Identification of IMO Regulations relating to Unmanned Operations of Maritime Autonomous Surface Ships
- SOLAS Convention and Related Mandatory IMO Instruments -

by

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Abstract

The Maritime Safety Committee (MSC) of International Maritime Organization (IMO), at its 98th session held on June 2017, agreed to include a new agenda item “Regulatory scoping exercise for the use of Maritime Autonomous Surface Ships (MASS)” in order to determine how the safe, secure and environmentally sound operation of MASS may be introduced in IMO instruments. In the regulatory scoping exercise, it is necessary to identify IMO regulations: (1) which preclude unmanned operations; (2) which would have no application to unmanned operations; and (3) which do not preclude unmanned operations but may need to be amended for enabling the construction and operation of MASS. The purpose of this investigation is to identify IMO regulations attributed to the aforementioned cases, in order to contribute to the work of the MSC. Specifically, regulations in the International Convention for the Safety of Life at Sea (SOLAS Convention) are investigated. The SOLAS Convention makes many IMO instruments mandatory in its text. Requirements in the IMO instruments which are made mandatory by the SOLAS Convention are also investigated. Based on the results of the investigation, suggestions for research and development of unmanned ships are considered.

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1 Introduction

1.1 Background and purpose

The Maritime Safety Committee (MSC) of International Maritime Organization (IMO), at its 98th session (MCS 98) held on June 2017, considered an IMO document[1)] proposing a new work item on Maritime Autonomous Surface Ships (MASS) together with other document commenting on it[2)].

According to the document[1)], maritime sector is witnessing an increased deployment of to deliver safe, cost-effective and high quality results. In this context, MASS could include ships with different levels of automation, from partially automated systems that assist the human crew to fully autonomous systems which are able to undertake all aspects of a ships' operation without the need for human intervention. Significant academic and commercial research and

development is ongoing on all aspects of MASS, including remotely-controlled and autonomous navigation, vessel monitoring and collision avoidance systems.

The MSC, after discussion, agreed to include a new agenda item "Regulatory scoping exercise for the use of Maritime Autonomous Surface Ships (MASS)" in order to determine how the safe, secure and environmentally sound operation of MASS may be introduced in IMO instruments[3]. In the regulatory scoping exercise[1], it is necessary to identify IMO regulations:

.1 which preclude unmanned operations;
.2 which would have no application to unmanned operations; and
.3 which do not preclude unmanned operations but may need to be amended for enabling the construction and operation of unmanned ships.

Hereafter, the above mentioned cases are expressed as "preclusive case", "inapplicable case" and "amendment required case", respectively, in this paper.

The purpose of this investigation is to identify IMO regulations attributed to the aforementioned cases, in order to support the work of the MSC.

1.2 Scope of the investigation

IMO has developed a number of international regulations and has been amending them to minimize out-of-date regulations. Among the international regulations developed by IMO, the following conventions are deeply related to unmanned operation of ships:

.1 International Regulations for Preventing Collisions at Sea, 1972 (COLREGs);
.2 International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978 (STCW Convention); and
.3 International Convention for the Safety of Life at Sea, 1974 (SOLAS Convention)

Among the aforementioned three international regulations, COLREGs and STCW Convention are deemed to be investigated by other organizations from the view point of unmanned operation of ships.

The SOLAS Convention is one of the most important conventions developed by IMO and the Convention has significant effect on ship design. The author investigates the regulations in the Convention, other than appendices to the annex to the Convention, i.e. forms for certificates. The following two protocols are investigated together with the International Convention for the Safety of Life at Sea, 1974:

.1 the protocol of 1978 relating to the International Convention for the Safety of Life at Sea, 1974; and
.2 the protocol of 1988 relating to the International Convention for the Safety of Life at Sea, 1974.

Hereafter, the SOLAS Convention means the International Convention for the Safety of Life at Sea, 1974, and the aforementioned two protocols. The author investigates the Convention including all amendments and draft amendments to the Convention adopted by up to 98th session of the MSC (MSC 98) held on June 2017[4]. The results of the investigation are set out in section 2 of this paper. In the section, unless expressly specified otherwise, "chapter" means chapter of the annex to the SOLAS Convention. In this paper, the expression "SOLAS regulation XX/YY" means regulation YY in chapter XX of the annex to the SOLAS Convention.

For the purpose of the investigation, neither officers and crew nor passengers and infants, i.e. children under one year of age which are not passengers according to the definition in chapter I of the Convention, are assumed to be onboard unmanned ships. Thus, the investigation does not cover the requirements applicable only to passenger ships. Likewise, it does not cover the requirements applicable only to existing ships.

The Convention makes many IMO instruments mandatory in its text. Namely, the Convention is the basis for various mandatory IMO instruments. Table 1 shows the IMO instruments which are made mandatory by the Convention. The author investigates the text of the IMO instruments listed in the table other than those mentioned below, including all amendments and draft amendments adopted by up to MSC 98.[5] The investigation does not cover the following five IMO instruments listed in the table for the following reasons:

.1 1994 HSC Code (No. 21) is only applicable to existing ships as provided in SOLAS regulation X/3.1.1;
.2 The RO Code (No. 23) is the requirements for recognized organizations but not for ships as provided in SOLAS regulation XI-1/1;
.3 The Casualty Investigation Code (No. 25) incorporates and builds on the best practices in marine casualty and marine incident investigation and is not the requirements for ships;

Table 1 IMO instruments which are made mandatory by SOLAS Convention

No.	Document ID	Name of IMO instrument
1	MSC.215(82)	Performance standard for protective coatings for dedicated seawater ballast tanks in all types of ships and double-side skin spaces of bulk carriers
2	MSC.133(76)	Technical provisions for means of access for inspections
3	MSC.287(87)	Goal-based Ship Construction Standards for Bulk Carriers and Oil Tankers
4	MSC.288(87)	Performance standard for protective coatings for cargo oil tanks of crude oil tankers
5	MSC.289(87)	Performance standard for alternative means of corrosion protection for cargo oil tanks of crude oil tankers
6	MSC.337(91)	Code on noise levels on board ship
7	MSC.267(85)	International Code on Intact Stability, 2008 (2008 IS Code)
8	*MSC.391(95)*	*International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF Code)*
9	MSC.98(73)	International Code for Fire Safety Systems (FSS Code)
10	MSC.307(88)	International Code for Application of Fire Test Procedures, 2010 (FTP Code 2010)
11	MSC.48(66)	International Life-Saving Appliance Code (LSA Code)
12	MSC.402(96)	Requirements for maintenance, thorough examination, operational testing, overhaul and repair of lifeboats and rescue boats, launching appliances and release gear
13	MSC.268(85)	International Maritime Solid Bulk Cargoes Code (IMSBC Code)
14	A.714(17)	Sub-chapter 1.9 of the Code of Safe Practice for Cargo Stowage and Securing (CSS Code)
15	MSC.23(59)	International Code for the Safe Carriage of Grain in Bulk (International Grain Code)
16	MSC.122(75)	International Maritime Dangerous Goods Code (IMDG Code)
17	MSC.4(48)	International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code)
18	MSC.5(48)	International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code)
19	*MSC.88(71)*	*International Code for the Safe Carriage of Packaged Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Wastes on Board Ships (INF Code)*
20	A.741(18)	International Management Code for the Safe Operation of Ships and for Pollution Prevention (ISM Code)
21	*MSC.36(63)*	*International Code of Safety for High-Speed Craft (1994 HSC Code)*
22	*MSC.97(73)*	*International Code of Safety for High-Speed Craft, 2000 (2000 HSC Code)*
23	*MSC.349(92)*	*Code for recognized organizations (RO Code)*
24	A.1049(27)	International Code on the Enhanced Programme of Inspections during Surveys of Bulk Carriers and Oil Tankers, 2011 (2011 ESP Code)
25	*MSC.255(84)*	*Code of the International Standards and Recommended Practices for a Safety Investigation into a Marine Casualty or Marine Incident (Casualty Investigation Code)*
26	SOLAS/CONF. 5 Resolution 2	International Code for the Security of Ships and of Port Facilities (ISPS Code)
27	*SOLAS/CONF.4 Resolution 4*	*Standards for the evaluation of scantlings of the transverse watertight vertically corrugated bulkhead between the two foremost cargo holds and for the evaluation of allowable hold loading of the foremost cargo hold (Bulk carrier bulkhead and double bottom strength standards)*
28	MSC.169(79)	Standards for owners' inspection and maintenance of bulk carrier hatch covers
29	*A.1070(28)*	*IMO Instruments Implementation Code (III Code)*
30	*MSC.385(94)*	*International Code for Ships Operating in Polar Waters (Polar Code)*

.4 Bulk carrier bulkhead and double bottom strength standards (No. 27) is only applicable to existing ships as provided in SOLAS regulation XII/6; and

.5 The III Code (No. 29) is the requirements for Contracting Governments but not for ships as provided in SOLAS regulation XIII/2.

Furthermore, the investigation does not cover the IMO instruments which are effective only in specific cases. Namely, the following four codes listed in the table are not investigated:

.1 The IGF Code (No. 8), which is applicable only to ships using gases or other low-flashpoint liquids as fuel, in lieu of complying with the requirement for limitation of use of oil fuel, i.e. SOLAS regulation II-2/4;

.2 The INF Code (No. 19), which is applicable only to ships carrying packaged irradiated nuclear fuel, plutonium or high-level radioactive wastes;

.3 2000 HSC Code (No. 22), which is applicable in lieu of requirements in chapter I to IV and regulations 18 to 20 of chapter V, as provided in chapter X; and

.4 Polar Code (No. 30), which is applicable only to ships operating in polar waters, as provided in chapter XIV.

The above mentioned nine IMO instruments are expressed with italic font in Table 1.

Some of the codes which are made mandatory by the SOLAS Convention include recommendatory parts. In this paper, only mandatory parts of the codes are considered for the purpose of identification of "preclusive case", "inapplicable case" and "amendment required case".

1.3 Assumptions for classification of requirements

In this paper, requirements for obligation of a ship's master or other ship's personnel are classified as "preclusive case". Requirements on accessibility of various equipment and controls are not investigated in this paper, while those may be unnecessary on unmanned ships. The following types of requirements and provisions are classified as "amendment required case":

.1 Manually operated systems and appliances;

.2 Provision of information to ship's personnel;

.3 Alerting or notification of an incident, including alarms, to ship's personnel;

.4 Means of communication onboard the ship; and

.5 Means of escape or means of evacuation from ships.

For the identification of above mentioned three cases, one of the following assumptions should be adopted:

.1 the master of an unmanned ship exists, while he/she is not onboard the ship, and ship's personnel are available during cargo handling, anchoring and berthing, while they are unavailable during sailing; or

.2 the master of an unmanned ship does not exist and ship's personnel are unavailable.

The former assumption is adopted for this investigation, taking into account that the latter one is more unrealistic. It should be noted that the results of classification heavily depend on the assumptions.

2 Investigation of SOLAS Convention

2.1 Overview of the Convention

The SOLAS Convention consists of the articles and the annex. The annex consists of the chapters specified in Table 2. Hereafter, each of the above mentioned chapters is briefly expressed as "chapter (number) of the SOLAS Convention" instead of "chapter (number) of the annex to the SOLAS Convention".

In these chapters, chapter VIII is applicable only to nuclear ships and not investigated in this paper. Chapters X and XIV are the provisions for the HSC Codes and the Polar Code, respectively. These chapters are not investigated in this paper for the same reason as for 2000 HSC Code and the Polar Code. Chapter XIII prescribes the obligations of Contracting Governments and is not investigated in this paper. Thus, the articles and the annex other than chapters VIII, X, XIII and XIV are investigated in this paper.

Regulations for alternative design and arrangements are not investigated in this paper. Namely, the following parts are not investigated:

Part F (regulation 55) of Chapter II-1;

Part F (regulation 17) of Chapter II-2; and

Part C (regulation 38) of Chapter III.

It should be noted that the annex other than chapter I can be amended in accordance with article VIII(b)(vi)(2) of the Convention, so called "tacit procedure", where an adopted amendment will be deemed to have been accepted unless either more than one third of the Contracting Governments, or Contracting Governments the combined merchant fleets of which constitute not less than fifty per cent of the gross tonnage of the world's merchant fleet, notified objection within a specified period. On the other hand, the articles and chapter I of the annex should be amended in accordance with article VIII(b)(vi)(1) of the Convention, so called "explicit procedure", where an adopted amendment will not be deemed to have been accepted until two thirds of the Contracting Governments submit acceptance. The acceptance, as well as entry into force, of the amendment in accordance with "explicit procedure" is difficult, in general, and may take long time.

Table 2 Chapters of the annex to the SOLAS Convention

Chapter	Title
I	General provisions
II-1	Construction - Structure, subdivision and stability, machinery and electrical installations
II-2	Construction - Fire protection, fire detection and fire extinction
III	Life saving appliances and arrangements
IV	Radiocommunications
V	Safety of navigation
VI	Carriage of cargoes and oil fuels
VII	Carriage of dangerous goods
VIII	Nuclear ships
IX	Management for the safe operation of ships
X	Safety measures for high-speed craft
XI-1	Special measures to enhance maritime safety
XI-2	Special measures to enhance maritime security
XII	Additional safety measures for bulk carriers
XIII	Verification of compliance
XIV	Safety Measures for Ships Operating in Polar Waters

2.2 Articles

Table 3 indicates issues prescribed in the articles of the SOLAS Convention and the article numbers of the 1974 Convention, the 1978 protocol and the 1988 protocol. In these articles, ship's personnel is referred to only in article IV of the 1974 Convention, i.e. cases of force majeure. The relevant text is as follows:

> "Persons who are on board a ship by reason of force majeure or in consequence of the obligation laid upon the master to carry shipwrecked or other persons shall not be taken into account for the purpose of ascertaining the application to a ship of any provisions of the present Convention."

This text is neither "preclusive case", "inapplicable case" nor "amendment required case".

2.3 Chapter I - General provisions

Chapter I of the SOLAS Convention mainly prescribes the procedural issues. Table 4 shows the parts and regulations of this chapter. This chapter does not include regulation applicable only to passenger ships.

In chapter I, the obligation of the ship's master is referred to, twice, in paragraph (c) of regulation 11, i.e. maintenance of conditions after survey. In both cases, the obligation of the master is prescribed as "the master or owner of the ship shall …". Therefore, the text in the paragraph is neither "preclusive case", "inapplicable case" nor "amendment required case".

Table 3 Issues prescribed in the articles of the SOLAS Convention and the article numbers

Prescribed issue	Article number		
	1974 Convention	1978 Protocol	1988 Protocol
General obligations	I	I	I
Application	II	II	
Communication of information		III	III
Laws, regulations	III		
Cases of force majeure	IV		
Carriage of persons in emergencies	V		
Prior treaties and conventions	VI		II
Special rules drawn up by agreement	VII		
Amendments	VIII		VI
Signature, ratification, acceptance, approval and accession	IX	IV	IV
Entry into force	X	V	V
Denunciation	XI	VI	VII
Depositary	XII	VII	VIII
Languages	XIII	VIII	IX

Table 4 Parts and regulations of chapter I

Part A	**Application, definitions, etc.**
	Regulation 1 Application
	Regulation 2 Definitions
	Regulation 3 Exceptions
	Regulation 4 Exemptions
	Regulation 5 Equivalents
Part B	**Surveys and certificates**
	Regulation 6 Inspection and survey
	Regulation 7 Surveys of passenger ships
	Regulation 8 Surveys of life-saving appliances and other equipment of cargo ships
	Regulation 9 Surveys of radio installations of cargo ships
	Regulation 10 Surveys of structure, machinery and equipment of cargo ships
	Regulation 11 Maintenance of conditions after survey
	Regulation 12 Issue or endorsement of certificates
	Regulation 13 Issue or endorsement of certificates by another Government
	Regulation 14 Duration and validity of certificates
	Regulation 15 Forms of certificates and records of equipment
	Regulation 16 Availability of certificates
	Regulation 17 Acceptance of certificates
	Regulation 18 Qualification of certificates
	Regulation 19 Control
	Regulation 20 Privileges
Part C	**Casualties**
	Regulation 21 Casualties

2.4 Chapter II-1 - Construction - Structure, subdivision and stability, machinery and electrical installations

2.4.1 General characteristics and overview of the chapter

Some requirements in chapter II-1 are related to manual operations by ships' personnel, while the majority of requirements are related to ship design. Table 5 shows the parts and regulations of this chapter. The right column of this table indicates the regulations applicable only to passenger ships, which are not investigated in this paper.

This chapter makes the following codes and performance standards mandatory:

- Performance standard for protective coatings for dedicated seawater ballast tanks in all types of ships and double-side skin spaces of bulk carriers;
- Technical provisions for means of access for inspections;
- Goal-based Ship Construction Standards for Bulk Carriers and Oil Tankers;
- Performance standard for protective coatings for cargo oil tanks of crude oil tankers;
- Performance standard for alternative means of corrosion protection for cargo oil tanks of crude oil tankers;
- Code on noise levels on board ship;
- International Code on Intact Stability, 2008 (2008 IS Code); and
- International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF Code).

As mentioned in paragraph 1.2 of this paper, the IGF Code is not investigated. Similarly, Part G, i.e. regulations 56 and 57 are not investigated. Furthermore, as mentioned in paragraph 2.1 of this paper, part F, i.e. regulation 55, is not investigated. The respective regulations other than those applicable only to passenger ships and regulation 55 are investigated in the next paragraph.

2.4.2 Classification of requirements in view of unmanned operation

(1) Part A - General

Regulations 1 to 3 are application provision and definitions. These regulations are applicable to unmanned ships.

(2) Part A-1 - Structure of ships

Regulations 3-1 and 3-2 are applicable to unmanned ships. Regulation 3-2 makes "Performance standard for protective coatings for dedicated seawater ballast tanks in all types of ships and double-side skin spaces of bulk carriers" mandatory and this performance standard is also applicable to unmanned ships, as mentioned in paragraph 3.1 of this paper.

