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GUIDELINES FOR SURVEY OF INTELLIGENT CARGO MANAGEMENT OF CHEMICAL TANKERS

2023

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Preface

With the development of intelligent and information-based ships, the liquid cargo management and control system which is one of the important parts of liquid cargo ships is becoming increasingly complicated and intelligent, and has become an integrated management and control system combining multiple disciplines including sensors, computer, automatic control, electronic information and bit data technology as well as ship management. In order to cater to the development of ship liquid cargo control system, enhance the safety and reliability of cargo transportation, improve liquid cargo loading/unloading efficiency, relieve fatigue of persons during cargo loading/unloading, enhance safety of ships and persons, shorten ship stay time in port and finally achieve the fundamental objective of enhancing safety and improving economic returns, the Guidelines for Survey of Intelligent Cargo Management of Chemical Tankers have developed by ISC.

Taking chemical tankers as the object, the Guidelines provide supplementary explanations and detailed provisions for intelligent cargo management in Chapter 6 of the Rules for Intelligent Ships through investigating the cargo management procedures of chemical tankers and by considering the characteristics of the cargo systems of chemical tankers, based on the study of the requirements of relevant rules and regulations for cargo of chemical tankers, so as to provide guidance for intelligent cargo systems of chemical tankers and contribute to safer, more economical and efficient operation of chemical tankers.

The Guidelines take cargo/tank monitoring, early warning/alarm and assistant decision-making, intelligent stowage, automatic cargo loading/unloading, and intelligent tank cleaning functions of the chemical tanker cargo management system as intelligent objectives. Based on with the current status of the chemical tanker cargo management, the Guidelines mainly cover system technical requirements, plans and documents, initial survey of class notations and post-construction surveys, etc.

The Guidelines are prepared and updated by China Classification Society and published on the website http://www.ISC.org.cn. Users may send feedback to ig@ISC.org.cn in case of any comments on the Guidelines.

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Chapter 1 General

1.1 Purpose

1.1.1 The Guidelines provide detailed technical requirements and survey requirements for class notations for intelligent cargo management on chemical tankers, including cargo/tank monitoring, early warning/alarming and assistant decision-making, intelligent stowage, automatic cargo loading/unloading and intelligent tank cleaning functions. The Guidelines may be used as guidance documents for ISC surveyors, ship designers, manufacturers, service providers and ship management companies.

1.2 Application

1.2.1 The Guidelines are applicable to chemical tankers applying for ISC intelligent cargo management class notations. The description and requirements of class notations are as defined in 6.2.1 of Chapter 6 of ISC Rules for Intelligent Ships.

1.2.2 The Guidelines are applicable to approval and survey of cargo/tank monitoring, early warning/alarm and assistant decision-making, intelligent stowage, automatic cargo loading/unloading and intelligent tank cleaning.

1.3 Definition

1.3.1 For the purpose of the Guidelines, the following definition applies:

(1) Cargo control station refers to the place for centralized monitoring and remote control of cargo related operations including safe loading/unloading of cargo, de-ballasting/ballasting of ballast water as well as ship status.

1.4 General requirements

1.4.1 Intelligent cargo management is to comply with relevant requirements in Chapters 1 and 6 of Rules for Intelligent Ships.

1.4.2 Cargo/tank monitoring, early warning/alarm and auxiliary decision making, intelligent stowage and intelligent tank cleaning systems are to comply with the requirements for Category II computer systems in Section 6, Chapter 2, PART SEVEN of the Rules for Classification of Sea-going Steel Ships. Automatic cargo loading/unloading systems are to comply with the requirements for Category III computer systems.

1.4.3 Sensors provided for the intelligent cargo management system are to comply with the requirements of 2.7.1, Section 7, Chapter 2, PART SEVEN of the Rules for Classification of Sea-going Steel Ships.

1.4.4 When applying the intelligent cargo management System in accordance with the Guidelines, care is to be taken to satisfy the relevant requirements of international conventions, flag state administrations, port state supervisory authorities and regional organizations.

1.4.5 The systems of intelligent cargo management are normally supplied by the main power, and will automatically be switched to standby power in case of failure of main power supply. Uninterrupted power supply (UPS) may be used as the standby power, with a capacity of maintaining power supply for at least 30 minutes.

1.4.6 Intelligent cargo management system is to be concentrated in the cargo control station.

1.4.7 Indicative signals or information for early warning/alarming of intelligent cargo management system and suggested operation from the assistant decision-making system of the intelligent cargo management system are to be capable of being acknowledged and reset from the cargo control station.

1.4.8 Intelligent cargo management system may be an independent system (independent of conventionally designed loading computer and related systems), or may be a system based on the conventionally designed loading computer and related systems and to perform data acquisition and integration utilizing the hardware/sensors already available. The intelligent cargo management system is to be designed following the single fault safety principle so that one single fault will not generate other faults and the risk caused by the single fault is to be as low as possible.

1.4.9 Intelligent cargo management system is to be provided with product database, and according to the functional requirements of the system, save the corresponding data files. The product database is to be extensible and can be modified by authorized persons according to the

changing characteristics of the products and the needs of shipowners. If an approval document is intended to be modified, it is to be submitted to ISC for approval by the surveyor before modification by an authorized person.

1.4.10 The intelligent cargo management system is to be provided with communication self-check function. When the communication line is abnormal (including but not limited to data loss, data error, system module communication failure, and system interface communication failure), the intelligent cargo management system is to send an alarm and assistant decision-making suggestions.

1.4.11 The intelligent cargo management system is to specify the administrative authority of system users.

(1) Users who have not logged in are prohibited from modifying early warning and alarm thresholds and cargo management related operations;

(2) Account authority of system users is to be ranked to clarify the responsibilities and authorities of different accounts, so that only the system functions that are clearly authorized are allowed to be used.

