting system and report to the remote operation center where applicable to let the fire-fighting system make decisions and take measures when the concentration of hazardous gas generated in cargo holds is too high;

⑧ monitor cargo hold environmental condition, cargo securing condition, cargo tanker's cargo containment and loading and unloading systems. In case of abnormality, give an alarm to the navigation control system where applicable to let the remote operation center make decisions and control the process;

⑨ monitor temperature of structural members. In case of abnormality, give an alarm to the navigation control system where applicable to let the remote operation center make decisions and control the process;

(6) relevant safety evaluation analysis and decision-making requirements may be added based on the actual conditions and safety needs of the ship.

8.4.3.7 The hull safety system is to be able to send operation request to the navigation control system or send remote control request to the remote operation center, including the following systems or devices:

(1) the propulsion system to adjust the speed;

(2) the maneuvering system to adjust the course;

(3) the ballast water system to adjust the ballast water volume of each ballast tank;

(4) the operation mechanism of the cargo hold hatch cover, opening and closing the hatch cover;

(5) the operation mechanism of watertight doors and watertight small hatch covers, opening or closing;

(6) the bilge system, discharging bilge;

(7) other related systems or appliances may be added based on the actual conditions and safety needs of the ship.

8.4.3.8 The hull safety system is to be able to remotely control the following systems and appliances:

(1) the operation mechanism of the cargo hold hatch cover, opening and closing the hatch cover;

(2) the operation mechanism of watertight doors and watertight small hatch covers, opening and closing;

(3) the ballast water system to adjust ballast water volume of ballast tanks;

(4) the bilge system, discharging bilge;

(5) other related systems or appliances may be added based on the actual conditions and safety needs of the ship.

8.4.3.9 Self-check and failure handling are to comply with the following requirements:

(1) auto-check of systems and related equipment;

(2) in case of systematic failure, report to the navigation control system and remote operation center.

8.5 Survey and tests

8.5.1 Plans and information specified in 8.5.1.1 to 8.5.1.3 are to be submitted to ISC for approval. When it is deemed necessary by ISC, the scope of plans and information submitted may be expanded.

8.5.1.1 Load lines, subdivision and stability

(1) General arrangement;

(2) Calculations of intact stability;

(3) Calculations of grain stability, if applicable;

(4) Calculations of damage stability, if applicable;

(5) Pilot ladder and/or embarkation arrangement, if any;

(6) Door and window arrangement;

(7) Cross-flooding device arrangement, calculations and usage instructions, if any;

(8) Lines or offsets, for information;

(9) Capacity plan, for information;

(10) Calculations of freeboard, for information;

(11) Plan of load line marks;

(12) Gangway arrangement and structural plan, if applicable;

(13) Bow and stern door arrangement, if applicable;

(14) Ventilator arrangement (natural ventilation, machinery ventilation);

(15) Guardrails, handholds, safe access and safety rope arrangement, if any;

(16) Small hatch cover arrangement;

(17) Cargo hold hatch coaming structural plan;

(18) Cargo hold hatch cover arrangement and structural plan, including strength calculation;

(19) Structural plan of engine room casing;

(20) Arrangement of air pipes;

(21) Arrangement of scuppers, inlets and dischargers;

(22) Arrangement of freeing ports.

8.5.1.2 Hull structure

(1) Principal transverse sections;

(2) Construction profile, including longitudinal sections, decks, inner bottom, superstructures and deckhouses;

(3) Stem;

(4) Stern frame;

(5) Shell expansion;

(6) Oiltight and watertight bulkheads;

(7) Main engine seating and thrust bearing seating;

(8) Propeller shaft bracket;

(9) Arrangement of anchoring equipment including equipment number calculations;

(10) Rudder, rudder stock and tiller;

(11) Masts, derrick posts and crane pedestals, together with their support structures;

(12) Loading calculations of typical conditions (where applicable);

(13) Calculations of loading and unloading sequence;

(14) Calculations of ballast water exchange (where applicable);

(15) Ice strengthening structural plan (where applicable);

(16) Welding, including type and size of welds (where applicable);

(17) Hull and equipment manuals (for information).

8.5.1.3 Hull safety system

(1) Arrangement of the perception system;

(2) System design and principle diagram;

(3) System hardware specifications (for information);

(4) System manual (for information);

(5) System test procedures.

8.5.2 The hull safety system, including hardware and software, is to be approved by ISC.

8.5.3 After the installation, the hull safety system is to be subject to survey and tests according to the test procedures to verify the functions and effectiveness of the system.

CHAPTER 9 FIRE-FIGHTING

9.1 General requirements

9.1.1 The provisions of this Chapter apply to design and arrangement for fire protection, fire detection and fire extinction (hereinafter referred to as fire-fighting) of autonomous ships.

9.1.2 Spaces of fire risk onboard autonomous ships are those spaces where combustible substances (including solid, gas and liquid), electrical installations and machinery equipment are located or having other fire risk, including:

(1) machinery spaces of category A;

(2) other machinery spaces;

(3) cargo spaces;

(4) spaces containing electrical installations;

(5) other spaces prone to fire.

9.1.3 Spaces of fire risk onboard autonomous ships are to be constructed and arranged by steel and non-combustible materials as far as possible and one of the following measures are to be taken:

(1) separation from combustible substances;

(2) separation from sources of ignition;

(3) inerting of the spaces.