Table 5 Parts and regulations of chapter II-1 (1/2)

Parts and regulations			Passenger ships only
Part A	**General**		
	Regulation 1	Application	
	Regulation 2	Definitions	
	Regulation 3	Definitions relating to parts C, D and E	
Part A-1	**Structure of ships**		
	Regulation 3-1	Structural, mechanical and electrical requirements for ships	
	Regulation 3-2	Protective coatings of dedicated seawater ballast tanks in all types of ships and double-side skin spaces of bulk carriers	
	Regulation 3-3	Safe access to tanker bows	
	Regulation 3-4	Emergency towing arrangements and procedures	
	Regulation 3-5	New installation of materials containing asbestos	
	Regulation 3-6	Access to and within spaces in, and forward of, the cargo area of oil tankers and bulk carriers	
	Regulation 3-7	Construction drawings maintained on board and ashore	
	Regulation 3-8	Towing and mooring equipment	
	Regulation 3-9	Means of embarkation on and disembarkation from ships	
	Regulation 3-10	Goal-based ship construction standards for bulk carriers and oil tankers	
	Regulation 3-11	Corrosion protection of cargo oil tanks of crude oil tankers	
	Regulation 3-12	Protection against noise	
Part B	**Subdivision and stability**		
	Regulation 4	General	
Part B-1	**Stability**		
	Regulation 5	Intact stability	
	Regulation 5-1	Stability information to be supplied to the master	
	Regulation 6	Required subdivision index *R*	
	Regulation 7	Attained subdivision index *A*	
	Regulation 7-1	Calculation of the factor p_i	
	Regulation 7-2	Calculation of the factor s_i	
	Regulation 7-3	Permeability	
	Regulation 8	Special requirements concerning passenger ship stability	X
	Regulation 8-1	System capabilities and operational information after a flooding casualty on passenger ships	X
Part B-2	**Subdivision, watertight and weathertight integrity**		
	Regulation 9	Double bottoms in passenger ships and cargo ships other than tankers	
	Regulation 10	Construction of watertight bulkheads	
	Regulation 11	Initial testing of watertight bulkheads, etc.	
	Regulation 12	Peak and machinery space bulkheads, shaft tunnels, etc.	
	Regulation 13	Openings in watertight bulkheads below the bulkhead deck in passenger ships	X
	Regulation 13-1	Openings in watertight bulkheads and internal decks in cargo ships	
	Regulation 14	Passenger ships carrying goods vehicles and accompanying personnel	X
	Regulation 15	Openings in the shell plating below the bulkhead deck of passenger ships and the freeboard deck of cargo ships	
	Regulation 15-1	External openings in cargo ships	
	Regulation 16	Construction and initial tests of watertight doors, sidescuttles, etc.	
	Regulation 16-1	Construction and initial tests of watertight decks, trunks, etc.	
	Regulation 17	Internal watertight integrity of passenger ships above the bulkhead deck	X
	Regulation 17-1	Integrity of the hull and superstructure, damage prevention and control on ro-ro passenger ships	X
Part B-3	**Subdivision load line assignment for passenger ships**		X
	Regulation 18	Assigning, marking and recording of subdivision load lines for passenger ships	X

Table 5 Parts and regulations of chapter II-1 (2/2)

Parts and regulations			Passenger ships only
Part B-4	**Stability management**		
	Regulation 19	Damage control information	
	Regulation 19-1	Damage control drills for passenger ships	X
	Regulation 20	Loading of ships	
	Regulation 21	Periodical operation and inspection of watertight doors, etc., in passenger ships	X
	Regulation 22	Prevention and control of water ingress, etc.	
	Regulation 22-1	Flooding detection systems for passenger ships carrying 36 or more persons constructed on or after 1 July 2010	X
	Regulation 23	Special requirements for ro-ro passenger ships	X
	Regulation 24	Prevention and control of water ingress, etc., in cargo ships	
	Regulation 25	Water level detectors on single hold cargo ships other than bulk carriers	
Part C	**Machinery installations**		
	Regulation 26	General	
	Regulation 27	Machinery	
	Regulation 28	Means of going astern	
	Regulation 29	Steering gear	
	Regulation 30	Additional requirements for electric and electrohydraulic steering gear	
	Regulation 31	Machinery controls	
	Regulation 32	Steam boilers and boiler feed systems	
	Regulation 33	Steam pipe systems	
	Regulation 34	Air pressure systems	
	Regulation 35	Ventilating systems in machinery spaces	
	Regulation 35-1	Bilge pumping arrangements	
	Regulation 37	Communication between navigation bridge and machinery space	
	Regulation 38	Engineers' alarm	
	Regulation 39	Location of emergency installations in passenger ships	X
Part D	**Electrical installations**		
	Regulation 40	General	
	Regulation 41	Main source of electrical power and lighting systems	
	Regulation 42	Emergency source of electrical power in passenger ships	X
	Regulation 42-1	Supplementary emergency lighting for ro-ro passenger ships	X
	Regulation 43	Emergency source of electrical power in cargo ships	
	Regulation 44	Starting arrangements for emergency generating sets	
	Regulation 45	Precautions against shock, fire and other hazards of electrical origin	
Part E	**Additional requirements for periodically unattended machinery spaces**		
	Regulation 46	General	
	Regulation 47	Fire precautions	
	Regulation 48	Protection against flooding	
	Regulation 49	Control of propulsion machinery from the navigation bridge	
	Regulation 50	Communication	
	Regulation 51	Alarm system	
	Regulation 52	Safety systems	
	Regulation 53	Special requirements for machinery, boiler and electrical installations	
	Regulation 54	Special consideration in respect of passenger ships	X
Part F	**Alternative design and arrangements**		
	Regulation 55	Alternative design and arrangements	
Part G	**Ships using low-flashpoint fuels**		
	Regulation 56	Application	
	Regulation 57	Requirements for ships using low-flashpoint fuels	

Regulation 3-3 requires means to enable the crew to gain safe access to the bow of tankers even in severe weather conditions. This regulation can be classified as "amendment required case".

Regulation 3-4 requires a ship-specific emergency towing procedure and the requirement can be classified as “amendment required case”.

Regulations 3-5 and 3-6 are applicable to unmanned ships. In regulation 3-6, paragraph 2 requires means of access to cargo and other spaces for the purpose of inspection and is applicable to unmanned ships. This paragraph makes “technical provisions for means of access for inspections” mandatory and these technical provisions are applicable to unmanned ships, as mentioned in paragraph 3.2 of this paper.

Regulations 3-7 to 3-9 are applicable to unmanned ships.

Regulations 3-10 and 3-11 are applicable to unmanned ships. Regulation 10 makes “Goal-based Ship Construction Standards for Bulk Carriers and Oil Tankers” mandatory and this performance standard is also applicable to unmanned ships, as mentioned in paragraph 3.3 of this paper. Regulation 11 makes “performance standard for protective coatings for cargo oil tanks of crude oil tankers” and “performance standard for alternative means of corrosion protection for cargo oil tanks of crude oil tankers” mandatory and these performance standards are also applicable to unmanned ships, as mentioned in paragraphs 3.4 and 3.5 of this paper.

Regulation 3-12 can be classified as “amendment required case”, for the reason that the purpose of this regulation is protection of persons onboard against noise. This regulation makes “Code on noise levels on board ship” mandatory and the Code can also be classified as “amendment required case”, as mentioned in paragraph 3.6 of this paper.

(3) Part B - Subdivision and stability

Regulation 4 is applicable to unmanned ships.

(4) Part B-1 - Stability

Regulation 5 is applicable to unmanned ships. This regulation makes “International Code on Intact Stability, 2008” mandatory and the Code is basically applicable to unmanned ships, while a part of the Code can be classified as “amendment required case”, as mentioned in paragraph 3.7 of this paper.

Regulation 5-1 prescribes the provision of information to the ship’s master. This regulation is classified as “amendment required case”, based on the assumption mentioned in paragraph 1.3 of this paper.

Regulations 6 to 7-3 are applicable to unmanned ships. Here, it should be noted that paragraph 5 of regulation 7-2 refers to provision of information concerning the use of equalization devices to the master of the ship as follows:

> “5 Unsymmetrical flooding is to be kept to a minimum consistent with the efficient arrangements. Where it is necessary to correct large angles of heel, the means adopted shall, where practicable, be self-acting, but in any case where controls to equalization devices are provided they shall be operable from above the bulkhead deck of passenger ships and the freeboard deck of cargo ships. These fittings together with their controls shall be acceptable to the Administration. Suitable information concerning the use of equalization devices shall be supplied to the master of the ship.”

In this regard, the last sentence in paragraph 5 of regulation 7-2 can be classified as “amendment required case”. However, regulation 7-2 is basically applicable to unmanned ships, for the reason that equalization devices need not be provided depending on design of ships.

(5) Part B-2 - Subdivision, watertight and weathertight integrity

Regulations 9 to 12 are applicable to unmanned ships.

Paragraph 2 of regulation 13-1 includes the requirement on alarms. This paragraph is classified as “amendment required case”.

Regulations 15 to 16-1 are applicable to unmanned ships.

(6) Part B-4 - Stability management

Regulation 19 prescribes the provision of information to the ship’s personnel. This regulation is classified as “amendment required case”.

Paragraph 1 of regulation 20 prescribes the obligation of the ship’s master prior to departure. Therefore, this requirement may be applicable to unmanned ships, depending on the interpretation.

In regulation 22, paragraphs 4 and 9 refer to “the discretion of the master” concerning opening of watertight doors and these paragraphs are applicable to unmanned ships, taking into account that watertight doors of unmanned ships need not be opened during voyage. Paragraphs 10 and 11 require the ship’s master to ensure that an effective system of supervision and reporting of the closing and opening of the watertight doors is implemented. These requirements are applicable to unmanned ships, provided that watertight doors are always closed during voyage on unmanned ships.

Regulation 24 is applicable to unmanned ships.

Regulation 25 applies only to existing ships and is not investigated in this paper.

(7) Part C - Machinery installations

Paragraph 10 of regulation 26 refers to a language understandable by officers and crew members. This paragraph is classified as “amendment required case”.

Regulation 27 is applicable to unmanned ships.

Paragraph 3 of regulation 28 prescribes the provision of information to the ship’s personnel. This paragraph is classified as “amendment required case”.

Audible and visual alarms are required in paragraphs 5.2, 8.3 and 12.2 of regulations 29 and paragraph 3 of regulation 30. These paragraphs are, therefore, classified as “amendment required case”

In regulation 31, paragraph 2 requires alarms for ship’s personnel. This paragraph is classified as “amendment required case”. Paragraph 3 is the requirement for the arrangement and control where the main propulsion and associated machinery are under continuous manual supervision from a control room. This paragraph is classified as “inapplicable case”. Paragraph 4 is the requirement for “manually overriding” and classified as “amendment required case”. Paragraph 6, i.e. additional sub-paragraph .10 in paragraph 2 for ships constructed on or after 1 July 2004, refers to manual intervention by the officer in charge of the navigational watch and this paragraph can be classified as “amendment required case”.

Paragraphs 2 and 3 of regulations 32 requires alarms. These paragraphs are classified as “amendment required case”.

Regulations 33 to 35 are applicable to unmanned ships.

Paragraph 2.6.2 of regulation 35-1 requires alarms. This paragraph is classified as “amendment required case”.

Regulations 37 and 38 are requirements for communication and alarms. These regulations are classified as “amendment required case”.

(8) Part D - Electrical installations

Regulations 40 and 41 are applicable to unmanned ships, while paragraph 2.1 of regulation 41 may be classified as “inapplicable case”, for the reason that this paragraph is the requirement for illumination of parts of a ship normally accessible to and used by passengers or crew.

Regulations 43 to 45 are applicable to unmanned ships, while the capacity of emergency power required in paragraph 2 can be reduced on unmanned ships.

(9) Part E - Additional requirements for periodically unattended machinery spaces

Regulation 46 is applicable to unmanned ships.

Paragraph 1 of regulation 47 refers to alarms. This paragraph is classified as “amendment required case”.

Regulation 48 is applicable to unmanned ships.

Regulations 49 to 51, which refer to: control of propulsion machinery from the navigation bridge; communication between machinery control rooms, navigation bridge and engineers’ accommodation; and alarm system, respectively, can be classified as “amendment required case”.

Regulation 52 includes a requirement for alarms. This regulation is classified as “amendment required case”.

Paragraphs 4.2 to 4.4 of regulation 53 are the requirements for alarms. These paragraphs are classified as “amendment required case”.

2.4.3 Regulations of “preclusive case”, “inapplicable case” and “amendment required case”

Provisions of “preclusive case” were not identified. Provision of “inapplicable case” is included in regulation 31. Provisions of “amendment required case” are included in regulations 3-3, 3-6, 3-12, 5, 5-1, 7-2, 13-1, 19, 26, 28, 29, 31, 32, 35-1, 37, 38, 47, 49, 50, 51, 52 and 53.

In the IMO instruments which are made mandatory by this chapter, there are some recommendatory requirements which can be classified as “preclusive case” and “amendment required case”, as mentioned in paragraphs 3.1 to 3.7 of this paper, while these IMO instruments are applicable to unmanned ships, in general.

2.5 Chapter II-2 - Construction - Fire protection, fire detection and fire extinction

2.5.1 General characteristics and overview of the chapter

Many requirements in chapter II-2 are related to manual operations by ships’ personnel. In particular, many fire-fighting appliances are of manually operated types and the requirements for such fire-fighting appliances are categorized as “amendment required case”. Table 6 shows the parts and regulations of this chapter. The right column of this table indicates the regulations applicable only to passenger ships, which are not investigated in this paper.

Table 6 Parts and regulations of chapter II-2

Parts and regulations			Passenger ships only
Part A	**General**		
	Regulation 1	Application	
	Regulation 2	Fire safety objectives and functional requirements	
	Regulation 3	Definitions	
Part B	**Prevention of fire and explosion**		
	Regulation 4	Probability of ignition	
	Regulation 5	Fire growth potential	
	Regulation 6	Smoke generation potential and toxicity	
Part C	**Suppression of fire**		
	Regulation 7	Detection and alarm	
	Regulation 8	Control of smoke spread	
	Regulation 9	Containment of fire	
	Regulation 10	Fire-fighting	
	Regulation 11	Structural integrity	
Part D	**Escape**		
	Regulation 12	Notification of crew and passengers	
	Regulation 13	Means of escape	
Part E	**Operational requirements**		
	Regulation 14	Operational readiness and maintenance	
	Regulation 15	Instructions, onboard training and drills	
	Regulation 16	Operations	
Part F	**Alternative design and arrangements**		
	Regulation 17	Alternative design and arrangements	
Part G	**Special requirements**		
	Regulation 18	Helicopter facilities	
	Regulation 19	Carriage of dangerous goods	
	Regulation 20	Protection of vehicle, special category and ro-ro spaces	
	Regulation 20-1	Requirements for vehicle carriers carrying motor vehicles with compressed hydrogen or natural gas in their tanks for their own propulsion as cargo	
	Regulation 21	Casualty threshold, safe return to port and safe areas	X
	Regulation 22	Design criteria for systems to remain operational after a fire casualty	X
	Regulation 23	Safety centre on passenger ships	X

This chapter makes the following codes mandatory:

- International Code for Fire Safety Systems (FSS Code); and
- International Code for Application of Fire Test Procedures, 2010 (FTP Code 2010).

As mentioned in paragraph 2.1 of this paper, Part F, i.e. regulation 17, is not investigated. The respective regulations other than those applicable only to passenger ships and regulation 17 are investigated in the next paragraph.

2.5.2 Classification of requirements in view of unmanned operation

(1) Part A - General

Regulations 1 to 3 are applicable to unmanned ships. The FSS Code and the FTP Code 2010 are defined in regulation 3 and referred to throughout in this chapter as mandatory requirements. The results of investigation on the FSS Code and the FTP Code 2010 are set out in paragraphs 3.8 and 3.9, respectively.

(2) Part B - Prevention of fire and explosion

The following paragraphs of regulation 4 can be categorized as “amendment required case”, while this regulation is generally applicable to unmanned ships:

- Paragraph 2.2.5.2 requires a fuel line failure alarm;
- Paragraph 2.5.2 requires a high temperature alarm;
- Paragraph 5.1.4.3 requires locking arrangements under the control of the responsible ship’s officer;
- Paragraph 5.2.4 requires a watertight door capable of being manually closed for specific cases;
- Paragraph 5.3.2.2 requires locking arrangements controlled by the responsible ship’s officer;
- Paragraph 5.4.2 requires fixed gas warning systems for chemical tankers; and

- Paragraph 5.10.1 requires alarms.

Paragraph 2.2 of regulation 5 refers to means of control for: opening and closure of skylights; closure of openings in funnels; stopping ventilating fans; stopping forced and induced draught fans; oil fuel transfer pumps; oil fuel unit pumps; lubricating oil service pumps; thermal oil circulating pumps; and oil separators. This paragraph is classified as "amendment required case".

Regulation 6 is applicable to unmanned ships.

(3) Part C - Suppression of fire

Regulation 7, which refers to detection and alarm, can be classified as "amendment required case".

Paragraph 5 of regulation 8 requires manual control capability for smoke extraction systems. The requirement is classified as "amendment required case".

In regulation 9, paragraph 4.1.1.5.10 refers to an alarm only for remote-released sliding or power-operated doors. Except in paragraph 2.2.6, which is applicable only to passenger ships, capability of manual operation is required for fire and smoke dampers in paragraphs 4.1.1.9, 7.2.6, 7.3.1.3, 7.3.3 and 7.4.4. These paragraphs are classified as "amendment required case".

Paragraphs 2 to 4 of regulation 10 are provisions for "water supply systems", "portable fire extinguishers" and "fixed fire-extinguishing systems", respectively. Namely these paragraphs are for manually operated fire-fighting systems and appliances, and classified as "amendment required case". Paragraphs 5 to 9 require various types of manually operated fire-fighting systems and appliances for "machinery spaces", "control stations, accommodation spaces and service spaces", "cargo spaces", "cargo tanks" and "cargo pump rooms in tankers", respectively. Therefore, these paragraphs are classified as "amendment required case". Paragraph 10 is the requirements for "fire-fighter's outfit" and classified as "amendment required case".

Paragraphs 6.3.1 and 6.3.2 of regulation 11 refer to a high-level alarm and an over/under-pressure alarm, respectively. Paragraph 6.4 refers to provision of information to the ship's master. Therefore, these paragraphs are classified as "amendment required case".

(4) Part D - Escape

Regulation 12 is the requirement for notification of crew and passengers and classified as "amendment required case".

Regulation 13 is the requirement for means of escape and classified as "amendment required case".

(5) Part E - Operational requirements

Regulation 14, which refers to manually operated systems and appliances, can be classified as "amendment required case".