1.4.12 Product certification for the intelligent cargo management system and associated components is to comply with the requirements of 1.10.1 of Chapter 1 of the Rules for Intelligent Ships.

Chapter 2 Cargo/tank monitoring, early warning/alarm and assistant decision-making

2.1 Functional requirements

2.1.1 Cargo/tank monitoring, early warning/alarm and assistant decision-making system is to include, but not limited to, the following functions:

(1) The product database is to contain the list of products fit for carriage onboard and the Material Safety Data Sheet (MSDS) in accordance with the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code);

(2) Monitoring the status of cargoes/tanks, ballast tanks and void tanks adjacent to tanks on bard ships according to the characteristics of cargoes;

(3) Monitoring the status of cargo loading/unloading operations;

(4) Displaying the status parameters monitored;

(5) System status self-check;

(6) Early warning function to provide relevant assistant decision-making which will make the operator clearly understand the current working condition and make preparation in advance for the possible abnormal conditions, or prevent occurrence of abnormal conditions;

(7) Alarming function to analyze the abnormal data monitored and provide corresponding assistant decision-making so that the operator can promptly take relevant corrective measures.

2.2 Parameters to be Continuously monitored and displayed

2.2.1 At least the following parameters are to be continuously monitored and displayed:

(1) Liquid level in cargo tanks;

(2) Cargo temperature in cargo tanks;

(3) Temperature rise of liquid cargo per unit time in cargo tanks (according to special product transportation and loading/unloading requirements);

(4) Pressure in cargo tanks;

(5) Oxygen content in cargo tanks (Discontinuous monitoring may be adopted as appropriate, but safe control of oxygen content in cargo tanks are to be ensured);

(6) Liquid level in ballast tanks;

(7) Concentration of flammable gas in pump room (if applicable);

(8) Concentration of flammable gas in ballast tanks and void spaces adjacent to cargo tanks (if applicable);

(9) Concentration of toxic gas in ballast tanks and void spaces adjacent to cargo tanks (if applicable);

(10) Temperature of cargo heating/cooling medium (if applicable);

(11) Cargo heating/cooling medium pressure (if applicable);

(12) Temperature of structural members adjacent to independent tank support blocks (if applicable).

2.2.2 In addition to the parameters listed in 2.2.1, the following parameters are to be continuously monitored and displayed during loading/unloading operations:

(1) Inert gas system (if applicable):

① state of inert gas installation status (operation/stop/fault);

② shore inert gas supply status (supply stopped/normal supply).

(2) Liquid cargo system status, including at least:

① remote control valve status (on/off/fault);

② opening degree of remote valve for adjusting liquid cargo pump (including stripping pump) outlet flow;

③ liquid cargo pump (including stripping pump) status (running/stopped/standby/fault);

④ revolution (stroke number) of liquid cargo pump (including stripping pump) and pressure controlled by cargo pump speed control valve

⑤ inlet pressure of liquid cargo pump (including stripping pump) if applicable;

⑥ outlet pressure of liquid cargo pump (including stripping pump);

⑦ outlet pressure of liquid cargo line (including stripping line) if applicable.
(3) Vapor pressure of the liquid cargo vapor recovery system (if applicable);
(4) Ballast water system status, including at least:
① operating status of ballast water treatment unit (if applicable);
② status of remote control valve (on/off/fault);
③ opening degree of remote valve for adjusting ballast pump outlet flow;
④ status of ballast pump (running/stopped/standby/fault);
⑤ ballast pump speed or speed control valve control pressure;
⑥ ballast pump inlet pressure (if applicable);
⑦ ballast pump outlet pressure.
(5) Floating state of ship;
(6) Ship stability;
(7) Still water bending moment and still water shear force.

2.3 Early warning and assistant decision-making

2.3.1 Cargo/cargo tank monitoring, early warning/alarm and assistant decision-making system is to have corresponding early warning function. This system is to be capable of releasing early warning signals after overall consideration of the change of the current conditions to caution the operators of the possible abnormal conditions and provide the operators with assistant decisions, so that the operators can have enough time to make preparation in advance to prevent or postpone the occurrence of abnormal situations, and possible damage to be caused by the possible abnormal situations may be reduced.
2.3.2 The early warning is to be set for variation trend of at least the following parameters:
(1) Liquid level in cargo tanks;
(2) Cargo temperature in cargo tanks;
(3) Temperature rise of liquid cargo per unit time in cargo tanks (according to special product transportation and loading/unloading requirements);
(4) Pressure in cargo tanks;
(5) Oxygen content in cargo tanks;
(6) Liquid level in ballast tanks;
(7) Concentration of flammable gas in pump room (if applicable);
(8) Concentration of flammable gas in ballast tanks, void spaces, double bottom tanks adjacent to cargo tanks (if applicable).
2.3.3 In addition to the provisions in 2.3.2, the early warning function for the following parameters is to be set during loading/unloading operation:
(1) For liquid cargo system, including at least:
① inlet pressure of liquid cargo pumps (including stripping pumps) if applicable;
② outlet pressure of liquid cargo pump (including stripping pump);
③ outlet pressure of liquid cargo pipeline (including striping pipeline).
(2) Vapor pressure of liquid cargo vapor recovery system;
(3) Ballast system, including at least:
① Ballast pump inlet pressure (if applicable);
② Ballast pump outlet pressure.
(4) Floating state of ship;
(5) Ship stability;
(6) Still water bending moment and still water shear force.
2.3.4 At least the early warning and assistant decision-making functions listed in Table 2.3.4 are to be provided:

Table 2.3.4

No.	Function category	Early warning status	Assistant decision-making function
1.	Cargo level change early warning and assistant decision-making	Liquid level rise	Set liquid level early warning threshold, give early warning and prompt the crew to check the status of cargo tanks and cargoes.
		Liquid level fall	Set liquid level early warning threshold, give early warning and prompt the crew to check the status of cargo tanks and cargoes.
No.	Function category	Early warning status	Assistant decision-making function