9.1.4 If none of the three measures mentioned in 9.1.3 can be satisfied, combustible gas detection, fire detection and alarm, and fire extinguishing measures, or other measures providing equivalent safety level based on risk analysis, are to be provided, according to the applicable requirements of this Chapter mentioned below.

9.2 Goal

9.2.1 The fire safety goal of autonomous ships is to:

(1) prevent the occurrence of fire and explosion;

(2) reduce the risk of damage caused by fire to the ship, its cargo and the environment;

(3) contain, control and suppress fire and explosion in the space of origin.

9.3 Functional requirements

9.3.1 To achieve the goals set out in 9.2.1, the following functional requirements on fire-fighting are to be met:

9.3.1.1 Fire detection

(1) detection of leakage of combustible substance and accumulation of flammable gas in spaces of fire risk;

(2) detection of any fire in spaces of fire risk;

(3) monitoring of the condition of the fire-fighting system.

9.3.1.2 Communication

(1) transmitting monitored system status information and sending alarm signals to the remote operation center;

(2) receiving remote control instructions from remote operation center.

9.3.1.3 The ship structure and arrangement of compartments are to be such that occurrence and spread of fire can be prevented.

9.3.1.4 Precautions to avoid occurrence of fire and explosion can be automatically taken.

9.3.1.5 Any fire in the space of origin can be automatically contained and extinguished .

9.4 Probability of ignition

9.4.1 Arrangements of fuel oil, lubricating oil and other flammable oil onboard autonomous ships are to comply with the applicable requirements of SOLAS Regulation II-2/4.2.

9.4.2 In addition to the requirements of 9.4.1, fire protection measures for machinery spaces are also to comply with the applicable requirements of 3.9.1.2, Chapter 3, PART SEVEN of ISC Rules for Classification of Sea-going Steel Ships.

9.4.3 Use of fire protection materials is to comply with applicable requirements of SOLAS Regulation II-2/5.3. If primary deck coverings are applied in spaces with electric installations, they are to be of approved materials which will not readily ignite, and fire resistance is to be determined in accordance with the IMO Fire Test Procedures Code.

9.4.4 In spaces where penetration of oil is possible, the surface of insulation is to be impervious to oil or oil vapors.

9.5 Detection and alarm

9.5.1 The following means are to be provided for detection of leakage of combustible substance and accumulation of flammable gas:

(1) For spaces where leakage or volatilization of flammable gas is possible, a fixed flammable gas detection system is to be provided, the arrangement of which is to take into account of the compartment arrangement and ventilation, so as to readily and effectively detect potential leakage or volatilization of flammable gas;

(2) When the flammable gas concentration reaches the preset threshold value (i.e., not higher than 10% of the lower flammable limit), an alarm signal is to be automatically sent to the remote operation center, and meanwhile power ventilation system is to be automatically activated or increase the ventilation capacity so as to prevent accumulation of flammable gas.

9.5.2 Spaces of fire risk are to be provided with a television monitoring system, which is to be so designed and arranged that all important parts of the space are covered. The system is to be capable of sending images to the remote operation center.

9.5.3 Spaces of fire risk are to be provided with a fixed fire detection and fire alarm system that

complies with the following requirements:

(1) The type and arrangement of the detector is to comply with the applicable requirements of SOLAS Regulation II-2/7 and the International Code for Fire Safety Systems;

(2) The system is to be so designed and arranged that it can quickly detect the initial fire within the space in a normal condition. False alarm is to be prevented. The air flow caused by machinery is not to lead to the failure of the detection system;

(3) The detector is to act due to heat, smoke or other products from combustion, flame or any combination of them. The detector in each space is to be the combination of two different types of probes, so that the system can response to more than one type of signs of fire;

(4) The system is to be capable of self-check. An alarm sign is to be sent to the remote operation center in case of failure of electric power supply or the system;

(5) The detector is to be so positioned that the remote operation center can determine the location of fire origin;

(6) If means for calibration of detector sensitivity is installed, necessary measures are to be provided to ensure the fixing and identification of its set value;

(7) If temporary switching off of a special loop or detector is intended, this situation is to be clearly indicated. After a given interval of time, the function of this loop or detector is to be automatically resumed;

(8) If any sign of fire is detected by a detector, the ship is to be capable of timely sending fire alarm signal to the remote operation center.

9.6 System monitoring and control

9.6.1 The conditions of the following systems are to be monitored, as applicable:

(1) power ventilation system;

(2) flammable gas detection system;

(3) fire detection and alarm system;

(4) local water-based fire-extinguishing system;

(5) gas fire-extinguishing system.

9.6.2 The ship is to be capable of sending the status information of system monitoring as described in 9.6.1 to the remote operation center in real time, and timely sending alarm signals in case of system failure.

9.6.3 The following systems are to be capable of receiving the remote operation controls from the remote operation center, as applicable;

(1) power ventilation system;

(2) local water-based fire-extinguishing system;

(3) gas fire-extinguishing system;

(4) oil pumps in machinery spaces, etc.

9.7 Containment of fire

9.7.1 The minimum fire integrity of the bulkheads and deck of autonomous ships are to comply with the provisions in Tables 9.1 and 9.2.

Table 9.1 Fire integrity of bulkheads separating adjacent spaces[1]

Spaces		1	2	3	4	5
1	Electric installation spaces[2]	*	A-0	A-60	A-15	A-60
2	Means of access		C	A-0	A-0	A-0
3	Category A machinery spaces			*	A-0	A-0[3]
4	Other machinery spaces				A-0	A-0
5	Cargo spaces					*

Note: 1 See SOLAS Regulation II-2/3 for the definition of fire integrity classes.