Regulation 15, which refers to instructions, onboard training and drills, can be classified as "amendment required case", for the reason that this regulation refers to onboard training in the use of the ship's fire-extinguishing systems and appliances in accordance with provisions of regulation III/19.4.1 but regulation III/19.4.1 does not require boarding of crew members, as mentioned in paragraph 2.6.2 (2) of this paper.

Regulation 16 can be classified as "amendment required case", for the reason that this regulation does not refer to the obligation of persons onboard directly, while this regulation refers to a operation booklet and operation of inert gas system, which may be completed during cargo handling.

(6) Part G - Special requirements

In regulation 18, paragraphs 2, 4, 5 and 8 require foam fire-fighting appliances for helicopter landing areas, means of escape from helideck, various fire-fighting appliances for helideck, and operations manuals, respectively. These paragraphs are classified as "amendment required case".

Regulation 19 requires water supplies, detection systems, personal protection equipment, portable fire-extinguishers and water spray systems. Therefore, many parts of this regulation can be classified as "amendment required case".

In regulation 20, paragraphs 4 and 6 require detection and alarm systems and fire-fighting systems and appliances, respectively. These paragraphs are classified as "amendment required case".

Regulation 20-1 is applicable to unmanned ships.

2.5.3 Regulations of "preclusive case", "inapplicable case" and "amendment required case"

Provisions of "preclusive case" and "inapplicable case" were not identified in this chapter. Provisions of "amendment required case" are included in regulations 4, 5, 7, 8, 9, 10, 11, 12, 13, 15, 16 and 18 to 20.

As mentioned in paragraph 3.8 of this paper, the FSS Code includes some requirements classified as "amendment required case".

It is obvious that for the application to unmanned ships, this chapter should be comprehensively reviewed together with the FSS Code. In particular, it is necessary to review the requirements for fire-extinguishing/fire-fighting systems and appliances, which are mainly included in regulation 10 of this chapter and the FSS Code.

2.6 Chapter III - Life saving appliances and arrangements

2.6.1 General characteristics and overview of the chapter

Chapter III prescribes life-saving appliances and some of the regulations in this chapter need not apply to unmanned ships, in case that life-saving appliances are only for personnel living on ships. Table 7 shows the parts, sections and regulations of this chapter. The right column of this table indicates the regulations applicable only to passenger ships, which are not investigated in this paper.

This chapter makes the following code and requirements mandatory:

- International Life-Saving Appliance (LSA) Code; and
- Requirements for maintenance, thorough examination, operational testing, overhaul and repair of lifeboats and rescue boats, launching appliances and release gear.

The outlines of the Code and the Requirements are introduced in paragraphs 3.10 and 3.11, respectively.

As mentioned in paragraph 2.1 of this paper, part C of this chapter, i.e. regulation 38, is not investigated. The respective regulations other than those applicable only to passenger ships and regulation 38 are investigated in the next paragraph.

2.6.2 Classification of requirements in view of unmanned operation

(1) Part A - General

It is possible to apply regulations 1 to 5 to unmanned ships, while these regulations, probably, need not apply to such ships. Regulation 4 makes the LSA Code mandatory and the Code is investigated in paragraph 3.10 of this paper.

(2) Part B - Requirements for ships and life saving appliances

Regulation 6, which requires “radio life-saving appliances”, “distress flares” and “onboard communications and alarm systems”, can be classified as “amendment required case”.

In regulation 7, paragraph 1, which requires lifebuoys, may be applicable to unmanned ships. On the other hand, paragraphs 2 and 3, which require “lifejackets” and “immersion suits and anti-exposure suits”, respectively, can be classified as “inapplicable case”, under the assumption that all personnel wear appropriate clothing during onboard the ship, taking into account the assumption that persons are onboard only during cargo handling, anchoring and berthing.

Regulations 8 and 9, which require “muster list and emergency instructions” and “operating instructions for survival craft”, respectively, can be classified as “amendment required case”.

Paragraphs 2 and 3 of regulation 10 require “there shall be a sufficient number of crew members onboard for operating the survival craft and launching arrangements required for abandonment by the total number of persons onboard” and “a deck officer or certificated person shall be placed in charge of each survival craft to be used”, respectively. These paragraphs can be classified as “preclusive case” in conjunction with regulation 31, which requires installation of survival craft.

Regulations 11 to 13 are applicable to unmanned ships, if survival craft are installed. Regulation 11 makes “Requirements for maintenance, thorough examination, operational testing, overhaul and repair of lifeboats and rescue boats, launching appliances and release gear” mandatory and the requirements are investigated in paragraph 3.11 of this paper.

Regulation 14 is applicable to unmanned ships, if rescue boats are installed.

Regulation 15 is applicable to unmanned ships, if marine evacuation systems are installed.

Regulations 16 is applicable to unmanned ships, if survival crafts are installed.

Regulation 17 is applicable to unmanned ships, if rescue boats are installed.

Regulations 17-1 and 18 are applicable to unmanned ships, while these regulations may not function.

Regulation 19 on “emergency training and drills” can be classified as “amendment required case”, for the reason that boarding of crew members is not required, while onboard trainings and drills are required for onboard crew members.

Regulation 20 can be applicable to unmanned ships, provided that weekly and monthly inspections in accordance with paragraphs 6 and 7 of this regulation are achieved without onboard personnel. However, the requirement for such inspection is classified as “preclusive case”, in general.

Table 7 Parts, sections and regulations of chapter III

Parts and regulations			Passenger ships only
Part A	**General**		
	Regulation 1	Application	
	Regulation 2	Exemptions	
	Regulation 3	Definitions	
	Regulation 4	Evaluation, testing and approval of life saving appliances and arrangements	
	Regulation 5	Production tests	
Part B	**Requirements for ships and life saving appliances**		
Section I	**Passenger ships and cargo ships**		
	Regulation 6	Communications	
	Regulation 7	Personal life saving appliances	
	Regulation 8	Muster list and emergency instructions	
	Regulation 9	Operating instructions	
	Regulation 10	Manning of survival craft and supervision	
	Regulation 11	Survival craft muster and embarkation arrangements	
	Regulation 12	Launching stations	
	Regulation 13	Stowage of survival craft	
	Regulation 14	Stowage of rescue boats	
	Regulation 15	Stowage of marine evacuation systems	
	Regulation 16	Survival craft launching and recovery arrangements	
	Regulation 17	Rescue boat embarkation, launching and recovery arrangements	
	Regulation 17-1	Recovery of persons from the water	
	Regulation 18	Line-throwing appliances	
	Regulation 19	Emergency training and drills	
	Regulation 20	Operational readiness, maintenance and inspections	
Section II	**Passenger ships (Additional requirements)**		X
	Regulation 21	Survival craft and rescue boats	X
	Regulation 22	Personal life saving appliances	X
	Regulation 23	Survival craft and rescue boat embarkation arrangements	X
	Regulation 24	Stowage of survival craft	X
	Regulation 25	Muster stations	X
	Regulation 26	Additional requirements for ro-ro passenger ships	X
	Regulation 26	Additional requirements for ro-ro passenger ships	X
	Regulation 27	Information on passengers	X
	Regulation 28	Helicopter landing and pick-up areas	X
	Regulation 29	Decision support system for masters of passenger ships	X
	Regulation 30	Drills	X
Section III	**Cargo ships (Additional requirements)**		
	Regulation 31	Survival craft and rescue boats	
	Regulation 32	Personal life saving appliances	
	Regulation 33	Survival craft embarkation and launching arrangements	
Section IV	**Life saving appliances and arrangements requirements**		
	Regulation 34		
Section V	**Miscellaneous**		
	Regulation 35	Training manual and onboard training aids	
	Regulation 36	Instructions for onboard maintenance	
	Regulation 37	Muster list and emergency instructions	
Part C	**Alternative design and arrangements**		
	Regulation 38	Alternative design and arrangements	

Regulation 31 requires at least one survival craft regardless of number of persons onboard. Therefore, this regulation can be classified as “preclusive case” in conjunction with regulation 10, which requires onboard crew for survival craft.

Regulation 32 is applicable to unmanned ships, while the requirements related to lifejackets and immersion may have no effect on such ships.

Regulation 33 is applicable to unmanned ships, if survival craft are installed.

Regulation 34 makes the LSA Code mandatory, in general, while the Code is also made mandatory by regulation 4.

Regulations 35 and 36, which refer to: training manual and on-board training aids; and instructions for on-board maintenance of life saving appliances, respectively, can be classified as “amendment required case”.

Regulation 37, which refers to muster list and emergency instructions, can be classified as “amendment required case”, similar to regulation 8.

2.6.3 Regulations of “preclusive case”, “inapplicable case” and “amendment required case”

Provisions of “preclusive case” are included in regulation 10 in conjunction with regulation 31. Provisions of “inapplicable case” are included in regulation 7. Provisions of “amendment required case” are included in regulations 6, 8, 19 and 35 to 37.

As mentioned in paragraph 3.11 of this paper, paragraph 4.1 of the requirements for maintenance, thorough examination, operational testing, overhaul and repair of lifeboats and rescue boats, launching appliances and release gear, i.e. the requirement on a ship’s senior officer’s direction of weekly and monthly inspections of the equipment, is classified as “preclusive case”.

It is obvious that this chapter should be comprehensively reviewed together with the LSA Code, for the application to unmanned ships.

2.7 Chapter IV - Radiocommunications

2.7.1 General characteristics and overview of the chapter

Chapter IV prescribes radio communication and radio communication is, in general, indispensable for MASS. On the other hand, radio communications between persons onboard and shoreside will be unnecessary for unmanned ships during sailing. Table 8 shows the parts and regulations of this chapter. The right column of this table indicates the regulations only applicable to the Contracting Governments. The respective regulations are investigated in the next paragraph.

Table 8 Parts and regulations of chapter IV

Parts and regulations			Requirement for Governments
Part A	**General**		
	Regulation 1	Application	
	Regulation 2	Terms and definitions	
	Regulation 3	Exemptions	
	Regulation 4	Functional requirements	
	Regulation 4-1	GMDSS satellite providers	X
Part B	**Undertakings by Contracting Governments**		X
	Regulation 5	Provision of radiocommunication services	X
	Regulation 5-1	Global Maritime Distress and Safety System identities	X
Part C	**Ship requirements**		
	Regulation 6	Radio installations	
	Regulation 7	Radio equipment: General	
	Regulation 8	Radio equipment: Sea area A1.	
	Regulation 9	Radio equipment: Sea areas A1 and A2	
	Regulation 10	Radio equipment: Sea areas A1, A2 and A3	
	Regulation 11	Radio equipment: Sea areas A1, A2, A3 and A4	
	Regulation 12	Watches	
	Regulation 13	Sources of energy	
	Regulation 14	Performance standards	
	Regulation 15	Maintenance requirements	
	Regulation 16	Radio personnel	
	Regulation 17	Radio records	
	Regulation 18	Position-updating	

2.7.2 Classification of requirements in view of unmanned operation

(1) Part A - General

Regulations 1 to 4 are, in general, applicable to unmanned ships.

(2) Part C - Ship requirements

Regulation 6 is, in general, applicable to unmanned ships.

Paragraph 1.6 of regulation 7 and paragraph 3 of regulation 8 require that satellite EPIRBs and EPIRBs shall be ready to be manually released and capable of being carried by one person into a survival craft and capable of being activated manually, respectively. These paragraphs are classified as "amendment required case".

Regulations 9 to 11 are, in general, applicable to unmanned ships.

Regulation 12, which requires continuous watch for specific radiocommunications, can be classified as "amendment required case", while this regulation may be classified as "preclusive case" if this regulation is interpreted that continuous watch shall be carried out by persons onboard.

Regulations 13 to 15 are applicable to unmanned ships.

Regulation 16, which requires personnel qualified for distress and safety radiocommunication purposes, can be classified as "preclusive case".

Regulations 17 and 18 are, in general, applicable to unmanned ships.

2.7.3 Regulations of "preclusive case", "inapplicable case" and "amendment required case"

A provision of "preclusive case" is included in regulation 16. Provisions of "inapplicable case" were not identified. Provisions of "amendment required case" are included in regulations 7, 8 and 12.

2.8 Chapter V - Safety of navigation

2.8.1 General characteristics and overview of the chapter

Chapter V prescribes various issues related to safety of navigation. Many requirements in this chapter are related to systems and equipment manually operated by ships' personnel. Some of regulations in this chapter prescribe obligation of Contracting Governments and IMO. Table 9 shows the regulations of this chapter. The right column of this table indicates the regulations not applicable to cargo ships, which are applicable only to the Contracting Governments, IMO or passenger ships. The respective regulations other than those not applicable to cargo ships are investigated in the next paragraph.

2.8.2 Classification of requirements in view of unmanned operation

Regulations 1 to 3 are, in general, applicable to unmanned ships.

Regulation 6 contains such requirement applicable to unmanned ships that ships transiting the region of icebergs guarded by the Ice Patrol during the ice season are required to make use of the services provided by the Ice Patrol. The other requirements in this regulation are applicable only to the Contracting Governments.

Paragraph 7 of regulation 11 requires that the master of a ship shall comply with the requirements of adopted ship reporting systems and report to the appropriate authority all information required in accordance with the provisions of each such system. This requirement can be classified as "amendment required case", while it can be classified as "preclusive case", depending on the interpretation.

Regulation 14 contains the requirement that each seafarer shall be required to understand and, where appropriate, give orders and instructions and to report back in that language. This requirement can be classified as "inapplicable case". The other requirements in this regulation can be classified as "amendment required case", while these requirements may be applicable to unmanned ships depending on the interpretation.

Regulation 15, which refers to bridge work, can be classified as "amendment required case".

Regulation 16 is applicable to unmanned ships, while this regulation refers to a ship's master, provided that the master is appointed even though he/she is not onboard the ship during voyage.

Regulations 17 and 18 are applicable to unmanned ships.

Regulation 19, which refers to equipment and information for persons onboard such as a magnetic compass and a nautical chart, can be classified as "amendment required case".

Regulations 19-1 to 20 are applicable to unmanned ships.

Regulation 21 is relevant to information for onboard crew and classified as "amendment required case".

Table 9 Regulations of chapter V

Regulation number	Title	Requirement not applicable to cargo ships
1	Application	
2	Definitions	
3	Exemptions and equivalents	
4	Navigational warnings	X
5	Meteorological services and warnings	X
6	Ice Patrol Service	
7	Search and rescue services	X
8	Life-saving signals	X
9	Hydrographic services	X
10	Ships' routing	X
11	Ship reporting systems	
12	Vessel traffic services	X
13	Establishment and operation of aids to navigation	X
14	Ships' manning	
15	Principles relating to bridge design, design and arrangement of navigational systems and equipment and bridge procedures	
16	Maintenance of equipment	
17	Electromagnetic compatibility	
18	Approval, surveys and performance standards of navigational systems and equipment and voyage data recorder	
19	Carriage requirements for shipborne navigational systems and equipment	
19-1	Long-range identification and tracking of ships	
20	Voyage data recorders	
21	International Code of Signals and IAMSAR Manual	
22	Navigation bridge visibility	
23	Pilot transfer arrangements	
24	Use of heading and/or track control systems	
25	Operation of main source of electrical power and steering gear	
26	Steering gear: Testing and drills	
27	Nautical charts and nautical publications	
28	Records of navigational activities and daily reporting	
29	Life-saving signals to be used by ships, aircraft or persons in distress	
30	Operational limitations	X
31	Danger messages	
32	Information required in danger messages	
33	Distress situations: obligations and procedures	
34	Safe navigation and avoidance of dangerous situations	
34-1	Master's discretion	
35	Misuse of distress signals	
Appendix	Rules for the management, operation and financing of the North Atlantic ice patrol	X

Regulation 22 can be classified as "amendment required case", for the reason that this regulation is relevant to information for persons onboard.

Paragraph 2.2 of regulation 23, which refers to supervision of operation related to pilot transfer by a responsible officer, can be classified as "preclusive case".

Regulation 24 requires that a qualified helmsperson shall be ready at all times in hazardous navigational situations including high traffic density and restricted visibility. This regulation can be classified as "preclusive case".

Regulation 25 is applicable to unmanned ships.

In regulation 26, paragraphs 1 and 3 refer to the test of steering gear by the ship's crew and familiarity of ships' officers with the operation of steering systems, respectively. These paragraphs are classified as "preclusive case".

Regulation 27 is applicable to unmanned ships.

Regulation 28 is applicable to unmanned ships, while paragraph 1 requires keeping a record onboard.

Regulation 29, which refers to life-saving signals, can be classified as "amendment required case".

Paragraph 1 of regulation 31 prescribes the obligation of a ship's master on the notification of danger to other ships. This paragraph is classified as "preclusive case".

Regulation 32 is applicable to unmanned ships.

Regulation 33 prescribes the obligations of a ship's master on distress situations. This paragraph is classified as "preclusive case".

Regulation 34 refers to the obligation of a ship's master prior to proceeding to sea. Hence, this regulation is deemed applicable to unmanned ships, depending on the interpretation of this regulation.

Regulation 34-1 requires that the owner, the charterer, the company operating the ship, or any other person shall not prevent or restrict the master of the ship from taking or executing any decision which, in the master's professional judgement, is necessary for safety of life at sea and protection of the marine environment. This regulation can be classified as "amendment required case", depending on the interpretation of "the master".

Regulation 35 is applicable to unmanned ships.

2.8.3 Regulations of "preclusive case", "inapplicable case" and "amendment required case"

Provisions of "preclusive case" are included in regulations 23, 24, 26, 31 and 33. A provision of "inapplicable case" is included in regulation 14. Provisions of "amendment required case" are included in regulations 11, 14, 15, 19, 21, 22, 29, 34-1.

2.9 Chapter VI - Carriage of cargoes and oil fuels

2.9.1 General characteristics and overview of the chapter

Chapter VI mainly refers to cargo related issues. Table 10 shows the parts and regulations of this chapter. This chapter makes the following codes or a part of a code, mandatory:

- International Maritime Solid Bulk Cargoes Code (IMSBC Code);
- Sub-chapter 1.9 of the Code of Safe Practice for Cargo Stowage and Securing (CSS Code); and
- International Code for the Safe Carriage of Grain in Bulk (International Grain Code).

These codes are investigated in paragraphs 3.12, 3.13 and 3.14 of this paper, respectively.

The respective regulations of this chapter are investigated in the next paragraph.