2.	Liquid cargo temperature change early warning and assistant decision-making	Too low temperature	Set the early warning threshold of the products according to the characteristics of the products (such as boiling point, melting point, etc.). When the threshold is reached, give early warning and the operational instruction for starting heating equipment.
		Too high temperature	Set the early warning threshold of the products according to the characteristics of the products (such as boiling point, melting point, etc.). When the threshold is reached, give early warning and the operational instruction for starting cooling equipment. If no cooling equipment is available, prompt the crew to carry out deck watering, de-ballasting or other cooling operations on the cargo tank to be cooled.
		Temperature rise too fast	For products with temperature rise limit per unit time, set early warning threshold. When the threshold is reached, give the early warning and prompt the crew to operate.
		Assistant decision-making for special cargo heating	For cargo with special heating instruction, advise the crew to heat the cargo or preserve heat, so that cargo temperature is increased to the discharging temperature but not exceeding the maximum discharging temperature before the ship arrives at the port.
		Heating optimization scheme assistant decision-making	For products with heating/heat preservation requirements, the system is to optimize the heating scheme to reduce boiler fuel consumption provided the cargo transportation requirements are satisfied, and to prompt the crew to operate. At least the following is to be considered: (1) reducing holding temperature of products; (2) reducing boiler ignition times.
3.	Pressure change in cargo tank early warning and assistant decision-making	Abnormal pressure	Set the early warning threshold according to the design pressure of the cargo tank. When the threshold is reached, give early warning and prompt the crew to check the pressure of the cargo tank.
			When the cargo tank is protected by inert gas, the upper and lower early warning thresholds are to be set according to the design pressure of the cargo tank and the lowest protection pressure of the inert gas system. When the thresholds are reached, prompt crew to check the pressure of the cargo tank and the supply pressure of inert gas.
4.	Oxygen content in cargo tank early warning and assistant decision-making	Abnormal oxygen content	Set early warning threshold of the oxygen content in cargo tank according to the characteristics of the products. When the threshold is reached, give early warning and prompt the crew to conduct the inert operation.
5.	Ballast tank liquid level early warning and assistant decision-making	Liquid level early warning	For the cargo tank carrying water-sensitive products, the liquid level early warning threshold is be set for its adjacent ballast tank. When the threshold is reached, give early warning and prompt the crew to check the ballast tank.
6.	Product inhibitor early warning and assistant decision-making	Inhibitor expiration early warning	According to the characteristics of the products and the expiry date of the inhibitor, judge and prompt the crew to add inhibitor during the voyage.
		Inhibitor ambient early warning	According to the characteristics of the inhibitor (oxygen dependent/anaerobic type), set early warning threshold of the oxygen content in the cargo tank. When the threshold is reached, give early warning and prompt the crew to conduct inerting operation.
			According to the characteristics of the inhibitor (suitable temperature), set the product temperature early warning threshold. When the threshold is reached, give early warning and prompt the crew to start the heating or cooling equipment.

2.3.5 In addition to the provisions of 2.3.4, the loading/ unloading operation is at least to have the early warning and assistant decision-making functions listed in Table 2.3.5

Table 2.3.5

No.	Function category	Early warning status	Assistant decision-making function
1.	Tank level early warning and assistant decision-making	Liquid level during loading early warning	During loading, when the liquid level early warning threshold is reached, give early warning and prompt crew to close down the valve to reach the recommended rate of the system to avoid loading exceeding the target liquid level.
		Liquid level during unloading early warning	During unloading, when the liquid level is close to 0, give early warning after judging on the cargo pump outlet pressure or working current change, and prompt the crew to prepare to strip tank or unload the next tank.
		Liquid level change during loading /unloading early warning	During loading/unloading, calculate the change rate of level in cargo tank according to the capacity table, pump and valve performance, and give the predicted curve of liquid level change. When the difference between the actual curve and the predicted curve is too large, give early warning as appropriate and prompt the crew to check the corresponding valves, pumps and pipelines.
		Operation time prediction	Calculate remaining operation time according to the theoretical flow rate of cargo pump, capacity table and liquid level change rate
		Cargo metering early warning during loading/unloading	During loading/unloading, compare the number of ships loaded to the number of shores in real time. If the difference between the number of ships and shores exceeds the threshold, prompt the crew to check valves, pumps and pipelines.
2.	Ballast tank liquid level early warning and assistant decision-making	Liquid level during ballasting process early warning	During ballasting, give early warning when the liquid level warning threshold is reached, and prompt the crew to prepare for the next step of operation.
		Liquid level during de-ballasting process early warning	During de-ballasting, give early warning when the liquid level is close to 0, and prompt the crew to prepare for the next step of operation.
		Operation time prediction	Calculate the remaining operation time according to the theoretical flow rate of ballast pump, tank capacity table and liquid level change rate.
		Liquid level change during ballasting/de-ballasting early warning	During ballasting/de-ballasting, calculate the theoretical flow according to the outlet pressure of the ballast pump and the performance curve of the ballast pump, compare the theoretical flow to the actual liquid level change rate, give early warning to the crew according to the difference, and give suggestions such as adjusting the valve and checking the actual liquid level.
3.	Vapor recovery system vapor pressure early warning and assistant decision-making	High vapor pressure early warning	When the pressure of the vapor recovery pipeline reaches the high pressure early warning threshold, give early warning and operation suggestions to the crew.
		Low vapor pressure early warning	When the steam recovery pipeline pressure reaches the low pressure early warning threshold, give early warning and provide operational advice to the crew.
4.	Liquid cargo pipeline status early warning and assistant decision-making	Low pipe outlet pressure early warning	When the pipe outlet pressure is lower than the early warning threshold, give early warning and prompt the crew to improve the output of the liquid cargo pump.
		High pipe outlet pressure early warning	When the pipe outlet pressure is higher than the early warning threshold, give early warning and prompt the crew to reduce the output of the liquid cargo pump.
		Pipe damage early warning	When the difference between the pressure in the manifold area and the pressure at the pipe outlet exceeds the early warning threshold, give early warning of excessive pipe damage and prompt the crew to check pipeline or valve.
5.	Ballast pump and pipeline condition early	Low pump outlet pressure during ballasting early	When the ballast pump is performing ballast operation, give early warning when the ballast pump outlet pressure is lower than the early warning threshold and