2 Pilot station is included.

3 If dangerous cargoes are carried, the requirements of SOLAS Regulation II-2/19.3.8 are to be complied with.

Table 9.2 Fire integrity of decks separating adjacent spaces

Spaces above deck / Spaces below deck		1	2	3	4	5
1	Electric installation spaces	A-0	A-0	A-60	A-0	A-0
2	Means of access	A-0	*	A-0	A-0	A-0
3	Category A machinery spaces	A-60	A-0	*	A-60	A-30
4	Other machinery spaces	A-15	A-0	A-0	*	A-0
5	Cargo spaces	A-60	A-0	A-0	A-0	*

9.7.2 Penetrations in the fire divisions are to comply with the applicable requirements of SOLAS Regulation II-2/9.3, so as to prevent heat transmission.

9.7.3 Doors on fire divisions are to comply with the applicable requirements of SOLAS Regulation II-2/9.4.2.

9.7.4 Openings on the boundaries of machinery spaces are to comply with the applicable requirements of SOLAS Regulation II-2/9.5.

9.7.5 The design and arrangement of the ventilation system is to comply with the applicable requirements of SOLAS Regulation II-2/9.7.

9.8 Fire fighting

9.8.1 A fixed gas fire extinguishing system or equivalent system is to be provided in spaces of fire risk. Means are to be taken to prevent the influence on ship safety due to the release of

fire-fighting media of equivalent fire-fighting system.

9.8.2 Unless fire in a space where any equipment located within will not cause failure of propulsion, internal combustion engine for main propulsion and serving as other driving sources, boilers, inert gas generator supplied by fuel oil and fuel oil units are to be provided with a local water-based fire-extinguishing system or equivalent system. Such system is to comply with the following requirements:

(1) design and arrangement of the system are to comply with the requirements of MSC.1/Circ.1387;

(2) the system can automatically release fire extinguishing medium. The automatic release is to be jointly triggered by any of the following detector combinations:

① combination of two approved flame detectors;

② combination of approved flame detector and smoke detector;

③ combination of other approved detectors.

9.8.3 Other than machinery spaces of category A, the automatic release of the system described in 9.8.1 is to be triggered by combination of two different types of probes. For machinery spaces of category A, the system described in 9.8.1 is to be automatically released after the closing actions according to 9.8.4 are completed.

9.8.4 In the event of a fire, the ventilation system and openings in the space of origin are to be closed automatically before the release of fire-extinguishing media. For machinery spaces of category A, the following devices are to be closed automatically after 2 minutes after the joint triggering by detectors:

(1) ventilation fans;

(2) external openings, and ventilator dampers;

(3) forced and induced draught fans;

(4) pumps, including oil fuel transfer pump, oil fuel unit pumps, lubricating oil service pumps, thermal oil circulating pumps and oil separators (purifiers);

(5) emergency shut-off valves.

9.8.5 After a fire alarm signal is received, video surveillance of the space is to be automatically activated in the remote operation center. After the fire is confirmed, the operation in 9.8.4 is to be executed by remote control, and fixed fire-extinguishing system and local water-based fire-extinguishing system are to be remotely controlled by the remote operation center.

9.8.6 The fire extinguishing system is to be designed with self-check function. In case of failure of the system, a failure alarm signal is to be sent to the remote operation center.

9.8.7 The volume of gas fire media is not to be less than twice that of the space of the maximum volume.

9.9 Structural integrity

9.9.1 In order to ensure that the structural integrity is not degraded due to fire, the following

requirements are to complied with:

(1) the hull, structural bulkheads, decks, superstructures and deckhouses are to be constructed of steel or other equivalent material;

(2) crowns and casings of machinery spaces of category A are to be of steel construction;

(3) if the structure of aluminum alloy is provided, the requirements of SOLAS Regulation II-2/11.3 are to be complied with.

9.10 Inert gas system

9.10.1 If inert gas system and nitrogen generator system are installed for inerting of compartments onboard, the systems are to comply with applicable requirements of Chapter 4, PART SIX of ISC Rules for Classification of Sea-going Steel Ships. However, the nitrogen content in a space is to be determined according the specific feature of the space, and normally is to be kept below 8%.

9.11 Alternative design and arrangement requirements

9.11.1 The fire safety design and arrangement of autonomous ships may deviate from the prescriptive requirements of this chapter, provided that such design and arrangement comply with the fire safety goals and functional requirements of this Chapter.

9.11.2 If alternative design and arrangement are provided, they are to be subject to engineering analysis, evaluation and approval according to relevant ISC guidelines for implementation of alternative design and arrangement.

9.12 Survey and tests

9.12.1 The following plans and documents are to be provided as applicable:

(1) fire zones and fire compartment divisions;

(2) details of construction of fire protection bulkheads, decks;

(3) arrangement of ventilation system and controls of fire dampers;

(4) arrangement of fixed fire extinguishing systems (including the fire-extinguishing system for scavenge spaces of crosshead type diesel engines) together with extinguishing medium calculations;

(5) arrangement of fixed local water-based fire-extinguishing systems and calculations;

(6) arrangement of fixed fire detection and fire alarm system;

(7) arrangement of flammable gas detection system;

(8) other plans and documents as deemed necessary by ISC.

9.12.2 The principal materials, equipment and installations used for the fire safety of autonomous ships are all to be provided with appropriate ISC product certificates.