2.9.2 Classification of requirements in view of unmanned operation

(1) Part A - General provisions

Regulations 1 and 1-1 are applicable to unmanned ships.

Regulation 1-2 makes the IMSBC Code mandatory and the Code is investigated in paragraph 3.12 of this paper.

Regulation 2 prescribes the provision of cargo information to ship's personnel. This regulation is classified as "amendment required case". Paragraph 2.1 of this regulation makes sub-chapter 1.9 of the CSS Code mandatory and sub-chapter 1.9 of the Code is investigated in paragraph 3.13 of this paper.

Table 10 Parts and regulations of chapter VI

Part A General provisions		
	Regulation 1	Application
	Regulation 1-1	Definitions
	Regulation 1-2	Requirements for the carriage of solid bulk cargoes other than grain
	Regulation 2	Cargo information
	Regulation 3	Oxygen analysis and gas detection equipment
	Regulation 4	The use of pesticides in ships
	Regulation 5	Stowage and securing
	Regulation 5-1	Material safety data sheets
	Regulation 5-2	Prohibition of the blending of bulk liquid cargoes and production
Part B Special provisions for solid bulk cargoes		
	Regulation 6	Acceptability for shipment
	Regulation 7	Loading, unloading and stowage of solid bulk cargoes
Part C Carriage of grain		
	Regulation 8	Definitions
	Regulation 9	Requirements for cargo ships carrying grain

Regulation 3 is applicable to unmanned ships, while “an appropriate instrument for measuring the concentration of gas or oxygen” required by this regulation will not be for use by persons onboard.

Regulations 4 to 5-2 are applicable to unmanned ships.

(2) Part B - Special provisions for solid bulk cargoes

Regulation 6 refers to provision of information to the ship’s master. Hence, this regulation is classified as “amendment required case”.

In regulation 7, paragraph 2 refers to the provision of information to the ship’s personnel. This paragraph is classified as “amendment required case”. Paragraphs 3 to 5 prescribe the obligation of the ship’s master and the terminal representative. Paragraph 6 requires that the master shall ensure that ship's personnel continuously monitor cargo operations. These requirements are applicable to unmanned ships under the assumption mentioned in paragraph 1.3 of this paper, depending on the interpretation, for the reason that these requirements are for cargo handling.

(3) Part C - Carriage of grain

This part makes the International Grain Code mandatory and the Code is investigated in paragraph 3.14 of this paper.

2.9.3 Regulations of “preclusive case”, “inapplicable case” and “amendment required case”

Provisions of “preclusive case” and “inapplicable case” were not identified. Provisions of “amendment required case” are included in regulations 2, 6 and 7.

As mentioned in paragraphs 3.12 to 3.14 of this paper, the Codes which are made mandatory by this chapter include some requirements classified as “preclusive case” and “amendment required case”.

2.10 Chapter VII - Carriage of dangerous goods

Chapter VII prescribes carriage of dangerous goods. Table 11 shows the parts and regulations of this chapter. This chapter makes the following codes mandatory:

- International Maritime Dangerous Goods Code (IMDG Code);
- International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code);
- International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code); and
- International Code for the Safe Carriage of Packaged Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Wastes on Board Ships (INF Code).

In these codes, the INF Code is not investigated in this paper as mentioned in paragraph 1.2 of this paper.

In this chapter, regulations on reporting of incidents involving dangerous goods, i.e. regulations 6 and 7-4, are classified as “preclusive case”, for the reason that these regulations prescribe the obligation of the ship’s master in case of accidents.

The regulations of this chapter other than those mentioned above are generally applicable to unmanned ships.

Parts A, A-1, B, C and D make the IMDG Code, the IMSBC Code with regard to dangerous goods, the IBC Code, the IGC Code and the INF Code mandatory, respectively. The IMDG Code, the IMSBC Code, the IBC Code and the IGC Code are investigated in paragraphs 3.15, 3.12, 3.16 and 3.17 of this paper, respectively.

As mentioned in paragraphs 3.15 to 3.17 of this paper, the IMDG Code, the IBC Code and the IGC Code include some requirements classified as “preclusive case”, “inapplicable case” and “amendment required case”.

2.11 Chapter IX - Management for the safe operation of ships

This chapter makes the International Management Code for the Safe Operation of Ships and for Pollution Prevention (ISM Code) mandatory, and the Code is investigated in paragraph 3.18 of this paper. Table 12 shows the regulations of this chapter.

This chapter is applicable to unmanned ships, as a whole. The ISM Code is also applicable to unmanned ships, on the whole, as mentioned in paragraph 3.18 of this paper.

Table 11 Parts and regulations of chapter VII

Part A	**Carriage of dangerous goods in packaged form**	
	Regulation 1	Definitions
	Regulation 2	Application
	Regulation 3	Requirements for the carriage of dangerous goods
	Regulation 4	Documents
	Regulation 5	Cargo Securing Manual
	Regulation 6	Reporting of incidents involving dangerous goods
Part A-1	**Carriage of dangerous goods in solid form in bulk**	
	Regulation 7	Definitions
	Regulation 7-1	Application
	Regulation 7-2	Documents
	Regulation 7-3	Stowage and segregation requirements
	Regulation 7-4	Reporting of incidents involving dangerous goods
	Regulation 7-5	Requirements for the carriage of dangerous goods in solid form in bulk
Part B	**Construction and equipment of ships carrying dangerous liquid chemicals in bulk**	
	Regulation 8	Definitions
	Regulation 9	Application to chemical tankers
	Regulation 10	Requirements for chemical tankers
Part C	**Construction and equipment of ships carrying liquefied gases in bulk**	
	Regulation 11	Definitions.
	Regulation 12	Application to gas carriers
	Regulation 13	Requirements for gas carriers
Part D	**Special requirements for the carriage of packaged irradiated nuclear fuel, plutonium and high-level radioactive wastes on board ships**	
	Regulation 14	Definitions
	Regulation 15	Application to ships carrying INF cargo
	Regulation 16	Requirements for ships carrying INF cargo

Table 12 Regulations of chapter IX

Regulation 1	Definitions	Regulation 4	Certification
Regulation 2	Application	Regulation 5	Maintenance of conditions
Regulation 3	Safety management requirements	Regulation 6	Verification and control

2.12 Chapter XI-1 - Special measures to enhance maritime safety

Chapter XI-1 refers to various issues. Table 13 shows the regulations of this chapter. This chapter makes the following codes mandatory:

- Code for recognized organizations (RO Code);
- International Code on the Enhanced Programme of Inspections during Surveys of Bulk Carriers and Oil Tankers, 2011 (2011 ESP Code); and
- Code of the International Standards and Recommended Practices for a Safety Investigation into a Marine Casualty or Marine Incident (Casualty Investigation Code).

In these codes, the RO Code and the Casualty Investigation Code are not investigated in this paper, as mentioned in paragraph 1.2 of this paper, and 2011 ESP Code is investigated in paragraph 3.19.

This chapter is applicable to unmanned ships, as a whole. As mentioned in paragraph 3.19 of this paper, 2011 ESP Code is also applicable to unmanned ships, in principle.

2.13 Chapter XI-2 - Special measures to enhance maritime security

2.13.1 General characteristics and overview of the chapter

Chapter XI-2 refers to security issues and makes the International Code for the Security of Ships and of Port Facilities (ISPS Code) mandatory. Table 14 shows the regulations of this chapter. The respective regulations of this chapter are investigated in the next paragraph.

Table 13 Regulations of chapter XI-1

Regulation 1	Authorization of recognized organizations
Regulation 2	Enhanced surveys
Regulation 2-1	Harmonization of survey periods of cargo ships not subject to the ESP Code
Regulation 3	Ship identification number
Regulation 3-1	Company and registered owner identification number
Regulation 4	Port State control on operational requirements
Regulation 5	Continuous Synopsis Record
Regulation 6	Additional requirements for the investigation of marine casualties and incidents
Regulation 7	Atmosphere testing instrument for enclosed spaces

Table 14 Regulations of chapter XI-2

Regulation 1	Definitions
Regulation 2	Application
Regulation 3	Obligations of Contracting Governments with respect to security
Regulation 4	Requirements for Companies and ships
Regulation 5	Specific responsibility of Companies
Regulation 6	Ship security alert system
Regulation 7	Threats to ships
Regulation 8	Master’s discretion for ship safety and security
Regulation 9	Control and compliance measures
Regulation 10	Requirements for port facilities
Regulation 11	Alternative security arrangements
Regulation 12	Equivalent security arrangements
Regulation 13	Communication of information

2.13.2 Classification of requirements in view of unmanned operation

Regulations 1 to 3 are applicable to unmanned ships.

Regulation 4 makes the ISPS Code mandatory together with regulation 1 and the ISPS Code is investigated in paragraph 3.20 of this paper.

Regulation 5 requires the Company to ensure that the ship’s master onboard is accessible to security related information. This regulation can be classified as “amendment required case”.

Regulation 6 requires a ship security alert system, which shall be capable of being activated from the navigation bridge and in at least one other location. Namely, this regulation requires a manually operated system. Therefore, this regulation is classified as “amendment required case”.

Regulation 7 prescribes the obligation of Contracting Governments. This regulation is applicable to unmanned ships.

Regulation 8 refers to the ship’s master's discretion for ship safety and security. This regulation can be classified as “amendment required case”.

Regulations 9 and 10 are not the requirements for ships and applicable to unmanned ships.

Regulations 11 and 12 are alternative and equivalent security arrangements, respectively, and applicable regardless of ship’s manning.

Regulation 13 prescribes communication of information. This regulation is applicable regardless of ship’s manning.

2.13.3 Regulations of “preclusive case”, “inapplicable case” and “amendment required case”

Provisions of “preclusive case” and “inapplicable case” were not identified. The requirements classified as “amendment required case” are included in regulations 5, 6 and 8.

Furthermore, as mentioned in paragraph 3.20 of this paper, the ISPS Code includes some requirements classified as “preclusive case” and “amendment required case”.

2.14 Chapter XII - Additional safety measures for bulk carriers

Chapter XII refers to additional safety measures for bulk carriers. Some of the requirements in this chapter are applicable only to existing ships. Table 15 shows the regulations of this chapter. The right column of this table indicates the regulations only for existing ships as a whole, which are not investigated in this paper.

Table 15 Regulations of chapter XII

Regulations		Existing ships only
Regulation 1	Definitions	
Regulation 2	Application	
Regulation 3	Implementation schedule	X
Regulation 4	Damage stability requirements applicable to bulk carriers	
Regulation 5	Structural strength of bulk carriers	
Regulation 6	Structural and other requirements for bulk carriers	
Regulation 7	Survey and maintenance of bulk carriers	
Regulation 8	Information on compliance with requirements for bulk carriers	
Regulation 9	Requirements for bulk carriers not being capable of complying with regulation 4.3 due to the design configuration of their cargo holds	X
Regulation 10	Solid bulk cargo density declaration	
Regulation 11	Loading instrument	
Regulation 12	Hold, ballast and dry space water ingress alarms	
Regulation 13	Availability of pumping systems	
Regulation 14	Restrictions from sailing with any hold empty	

This chapter makes the following two standards mandatory:

- Standards for the evaluation of scantlings of the transverse watertight vertically corrugated bulkhead between the two foremost cargo holds and for the evaluation of allowable hold loading of the foremost cargo hold, which is not investigated in this paper as mentioned in paragraph 1.2; and
- Standards for owners' inspection and maintenance of bulk carrier hatch covers, which is investigated in paragraph 3.21 of this paper.

Most of the provisions in this chapter are design requirements and applicable to unmanned ships, while the following requirements can be classified as "amendment required case":

.1 Regulation 8 refers to a booklet for ship's personnel required by SOLAS regulation VI/7.2;

.2 Regulation 11 requires onboard loading instrument; and

.3 Regulation 12 refers to audible and visual alarms located on the navigation bridge.

As mentioned in paragraph 3.21 of this paper, Standards for owners' inspection and maintenance of bulk carrier hatch covers are applicable to unmanned ships.

3 Investigation of related mandatory IMO instruments

3.1 Performance standard for protective coatings for dedicated seawater ballast tanks in all types of ships and double-side skin spaces of bulk carriers

"Performance standard for protective coatings for dedicated seawater ballast tanks in all types of ships and double-side skin spaces of bulk carriers" provides technical requirements for protective coatings in dedicated seawater ballast tanks of all types of ships of not less than 500 gross tonnage and double-side skin spaces arranged in bulk carriers of 150 m in length and upwards. Table 16 shows the contents of this performance standard. This performance standard is applicable to unmanned ships as a whole.

3.2 Technical provisions for means of access for inspections

"Technical provisions for means of access for inspections" were first adopted by Resolution MSC.133(76) and all the provisions were replaced by the amendment adopted by Resolution MSC.158(78). Table 17 shows the contents of these technical provisions. These technical provisions are applicable to unmanned ships as a whole.

3.3 Goal-Based Ship Construction Standards for Bulk Carriers and Oil Tankers

"Goal-Based Ship Construction Standards for Bulk Carriers and Oil Tankers" includes basic requirements for structure and construction of bulk carriers and oil tankers. Table 18 shows the contents of the standards. These standards are applicable to unmanned ships as a whole.

Table 16 Contents of Performance standard for protective coatings for dedicated seawater ballast tanks in all types of ships and double-side skin spaces of bulk carriers

1	Purpose
2	Definitions
3	General principles
4	Coating standard
5	Coating system approval
6	Coating inspection requirements
7	Verification requirements
8	Alternative systems
Annex 1	Test procedures for coating qualification for dedicated seawater ballast tank of all types of ships and double-side skin spaces of bulk carriers
	Appendix 1　Test on simulated ballast tank conditions
	Appendix 2　Condensation chamber test
Annex 2	Example of daily log and non-conformity report
Annex 3	Dry film thickness measurements

Table 17 Contents of Technical provisions for means of access for inspections

1	Preamble
2	Definitions
3	Technical provisions
Table 1	Means of access for ballast and cargo tanks of oil tankers
Table 2	Means of access for bulk carriers

Table 18 Contents of Goal-Based Ship Construction Standards for Bulk Carriers and Oil Tankers

1	Preamble	4	Tier I - Goals
2	Scope	5	Tier II - Functional requirements
3	Structure	6	Tier III - Verification of conformity

3.4　Performance standard for protective coatings for cargo oil tanks of crude oil tankers

“Performance standard for protective coatings for cargo oil tanks of crude oil tankers” provides technical requirements for the minimum standard for protective coatings to be applied in cargo oil tanks during the construction of new crude oil tankers.　Table 19 shows the contents of this performance standard.　This standard is applicable to unmanned ships as a whole.

3.5　Performance standard for alternative means of corrosion protection for cargo oil tanks of crude oil tankers

“Performance standard for alternative means of corrosion protection for cargo oil tanks of crude oil tankers” provides technical requirements for the minimum standard for means of corrosion protection or utilization of corrosion resistant material other than protective coating to be used for cargo oil tanks during construction of crude oil tankers. Table 20 shows the contents of this performance standard.　This standard is applicable to unmanned ships as a whole.

Table 19 Contents of performance standard for protective coatings for cargo oil tanks of crude oil tankers

1	Purpose
2	Definitions
3	General principles
4	Coating standard
5	Coating system approval
6	Coating inspection requirements
7	Coating verification requirements
8	Alternative coating systems
Annex 1	Test procedures for coating qualification for cargo oil tanks of crude oil tankers
Annex 2	Example of daily log and non-conformity report

Table 20 Contents of performance standard for alternative means of corrosion protection for cargo oil tanks of crude oil tankers

1 Purpose	
2 Definition	
3 Application	
Annex	Performance standard for corrosion resistant steel
	1 Purpose
	2 General principles
	3 Corrosion resistant steel standard
	4 Approval
	5 Inspection and verification requirements
	Appendix Test procedures for qualification of corrosion resistant steel for cargo tanks in crude oil tankers

3.6 Code on noise levels on board ship

"Code on noise levels on board ship" determines the acceptable noise level of respective types of ships. Table 21 shows the contents of the Code. The right column of this table indicates non-mandatory parts. The mandatory parts of the Code are applicable to unmanned ships, in principle, while paragraph 3 of Appendix 2 to the Code, i.e. the recommendatory part as determined in paragraph 1.1.3 of the Code, includes provision on responsibility of ship's personnel.

3.7 International Code on Intact Stability, 2008

The International Code on Intact Stability, 2008 (2008 IS Code) refers to the intact stability. Some of the requirements in the Code are applicable only to passenger ships. Table 22 shows the contents of the Code. The right column of this table indicates non-mandatory portion, which are not investigated in this paper.

The second sentence in paragraph 2.1.7 of Part A of the Code reads "when curves or tables of minimum operational metacentric height (GM) or maximum centre of gravity (VCG) versus draught covering the operational trims are not available, the master must verify that the operating condition does not deviate from a studied loading condition, or verify by calculation that the stability criteria are satisfied for this loading condition taking into account trim effects". Namely, the Code prescribes the obligation of the ship's master under specific condition and this part can be classified as "amendment required case". However, the aforementioned sentence can be complied with only by design. The provisions on responsibility of ship's personnel other than the aforementioned sentence are included only in Part B, i.e. non-mandatory part. Therefore, the Code is basically applicable to unmanned ships, while a part of it can be classified as "amendment required case".

Table 21 Contents of code on noise levels on board ship

Contents		Non-mandatory part
Preamble		(No requirements)
Chapter 1	General	1.3.2 and 1.3.3 only
Chapter 2	Measuring equipment	
Chapter 3	Measurement	3.4.2 and 3.4.3 only
Chapter 4	Maximum acceptable sound pressure levels	
Chapter 5	Noise exposure limits	X
Chapter 6	Acoustic insulation between accommodation spaces	6.3 only
Chapter 7	Hearing protection and warning information	7.3 only
Appendix 1	Format for noise survey report	
Appendix 2	Guidance on the inclusion of noise issues in safety management systems	X
Appendix 3	Suggested methods of attenuating noise	X
Appendix 4	Simplified procedure for determining noise exposure	X

Table 22 Contents of international code on intact stability, 2008 (2008 IS Code)

Contents			Non-mandatory
Preamble			(No requirements)
Introduction			
Part A	Mandatory Criteria		
	Chapter 1	General	
	Chapter 2	General criteria	
	Chapter 3	Special criteria for certain types of ships	
Part B	Recommendations for certain types of ships and additional guidelines		X
	Chapter 1	General	X
	Chapter 2	Recommended design criteria for certain types of ships	X
	Chapter 3	Guidance in preparing stability information	X
	Chapter 4	Stability calculations performed by stability instruments	X
	Chapter 5	Operational provisions against capsizing	X
	Chapter 6	Icing considerations	X
	Chapter 7	Considerations for watertight and weathertight integrity	X
	Chapter 8	Determination of lightship parameters	X
Annex 1	Detailed guidance for the conduct of an inclining test		X
Annex 2	Recommendations for skippers of fishing vessels on ensuring a vessels endurance in conditions of ice formation		X

3.8 International Code for Fire Safety Systems

3.8.1 Outline of the Code

The International Code for Fire Safety Systems (FSS Code) prescribes specifications of fire safety systems required by chapter II-2 of the SOLAS Convention. Table 23 shows the contents of the Code. The right column of this table indicates the relevant SOLAS regulations. Here, it should be noted that the systems and equipment referred to in the Code are basically manually operated by persons onboard, except “automatic sprinkler, fire detection and fire alarm systems”. Requirements in the Code or in chapter II-2 of the SOLAS Convention relating to manually operated systems and equipment can be classified as “amendment required case”.