No.	Function category	Early warning status	Assistant decision-making function
	warning and assistant decision-making	warning	prompt the crew to check the ballast pump.
		Low pump outlet pressure during de-ballasting early warning	When the ballast pump is performing de-ballasting operation, give early warning when the ballast pump outlet pressure is lower than the early warning threshold and prompt the crew to check the ballast pump.
6.	Ship stowage state early warning and assistant decision-making	Floating state early warning	Give early warning when the ship's heeling or trim exceeds the early warning threshold, prompt the crew to adjust the loading /unloading sequence or ballast plan, and give suggestions on the loading/unloading sequence or ballast plan.
		Stability early warning	When the difference between the GM value of the ship and the permissible GM value reaches the early warning threshold, give early warning and suggestions on loading/unloading sequence or ballast plan.
		Still water bending moment and shear force early warning	When the ratios of the values of still water bending moment and shear force to the permissible values reach the early warning threshold, give early warning and suggestions on loading/unloading sequence or ballast plan.
7.	Loading rate early warning and assistant decision-making	Loading rate conversion early warning	During the loading process, when the cargo tank cargo pipe inlet has been immersed in the cargo, give early warning and prompt the crew that the initial loading rate can be converted to the maximum loading rate.

2.4 Alarming and assistant decision-making

2.4.1 When any of the following abnormal conditions is detected, cargo/cargo tanks monitoring, alarming and assistant decision-making system is to release an alarm:

(1) Abnormal change of liquid level in cargo tanks, such as abnormal increase or decrease of liquid level in cargo tanks;

(2) Too high cargo temperature in cargo tanks;

(3) Too low cargo temperature in cargo tanks;

(4) Abnormal change of liquid cargo temperature in cargo tanks (such as abnormal rise or decrease of liquid cargo temperature in cargo tanks, which may be accompanied by chemical polymerization or other possible abnormal reactions);

(5) Too high pressure in cargo tanks;

(6) Too low pressure in cargo tanks;

(7) Too high oxygen content in cargo tanks;

(8) Abnormal change of liquid level of ballast tanks, such as abnormal increase or decrease of liquid level in the ballast tanks;

(9) High concentration of flammable gas in cargo pump room (if applicable);

(10) High concentration of flammable gas in ballast tanks, void spaces and double bottom tanks adjacent to cargo tanks (if applicable).

2.4.2 In addition to the provisions in 2.4.1, the alarming functions for the following parameters are also to be provided during loading/unloading operation:

(1) Fault of inert gas plant failure;

(2) Liquid cargo system fault, including at least:

① remote control valve fault;

② liquid cargo pump (including stripping pump) fault;

③ too low pressure of liquid cargo pump (including stripping pump) outlet ;

④ too high pressure of liquid cargo pump (including stripping pump) outlet ;

⑤ too low pressure of liquid cargo pipeline (including stripping pipeline) outlet ;

⑥ too high pressure of liquid cargo pipeline (including stripping pipeline) outlet.

(3) Liquid cargo vapor recovery system, including at least:

① too high vapor pressure;

② too low vapor pressure; (alarm pressure not less than atmospheric pressure for the inerted cargo tank).

(4) Ballast system fault, including at least:

① fault of ballast water treatment unit;
② fault of remote control valve;
③ fault of ballast pump;
④ ballast pump inlet pressure too low;
⑤ ballast pump outlet pressure too high.
(5) Abnormal ship floating state;
(6) Abnormal ship stability;
(7) Still water bending moment and still water shear force too high;
(8) Abnormal loading rate.

2.4.3 At least the alarming and assistant decision-making functions listed in Table 2.4.3 are to be provided.

Table 2.4.3

No.	Function category	Alarming status	Assistant decision-making function
1.	cargo level change alarming and assistant decision-making	Abnormal liquid level rise	Set liquid level alarm threshold, release alarm and prompt the crew to check cargo tanks and cargoes.
		Abnormal liquid level drop	Set liquid level alarm threshold, release alarm and prompt the crew to check cargo tanks and cargoes.
2.	Too high liquid cargo temperature in cargo tank alarming and assistant decision-making	Too high temperature	Set the alarm threshold of the products according to the characteristics of the products (such as boiling point, melting point, etc.). When the threshold is reached, release alarm and give operational instruction for starting cooling equipment If no cooling equipment is available, prompt the crew to carry out deck watering, de-ballasting or other cooling operations on the compartment to be cooled.
		High temperature alarming	Set the design maximum temperature alarm threshold of cargo tanks. When the threshold is reached, release alarm and give operational instruction for starting cooling equipment. If no cooling equipment is available, prompt the crew to carry out deck watering, de-ballasting or other cooling operations on the compartment to be cooled.
3.	Too low liquid cargo temperature in cargo tank alarming and assistant decision-making	Too low temperature	Set alarm threshold of the products according to the characteristics of the products (such as boiling point, melting point, etc.). When the threshold is reached, release alarm and give operational instruction for starting heating equipment.
		Low temperature alarming	Set low temperature alarm threshold according to cargo tank design and practical operational requirements. When the threshold is reached, release alarm and give operational instruction for starting heating equipment.
4.	Too high cargo tank pressure alarming and assistant decision-making	Too high pressure	Set alarm threshold according to the design pressure of the cargo tank (i.e. PV valve opening pressure). When the threshold is reached, release alarm and prompt the crew to check state of cargoes and cargo tanks
5.	Too low cargo tank pressure alarming and assistant decision-making	Too low pressure	Set alarm threshold according to the design pressure of the cargo tank (i.e. PV valve opening pressure). When the threshold is reached, release alarm and prompt the crew to check state of cargoes and cargo tanks
6.	Oxygen content in cargo tank alarming and assistant decision-making	Abnormal oxygen content	Set the alarm threshold of the oxygen content in cargo tank according to the characteristics of the products. When the threshold is reached, release alarm and prompt the crew to conduct the inert operation.
7.	Abnormal level change of ballast tank alarming and assistant decision-making	Abnormal level change alarming	Set the alarm threshold of ballast tank level rising or falling. When the threshold is reached, release alarm and prompt the crew to check the ballast tank.