9.12.3 The following systems are to be subject to testing and verification after installation onboard, to confirm that the performance of the system and its equipment is in compliance with

the requirements of the Guidelines:

(1) fixed fire extinguishing system;

(2) local water-based fire extinguishing system;

(3) fixed fire detection and fire alarm system;

(4) flammable gas detection system;

(5) remote control system.

CHAPTER 10 ENVIRONMENTAL PROTECTION

10.1 General requirements

10.1.1 This Chapter applies to the design, arrangement and management of autonomous ships in relation to environmental protection.

10.1.2 Environmental protection indexes, energy efficiency indexes, structural arrangement and application of material of autonomous ships are to comply with the provisions of the International Convention for the Prevention of Pollution from Ships (hereinafter referred to as MARPOL), the International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004 (hereinafter referred to as BWM Convention), the International Convention on the Control of Harmful Anti-fouling Systems on Ships, 2001 (hereinafter referred to as AFS Convention), Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships, 2009 (hereinafter referred to as the Recycling Convention).

10.1.3 The operational requirements specified in plans, procedures, manuals and records, etc., which need the participation of crew members, as provided in MARPOL, BWM Convention, AFS Convention and the Recycling Convention, are to be satisfied by means of equivalent alternative methods.

10.1.4 Environmental protective equipment and its systems onboard (mainly including oil-contaminated water management, exhaust emission control and ballast water management) are to be capable of autonomous operation and can be switched to the remote control mode by the remote operation center as required.

10.1.5 For oil and oily mixtures, noxious liquid substances, harmful substances carried by sea in packaged form, sewage as well as garbage defined respectively in Annexes I, II, III, IV, V of MARPOL, if zero discharge at sea is achieved, the notation ZWPD may be assigned.

10.2 Goal

10.2.1 In order to preserve the human environment in general and the marine environment in particular, eliminate or alleviate the pollution from ships on sea waters and the atmosphere, measures are to be provided to prevent harmful influence from autonomous ships on the environment as far as practicable, and emergency response is to be initiated after the occurrence of a pollution accident.

10.3 Functional requirements

10.3.1 In order to achieve the goal in 10.2.1, autonomous ships are to at least have the following functions:

10.3.1.1 Perception

(1) Oil-contaminated water management: ship position information, ship speed information,

oil-contaminated water level, condition of oil-contaminated water treatment facility, etc.;

(2) Exhaust emission control: ship position information, condition of fuel change-over equipment, condition of post treatment facility, etc.;

(3) Ballast water management: ship position information, condition of ballast water treatment facility, etc.

10.3.1.2 Communication

(1) Environment protection equipment and system operation condition is to be sent in real time and malfunction alarm is to be sent timely to the remote operation center, and instructions from the remote operation center is to be received.

(2) Reports are to be sent to the remote operation center according to the specified procedures.

10.3.1.3 Decision-making, operation and report

(1) Oil-contaminated water management: decision of management is to be made according to the ship position, total volume/oil content of oil-contaminated water, emission requirements of the navigation area, etc., and such operation is to be conducted automatically or through remote control from the remote operation center;

(2) Exhaust(NO_X/SO_X) emission: decision on change-over of fuel and/or starting or stopping of post-treatment unit is to be made according to the ship position information, the boundaries of emission control areas, and emission requirements of navigation areas, and such operation is to be conducted automatically or through remote control from the remote operation center;

(3) Ballast water management: decision on ballast water treatment or exchange is to be made according to the ship position information, and such operation is to be conducted automatically or through remote control from the remote operation center;

(4) Reports on the above three decisions and operations are to be prepared according to the prescribed procedures.

10.4 Prescriptive requirements

10.4.1 For oil-contaminated water management, in addition to the applicable provisions in MARPOL Annex I, the following requirements are also to be complied with:

10.4.1.1 Oil and oily mixtures, including oily bilge water, oil residue (sludge) and slops are to be automatically collected and stored.

10.4.1.2 Autonomous decision is to be made on whether to discharge overboard and operate related equipment and systems as appropriate, according to the tank level, oil concentration, ship position and ship speed.

10.4.1.3 Operation status of equipment and systems related to oily-water separation for bilge water, and monitoring of oil discharge as well as failure alarms are to be sent to the remote operation center, and remote instructions from the remote operation center are to be accepted as necessary.

10.4.1.4 After connection to the reception facility, automatic or remote-controlled discharge is to

be carried out as instructed by the remote operation center.

10.4.1.5 Electronic recording of all automatic operation are to be made.

10.4.1.6 For oil spillage control, plans are to be designed and developed at least according to but not limited to the following requirements so as to minimize the hazards of oil or oily mixtures to the environment:

(1) video surveillance on oil spillage is to be installed or equivalent measures are to be taken, such as installing oil spillage monitoring radar;

(2) the remote operation center is to keep watching every hour and once oil spillage is detected, the video is to be played back to evaluate the degree of pollution and identify origin of spillage; where monitoring equipment can give oil spillage alarm automatically, the remote operation center does not need to monitor regularly;

(3) the remote operation center is to immediately report the pollution to the nearest coastal state and/or port Authority;

(4) the remote operation center is to be capable of controlling or mitigating oil spillage by means of remote control;

(5) depending on the situation of oil spillage, the remote operation center may appoint a designated person to quickly handle the spillage.