The respective chapters of the Code are investigated in the next paragraph.

3.8.2 Classification of requirements in view of unmanned operation

Chapter 1 is applicable to unmanned ships.

The requirements in chapters 2 to 4, are applicable to unmanned ships, in general, for the reason that these are design requirements for respective systems and equipment, while paragraph 2.2.4, which requires marking of information on Emergency Escape Breathing Devices (EEBDs), can be classified as “amendment required case”.

Paragraph 2.1.1.3 of chapter 5 requires that means shall be provided for the crew to safely check the quantity of the fire extinguishing medium in the containers. Paragraph 2.2.4.1.3 requires that it shall be possible to manually regulate the discharge rate of carbon dioxide into the protected spaces for Low-pressure CO_2 system. These requirements can be classified as “amendment required case”.

Paragraph 3.1.1 of chapter 6 requires that a fixed high-expansion foam fire-extinguishing system shall be capable of manual release. Paragraph 3.1.7 requires that means shall be provided for the crew to safely check the quantity of the foam concentrate. These requirements can be classified as “amendment required case”.

Chapter 7 just refers to guidelines and does not include concrete mandatory requirements.

Chapter 8 is applicable to unmanned ships, in general, for the reason that the requirements in this chapter are for design, while the alarms required by this chapter are for persons onboard the ship and the requirements on alarms can be classified as “amendment required case”

Chapters 9 and 10 prescribe the specification of fixed fire detection and fire alarm systems the purpose of which is just a notification of fire to persons onboard. Chapter 9 further requires manually operated call points. Chapter 10 further requires that means to manually acknowledge all alarm and fault signals shall be provided at the control panel of sample extraction smoke detection systems. Hence, these chapters are classified as “amendment required case”.

Chapter 11 just refers to guidelines and does not include concrete mandatory requirements. However, the purpose of the system referred to in this chapter is for escape. Hence, this chapter can be classified as “amendment required case”.

Table 23 Contents of International Code for Fire Safety Systems

Chapter		SOLAS regulation
Preamble		
Chapter 1	General	
Chapter 2	International shore connections	II-2/10
Chapter 3	Personnel protection	II-2/10
Chapter 4	Fire extinguishers	II-2/10
Chapter 5	Fixed gas fire-extinguishing systems	II-2/10
Chapter 6	Fixed foam fire-extinguishing systems	II-2/10
Chapter 7	Fixed pressure water-spraying and water-mist fire-extinguishing systems	II-2/10
Chapter 8	Automatic sprinkler, fire detection and fire alarm systems	II-2/7, II-2/10
Chapter 9	Fixed fire detection and fire alarm systems	II-2/7
Chapter 10	Sample extraction smoke detection systems	II-2/7
Chapter 11	Low-location lighting systems	II-2/13
Chapter 12	Fixed emergency fire pumps	II-2/10
Chapter 13	Arrangement of means of escape	II-2/13
Chapter 14	Fixed deck foam systems	II-2/10
Chapter 15	Inert gas systems	II-2/4
Chapter 16	Fixed hydrocarbon gas detection systems	II-2/4
Chapter 17	Helicopter facility foam firefighting appliances	II-2/18

Chapter 12 is applicable to unmanned ships for the reason that the requirements in this chapter are for design, while the system is used for fire-fighting basically by ship's personnel.

Chapter 13 prescribes the arrangement for means of escape and can be classified as "amendment required case", but not as "inapplicable case", taking into account that means of escape may be used by shore-side personnel.

Chapters 14 to 16 are applicable to unmanned ships, for the reason that the requirements in these chapters are for design.

Chapter 17 prescribes specifications of manually operated foam firefighting appliances for helidecks and helicopter landing areas. Hence, this chapter is classified as "amendment required case".

3.9 International Code for Application of Fire Test Procedures, 2010

The International Code for Application of Fire Test Procedures, 2010 (2010 FTP Code) prescribes the application of various test procedures to materials and fire safety systems and equipment. Table 24 shows the contents of the Code.

The code is applicable to fire safety systems and appliances for ships regardless of manned or unmanned.

3.10 International Life-Saving Appliance Code

The International Life-Saving Appliance (LSA) Code prescribes specifications of life-saving appliances required by chapter III of the SOLAS Convention. Table 25 shows the contents of the Code.

As mentioned in paragraph 2.6.3 of this paper, the Code should be comprehensively reviewed in conjunction with chapter III of the SOLAS Convention, while it could be, in principle, applicable to unmanned ships, if life-saving appliances were required for such ships.

3.11 Requirements for maintenance, thorough examination, operational testing, overhaul and repair of lifeboats and rescue boats, launching appliances and release gear

"Requirements for maintenance, thorough examination, operational testing, overhaul and repair of lifeboats and rescue boats, launching appliances and release gear" prescribes inspection and maintenance of survival crafts, rescue boats and their launching appliances, hereafter expressed with "the equipment" in this paragraph. Table 26 shows the contents of this mandatory instrument.

Table 24 Contents of International Code for Application of Fire Test Procedures, 2010

1	Scope
2	Application
3	Definitions
4	Testing
5	Approval
6	Products which may be installed without testing and/or approval
7	Use of equivalents and modern technology
8	Period of grace for type approvals issued in accordance with the previous FTP Code
9	List of references
Annex 1	Fire test procedures
	Preamble
	Part 1　Non-combustibility test
	Part 2　Smoke and toxicity test
	Part 3　Test for “A”, “B” and “F” class divisions
	Part 4　Test for fire door control systems
	Part 5　Test for surface flammability (Test for surface materials and primary deck coverings)
	Part 6　(blank)
	Part 7　Test for vertically supported textiles and films
	Part 8　Test for upholstered furniture
	Part 9　Test for bedding components
	Part 10　Test for fire-restricting materials for high-speed craft
	Part 11　Test for fire-resisting divisions of high-speed craft
Annex 2	Products which may be installed without testing and/or approval
Annex 3	Fire protection materials and required approval test methods
Annex 4	Interpretation of SOLAS chapter II-2, regulations 5.3 and 6.2 (MSC/Circ.1120)

Table 25 Contents of International Life-Saving Appliance Code

Preamble	Chapter IV　Survival Craft
Chapter I　General	4.1 General requirements for liferafts
1.1　Definition	4.2　Inflatable liferafts
1.2　General requirements for life -saving appliances	4.3　Rigid liferafts
Chapter II　Personal Life-Saving Appliances	4.4　General requirements for lifeboats
2.1　Lifebuoys	4.5　Partially enclosed lifeboats
2.2　Lifejackets	4.6　Totally enclosed lifeboats
2.3　Immersion suits	4.7　Free fall lifeboats
2.4　Anti-exposure suits	4.8　Lifeboats with a self-contained air support system
2.5　Thermal protective aids	4.9　Fire protected lifeboats
Chapter III　Visual Signals	Chapter V　Rescue Boats
3.1　Rocket parachute flares	5.1　Rescue boats
3.2　Hand flares	Chapter VI　Launching and Embarkation Appliances
3.3　Buoyant smoke signals	6.1　Launching and embarkation appliances
	6.2　Marine evacuation systems
	Chapter VII　Other Life-Saving Appliances
	7.1　Line-throwing appliances
	7.2　General alarm and public address system

Table 26 Contents of Requirements for maintenance, thorough examination, operational testing, overhaul and repair of lifeboats and rescue boats, launching appliances and release gear

1	General
2	Application
3	Authorization
4	Qualification levels and certification
5	Reports and records
6	Specific procedures for inspection, maintenance, thorough examination, operational testing, overhaul and repair
7	Requirements for authorization of service providers
8	Requirements for certification of personnel

In the requirements, paragraph 4.1 requires that weekly and monthly inspections and routine maintenance of the equipment shall be conducted under the direction of a senior ship's officer. According to this requirement, a senior ship's officer should be on duty at the time of weekly and monthly inspections of the equipment. Hence, this requirement can be applicable to unmanned ships, provided that weekly and monthly inspections in accordance with paragraphs 6 and 7 of SOLAS regulation III/20 are achieved without the work during sailing. However, the requirement for such inspection can be classified as "preclusive case" depending on duration of voyage.

3.12 International Maritime Solid Bulk Cargoes Code

3.12.1 Outline of the Code

The International Maritime Solid Bulk Cargoes (IMSBC) Code prescribes the requirements for carriage of solid cargoes in bulk. Table 27 shows the contents of the Code. The right column of this table indicates the non-mandatory parts, which are not investigated in this paper. Here, section 11 of the Code is basically non-mandatory except paragraph 11.1.1, which refers to chapter XI-2 of the SOLAS Convention and the International Code for the Security of Ships and of Port Facilities.

Sections 1 to 10 of the main text and main features of Appendix 1 are investigated in the next paragraphs.

3.12.2 Classification of requirements in sections 1 to 10 in view of unmanned operation

While section 1 is, in general, applicable to unmanned ships, paragraph 1.3.2 refers to a provision of information to the ship's master on cargoes not listed in the Code. This paragraph is classified as "amendment required case".

In section 2, paragraph 2.1.1 refers to a provision of cargo information to the ship's master. Paragraph 2.1.3.1 requires that the master shall be able to calculate the stability for the anticipated worst conditions during the voyage, etc. These paragraphs are classified as "amendment required case".

In section 3, paragraph 3.1.2 requires fire safety risk assessments by the ship's crew for cargo handling areas on self-unloading bulk carriers featuring internally installed conveyor systems within the ship's structure. This paragraph is classified as "amendment required case". Paragraph 3.2 refers to entry into enclosed space and paragraph 3.2.6 requires supervision of a responsible officer for emergency entry into a cargo space. These paragraphs are applicable to unmanned ships under the assumption mentioned in paragraph 1.3 of this paper, taking into account that entry into enclosed spaces may be necessary during cargo handling.

In section 4, paragraph 4.2.1 and 4.3 refer to a provision of cargo information and certificate of test, respectively, to the ship's personnel. These paragraphs are classified as "amendment required case".

Sections 5 and 6 are applicable to unmanned ships.

Table 27 Contents of International Maritime Solid Bulk Cargoes Code

Contents		Non-mandatory
Foreword		(No requirements)
Section 1	General provisions	
Section 2	General loading, carriage and unloading precautions	
Section 3	Safety of personnel and ship	
Section 4	Assessment of acceptability of consignments for safe shipment	
Section 5	Trimming procedures	
Section 6	Methods of determining the angle of repose	
Section 7	Cargoes that may liquefy	
Section 8	Test procedures for cargoes that may liquefy	
Section 9	Materials possessing chemical hazards	
Section 10	Carriage of solid wastes in bulk	
Section 11	Security provisions	Other than 11.1.1
Section 12	Stowage factor conversion Tables	X
Section 13	References to related information and recommendations	X
Appendix 1	Individual schedules of solid bulk cargoes	See Table 28
Appendix 2	Laboratory test procedures, associated apparatus and standards	X
Appendix 3	Properties of solid bulk cargoes	X
Appendix 4	Index	X
Appendix 5	Bulk Cargo Shipping Names in three languages (English, Spanish and French)	

In section 7, the first sentence of paragraph 7.1.1 reads that the purpose of this section is to bring to the attention of ship's masters, etc., on the risks associated with liquefaction and the precautions to minimize the risk. The first sentence of paragraph 7.3.1.5 reads "masters shall be cautioned about the possible danger of using water to cool these cargoes while the ship is at sea". These sentences can be regarded as the provision of information to ships' masters and classified as "amendment required case".

Sections 8 and 9 are applicable to unmanned ships.

In section 10, paragraph 10.9 reads that the ship's master shall immediately inform the competent authorities in the event that a waste will constitute a danger for the ship or the environment. This paragraph is classified as "amendment required case".

In summary, requirements classified as "amendment required case" are included in sections 1 to 4, 7 and 10.

3.12.3 Main features of Appendix 1 in view of unmanned operation

Appendix 1 to the IMSBC Code is individual schedules for solid bulk cargoes and individual schedules consist of parts and sections specified in Table 28. The right column of this table indicates non-mandatory parts, which are not investigated in this paper. The middle column of this table indicates the parts not included in all individual schedules.

In sections for "Loading" and "Precautions" of some individual schedules, there are requirements on provision of a certificate or a declaration on cargo properties to the ship's master. These requirements are classified as "amendment required case".

Sections for "Loading" of some individual schedules include:

.1 requirements for the ship's master on the preparation of loading and departure, which are classified as "amendment required case", but not as "preclusive case" for the reason that these requirements can be complied with by the master on shore;

.2 requirements for temperature monitoring including provision of the information to the ship's master, which are classified as "amendment required case"; and

.3 a requirement on awareness of the ship's master on specific properties of a cargo, which is classified as "amendment required case".

Sections for "Precautions" of some individual schedules include:

.1 provisions on awareness of the ship's master and officers on ineffectiveness of ship's fixed gas fire-fighting installation for specific cargoes, which are classified as "amendment required case";

Table 28 Parts and sections for individual schedules for solid bulk cargoes

Parts and sections	Not in all schedules	Non-mandatory
Bulk Cargo Shipping Name (BCSN)		
Application provision	X	
Description		X
Characteristics		See below
Angle of repose		X
Bulk density		X
Stowage factor		X
Size		X
Class		
Group		
Hazard		X
Stowage & segregation		
Hold cleanliness		
Weather precautions		
Loading		
Precautions		
Ventilation		
Carriage		
Discharge		
Clean-up		
Emergency procedures	X	X
Appendix	X	

.2 provisions on the approval of departure by the ship's master regarding cargo conditions, which are classified as "amendment required case"; and

.3 a requirement that the ship's master shall post warnings, which is classified as "amendment required case".

In sections for "Carriage" of some individual schedules for cargoes which may liquefy, the ship's master is required to take appropriate action when a cargo shows an indication of liquefaction. These requirements are classified as "preclusive case".

In appendices to individual schedules for BROWN COAL BRIQUETTES, COAL and Ferrosilicon cargoes, there are some provisions for the ship's master's obligations and these provisions are classified as "amendment required case".

In summary, the requirements classified as "amendment required case" are included in sections for "Loading" and "Precautions" and appendices to some individual schedules. The requirements classified as "preclusive case" are those for the emergency actions when a cargo shows an indication of liquefaction.

3.13 Sub-chapter 1.9 of the Code of Safe Practice for Cargo Stowage and Securing

SOLAS regulation VI/2.2.1, i.e. the requirement for cargo information, makes sub-chapter 1.9 of Code of Safe Practice for Cargo Stowage and Securing (CSS Code) mandatory, while the CSS Code is, in general, non-mandatory.

Paragraph 1.9.1 of the CSS Code is applicable to unmanned ships.

Paragraph 1.9.2 of the CSS Code requires that the ship's master should be provided with adequate information regarding the cargo. Hence, this requirement is classified as "amendment required case".

3.14 International Code for the Safe Carriage of Grain in Bulk

The International Code for the Safe Carriage of Grain in Bulk (International Grain Code) prescribes the requirements for carriage of grain in bulk. Table 29 shows the contents of the Code. The requirements in the Code are for stability and strength and applicable to unmanned ships, in general, except some requirements referred to below.

Paragraphs 6.1 refers to the provision of information to the ship's master. This paragraph is classified as "amendment required case".

Table 29 Contents of International Code for the Safe Carriage of Grain in Bulk

Part A	Specific requirements
1	Application
2	Definitions
3	Document of authorization
4	Equivalents
5	Exemption for certain voyages
6	Information regarding ship's stability and grain loading
7	Stability requirements
8	Stability requirements for existing ships
9	Optional stability requirements for ships without documents of authorization carrying partial cargoes of bulk grain
10	Stowage of bulk grain
11	Strength of grain fittings
12	Division loaded on both sides
13	Division loaded on one side only
14	Saucers
15	Bundling of bulk
16	Overstowing arrangements
17	Strapping or lashing
18	Securing with wire mesh
Part B	Calculation of assumed heeling moments and general assumptions
1	General assumptions
2	Assumed volumetric heeling moment of a filled compartment, trimmed
3	Assumed volumetric heeling moment of a filled compartment, untrimmed
4	Assumed volumetric heeling moments in trunks
5	Assumed volumetric heeling moment of a partly filled compartment
6	Other assumptions

Paragraphs 7.2 and 7.3 prescribe the obligation of the ship's master on demonstration of the stability of the ship and on keeping the ship upright before proceeding to sea. These requirements seem to be classified as "preclusive case". It should, however, be noted that unmanned ships may comply with these requirements depending on the interpretation, for the reason that these requirements are not for during voyage. Therefore, these requirements are classified as "amendment required case".

3.15 International Maritime Dangerous Goods Code

3.15.1 Outline of the Code

The International Maritime Dangerous Goods (IMDG) Code prescribes the requirements for carriage of packaged dangerous goods. Table 30 shows the contents of the Code. The following non-mandatory parts, which are specified in paragraph 1.1.1.5 of the Code, are not investigated in this paper:

.1 paragraph 1.1.1.8 (Notification of infringements);
.2 paragraphs 1.3.1.4 to 1.3.1.7 (Training);
.3 chapter 1.4 (Security provisions) except 1.4.1.1, which is mandatory;
.4 section 2.1.0 of chapter 2.1 (Class 1 – Explosives, Introductory notes);
.5 section 2.3.3 of chapter 2.3 (Determination of flashpoint);
.6 columns 15 and 17 of the Dangerous Goods List in chapter 3.2;
.7 the segregation flow chart and example in the annex to chapter 7.2;
.8 section 5.4.5 of chapter 5.4 (Multimodal Dangerous Goods Form), insofar as the layout of the form is concerned;
.9 chapter 7.8 (Special requirements in the event of an incident and fire precautions involving dangerous goods);
.10 section 7.9.3 (Contact information for the main designated national competent authorities); and
.11 appendix B.