2.4.4 In addition to the provisions of 2.4.3, the loading/unloading operation is at least to have the alarming and assistant decision-making functions listed in Table 2.4.4.

Table 2.4.4

No.	Function category	Alarming status	Assistant decision-making function
1.	Tank level alarming and assistant decision-making	Liquid level alarming during loading (full loaded)	During loading, when the liquid level alarm threshold is reached, release an alarm and prompt the crew to operate.
		Target level alarming during loading (partially loaded)	During loading, when the target level is reached, release an alarm and prompt the crew to operate.
		Liquid level alarming during unloading	During unloading, when the cargo pump is emptied, release an alarm and prompt the crew to operate.
		Empty cargo tank level alarming during unloading	During unloading, when the liquid level in the empty cargo tank reaches the alarm threshold, release an alarm to remind the crew that the unloading line is crossed with others, and automatically stop unloading.
		Cargo metering alarming during loading/unloading	During loading/unloading, compare the number of ships loaded to the number of shores in real time. If the difference between the number of ships and shores exceeds the threshold, automatically stop loading/unloading and prompt the crew to check relevant valves, pumps and pipelines.
2.	Ballast tank level alarming and assistant decision-making	High liquid level alarming during ballasting process	During ballasting, release an alarm when the liquid level alarm threshold is reached, and automatically stop ballasting.
3.	Liquid cargo pump and pipeline condition alarming and assistant decision-making	Fault of liquid cargo pump alarming	When a component of liquid cargo pump fails, release an alarm and inform the crew of the fault type, including frequency converter fault, high motor winding temperature and high motor bearing temperature.
		Fault of cargo pipeline valves alarming	Release an alarm of fault when the valve on the liquid cargo pipeline cannot operate.
		Too low pump outlet pressure alarming	When the pump outlet pressure is lower than the alarm threshold, release an alarm, prompt the crew to operate and check the condition of the liquid cargo pump.
		Too high pump outlet pressure alarming	When the pump outlet pressure is higher than the alarm threshold, release an alarm, prompt the crew to operate, stop the pump and check the condition of the liquid cargo pump.
		Too low pipeline outlet pressure alarming	When the pipeline outlet pressure is lower than the alarm threshold, release an alarm, prompt the crew to operate, and provide the reason for low pressure.
		Too high pipeline outlet pressure alarming	When the pipeline outlet pressure is high than the alarm threshold, release an alarm, prompt the crew to operate, and provide the reason for high pressure.
4.	Vapor recovery system alarming and assistant decision-making	Too high vapor pressure alarming	When vapor pressure is higher than the alarm threshold, release an alarm and give operation suggestions to the crew.
		Too low vapor pressure alarming	When vapor pressure is lower than the alarm threshold, release an alarm and give operation suggestions to the crew.
		Oxygen content alarming	When the oxygen content in vapor is higher than 8%, release an alarm and give operation suggestions to the crew.
		No flow alarming	When there is on flow in flowmeter, release an alarm and give operation suggestions to the crew.
5.	Ballast pump and pipeline condition alarming and assistant	Fault of ballast pump alarming	When a component of ballast pump fails, release an alarm and inform the crew of the fault type, including too high bearing temperature and too high pump housing temperature, etc., and give operation suggestions to the

No.	Function category	Alarming status	Assistant decision-making function
	decision-making		crew.
		Fault of pipeline valves alarming	Release an alarm of fault when the valves on the ballast pipeline cannot operate, and give operation suggestions to the crew.
		Too low pump inlet pressure alarming	When ballast pump inlet pressure is lower than the alarm threshold, release an alarm and give operation suggestions to the crew.
		Too high pump outlet pressure alarming	When ballast pump outlet pressure is higher than the alarm threshold, release an alarm and give operation suggestions to the crew.
6.	Ship stowage alarming and assistant decision-making	Abnormal floating state alarming	Release an alarm when fore/aft draft, heeling or trim exceeds the alarm threshold, prompt the crew to stop loading/unloading, and give suggestions on the loading/unloading sequence or ballast plan.
		Abnormal stability alarming	When the difference between the GM value of the ship and the permissible GM value reaches the alarm threshold, release an alarm, prompt the crew to stop loading/unloading, and give suggestions on loading/unloading sequence or ballast plan.
		Too high still water bending moment and still water shear force alarming	When the ratios of the values of still water bending moment and shear force to the permissible values reach the alarm threshold, release an alarm and give suggestions on loading/unloading sequence or ballast plan.
7.	Loading rate alarming	Abnormal initial loading rate alarming	For cargoes prone to static electricity, when the initial rate exceeds 1m/s linear speed, release an alarm and prompt the crew to slow down.
		Abnormal maximum loading rate alarming	When the loading volume at the maximum rate exceeds 80% of the volume of the gas escaping from the ventilation system of the target tank, release an alarm and prompt the crew to slow down.