10.4.2 For control of exhaust gas emission, the following requirements are also to be complied with in addition to MARPOL Annex VI, ISC Guidelines for Application of Selective Catalytic Reduction (SCR) System Onboard Ships, and ISC Guidelines for Design and Installation of Exhaust Gas Cleaning Systems:

10.4.2.1 The exhaust gas cleaning system (EGC system) and selective catalytic reduction system (SCR system) installed for compliance with SOx and NOx emission requirements are to be capable of automatic control of system starting, stopping and operation according to the position of the ship and the emission regulations in the waters of intended voyage.

10.4.2.2 The EGC and SCR systems are to be subject to conditional monitoring and fitness assessment according to the requirements in 4.4.8 of Chapter 4 of the Guidelines, and plans for maintenance, servicing, examination and survey are to be made based on the monitoring and assessment results.

10.4.2.3 Primary working parameters , starting/stopping and operation of the EGC and SCR systems are to be automatically recorded and be transmitted to the remote operation center for archiving so that they can be readily available if required during inspection.

10.4.2.4 After the ship is satisfactorily connected to the reception facility, residue generated from the operation of the EGC system is to be discharged automatically or by remote-control as instructed by the remote operation center.

10.4.2.5 If the ship cannot meet the prescribed emission requirements due to system failure, failure information is to be automatically sent to the remote operation center so that a timely report can be sent to the Administration.

10.4.2.6 Filters installed in EGC and SCR auxiliary systems are to be capable of automatic cleaning according to the prescribed procedure.

10.4.2.7 Working parameters and equipment status information required for remote control of EGC and SCR systems are to be indicated in remote operation center, e.g. working conditions of bypassing or isolation device, starting/stopping of pumps/fans, etc.

10.4.2.8 If the chemical agent used may potentially generate hazardous gas, real time monitoring and automatic eliminating is to be carried out. If the hazardous gas concentration is not reduced to the reasonable range, an alarm is to be sent to the remote operation center.

10.4.3 For ballast water management, in addition to the applicable requirements in the BWM Convention and Chapter 26 of PART EIGHT of ISC Rules for Classification of Sea-going Steel Ships, the following requirements are to be complied with:

10.4.3.1 All manual testing, controlling and recording required for the operation of the BWMS are to be automatically achieved.

10.4.3.2 When the BWMS is bypassed or overridden, an alarm is to be sent to the remote operation center.

10.4.3.3 If the BWMS may potentially generate hazardous gas, automatic detection and elimination is to be carried out. If the hazardous gas concentration is not reduced to the specified range, an alarm is to be sent to the remote operation center.

10.4.3.4 Sampling facilities appropriate to the equipment operation and management mode of autonomous ships are to be provided and the sampling process is to be recorded.

10.5 Survey and tests

10.5.1 The following plans and documents are to be submitted for approval in addition to the plans and documents required by applicable rules and guidelines for submission:

(1) checklists for monitoring and alarming of pollution prevention equipment and its system;

(2) autonomous decision- making systems for oil-contaminated water management, exhaust gas emission and ballast water management (including control logic, functional diagrams, etc.).

10.5.2 Effectiveness of the condition monitoring, autonomous decision-making and automatic control function and also remote control function of pollution prevention equipment and its system is to be verified.

CHAPTER 11 SHIP SECURITY

11.1 General requirements

11.1.1 An effective security system is to be provided by the ship with at least the following functions:

(1) access control;

(2) detection, surveillance and alarms;

(3) security communication.

11.1.2 Computer systems and their network design used for all autonomous and remote control operations in the ship and in the remote operation center are to comply with the requirements of Chapter 13 of the Guidelines.

11.1.3 Ship security plans and their implementation as required by the flag State Administrations are to be part of the remote operation center management system as specified in Chapter 12 of the Guidelines.

11.2 Goal

11.2.1 The goal of this chapter is to provide the requirements on the design, installation and operation of the security system in order to prevent unauthorized entry into the ship.

11.3 Functional requirements

11.3.1 To achieve the goal in 11.2.1, the security system is to fulfil the functional requirements provided in 11.3.2 to 11.3.4.

11.3.2 Access control

11.3.2.1 The ship structures and spaces are to be so arranged as to be capable of physically preventing unauthorized access.

11.3.3 Detection, surveillance and alarms

11.3.3.1 The remote operation center is to be capable of detecting and identifying a suspected target which follows, approaches and interferes with the ship, and can monitor the entry into the means of access to the ship and into the sensitive spaces in the ship.

11.3.3.2 Where the ship finds the approach of a suspected target, it is to send alarm to the remote operation center.

11.3.4 Security communication

11.3.4.1 The remote operation center is to be able to automatically receive the security information on the intended navigation routes released by the Company and/or relevant Authority.

11.3.4.2 The ship is to be able to receive all externally broadcast security information as sea, store and process the security information detected and monitored onboard, and transmit the information to the remote operation center.

11.4 Prescriptive requirements

11.4.1 Access control

11.4.1.1 To meet the functional requirements in 11.3.2 above, the number of openings in the external boundaries of hull, superstructures and deck house are to be minimized to meet the minimum requirements of the intended usage. The door to any means of access in the ship is to be capable of automatic closing. The locking arrangement of doors and access (e.g. small hatchways) is to be so designed that they can be only opened from the entry side by a person authorized to enter and can be remotely closed by the remote operation center.

11.4.2 Detection, surveillance and alarms

11.4.2.1 To meet the functional requirements specified in 11.3.3.1, the range of onboard detection and surveillance systems is to cover overboard surrounding areas, means of access to the ship and restricted areas onboard. The detection capacity is to be such that a suspected object of at least a standard container size, within a range of 2 nautical miles, as well as its direction of movement and speed, can be identified.