The respective parts of the Code are investigated in the next paragraph.

3.15.2 Classification of requirements in view of unmanned operation

The mandatory requirements in part 1 are applicable to unmanned ships.

Parts 2 to 4 are applicable to unmanned ships.

In part 5, paragraph 5.5.2.5.5 requires that the ship's master shall be informed prior to the loading of a fumigated cargo transport unit. This requirement is classified as "amendment required case".

Part 6 is applicable to unmanned ships.

In the mandatory requirements in part 7, chapter 7.3 includes a provision of information to the ship's master, which is classified as "amendment required case". Paragraph 7.5.2.13 requires that the master of a ship carrying dangerous goods in ro-ro cargo spaces shall ensure that, during loading and unloading operations and during the voyage, regular inspections of these spaces are made by an authorized crew member or responsible person in order to achieve early detection of any hazard. This requirement is classified as "preclusive case".

It should be noted that the following text was included in up to 35-10 version of the IMDG Code, until deleted by Amendment 36-12 adopted by Resolution MSC.328(90):

"7.1.1.8 Stowage "on deck only" has been prescribed in cases where:

.1 constant supervision is required; or

.2 accessibility is particularly required; or

.3 there is a substantial risk of formation of explosive gas mixtures, development of highly toxic vapours, or unobserved corrosion of the ship."

Taking the above mentioned text into consideration, cargoes required to be stowed "on deck only" may have not to be stowed on unmanned ships, for the reason that constant supervision and accessibility will not be maintained on unmanned ships. To the contrary, such cargo may be stowed "under deck" on unmanned ships, taking into account risks on lives onboard such ships.

Appendix A is applicable to unmanned ships.

Table 30 Contents of International Maritime Dangerous Goods Code (1/2)

Part 1	General provisions, definitions and training	
	Chapter 1	General Provisions
	Chapter 1.2	Definitions, units of measurement and abbreviations
	Chapter 1.3	Training
	Chapter 1.4	Security provisions
	Chapter 1.5	General provisions concerning radioactive material
Part 2	Classification	
	Chapter 2	Introduction
	Chapter 2.1	Class 1 – Explosives
	Chapter 2.2	Class 2 – Gases
	Chapter 2.3	Class 3- Flammable liquids
	Chapter 2.4	Flammable solids; substances liable to spontaneous combustion; substances which, in contact with water, emit flammable gases
	Chapter 2.5	Class 5 – Oxidizing substances and organic peroxides
	Chapter 2.6	Class 6 – Toxic and infectious substances
	Chapter 2.7	Class 7 – Radioactive material
	Chapter 2.8	Class 8 – Corrosive substances
	Chapter 2.9	Miscellaneous dangerous substances and articles (class 9) and environmentally hazardous substances
	Chapter 2.10	Marine pollutants
Part 3	Dangerous Goods List, Special Provisions and Exceptions	
	Chapter 3.1	General
	Chapter 3.2	Dangerous Goods List
	Chapter 3.3	Special provisions applicable to certain substances, materials or articles
	Chapter 3.4	Dangerous goods packed in limited quantities
	Chapter 3.5	Dangerous goods packed in excepted quantities
Part 4	Packing and Tank Provisions	
	Chapter 4.1	Use of packagings, including intermediate bulk containers (IBCs) and large packagings
	Chapter 4.2	Use of portable tanks and multiple-element gas containers (MEGCs)
	Chapter 4.3	Use of bulk containers
Part 5	Consignment Procedures	
Chapter 5.1	General provisions	
	Chapter 5.2	Marking and labelling of packages including IBCs
	Chapter 5.3	Placarding and marking of cargo transport units
	Chapter 5.4	Documentation
	Chapter 5.5	Special provisions
Part 6	Construction and testing of packagings, intermediate bulk containers (IBCs), large packagings, portable tanks, multiple-element gas containers (MEGCs) and road tank vehicles	
	Chapter 6.1	Provisions for the construction and testing of packagings
	Chapter 6.2	Provisions for the construction and testing of pressure receptacles, aerosol dispensers, small receptacles containing gas (gas cartridges) and fuel cell cartridges containing liquefied flammable gas
	Chapter 6.3	Provisions for the construction and testing of packagings for class 6.2 infectious substances of category A
	Chapter 6.4	Provisions for the construction, testing and approval of packages for radioactive material and for the approval of such material
	Chapter 6.5	Provisions for the construction and testing of intermediate bulk containers (IBCs)
	Chapter 6.6	Provisions for the construction and testing of large packagings.
	Chapter 6.7	Provisions for the design, construction, inspection and testing of portable tanks and multiple-element gas containers (MEGCs)
	Chapter 6.8	Provisions for road tank vehicles
	Chapter 6.9	Provisions for the design, construction, inspection and testing of bulk containers

Table 30 Contents of International Maritime Dangerous Goods Code (2/2)

Part 7	Provisions concerning Transport Operations
Chapter 7.1	General stowage provisions
Chapter 7.2	General segregation provisions
Chapter 7.3	Consigning operations concerning the packing and use of cargo transport units (CTUs) and related provisions
Chapter 7.4	Stowage and segregation on containerships
Chapter 7.5	Stowage and segregation on ro-ro ships
Chapter 7.6	Stowage and segregation on general cargo ships
Chapter 7.7	Shipborne barges on barge-carrying ships
Chapter 7.8	Special requirements in the event of an incident and fire precautions involving dangerous goods
Chapter 7.9	Exemptions, approvals and certificates
Appendix A	List of generic and N.O.S. proper shipping names
Appendix B	Glossary of terms

3.16 International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk

3.16.1 Outline of the Code

The International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code) prescribes the requirements for carriage of dangerous chemicals, which are generally liquids, in bulk. Table 31 shows the contents of the Code. The Code is made mandatory not only by the SOLAS Convention but also by the International Convention for the Prevention of Pollution From Ships (MARPOL Convention). The Code is, therefore, applicable to ships not engaged in the international voyage, while the other codes which are made mandatory only by the SOLAS Convention need not apply to ships not engaged in the international voyage, in general.

The respective chapters of the Code are investigated in the next paragraph.

3.16.2 Classification of requirements in view of unmanned operation

Paragraph 1.5.3 in chapter 1 requires that the ship's master or owner of the ship shall report at the earliest opportunity to the Administration whenever an accident occurs to a ship, etc. This requirement can be complied with by unmanned ships, if an accident is recognized and communicated to an appropriate person on-shore. Chapter 1 is, therefore, applicable to unmanned ships, in general.

Table 31 Contents of International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk

Preamble	
Chapter 1	General
Chapter 2	Ship survival capability and location of cargo tanks
Chapter 3	Ship arrangements
Chapter 4	Cargo containment
Chapter 5	Cargo transfer
Chapter 6	Materials of construction, protective linings and coatings
Chapter 7	Cargo temperature control
Chapter 8	Cargo tank venting and gas-freeing arrangements
Chapter 9	Environmental control
Chapter 10	Electrical installations
Chapter 11	Fire protection and fire extinction
Chapter 12	Mechanical ventilation in the cargo area
Chapter 13	Instrumentation
Chapter 14	Personnel protection
Chapter 15	Special requirements
Chapter 16	Operational requirements
Chapter 17	Summary of minimum requirements
Chapter 18	List of products to which the Code does not apply
Chapter 19	Index of Products Carried in Bulk
Chapter 20	Transport of liquid chemical wastes
Chapter 21	Criteria for assigning carriage requirements for products subject to the IBC Code

Paragraph 2.2.5 in chapter 2 requires the provision of stability information to the ship's master. This paragraph is classified as "amendment required case".

Chapters 3 and 4 are applicable to unmanned ships.

Paragraph 5.6.1 in chapter 5 requires that cargo-transfer systems shall be provided with one stop-valve capable of being manually operated on each tank filling and discharge line. This requirement is classified as "amendment required case".

Chapter 6 is applicable to unmanned ships.

Paragraph 7.1.3 in chapter 7 requires that heating or cooling systems for cargo temperature control shall be provided with valves to isolate the system for each tank and to allow manual regulation of flow. This requirement is classified as "amendment required case".

In chapter 8, paragraph 8.2.6 regarding cargo tank venting is the provision of information, to the ship's master, on the maximum permissible loading and unloading rates for each tank or group of tanks. This requirement is classified as "amendment required case".

Chapters 9 to 13 are applicable to unmanned ships. It should be noted that chapter 11 of the Code requires to apply the requirements for tankers in chapter II-2 of the SOLAS Convention to ships covered by the Code, irrespective of tonnage including ships of less than 500 tons gross tonnage, and determines the fire safety requirements applicable only to ships covered by the Code in lieu of some requirements in chapter II-2 of the SOLAS Convention. "Chapter 11 is applicable to unmanned ships" means that the fire safety requirements specifically for ships covered by the Code are applicable to unmanned ships covered by the Code. However, it does not mean that all fire safety requirements, including those required by chapter II-2 of the SOLAS Convention, are applicable to unmanned ships.

Chapter 14 of the Code is the requirements for personnel protection. Paragraph 14.1 requires protective equipment for the protection of crew members who are engaged in loading and discharging operations. This requirement is applicable to unmanned ships. Paragraph 14.2 requires that at least three safety equipment are provided for ships carrying toxic products, etc. This requirement is classified as "amendment required case". Paragraph 14.3 requires that ships carrying specific cargoes shall be provided with suitable respiratory and eye protection, etc., sufficient for every person on board for emergency escape purposes. This requirement is classified as "inapplicable case".

Chapter 15 prescribes special requirements for specific cargoes. Paragraph 15.5, i.e. the regulation for Hydrogen peroxide solutions, includes:

.1 the requirement for certification from the shipper to the ship's master, which is classified as "amendment required case"; and

.2 the requirement for protective clothing for each crew member involved in cargo-transfer operations, which is classified as "inapplicable case".

Paragraph 15.8, i.e. the regulation for propylene oxide or ethylene oxide/propylene oxide mixtures with an ethylene oxide content of not more than 30% by mass, requires that the automatic control system of cooling system for maintaining the liquid temperature below the boiling temperature shall also be capable of being manually operated. This requirement is classified as "amendment required case".

Chapter 16 prescribes operational requirements. Paragraph 16.2 prescribes the information onboard and contains requirements classified as "amendment required case". Paragraph 16.3.3 requires that officers shall be trained in emergency procedures to deal with various conditions. This requirement is classified as "inapplicable case", while this requirement can be classified as "preclusive case" when the requirement is interpreted as "trained officers shall be onboard for emergency".

Chapters 17 to 21 are applicable to unmanned ships.

3.17 International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk

3.17.1 Outline of the Code

The International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code) prescribes the requirements for carriage of liquefied gases in bulk. Table 32 shows the contents of the Code.

Chapter 19 determines the application of the requirements in the Code to respective cargoes and should apply to unmanned ships. Appendices 1 to 3 are form for information and certificate and can be used regardless of manned or unmanned ships. Appendices 4 and 5 are material and design requirements and applicable to unmanned ships. Therefore, chapter 19 and all appendices are not investigated in this paper. Chapters 1 to 18 are investigated in the next paragraph.

Table 32 Contents of International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk

Preamble	
Chapter 1	General
Chapter 2	Ship survival capability and location of cargo tanks
Chapter 3	Ship arrangements
Chapter 4	Cargo containment
Chapter 5	Process pressure vessels and liquids, vapour and pressure piping systems
Chapter 6	Materials of construction and quality control
Chapter 7	Cargo pressure/Temperature control
Chapter 8	Vent systems for cargo containment
Chapter 9	Cargo containment system atmosphere control
Chapter 10	Electrical installations
Chapter 11	Fire protection and extinction
Chapter 12	Artificial ventilation in the cargo area
Chapter 13	Instrumentation and automation systems
Chapter 14	Personnel protection
Chapter 15	Filling limits for cargo tanks
Chapter 16	Use of cargo as fuel
Chapter 17	Special requirements
Chapter 18	Operating requirements
Chapter 19	Summary of minimum requirements
Appendix 1	IGC Code product data reporting form
Appendix 2	Model form of International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk
Appendix 3	Example of an addendum to the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk
Appendix 4	Non-metallic materials
Appendix 5	Standard for the use of limit state methodologies in the design of cargo containment systems of novel configuration

3.17.2 Classification of requirements in view of unmanned operation

Chapter 1 is applicable to unmanned ships.

Paragraph 2.2.5 in chapter 2 requires that the ship's master shall be supplied with a loading and stability information booklet. This requirement is classified as "amendment required case".

Chapters 3 and 4 are applicable to unmanned ships.

Paragraph 5.5 in chapter 5 requires manually operated valves for isolation of cargo tanks and piping systems. These requirements are classified as "amendment required case".

Chapter 6 is applicable to unmanned ships.

Paragraph 7.4 in chapter 7 requires that each system for oxidation of boil off gas (BOG) shall have provision to manually isolate its gas fuel supply from a safely accessible position, and that those arrangements shall be made to enable the combustion chamber to be manually purged. These requirements are classified as "amendment required case".

Paragraphs 8.2.8 and 8.2.9 require that changing set pressure of one of pressure relief valves and isolation of a pressure relief valve, respectively, shall be carried out under the supervision of the ship's master. These requirements are classified as "amendment required case".

Chapters 9 and 10 are applicable to unmanned ships.

It should be noted that chapter 11 of the Code requires to apply the requirements for tankers in chapter II-2 of the SOLAS Convention to ships covered by the Code, irrespective of tonnage including ships of less than 500 tons gross tonnage, and determines the fire safety requirements applicable only to ships covered by the Code in lieu of some requirements in chapter II-2 of the SOLAS Convention, similar to chapter 11 of the IBC Code. In the specific requirements prescribed in chapter 11 of the Code, paragraph 11.6 requires "fire-fighter's outfit". This paragraph is classified as "amendment required case" similar to paragraph 10 of regulation 10 in chapter II-2 of the SOLAS Convention.

Chapters 12 and 13 are applicable to unmanned ships, while paragraph 13.6.11 requires a manual isolating valve for gas sampling lines only in case that gas sampling equipment is located in a non-hazardous space.

Chapter 14 is the requirements for “personnel protection” and classified as “amendment required case”.

Paragraph 15.6.3 in chapter 15 requires that the ship’s master shall keep a document specifying the maximum allowable loading limits onboard. This paragraph is classified as “amendment required case”.

Paragraph 16.4.6 in chapter 16 requires that individual master valves for spaces containing gas consumers shall be operated manually from within the space, and at least one remote location. Paragraph 16.5.2.1 requires that all rotating equipment utilized for conditioning the cargo for its use as fuel shall be arranged for manual remote stop from the engine-room. Paragraph 16.6.3.2 requires that a manually operated shut-off valve shall be fitted on the pipe of each gas-burner. These paragraphs are classified as “amendment required case”.

Paragraph 17.13.5 in chapter 17 is the requirements for “personnel protection” from chlorine and classified as “amendment required case”.

In chapter 18, paragraphs 18.2 and 18.3 require cargo operation manuals and cargo information onboard, respectively. These requirements are classified as “amendment required case”. Paragraph 18.4 includes the sentence “the master shall ascertain that the quantity and characteristics of each product to be loaded are within the limits ...”. This requirement may be applicable to unmanned ships depending on the interpretation, for the reason that the requirement can be complied with prior to departure. Paragraph 18.7 requires that the ship’s officers shall be trained in emergency procedures. This requirement is classified as “inapplicable case”, while this requirement can be classified as “preclusive case” when the requirement is interpreted as “trained officers shall be onboard for emergency”, similar to paragraph 16.3.3 of the IBC Code. Paragraph 18.9 prescribes the obligations of ship’s officers with regard to cargo sampling. This paragraph can be applicable to unmanned ships, for the reason that cargo sampling is carried out prior to departure, while this paragraph may be classified as “amendment required case” depending on the interpretation. Paragraph 18.10 refers to manual operations of emergency shutdown system to stop cargo flow in the event of an emergency either internally within the ship, or during cargo transfer to ship or shore. Therefore, this paragraph is classified as “amendment required case” when a transfer of cargo inside the ship during voyage is anticipated.

3.18 International Management Code for the Safe Operation of Ships and for Pollution Prevention

The International Management Code for the Safe Operation of Ships and for Pollution Prevention (ISM Code) requires the safety-management system to ensure compliance with mandatory rules and regulations. Table 33 shows the contents of the Code. The Code mainly prescribes the obligations of “the Company”. Paragraphs 5 and 6 of the Code refer to the ship’s master’s authority and responsibility. These requirements may be applicable to unmanned ships depending on the interpretation, while they may be classified as “preclusive case” under the interpretation that the master should be onboard in order to have the overriding authority and the responsibility to make decisions with respect to safety and pollution prevention.

3.19 International Code on the Enhanced Programme of Inspections during Surveys of Bulk Carriers and Oil Tankers, 2011

International Code on the Enhanced Programme of Inspections during Surveys of Bulk Carriers and Oil Tankers, 2011 (2011 ESP Code) specifies the procedures for, so called, enhanced survey required by chapter XI-1 of the SOLAS Convention. Table 34 shows the skeleton of the Code.

The Code can be regarded as applicable to unmanned bulk carriers and oil tankers, taking into account that the following requirements are related to ships’ personnel but can be complied with by unmanned ships, in general, under the assumption mentioned in paragraph 1.3 of this paper:

.1 As a condition for survey, a communication system should be arranged between the survey party and the responsible officer on deck, etc. (paragraphs 5.2.10 of Parts A and B in Annex 1 and paragraphs 5.2.7 of Parts A and B in Annex B);

.2 For surveys at sea or at anchorage, a communication system should be arranged among the survey party, the responsible officer on deck and the personnel in charge of ballast pump handling if boats or rafts are used (paragraphs 5.5.2 of Parts A and B in Annexes A and B); and

.3 Prior to commencement of any part of the renewal and intermediate survey, a survey planning meeting should be held between the attending surveyor(s), the owner's representative in attendance, the thickness measurement company operator (as applicable) and the master of the ship or an appropriately qualified representative appointed by the master or company (paragraphs 5.6.2 of Parts A and B in Annexes A and B).