Chapter 3 Intelligent Stowage

3.1 Functional requirements

3.1.1 The intelligent stowage system is used to generate the loading/unloading plan and sequence, and simulate the loading/unloading process. It has the function of calculating and providing the optimal stowage and loading/unloading sequence by considering various constraints of cargo, ship, dock, etc.

3.1.2 The intelligent stowage system is to be provided the function of automatic calculation and manual adjustment.

3.1.3 Intelligent stowage systems is normally to consider the following factors:

(1) Safety, environmental protection, energy efficiency;

(2) Floating state, stability and strength of the ship;

(3) Optimal trim (if applicable);

(4) Precautionary measures for special products.

3.2 Loading/unloading plan

3.2.1 The intelligent stowage system is to be able to generate the loading/unloading plan of the cargoes intended to be loaded at present.

3.2.2 The intelligent stowage system is to be provided with the functions of voyage information identification, loading condition check, stowage scheme generation, loading/unloading sequence calculation, ship position check and historical record inquiry.

3.2.3 The intelligent stowage system is to maintain a database of products fit for carriage on the ship, and the product database is to include at least the following:

(1) An approved list of products fit for carriage;

(2) Requirements of IBC code on carriage and loading/unloading of products;

(3) Approved Manual of Procedures and Arrangements;

(4) MSDS information of products fit for carriage;

(5) Dangerous chemical compatibility table;

(6) Dangerous chemical terminal information.

3.2.4 The voyage information identification function is to identify the following information according to the actual condition of the ship:

(1) Route information (including hydrology, minimum bridge height limits, etc.);

(2) Port information (including port and wharf draft limits, tide conditions, etc.);

(3) Air temperature (including air temperature of routes and loading/unloading ports);

(4) MSDS information of the products on the current voyage (provided by the owner of the products);

(5) Operational requirements for adding cargo inhibitors.

3.2.5 The loading condition check function is to include at least:

(1) Check of fitness for carriage of cargoes

① checking the fitness of products for carriage for the current voyage according to the list of products fit for carriage.

(2) Cargo compatibility check

① checking compatibility of cargoes in adjacent cargo tanks for the current voyage according to the table of compatibility of dangerous chemicals;

② checking cargo compatibility of the intended cargo tanks for the first three voyages and the last three voyages according to dangerous chemical compatibility table and IBC Code.

(3) Cargo tank availability check is at least to be based on the following factors:

① characteristics of cargoes to be loaded;

② liquid level in the cargo tank;

③ suitability and condition of cargo handling equipment;

④ cargo tank cleaning condition;

⑤ heating pipe condition (if heated cargo is loaded).

3.2.6 The intelligent stowage system is to be able to automatically calculate and optimize the stowage scheme according to the current condition of the ship. In addition to the provisions in

3.2.4 and 3.2.5, the following factors are also to be taken into account:
(1) Ship loading condition, including fuel oil, ballast water, fresh water, etc.;
(2) Cargo volume of each voyage (considering unlimited or limited cargoes);
(3) Density of cargoes;
(4) Influence of temperature on cargoes and cargo tanks (considering cargo flash point, freezing point, pour point and viscosity);
① for water-sensitive cargo, cargo pollution caused by excessive amount of condensed water on bulkhead is to be considered;
② for cargo that needs to be kept at low temperature, heat conduction of adjacent compartment or engine room is to be considered.
(5) Air permeability requirements of cargo;
(6) Product inhibitor properties and addition procedures (if applicable). It is to be noted that:
① inhibitor is to be matched with cargo temperature;
② inhibitor expiration date is to be matched with the voyage time.
(7) Volume of cargoes and tank capacity limits of cargo tank:
① the cargo volume of the cargo tank is not to exceed 98% of the tank capacity at the maximum temperature of the voyage;
② loading restrictions in the Loading Manual for cargoes of high density;
(8) Liquid cargo level;
(9) Cargo tank expansion allowance and void height;
(10) Multiple-job operation (i.e. simultaneous operation);
(11) Multi-batch loading/unloading operation;
(12) Ballast plan (ballast operation in port to be controlled to the minimum amount of water);
(13) Special requirements on cargoes for the expected voyage.
3.2.7 The intelligent stowage system is to be capable of calculating, generating and optimizing the loading/unloading sequence according to the stowage scheme, including the operation of cargo tanks and ballast tanks, and planning the operation sequence of pipeline, pump and valve.
3.2.7.1 The following factors are to be considered in the calculation of loading sequence:
(1) Characteristics and quantity of cargoes to be loaded;
(2) Pump, valve and piping requirements:
① compatibility requirements on pipelines from cargoes to be loaded;
② nominal diameter of pipe;
③ ship shore valve;
④ ballast pump flow.
(3) Wharf information:
① wharf loading flow;
② wharf shore tank height.
(4) Cargo loading pressure and temperature requirements (setting pressure vacuum valves, etc.);
(5) Loading rate limits (including initial, maximum and trim rates):
① Initial rate: for cargoes prone to generate static electricity, the initial rate is not to be more than 1m/s in linear velocity. After acceleration, the rate is not to be more than 7m/s in linear velocity.
② Maximum rate: the loading volume under the maximum rate is not to exceed 80% of the volume of gas escaping from the ventilation system of the tank;
③ Trim rate: consider the valve opening/closing and shore stop time, and the amount of cargo sent by shore pipes to the tank when changing tanks;
④ When converting the initial rate to the maximum rate, it is to be ensured that the cargo has immersed the cargo tank cargo oil pipe inlet.
(6) Void requirements for cargo tanks when the ship is heeling or trimming;
(7) Vapor recovery requirements;
(8) Cargo tank inerting requirements.
3.2.7.2 The following factors are to be considered in optimizing loading sequence:
(1) Minimum ballast water transfer;
(2) Minimum pipeline switching;
(3) Minimum pipe valve path;
(4) Cargo added with inhibitor is to be loaded later as far as possible;