11.4.2.2 To meet the functional requirements in 11.3.3.2, ship and its security system are to meet the following requirements:

(1) The detection system fitted on the ship is to be able to automatically send a warning to the remote operation center once detecting the approach of a suspected object;

(2) Onboard spaces and means of access are to be provided with adequate lighting. Detection, surveillance and lighting equipment is able to be controlled by the remote operation center, so as to facilitate remote security patrol.

(3) The ship is to be installed with a security alert system as required by SOLAS Regulation XI-2/6, so that the remote operation center can send the security warning to the Administration once it judges that the security of the ship is sabotaged.

11.4.3 Security communication

11.4.3.1 To meet the functional requirements in 11.3.4, the communication systems of the ship and the remote operation center are to be capable of keeping ship security communication, information and equipment smooth and unimpeded at all times, and security communication records are to be maintained.

11.5 Survey and tests

11.5.1 Plan approval

11.5.1.1 The following plans and documents are to be submitted to ISC for approval:

(1) arrangement of hull and compartment access and structures of doors and locking systems;

(2) security detection, surveillance and alarm system arrangement of the entire ship and scenario display system.

11.5.1.2 The following plans and documents are to be submitted to ISC for information:

(1) instructions on security communication of the ship and the remote operation center or other remote-control location.

11.5.2 Survey and tests

11.5.2.1 The range of survey during construction is to at least cover the following:

(1) arrangement of means of access on the ship and its compartments and locking devices;

(2) arrangement of the detection, surveillance and lighting equipment onboard the ship for security purpose.

11.5.2.2 Mooring tests or sea trials are to include the following:

(1) security function of onboard detection, surveillance and alarm systems;

(2) remote control function of the locking arrangements of the passageways/doors/access.

CHAPTER 12 REMOTE OPERATION CENTER

12.1 General requirements

12.1.1 The requirements in this Chapter provide function, safety and management requirements for the remote operation center for autonomous ships.

12.1.2 The equipment and personnel provided for the remote operation center are to be appropriate for the number of ships it controls.

12.1.3 If it is not applicable to implement the entire or partial requirements of this Chapter, an equivalent plan can be adopted subject to the agreement of ISC.

12.2 Goal

12.2.1 The goal of the remote operation center is to, by means of receiving the conditional information on autonomous ships, perform berth-to-berth monitoring and control of autonomous ships, so as to achieve the safety and pollution prevention requirements for such ships.

12.3 Functional requirements for the remote operation center

12.3.1 The remote operation center is at least to have the following functions:

(1) developing voyage plans and approving routes planning；

(2) continuous monitoring and displaying the condition and scenarios of ships, and presenting direct visual display if needed;

(3) monitoring the safety condition of ships and systems, presenting maintenance suggestions based on the condition of ships, so as to ensure the hull and systems of autonomous ships have adequate reliability to ensure safety of next voyage;

(4) overriding the autonomous navigation of autonomous ships as necessary, remotely operating the ships and systems;

(5) carrying out voice and data communication with pilots (if applicable), terminals, auxiliary tugs, surrounding manned ships, ship owners, vessel traffic service (VTS), etc.

(6) sending navigation supporting information in standardized content and format which can be automatically processed and used by the onboard navigation control system (e.g. meteorological and sea condition information, marine safety information, traffic service information, etc.);

(7) playing back history control orders and operations of the ship;

(8) monitoring the loading and unloading of ships (if applicable).

12.4 Arrangement of remote operation center

12.4.1 Arrangement of the remote operation center is to facilitate ship control by personnel, and arrangement of controllers is to follow the principle of ergonomics.

12.4.2 At least the following information on autonomous ships is to be displayed in the remote operation center:

(1) controlling status of ships: e.g. autonomous navigation, remote control, piloting, anchoring, berthing, etc.;

(2) routes of the ships: starting point, finishing point, turning point, current ship position, speed, direction, expected time of arrival, etc.;

(3) sea conditions and meteorological information of the sea area where the ship is located, including navigational warning;

(4) surrounding scenario information: including the information and state of surrounding moving and fixed objects, and displaying them in the nautical charts;

(5) display of ship conning information as required, including ship heading, UTC time, longitude and latitude, draft, revolutions of propulsion units, rudder angle, ship movement (heeling/rolling, trimming/pitching, heaving, etc.), etc.;

(6) display of state of ship systems as required. In case of an alarm, visual and audial alarm is to be released automatically.

12.5 System design principle for remote operation center

12.5.1 The design of the display system, alarming system, control system and computer system of the remote operation center is to comply with the applicable requirements Sections 2, 3, 4, 6, Chapter 2, PART SEVEN of ISC Rules for Classification of Sea-going Steel Ships.

12.5.2 Data servers used for receiving and storing data related to autonomous ships are to be positioned in at least two different locations (of at least A-60 fire division) and dynamically updated. Failure of one server is not to affect the function of the remote operation center.

12.5.3 In case of one failure (excluding fire) of the systems of the remote operation center, surveillance and control of the specified number of autonomous ships are not to be affected.

12.5.4 In case of fire of the remote operation center, surveillance and control of autonomous ships are to be able to be carried out in a backup control center in the distance (normally not in the same building). Such backup control center can be a mobile control center or a simple one.

12.5.5 The backup control center is at least to have the following functions:

(1) remotely operating a single autonomous ship;

(2) displaying main conditional information of the autonomous ship under control.