Table 33 Contents of International Management Code for the Safe Operation of Ships and for Pollution Prevention

Part A	Implementation	
	1	General
	2	Safety and environmental protection policy
	3	Company responsibilities and authority
	4	Designated person(s)
	5	Master's responsibility and authority
	6	Resources and personnel
	7	Shipboard operations
	8	Emergency preparedness
	9	Reports and analysis of non-conformities, accidents and hazardous occurrences
	10	Maintenance of the ship and equipment
	11	Documentation
	12	Company verification, review and evaluation
Part B	Certification and verification	
	13	Certification and periodical verification
	14	Interim certification
	15	Verification
	16	Forms of certificates

Table 34 Contents of International Code on the Enhanced Programme of Inspections during Surveys of Bulk Carriers and Oil Tankers, 2011

Annex A	Code on the Enhanced Programme of Inspections During Surveys of Bulk Carriers	Annex B	Code on the Enhanced Programme of Inspections During Surveys of Oil Tankers
Part A	Code on the Enhanced Programme of Inspections During Surveys of Bulk Carriers Having Single-Side Skin Construction	Part A	Code on the Enhanced Programme of Inspections During Surveys of Double-Hull Oil Tankers
	1 General		1 General
	2 Renewal survey		2 Renewal survey
	3 Annual survey		3 Annual survey
	4 Intermediate survey		4 Intermediate survey
	5 Preparations for survey		5 Preparations for survey
	6 Documentation on board		6 Documentation on board
	7 Procedures for thickness measurements		7 Procedures for thickness measurements
	8 Reporting and evaluation of survey		8 Reporting and evaluation of survey
	Annexes		Annexes
Part B	Code on the Enhanced Programme of Inspections During Surveys of Bulk Carriers Having Double-Side Skin Construction	Part B	Code on the Enhanced Programme of Inspections During Surveys of Oil Tankers other than Double-Hull Oil Tankers
	1 General		1 General
	2 Renewal survey		2 Renewal survey
	3 Annual survey		3 Annual survey
	4 Intermediate survey		4 Intermediate survey
	5 Preparations for survey		5 Preparations for survey
	6 Documentation on board		6 Documentation on board
	7 Procedures for thickness measurements		7 Procedures for thickness measurements
	8 Reporting and evaluation of survey		8 Reporting and evaluation of survey
	Annexes		Annexes

3.20 International Code for the Security of Ships and of Port Facilities

3.20.1 Outline of the Code

The International Code for the Security of Ships and of Port Facilities (ISPS Code), roughly speaking, provides the procedures to develop, review, approve and implement security plans for ships and port facilities. Table 35 shows the contents of the Code. As mentioned in SOLAS regulation XI-2/1.1.12, the Code consists of mandatory part, i.e. Part A, and recommendatory part, i.e. Part B. Only mandatory part is investigated in this paper, as mentioned in paragraph 1.2 of this paper.

Table 35 Contents of International Code for the Security of Ships and of Port Facilities

Preamble		Part B Guidance regarding the provisions of chapter XI-2 of the annex to the International Convention for the Safety of Life at Sea, 1974 as amended and Part A of this Code	
Part A Mandatory requirements regarding the provisions of chapter XI-2 of the International Convention for the Safety of Life at Sea, 1974, as amended			
Section 1	General	Section 1	Introduction
Section 2	Definitions	Section 2	Definitions
Section 3	Application	Section 3	Application
Section 4	Responsibilities of contracting governments	Section 4	Responsibilities of contracting governments
Section 5	Declaration of security	Section 5	Declaration of security
Section 6	Obligations of the company	Section 6	Obligations of the company
Section 7	Ship security	Section 7	Ship security
Section 8	Ship security assessment	Section 8	Ship security assessment
Section 9	Ship security plan	Section 9	Ship security plan
Section 10	Records	Section 10	Records
Section 11	Company security officer	Section 11	Company security officer
Section 12	Ship security officer	Section 12	Ship security officer
Section 13	Training, drills and exercises on ship security	Section 13	Training, drills and exercises on ship security
Section 14	Port facility security	Section 14	Port facility security
Section 15	Port facility security assessment	Section 15	Port facility security assessment
Section 16	Port facility security plan	Section 16	Port facility security plan
Section 17	Port facility security officer	Section 17	Port facility security officer
Section 18	Training, drills and exercises on port facility security	Section 18	Training, drills and exercises on port facility security
Section 19	Verification and certification for ships	Section 19	Verification and certification of ships

The Code, in general, requires that a ship's master and/or a ship security officer, hereafter expressed with "SSO", is onboard a ship.　The respective sections of Part A of the Code are investigated in the next paragraph.

3.20.2 Classification of requirements in view of unmanned operation

Sections 1 to 4 are applicable to unmanned ships.

Section 5 requires that a Declaration of Security shall be completed by the ship's master or the SSO on behalf of the ship, when a Declaration of Security is required by a Contracting Government.　This requirement can be classified as "preclusive case".

Section 6 requires the Company to ensure that the Ship Security Plan (SSP) contains a clear statement emphasizing the ship's master's authority and that the Company Security Officer, hereafter expressed with "CSO", the ship's master and the SSO are given the necessary support to fulfil their duties and responsibilities.　This regulation can be classified as "amendment required case".

Section 7 requires that the performance of all ship security duties are ensured and that the SSO and the Port Facility Security Officer, hereafter expressed with "PFSO", shall liaise and co-ordinate the appropriate actions in some cases. These requirements can be classified as "preclusive case".

Sections 8 to 10 are, in general, applicable to unmanned ships.

Paragraph 11.2.10 requires that a company security officer shall ensure effective communication and co-operation between the SSO and the relevant PFSOs and this paragraph can be classified as "amendment required case", while section 11 prescribes the obligations of a CSO and is applicable to unmanned ships, in general.

In section 12, paragraph 12.1 requires that an SSO shall be designated on each ship and paragraph 12.2 specifies the obligation of an SSO.　This section is classified as "preclusive case".

Section 13 is applicable to unmanned ships, in general.

In section 14, paragraph 14.5 requires that the SSO and the PFSO shall liaise and co-ordinate the appropriate actions in some cases.　This paragraph can be classified as "preclusive case".

Sections 15 to 18 are applicable to unmanned ships.

Section 19 is also applicable to unmanned ships, except it is necessary for issuance of an Interim International Ship Security Certificate that the ship's master, the SSO and other ship's personnel with specific security duties are familiar with their security duties and responsibilities.

3.21 Standards for owners' inspection and maintenance of bulk carrier hatch covers

The standards for owners' inspection and maintenance of bulk carrier hatch covers prescribes the requirements for the owners' inspection and maintenance of cargo hatch covers on board bulk carriers. Table 36 shows the contents of these standards.

The Standards mainly prescribes the obligations of ship owners and operators. The Standards are applicable to unmanned ships.

4 Discussion

4.1 Requirements classified as "preclusive case", "inapplicable case" and "amendment required case"

4.1.1 Requirements classified as "preclusive case"

The requirements/provisions classified as "preclusive case" were as follows:

.1 SOLAS regulations III/10 and III/31, which require a sufficient number of crew onboard for survival craft and installation of survival craft at least one regardless of number of persons onboard, respectively;

.2 SOLAS regulations III/20 and paragraph 4.1 of "Requirements for maintenance, thorough examination, operational testing, overhaul and repair of lifeboats and rescue boats, launching appliances and release gear", which require persons onboard for weekly and monthly inspections and routine maintenance of the life-saving appliances;

.3 SOLAS regulation IV/16, which requires that every ship shall carry personnel qualified for distress and safety radiocommunication purposes;

.4 SOLAS regulation V/23.2.2, which requires supervision of operation related to pilot transfer by a responsible officer;

.5 SOLAS regulation V/24, which requires that a qualified helmsperson shall be ready at all times in hazardous navigational situations including high traffic density and restricted visibility;

.6 SOLAS regulations V/26.1 and V/26.3, which refer to the test of steering gear by the ship's crew and familiarity of ships' officers with the operation of steering systems, respectively;

.7 SOLAS regulation V/31.1, which prescribes the obligation of a ship's master on the notification of danger to other ships;

.8 SOLAS regulation V/33, which prescribes the obligations of a ship's master on distress situations;

.9 Requirements for "appropriate actions" taken by the ship's master when a cargo shows an indication of liquefaction, set out in sections for "Carriage" in individual schedules for cargoes which may liquefy in Appendix 1 to the IMSBC Code;

.10 SOLAS regulations VII/6 and VII/7-4, which prescribe the obligation of the ship's master in case of accidents;

.11 Paragraph 7.5.2.13 of the IMDG Code, which requires the master of a ship carrying dangerous goods in ro-ro cargo spaces to ensure that regular inspections of these spaces are made by an authorized crew member or responsible person during loading, unloading and the voyage, in order to achieve early detection of any hazard;

.12 Section 5 of the ISPS Code, which requires that a Declaration of Security shall be completed by the ship's master or the SSO on behalf of the ship, when a Declaration of Security is required by a Contracting Government;

.13 Section 7 of the ISPS Code, which requires that the performance of all ship security duties are ensured and that the SSO and the PFSO shall liaise and co-ordinate the appropriate actions in some cases;

.14 Paragraphs 12.1 and 12.2 of the ISPS Code, which require that an SSO shall be designated on each ship for the specified obligation; and

.15 Paragraph 14.5 of the ISPS Code, which requires that the SSO and the PFSO shall liaise and co-ordinate the appropriate actions in some cases.

Table 36 Contents of Standards for owners' inspection and maintenance of bulk carrier hatch covers

1	Application
2	Maintenance of hatch covers and hatch opening, closing, securing and sealing systems
3	Inspection of hatch covers and hatch opening, closing, securing and sealing systems

It should be noted that identification of the requirements of “preclusive case” heavily depends on the assumption on the existence of ship’s personnel. In this paper, such requirements were identified under the assumption that the master of an unmanned ship exists, while he/she is not onboard the ship during sailing, and ship’s personnel are available during cargo handling, anchoring and berthing, while they are unavailable during sailing. Under the assumption, the majority of the requirements of “preclusive case” were for emergency including security incidents.

4.1.2 Requirements classified as “inapplicable case”

The requirements/provisions classified as “inapplicable case” were as follows:

.1 SOLAS regulation II-1/31.3, which is the requirement for the arrangement and control of main propulsion and associated machinery under continuous manual supervision from a control room;

.2 SOLAS regulations III/7.2 and III/7.3, which require lifejackets and immersion suits and anti-exposure suits, respectively, for sufficient number of persons onboard;

.3 SOLAS regulation V/14 regarding language, which requires that each seafarer shall be required to understand and, where appropriate, give orders and instructions and to report back in that language;

.4 Paragraph 14.3 of the IBC Code, which requires that ships carrying specific cargoes shall be provided with suitable respiratory and eye protection, etc., sufficient for every person on board for emergency escape purposes;

.5 Paragraph 15.5 of the IBC Code, which requires protective clothing for each crew member involved in cargo-transfer operations of Hydrogen peroxide solutions;

.6 Paragraph 16.3.3 of the IBC Code, which requires that ship’s officers shall be trained in emergency procedures to deal with various conditions; and

.7 Paragraph 18.7 of the IGC Code, which requires that the ship’s officers shall be trained in emergency procedures.

4.1.3 Requirements classified as “amendment required case”

As the results of investigation, many requirements/provisions in the SOLAS Convention and relevant mandatory IMO instruments were classified as “amendment required case”. Here, it should be noted that the investigation in this paper was carried out under the assumption set out in paragraph 1.3 of this paper. On the other hand, these assumptions for classification have not been widely adopted. Furthermore, the classification of the requirements heavily depends on the assumption on the availability of ship’s personnel during cargo handling, etc. It is, therefore, premature to precisely identify the requirements classified as “amendment required case”.

The assumptions for classification of the requirements are deeply related to the level of unmanned operations. Careful consideration is necessary on the assumptions for classification of the requirements, in order to further progress the regulatory scoping exercise.

4.2 Suggestions for research and development of MASS

4.2.1 Features of requirements classified as three cases

Fifteen requirements classified as “preclusive case” are listed in paragraph 4.1.1. Among these requirements, No. 12 to No. 15 are those in the ISPS Code related to SSO. Among eleven requirements other than those in the ISPS Code, six requirements (No. 2, No. 5, No. 7, No. 8, No. 9 and No. 10) are related to distress, accident, danger and hazardous situations. The remaining requirements are related to survival craft (No. 1 and No. 2), pilot transfer (No. 4), steering gear (No. 6) and regular inspections for dangerous goods (No. 11). The results of the investigation indicate that the requirements for boarding of able and responsible persons for emergency will be one of the bottle necks caused by the SOLAS Convention and the relevant mandatory IMO instruments for development of unmanned ships. Here, it should be noted that the feature of the requirements of “preclusive case” may be caused by the assumptions. However, it can be said that response to dangerous or emergency situations is one of the key features to enable unmanned ships.

4.2.2 Alternative design and arrangements, exemption and equivalence

As mentioned in paragraphs 2.5.3 and 2.6.3 of this paper, for the application to unmanned ships, comprehensive review is necessary for chapter II-2 of the SOLAS Convention and the FSS Code, in particular the requirements for fire-extinguishing/fire-fighting systems and appliances, and chapter III of the Convention and the LSA Code. However, comprehensive review of the requirements takes time. In view of this, the provisions for alternative design and arrangements may be used as an interim solution.

Chapters II-2 and III include provisions for alternative design and arrangements. Utilizing the provisions for alternative design and arrangement, it may be possible to avoid the conflict with the requirements in some parts of the SOLAS Convention. Concretely speaking, by utilizing SOLAS regulations II-1/55, II-2/17 and III/38, it may be possible to avoid conflict with the provisions in parts C, D, E and G of chapter II-1, parts B, C, D, E and G of chapter II-2, and part B of chapter III.

Furthermore, SOLAS regulations I/4 and I/5, which are "Exemptions" and "Equivalents", respectively, may be used for enabling unmanned ships. By utilizing SOLAS regulation I/4, it may be possible to avoid the conflict with the requirements in chapters II-1, II-2, III and IV of the SOLAS Convention. Similarly, by utilizing SOLAS regulation I/5, it may be possible to avoid the conflict with the requirements in the Convention on a particular fitting, material, appliance or apparatus, or type thereof.

On the other hand, the operational requirements in the SOLAS Convention should neither be exempted nor substituted by other means. Therefore, for ships to which the Convention applies, revision of the ISPS Code may be one of the key issues to enable unmanned operation of ships. Revision of chapters VI and VII of the Convention and the associated Codes may also be important to enable unmanned ships.

4.2.3 Subjects for respective types of cargoes

It may be necessary to review chapters VI and VII of the Convention and the associated Codes to enable unmanned ships. These chapters and codes include the requirements for respective types of cargoes. Therefore, a level of difficulty of research and development for unmanned operation of ships depends on types of cargoes, which are directly related to types of ships.

Taking into account the results of the investigation, important future subjects for respective types of ships and cargoes can be summarised as follows, in relation to chapters VI and VI of the Convention and the relevant codes:

.1 Oil tankers including product carriers: Oils can be carried under the SOLAS Convention without application of the requirements in chapters VI and VII, except regulation VI/5-1 regarding material safety data sheets;

.2 Chemical tankers: Dangerous liquid chemicals in bulk should be carried in accordance with the IBC Code, even on ships not engaged in international voyages. As mentioned in paragraph 3.16 of this paper, paragraph 16.3.3 of the IBC Code requires that officers shall be trained in emergency procedures to deal with various conditions. This requirement may be interpreted that trained officers shall be onboard for emergency. There is no other requirement in the IBC Code which may be classified as "preclusive case";

.3 Gas carriers: Liquefied gases in bulk should be carried in accordance with the IGC Code. As mentioned in paragraph 3.17 of this paper, paragraph 18.7 of the IGC Code requires that the ship's officers shall be trained in emergency procedures. This requirement may be interpreted that trained officers shall be onboard for emergency, similar to paragraph 16.3.3 of the IBC Code. Paragraph 18.10 of the IGC Code refers to manual operations of emergency shutdown. This requirement should also be considered if cargo transfer internally within the ship is envisaged;

.4 Bulk carries: Solid bulk cargoes should be carried in accordance with the IMSBC Code. As mentioned in paragraph 3.12 of this paper, individual schedules for cargoes which may liquefy (Group A cargoes) include the requirements for regular check of condition of cargoes and appropriate actions taken by the master when a cargo shows an indication of liquefaction. Furthermore, many requirements for monitoring of cargoes during voyage are included individual schedules for solid bulk cargoes set out in Appendix 1 to the Code; and

.5 Ships carrying packaged dangerous goods: Packaged dangerous goods should be carried in accordance with the IMDG Code. As mentioned in paragraph 3.15 of this paper, paragraph 7.5.2.13 of the IMDG Code requires that when dangerous goods are carried in a ro-ro cargo space, the space should be regularly inspected during voyage by responsible person, in order to achieve early detection of any hazard. Furthermore, acceptable conditions for stowage of "on deck only" dangerous goods may have to be clarified by IMO.

4.3 Amendment procedure

None of the text "preclusive case", "inapplicable case" or "amendment required case" is included either in the articles or chapter I of the SOLAS Convention. This means that all texts of "preclusive case", "inapplicable case" and

“amendment required case” can be amended in accordance with “tacit procedure”. Hence, it is procedurally practicable to amend the SOLAS Convention and related mandatory IMO instruments for enabling the construction and operation of MASS.

5 Conclusion

The requirements in the SOLAS Convention and twenty-one IMO instruments made mandatory by the Convention were investigated and the requirements of “preclusive case”, “inapplicable case” and “amendment required case” were identified. In addition, some suggestions for research and development of unmanned ships are considered, as mentioned in section 4.

It is our pleasure if the investigation contributes to the work of the MSC.