(5) Cargo heated or with heat preservation is to be loaded later as far as possible.
3.2.7.3 The following factors are to be considered in the calculation of unloading sequence:
(1) Characteristics and quantity of cargoes to be unloaded;
(2) Pump, valve and piping requirements:
① compatibility requirements on pipelines from cargoes to be unloaded;
② nominal diameter of pipe;
③ ship shore valve;
④ ballast pump flow;
⑤ quantity and flow of cargo pumps.
(3) Wharf information:
① wharf reception conditions (maximum acceptable unloading rate and pressure);
② shore tank height.
(4) Cargo unloading pressure and temperature requirements;
(5) Maximum cargo unloading rate;
(6) Shore tank height;
(7) Cargo tank inerting requirements.
3.2.7.4 The following factors are to be considered in optimizing loading sequence optimization:
(1) Minimum ballast water transfer;
(2) Minimum pipeline switching;
(3) Minimum pipe valve path;
(4) Cargo added with inhibitor is to be unloaded first as far as possible;
(5) Starting quantity and flow of the cargo pumps started;
(6) Position of the ship conducive to unloading;
(7) Increasing cargo tank pressure or temperature during stripping (if applicable).
3.2.8 The loading/unloading plan is to include assistant decision-making requiring manual operation in the loading/unloading process, including at least:
(1) Sampling of cargoes;
(2) Cargo pipeline and hose operation;
(3) Personnel protection requirements;
(4) Comparative check of numbers of ships and shores subject to loading/unloading.
3.2.9 Query of history record
The intelligent stowage system is to provide the history record query function, which can search and filter the historic records according to the key items of loading/unloading data.

3.3 Simulation of loading/unloading process

3.3.1 The intelligent stowage system is to be able to simulate and control relevant components and equipment to complete the following cargo operations according to the loading/unloading plan and based on the data of the cargo and the ship's loading /unloading equipment:
(1) Cargo operation during the period from arrival of the empty ship to departure of the ship fully loaded;
(2) Cargo operation during the period from arrival of the ship fully loaded to departure of the ship ballasted;
3.3.2 At least the following loading/unloading steps are to be included:
(1) Cargo tank inerting (if applicable);
(2) Cargo loading;
(3) Ballasting;
(4) Cargo unloading;
(5) De-ballasting;
(6) Tank stripping.

Chapter 4 Automatic Loading/Unloading

4.1 Functional requirements

4.1.1 The automatic cargo loading/unloading system is to satisfy the functional requirements specified in Chapter 2 and Chapter 3, on the basis of which, the automatic cargo loading/unloading system is also to have the function of automatic control of loading/unloading operation of chemical tankers.

4.1.2 The automatic loading/unloading system is to include the loading/unloading file system, with the function of automatically operate documents and forms necessary for ship loading/unloading operation.

4.2 Cargo loading/unloading file system

4.2.1 The cargo loading/unloading file system is to include but not to be limited to the following functions:

(1) completing;
(2) generating;
(3) uploading;
(4) storing historical data.

4.2.2 The cargo loading/unloading file system is at least to include automatic operation functions of the following files:

(1) Cargo Record Book;
(2) Cargo loading/unloading plan;
(3) Ballast operation plan;
(4) Tank cleaning operation plan (if provided with intelligent tank stripping function);
(5) Records of cargo characteristics and operation requirements;
(6) Ballast water record book or ballast water report form;
(7) Notification of readiness;
(8) Ship/shore checklist for cargo operation

4.2.3 The loading/unloading file system is to be provided with the function of automatic operation and manual modification.

4.3 Automatic loading/unloading

4.3.1 The automatic loading/unloading system is to be able to automatically control related components and equipment to complete loading/unloading operations according to the loading/unloading plan received and after confirming the readiness of pipes and valves.

4.3.2 Automatic cargo loading/unloading function is to include at least:

(1) Cargo loading;
(2) Cargo unloading;
(3) Ballasting, de-ballasting and transfer of ballast water.

Tank stripping, inerting and gas-freeing operations may be manual or automatic, depending on the provision of equipment and actual requirements.

4.3.3 Automatic cargo loading is to have the following functions:

(1) The system is to be able to autonomously control the intake valve of each cargo tank according to the stowage scheme and loading sequence plan;

(2) The system is to, based on the data monitored, automatically judge to adjust opening of the valve, control flow rate, and ensure switching to another tank when the current tank is loaded to the target value without overflowing;

(3) The system is to monitor the position of the ship (including buoyancy, stability and strength) in real time during loading, and adjust the loading plan according to the position of the ship.

4.3.4 Automatic ballasting is to have the following functions:

(1) The system is to be able to automatically operate ballast water tank according to the unloading sequence plan, including opening/closing valve, starting/stopping ballast pump, opening/closing ballast pump ballast inlet valve, and adjusting opening of outlet valve, to ensure switching to another ballast tank when the current ballast tank is ballasted to the target value without overflowing;

(2) The system is to monitor the position of the ship (including buoyancy, stability and strength)

in real time during unloading, and adjust the ballast plan according to the position of the ship.

4.3.5 Automatic unloading of cargoes is to be provided with the following functions:

(1) The system is to be able to autonomously operate cargoes in the cargo tank according to the unloading sequence plan, and automatically adjust cargo pump and pump outlet valve;

(2) The system is to be able to unload more than one cargo tanks at the same time, stop the completed cargo tanks and start unloading the next batch of cargo tanks;

(3) The system is to be able to monitor the unloaded cargo tanks in real time, and automatically stop unloading and alarm the crew in case of cargo being unloaded from the wrong tank;

(4) The system is to monitor the position of the ship (including buoyancy, stability and strength) in real time during unloading, and adjust the unloading plan according to the position of the ship.