(3) having communication functions as specified in 12.3.1(5).

12.6 Firefighting

12.6.1 Firefighting of the remote operation center is to meet the applicable requirements for appropriate locations of the region/state where the center is located.

12.7 Electric power supply

12.7.1 Relevant installations of the remote operation center are to be supplied at least by two circuits from different substations. In case of loss of electric power of one circuit, the power

supply is to be automatically switched to the other circuit.

12.7.2 In order to maintain continuous working of the remote operation center, UPS is to be provided to the systems required to keep continuous running and operation, with power supply duration of not less than 0.5 hours.

12.8 Environment of the remote operation center

12.8.1 The environment of the remote operation center, including the temperature, humidity and ventilation, etc., is to be appropriate for the equipment and systems in the center.

12.8.2 The remote operation center is to be provided with adequate lighting by at least two circuits as required in 12.7.1. The lamps are to be crossly arranged. In case of failure of one circuit, the other circuit is still to be able to provide necessary lighting required by operation.

12.8.3 Lighting supplied by UPS is to be provided for essential positions of operation in the remote operation center.

12.9 Operation personnel in the remote operation center

12.9.1 The number of the operation personnel in the remote operation center is to be appropriate for the number of the ships under control.

12.9.2 The remote operation center is at least to be equipped with the following personnel:

(1) ship remote operation personnel;

(2) ship equipment and system management personnel;

(3) maintenance personnel of systems of the remote operation center.

12.9.3 Ship remote operation personnel are to have deck officer (master) certificate, and are familiar with the performance and operation of the ship, which is to be verified through practical operation.

12.9.4 Ship equipment and system management personnel are to be familiar with the function, management and maintenance of various systems of the ship, and have been subject to theoretical training and have adequate operational experience.

12.10 Management requirements

12.10.1 The remote operation center is to establish a management mechanism which is at least to include the following:

(1) manning requirements and on-duty requirements;

(2) responsibility and qualification requirements of different posts;

(3) remote operation procedure;

(4) emergency response procedure;

(5) equipment and system maintenance procedure;

(6) cyber security risk identification and control measures;

(7) security measures.

12.11 Survey and tests

12.11.1 The following plans and documents are to be submitted for approval:

(1) arrangement of the remote operation center, including the firefighting system;

(2) electric power supply to systems of the remote operation center;

(3) scenario display system;

(4) ship condition display system;

(5) rationale of condition-based maintenance system;

(6) rationale of the function of the remote operation center;

(7) arrangement of data backup;

(8) drawing of equipment and system electric power supply;

(9) cyber security risk identification and control measures;

(10) management procedure for the remote operation center.

12.11.2 The systems and equipment of the remote operation center (including the software and hardware) that provide service for ships are to be subject to survey and certification by ISC.

12.11.3 The remote operation center is to be put into use after being subject to plan approval by ISC, and after the survey and tests are satisfactorily completed.

12.11.4 Each autonomous ship is to be linked to one or more remote operation centers, and monitoring and control can only be implemented after real ship control has been satisfactorily verified.

12.11.5 Maintenance and operation management procedures are to be established for the remote operation center, and maintenance and testing are to be carried out on a regular basis.

12.11.6 Inspection of the function and arrangement of the remote operation center is to be carried out by ISC annually to ensure that the intended function as designed has been maintained.

12.11.7 In case of software or hardware updating of the remote operation center, it is to be subject to re-survey and re-test by ISC.

CHAPTER 13 CYBER SECURITY

13.1 General requirements

13.1.1 The provisions of this Chapter apply to the network of autonomous ships.

13.2 Goal

13.2.1 The security threats to the network of autonomous ships are to be minimized through security configuration and measures such as identification, protection, detection, response and recovery of the cyber system.

13.3 Technical requirements for cyber security

13.3.1 The cyber threats to each system of the information system, operation system and remote operation center of autonomous ships are to be identified by risk assessment and risk management is to be carried out. Risk management is generally to include:

(1) identification of the responsibilities of users and key personnel, and management of remote operation center system, ship and company;

(2) identification of system, properties, data and performance and the risks to the operation and safety of ship after damage;

(3) protection of cyber event by technical measures and operation continuity is to be ensured. These measures include network configuration, network and system access control, communications and boundary protection, the use of protective and detecting software;

(4) prevention of cyber event by procedure protection measures. These measures include training and alertness, software maintenance, remote and local access right, use of mobile medium and equipment disposal;

(5) to implement of response plan for cyber event so as to backup and recover the network after cyber event.

13.3.2 Both the ship and company are to establish cyber risk management system.

13.3.3 The cyber system is to comply with the applicable requirements in Section 6, Chapter 2, PART SEVEN of ISC Rules for Classification of Sea-Going Steel Ships.

13.3.4 Measures for cyber security are to comply with the applicable requirements of ISC Guidelines for Cyber Security Requirements and Safety Assessment.

13.4 Surveys and tests

13.4.1 The following plans and documents are to be submitted to ISC for approval:

(1) cyber risk assessment report;

(2) framework of cyber system, node and equipment control strategy;

(3) cyber security control procedures.

13.4.2 Surveys and tests are to be carried out for relevant measures during the construction survey.

13.4.3 Audit is to be carried out for cyber risk management system during the annual survey to confirm that relevant measures are implemented effectively.

CHAPTER 14 SURVEY AND CERTIFICATION

14.1 General requirements

14.1.1 In order to obtain the class notation specified in 1.2.1 of Chapter 1 of the Guidelines, plan approval, surveys and tests are to be carried out for the ship so as to confirm that the applicable requirements of the Guidelines are complied with and the classification certificate is issued.