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7 Reference

1) MSC 98/20/2, by Denmark, Estonia, Finland, Japan, the Netherlands, Norway, the Republic of Korea, the United Kingdom and the United States, “Work Programme, Maritime Autonomous Surface Ships, Proposal for a regulatory scoping exercise”, February 2017
2) MSC 98/20/13, by the International Transport Workers' Federation, “Work Programme, Maritime Autonomous Surface Ships, Proposal for a regulatory scoping exercise, Comments on MSC 98/20/2”, 13 April 2017
3) MSC 98/23, “Report of the Maritime Safety Committee on its ninety-eighth session”, 28 June 2017
4) SOLAS Convention - Base text and amendments
   - Consolidated text of the International Convention for the Safety of Life at Sea, 1974 and its Protocol of 1988: articles, annexes and certificate (incorporating all amendments in effect from 1 July 2014)
   - Amendments to the International Convention for the Safety of Life at Sea, 1974, as amended:
     Resolution MSC.350(92), adopted on 21 June 2013;
     Resolution MSC.365(93), adopted on 22 May 2014;
     Resolution MSC.366(93), adopted on 22 May 2014;
     Resolution MSC.380(94), adopted on 21 November 2014;
     Resolution MSC.386(94), adopted on 21 November 2014;
     Resolution MSC.392(95), adopted on 11 June 2015;
     Resolution MSC.404(96), adopted on 19 May 2016;
     Resolution MSC.409(97), adopted on 25 November 2016; and
     Resolution MSC.421(98), adopted on 15 June 2017.
   - Resolution MSC.394(95), adopted on 11 June 2015, “Amendments to the Protocol of 1978 relating to the International Convention for the Safety of Life at Sea, 1974”
   - Resolution MSC.395(95), adopted on 11 June 2015, “Amendments to the Protocol of 1988 relating to the International Convention for the Safety of Life at Sea, 1974”
5 IMO instruments in Table 1 (Note: In the following list of documents, each number in the square brackets denotes the number in the left column of Table 1.)

[1] Performance standard for protective coatings for dedicated seawater ballast tanks in all types of ships and double-side skin spaces of bulk carriers

- Resolution MSC.215(82), adopted on 8 December 2006, “Performance standard for protective coatings for dedicated seawater ballast tanks in all types of ships and double-side skin spaces of bulk carriers”
- Resolution MSC.341(91), adopted on 30 November 2012, “Adoption of amendments to the performance standard for protective coatings for dedicated seawater ballast tanks in all types of ships and double side skin spaces of bulk carriers (Resolution MSC.215(82))

[2] Technical provisions for means of access for inspections

- Resolution MSC.133(76), adopted on 12 December 2002, “Adoption of technical provisions for means of access for inspections”
- Resolution MSC.158(78), adopted on 20 May 2004, “Adoption of amendments to the technical provisions for means of access for inspections”

[3] Goal-Based Ship Construction Standards for Bulk Carriers and Oil Tankers

- Resolution MSC.287(87), adopted on 20 May 2010, “Adoption of the international goal-based ship construction standards for bulk carriers and oil tankers”

[4] Performance standard for protective coatings for cargo oil tanks of crude oil tankers

- Resolution MSC.288(87), adopted on 14 May 2010, “Performance standard for protective coatings for cargo oil tanks of crude oil tankers”
- Resolution MSC.342(91), adopted on 30 November 2012, “Adoption of amendments to the performance standard for protective coatings for cargo oil tanks of crude oil tankers (Resolution MSC.288(87))”

[5] Performance standard for alternative means of corrosion protection for cargo oil tanks of crude oil tankers

- Resolution MSC.289(87), adopted on 14 May 2010, “Performance standard for alternative means of corrosion protection for cargo oil tanks of crude oil tankers”

[6] Code on noise levels on board ship

- Resolution MSC.337(91), adopted on 30 November 2012, “Adoption of the Code on noise levels on board ships”

[7] International Code on Intact Stability, 2008 (2008 IS Code)

- Resolution MSC.267(85), adopted on 4 December 2008, “Adoption of the International Code on Intact Stability, 2008(2008 IS Code)
- Resolution MSC.319(89), adopted on 20 May 2011, “Adoption of amendments to Part B of the International Code on Intact Stability, 2008 (2008 IS Code)”
- Resolution MSC.398(95), adopted on 5 June 2015, “Amendments to Part B of the International Code on Intact Stability, 2008 (2008 IS Code)”
- Resolution MSC.413(97), adopted on 25 November 2016, “Amendments to the Introduction and Part A of the International Code on Intact Stability, 2008 (2008 IS Code)
- Resolution MSC.415(97), adopted on 25 November 2016, “Amendments to Part B of the International Code on Intact Stability, 2008 (2008 IS Code)”

[8] International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF Code)

- Resolution MSC.391(95), adopted on 11 June 2015, “Adoption of the International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF Code)”

[9] International Code for Fire Safety Systems (FSS Code)

- Resolution MSC.98(73), adopted on 5 December 2000, “Adoption of the International Code for Fire Safety Systems”
- Resolution MSC.206(81), adopted on 18 May 2006, “Adoption of amendments to the International Code for Fire Safety Systems (FSS Code)”
- Resolution MSC.217(82), adopted on 8 December 2006, “Adoption of amendments to the International Code for Fire Safety Systems”
- Resolution MSC.292(87), adopted on 21 May 2010, “Adoption of amendments to the International Code for Fire Safety Systems”
- Resolution MSC.311(88), adopted on 3 December 2010, “Adoption of amendments to the International Code for Fire Safety Systems (FSS Code)”
- Resolution MSC.327(90), adopted on 25 May 2012, “Adoption of amendments to the International Code for Fire Safety Systems (FSS Code)”, with two Corrigenda

- SLS.12/Circ.148, 29 January 2015, “International Convention for the Safety of Life at Sea, 1974, Correction of editorial errors in the text of the 2012 amendments to the International Code For Fire Safety Systems (FSS Code) (Resolution MSC.327(90))”
- Resolution MSC.339(91), adopted on 30 November 2012, “Adoption of amendments to the International Code for Fire Safety Systems (FSS Code)”
- Resolution MSC.367(93), adopted on 22 May 2014, “Adoption of amendments to the International Code for Fire Safety Systems (FSS Code)”
- Resolution MSC.403(96), adopted on 19 May 2016, “Adoption of amendments to the International Code for Fire Safety Systems (FSS Code)”

[10] International Code for Application of Fire Test Procedures, 2010 (2010 FTP Code)

- Resolution MSC.307(88), adopted on 3 December 2010, “Adoption of the International Code for Application of Fire Test Procedures, 2010 (2010 FTP Code)”, with three Corrigenda

[11] International Life-Saving Appliance Code (LSA Code)

- Resolution MSC.48(66), adopted on 4 June 1996, “Adoption of the International Life-Saving Appliance (LSA) Code”
- Resolution MSC.207(81), adopted on 18 May 2006, “Adoption of amendments to the International Life-Saving Appliance (LSA) Code”
- Resolution MSC.218(82), adopted on 8 December 2006, “Adoption of amendments to the International Life-Saving Appliance (LSA) Code”
- Resolution MSC.272(85), adopted on 4 December 2008, “Adoption of amendments to the International Life-Saving Appliance (LSA) Code”
- Resolution MSC.293(87), adopted on 21 May 2010, “Adoption of amendments to the International Life-Saving Appliance (LSA) Code”
- Resolution MSC.320(89), adopted on 20 May 2011, “Adoption of amendments to the International Life-Saving Appliance (LSA) Code”
- Resolution MSC.368(93), adopted on 22 May 2014, “Amendments to the International Life-Saving Appliance (LSA) Code”
- Resolution MSC.425(98), adopted on 15 June 2017, “Amendments to the International Life-Saving Appliance (LSA) Code”

[12] Requirements for maintenance, thorough examination, operational testing, overhaul and repair of lifeboats and rescue boats, launching appliances and release gear

- Resolution MSC.402(96), adopted on 19 May 2016, “Requirements for maintenance, thorough examination, operational testing, overhaul and repair of lifeboats and rescue boats, launching appliances and release gear”

[13] International Maritime Solid Bulk Cargoes Code (IMSBC Code)

- Resolution MSC.268(85), adopted on 4 December 2008, “Adoption of the International Maritime Solid Bulk Cargoes (IMSBC) Code”
- Resolution MSC.318(89), adopted on 20 May 2011, “Adoption of amendments to the International Maritime Solid Bulk Cargoes (IMSBC) Code”
- Resolution MSC.354(92), adopted on 21 June 2013, “Amendments to the International Maritime Solid Bulk Cargoes (IMSBC) Code”
- Resolution MSC.393(95), adopted on 11 June 2015, “Amendments to the International Maritime Solid Bulk Cargoes (IMSBC) Code”
- Resolution MSC.426(98), adopted on 15 June 2017, “Amendments to the International Maritime Solid Bulk Cargoes (IMSBC) Code”

[14] Code of Safe Practice for Cargo Stowage and Securing (CSS Code)

- Resolution A.714(17), adopted on 6 November 1991, “Code of Safe Practice for Cargo Stowage and Securing”
- MSC/Circ.664, 22 December 1994, “Container and Cargoes, Code of Safe Practice for Cargo Stowage and Securing, Amendment to the CSS Code”
- MSC/Circ.691, 1 June 1995, “Container and Cargoes, Code of Safe Practice for Cargo Stowage and Securing, Amendment to the CSS Code”

- MSC/Circ.740, 4 June 1996, “Amendment to the Code of Safe Practice for Cargo Stowage and Securing (CSS Code)”
- MSC/Circ.812, 16 June 1997 “Amendments to the Guidelines for Securing Arrangements for the Transport of Road Vehicles on Ro-Ro Ships (Resolution A.581(14)) and the Code of Safe Practice for Cargo Stowage and Securing (Resolution A.714(17))”
- MSC/Circ.1026, 27 May 2002

[15] International Code for the Safe Carriage of Grain in Bulk (International Grain Code)

- Resolution MSC.23(59), adopted on 23 May 1991, “Adoption of the International Code for the Safe Carriage of Grain in Bulk”

[16] International Maritime Dangerous Goods Code (IMDG Code)

- Resolution MSC.406(96), adopted on 13 May 2016, “Amendments to the International Maritime Dangerous Goods (IMDG) Code”

[17] International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code)

- Resolution MSC.176(79), adopted on 10 December 2004, “2004 Amendments to the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code)”
- Resolution MSC.219(82), adopted on 8 December 2006, “Adoption of Amendments to the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk”
- Resolution MSC.340(91), adopted on 30 November 2012, “Adoption of Amendments to the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code)”
- Resolution MSC.369(93), adopted on 22 May 2014, “Adoption of Amendments to the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code)”

[18] International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code)

- Resolution MSC.370(93), adopted on 22 May 2014, “Amendments to the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code)”

[19] International Code for the Safe Carriage of Packaged Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Wastes on Board Ships (INF Code)

- Resolution MSC.88(71), adopted on 27 May 1999, “Adoption of the International Code for the Safe Carriage of Packaged Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Wastes on Board Ships (INF Code)”
- Resolution MSC.118(74), adopted on 6 June 2001, “Adoption of amendments to the International Code for the Safe Carriage of Packaged Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Wastes on Board Ships (INF Code)”
- Resolution MSC.135(76), adopted on 12 December 2002, “Adoption of amendments to the International Code for the Safe Carriage of Packaged Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Wastes on Board Ships (INF Code)”
- Resolution MSC.178(79), adopted on 10 December 2004, “Adoption of amendments to the International Code for the Safe Carriage of Packaged Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Wastes on Board Ships (INF Code)”
- Resolution MSC.241(83), adopted on 12 October 2007, “Adoption of amendments to the International Code for the Safe Carriage of Packaged Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Wastes on Board Ships (INF Code)”

[20] International Management Code for the Safe Operation of Ships and for Pollution Prevention (ISM Code)

- Resolution A.741(18), adopted on 4 November 1993, “International Management Code for the Safe Operation of Ships and for Pollution Prevention (International Safety Management (ISM) Code)”
- Resolution MSC.104(73), adopted on 5 December 2000, “Adoption of amendments to the International Safety Management (ISM) Code”
- Resolution MSC.179(79), adopted on 10 December 2004, “Adoption of amendments to the International Management Code for the Safe Operation of Ships and for Pollution Prevention (International Safety Management (ISM) Code)”

- Resolution MSC.195(80), adopted on 20 May 2005, “Adoption of amendments to the International Management Code for the Safe Operation of Ships and for Pollution Prevention (International Safety Management (ISM) Code)”
- Resolution MSC.273(85), adopted on 4 December 2008, “Adoption of amendments to the International Management Code for the Safe Operation of Ships and for Pollution Prevention (International Safety Management (ISM) Code)”
- Resolution MSC.353(92), adopted on 21 June 2013, “Adoption of amendments to the International Management Code for the Safe Operation of Ships and for Pollution Prevention (International Safety Management (ISM) Code)”

[21] International Code of Safety for High-Speed Craft” (1994 HSC Code)

- Resolution MSC.36(63), adopted on 20 May 1994, “Adoption of the International Code of Safety for High-Speed Craft”
- Resolution MSC.119(74), adopted on 6 June 2001, “Adoption of Amendments to the International Code of Safety for High-Speed Craft (Resolution MSC.36(63))”
- Resolution MSC.174(79), adopted on 10 December 2004, “Adoption of Amendments to the International Code of Safety for High-Speed Craft, 1994 (1994 HSC Code)”
- Resolution MSC.221(82), adopted on 8 December 2006, “Adoption of Amendments to the International Code of Safety for High-Speed Craft, 1994 (1994 HSC Code)”
- Resolution MSC.259(84), adopted on 16 May 2008, “Adoption of Amendments to the International Code of Safety for High-Speed Craft, 1994 (1994 HSC Code)”
- Resolution MSC.351(92), adopted on 21 June 2013, “Amendments to the International Code of Safety for High-Speed Craft, 1994 (1994 HSC Code)”
- Resolution MSC.423(98), adopted on 15 June 2017, “Amendments to the International Code of Safety for High-Speed Craft, 1994 (1994 HSC Code)”

[22] International Code of Safety for High-Speed Craft, 2000 (2000 HSC Code)

- Resolution MSC.97(73), adopted on 5 December 2000, “Adoption of the International Code of Safety for High-Speed Craft, 2000 (2000 HSC Code)”
- Resolution MSC.175(79), adopted on 10 December 2004, “Adoption of Amendments to the International Code of Safety for High-Speed Craft, 2000 (2000 HSC Code)”
- Resolution MSC.222(82), adopted on 8 December 2006, “Adoption of Amendments to the International Code of Safety for High-Speed Craft, 2000 (2000 HSC Code)”
- Resolution MSC.260(84), adopted on 16 May 2008, “Adoption of Amendments to the International Code of Safety for High-Speed Craft, 2000 (2000 HSC Code)”
- Resolution MSC.271(85), adopted on 4 December 2008), “Adoption of Amendments to the International Code of Safety for High-Speed Craft, 2000 (2000 HSC Code)”
  Resolution MSC.326(90), adopted on 24 May 2012, “Adoption of Amendments to the International Code of Safety for High-Speed Craft, 2000 (2000 HSC Code)”
- Resolution MSC.352(92), adopted on 21 June 2013, “Amendments to the International Code of Safety for High-Speed Craft, 2000 (2000 HSC Code)”
- Resolution MSC.424(98), adopted on 15 June 2017, “Amendments to the International Code of Safety for High-Speed Craft, 2000 (2000 HSC Code)”

[23] Code for recognized organizations (RO Code)

- Resolution MSC.349(92), adopted on 21 June 2013, “Code for Recognized Organizations (RO Code)”

[24] International Code on the Enhanced Programme of Inspections during Surveys of Bulk Carriers and Oil Tankers, 2011 (2011 ESP Code)

- Resolution A.1049(27), adopted on 30 November 2011, “International Code on the Enhanced Programme of Inspections during Surveys of Bulk Carriers and Oil Tankers, 2011 (2011 ESP Code)”, with Corrigendum
- Resolution MSC.371(93), adopted on 22 May 2014, “Amendments to the International Code on the Enhanced Programme of Inspections during Surveys of Bulk Carriers and Oil Tankers, 2011 (2011 ESP Code)”

- Resolution MSC.381(94), adopted on 21 November 2014, “Amendments to the International Code on the Enhanced Programme of Inspections during Surveys of Bulk Carriers and Oil Tankers, 2011 (2011 ESP Code)” with Corrigendum
- Resolution MSC.405(96), adopted on 19 May 2016, “Amendments to the International Code on the Enhanced Programme of Inspections during Surveys of Bulk Carriers and Oil Tankers, 2011 (2011 ESP Code)”
- Resolution MSC.412(97), adopted on 25 November 2016, “Amendments to the International Code on the Enhanced Programme of Inspections during Surveys of Bulk Carriers and Oil Tankers, 2011 (2011 ESP Code)”

[25] Code of the International Standards and Recommended Practices for a Safety Investigation into a Marine Casualty or Marine Incident (Casualty Investigation Code)

- Resolution MSC.255(84), adopted on 16 May 2008, “Adoption of the Code of the international standards and recommended practices for a safety investigation into a marine casualty or marine incident (Casualty Investigation Code)”
- Resolution MSC.390(94), adopted on 18 November 2014, “Amendments to the Code of the international standards and recommended practices for a safety investigation into a marine casualty or marine incident (Casualty Investigation Code)”

[26] International Code for the Security of Ships and of Port Facilities (ISPS Code)

- SOLAS/CONF.5, Conference Resolution 2, adopted on 12 December 2002, “Adoption of the International Code for the Security of Ships and of Port Facilities”
- Resolution MSC.196(80), adopted on 20 May 2005, “Adoption of amendments to the International Code for the Security of Ships and of Port Facilities”

[27] Standards for owners’ inspection and maintenance of bulk carrier hatch covers

- Resolution MSC.169(79), adopted on 9 December 2004, “Standards for owners’ inspection and maintenance of bulk carrier hatch covers”

[28] Standards for the evaluation of scantlings of the transverse watertight vertically corrugated bulkhead between the two foremost cargo holds and for the evaluation of allowable hold loading of the foremost cargo hold

- SOLAS/CONF.4 Resolution 4, adopted on 27 November 1997, “Standards for the evaluation of scantlings of the transverse watertight vertically corrugated bulkhead between the two foremost cargo holds and for the evaluation of allowable hold loading of the foremost cargo hold”

[29] IMO Instruments Implementation Code” (III Code)

- Resolution A.1070(28), adopted on 4 December 2013, “IMO Instruments Implementation Code (III Code)”

[30] International Code for Ships Operating in Polar Waters (Polar Code)

- Resolution MSC.385(94), adopted on 21 November 2014, “International Code for Ships Operating in Polar Waters (POLAR Code)