14.1.2 In addition to the provisions of this Chapter, requirements for basic procedures for plan approval, survey and the issuance and endorsement of certificate of the ship and its system, together with the types of survey, circle and validity of certificate are to follow relevant requirements of PART ONE of ISC Rules for Classification of Sea-Going Steel Ships.

14.1.3 The remote operation center of the ship is to be provided with valid approval certificate.

14.2 Maintenance of ship

14.2.1 A preventive and periodic maintenance system which is compatible with the reliability of the ship and its system is to be established and implemented so as to ensure that the ship and its system operate safely during the voyage, including the arrangement of:

(1) condition monitoring or health management of essential system;

(2) testing prior to the voyage;

(3) replacement of equipment and its components;

(4) dry-dock overhaul.

14.3 Survey conditions

14.3.1 Measures in the aspect of access, lighting, ventilation and electrical protection are to be provided for the construction and arrangement of ship so as to ensure that the survey, overhaul and maintenance of ship are carried out safely when the ship is under construction and at berth.

14.3.2 The shipborne system is to be easy for commissioning and testing.

14.4 Plan approval

14.4.1 In addition to the requirements of relevant chapters of the Guidelines, the scope of plans and documents to be submitted is to comply with the applicable requirements of ISC Rules for Classification of Sea-Going Steel Ships.

14.5 Survey during construction

14.5.1 In addition to the provisions of this regulation, survey during construction is to comply with the applicable requirements of Chapter 4, PART ONE of ISC Rules for Classification of Sea-Going Steel Ships.

14.5.2 In addition to the individual tests specified in each chapter of the Guidelines, the

integration tests of each sub-system are to be included.

14.5.3 The real ship test is to be carried out under the specified environmental conditions in accordance with the approved trial programmes so as to verify comprehensively functions of the ship and its system under various operation scenarios.

14.5.4 Equipment and systems of remote operation center serving the ship are to be tested and all functions of remote operation center such as monitoring, testing, remote control and emergency communication of the ship.

14.5.5 The builder is to assign a project leader who is responsible for the coordination of each system to achieve the final system-level function.

14.6 Survey after construction

14.6.1 Before delivery, a survey plan within a full life circle is to be established, including the remote operation center, to determine the scope and extent of each survey and methods for survey and test. The following inputs are considered:

(1) mandatory requirements of the Administration;

(2) relevant requirements of ISC Rules for Classification of Sea-Going Steel Ships and other applicable rules and guidelines;

(3) relevant requirements of the Guidelines;

(4) approved alternative design documents;

(5) shipowner's maintenance and overhaul system.

14.6.2 The survey plan of the ship is to be implemented after the endorsement of parties before put into service. The plan is to be maintained during service and necessary adjustment may be put forward according to the results of the technical condition assessment of the ship.

14.6.3 The scope of surveys after construction are to be in accordance with the approved survey plan so as to confirm that the hull structure and ship systems are maintained complying with the requirements of the Guidelines.

14.6.4 In the operation of the ship, the security measures of the software system is to comply with ISC' survey requirements for software.

14.7 Certification of remote operation center

14.7.1 Types of audit and certificate

14.7.1.1 Initial audit is to be carried out for remote operation center before put into service so as to confirm that relevant requirements of Chapter 12 and other chapters of the Guidelines are complied with and an annual audit is to be carried out within the validity of Remote operation center Approval Certificate (ScAC) so as to confirm that the center is maintained complying with relevant requirements of the Rules.

14.7.1.2 The validity of Remote operation center Approval Certificate (ScAC) is not to exceed 5 years. The approval certificate will be reissued after the renewal audit and it is confirmed that

relevant requirements of the Guidelines are complied with.

14.7.2 Initial audit

14.7.2.1 The arrangement, equipment and system plans as listed in 12.11.1 of Chapter 12 of the Guidelines are to be submitted to ISC for approval, among which the management system document of remote operation center is to be submitted to ISC for review.

14.7.2.2 The scope of field audit is at least to include the following items:

(1) to examine whether the arrangement of remote operation center and its equipment together with the installation and functions of system and power supply system are in compliance with the requirements of the approved plans;

(2) to confirm that the of fire safety of remote operation center has been checked and accepted by the Administration of the State satisfactorily;

(3) to verify that the environmental conditions of remote operation center meet the function realization needs;

(4) to verify the provision of operating personnel and his competence;

(5) to examine the security measures, including the reliability of network security;

(6) to confirm the provision safety, security and network management system documents and the effectiveness of implementation;

(7) to verify all functions such as monitoring, testing, remote control and emergency communication of at least one ship.

14.7.2.3 ISC will issue approval certificate for remote operation center when audited that the requirements of the Guidelines are met and ships under the management of the center are to be listed.

14.7.3 Annual audit

14.7.3.1 The annual audit is to be carried out 3 months before or after the anniversary date of the approval certificate.

14.7.3.2 The scope of audit is to be the same as that specified in 14.7.2.2 and changes which have not been approved are to be verified. After satisfactory audit, the approval certificate is to be endorsed.

14.7.4 Renewal audit

14.7.4.1 The renewal audit is to be carried out within 3 months before the expiry date of the approval certificate.

14.7.4.2 The scope of audit is to be the same as that specified in 14.7.3.2. After satisfactory audit, the approval certificate is to be reissued.