4.3.6 Automatic de-ballasting is to be provided with the following functions:

(1) The system is to be able to automatically operate ballast water tank according to the stowage scheme and loading time and sequence plan, including opening/closing valve, starting/stopping ballast pump, opening/closing ballast pump de-ballast inlet valve, and adjusting opening of outlet valve;

(2) The system is to monitor the position of the ship (including buoyancy, stability and strength) in real time during loading, and adjust the ballast plan according to the position of the ship.

4.3.7 If the system can automatically stripping cargo tanks, it is to be provided with the following functions:

(1) The system is to be able to autonomously perform tank stripping after the cargo tank enters the stripping state, including closing the pump outlet valve and stopping the operation of the cargo pump. The cargo pump/stripping pump is controlled to operate in the stripping mode. The stripping valve is automatically opened and compressed air is injected to carry out stripping.

4.3.8 If the system can automatically inerting cargo tanks, it is to be provided with the following functions:

(1) For a chemical tanker provided with inert gas generator, the system is to automatically control the inert gas system according to the pressure and oxygen content in the cargo tank during loading/unloading.

(2) For a chemical tanker only provided with nitrogen cylinders without an inert gas system, the system is to have assistant decision-making function for nitrogen operation if the valves related to cargo tank inerting are manually controlled.

4.3.9 If the system is capable of automatic gas-freeing of cargo tanks, the following functions are to be provided:

(1) The system is to be able to purge and replace mixed gas in cargo tanks through the ventilation system. Meanwhile, the concentrations of combustible gas and toxic gas in cargo tank area and accommodation area are to be monitored in real time to achieve automatic control of gas-freeing operation.

4.4 Safety control function

4.4.1 The automatic cargo loading/unloading system is to be provided with the function of hierarchical disposal of equipment and system failures.

4.4.2 The automatic cargo loading/unloading system is also to have the following emergency stop functions:

(1) Automatic emergency stop;

(2) Manual emergency stop.

4.4.3 The automatic loading/unloading process is to be able to be switched to manual operation at any time, and smooth and safe transition of loading/unloading equipment under operating condition during switching is to be ensured.

Chapter 5 Intelligent Tank Cleaning

5.1 Functional requirements

5.1.1 The intelligent tank cleaning system is to meet the functional requirements stipulated in Chapter 2 and Chapter 3. On this basis, the intelligent tank cleaning system is also have the functions of generating ship tank cleaning plan and evaluating tank cleaning results.

5.1.2 The intelligent tank cleaning system is to have at least the following functions:

(1) Establishment and update of knowledge base of tank cleaning operation;

(2) Generation of tank cleaning plan;

(3) Evaluation of tank cleaning results;

(4) History record call.

5.2 Intelligent tank cleaning plan

5.2.1 The intelligent tank cleaning system is to be equipped with a knowledge database of tank cleaning operation and is to include the following contents:

(1) The approved procedures and arrangement manual;

(2) Tank cleaning requirements specified in Annex II of the the International Convention for the Prevention of Pollution from Ships (hereinafter referred to as MARPOL);

(3) Tank cleaning requirements specified in IBC Code.

The knowledge database of tank cleaning operation may also include industry-recognized chemical tank cleaning guidelines and tank cleaning schemes approved by the owner or shipping company.

5.2.2 The intelligent tank cleaning system is to be able to develop a complete tank cleaning plan based on the following factors:

(1) The approved procedures and arrangement manual;

(2) Characteristics of the cargoes to be cleaned and to be loaded;

(3) Size and structural form of the cargo tank;

(4) Type and parameters of tank cleaning machines, including displacement, nozzle number/diameter, inlet pressure, range, etc.;

(5) Location and quantity of tank cleaning machines;

(6) Arrangement of tank cleaning piping (cyclic/non-cyclic);

(7) The number of cargo tanks to be cleaned simultaneously.

5.2.3 The intelligent tank cleaning plan is to include at least the following contents:

(1) According to the nature of the cargo and the form of the cargo tank, the appropriate method of tank cleaning is to be selected, which generally includes the following steps:

① prewashing;

② cleaning;

③ washing;

④ rinsing;

⑤ steaming;

⑥ draining;

⑦ drying.

(2) Duration of each step of tank cleaning;

(3) Selection of tank cleaning medium (fresh water or seawater);

(4) Matching of tank cleaning agents or additives, including type and quantity (if applicable);

(5) Setting of temperature and pressure of tank cleaning water;

(6) Calculation of tank cleaning water capacity;

(7) Initial setting of tank cleaning machine;

(8) Discharge requirements for tank cleaning water;

(9) Output of tank cleaning plan.

5.2.4 The intelligent tank cleaning system is to have the optimization function of tank cleaning plan, which is to at least include:

(1) Calculating minimum water quantity for tank cleaning;

(2) Developing a prewashing exemption plan (if applicable).

5.2.5 The cleaning plan is to be able to be manually adjusted according to the crew's needs or

actual conditions.

5.2.6 The development of tank cleaning plan may also be generated by reading the tank cleaning scheme in the knowledge base of tank cleaning.

5.3 Tank cleaning process monitoring and assistant decision-making

5.3.1 The intelligent tank cleaning system is to be able to monitor the status of cargo tank cleaning equipment in real time, including at least:

(1) Inlet water pressure of tank cleaning machine;

(2) Temperature of tank cleaning water;

(3) State of tank cleaning pump;

(4) State of tank cleaning machine, including nozzle speed/angle.

5.3.2 The intelligent tank cleaning system is to be able to at least propose the assistant decision-making suggestions listed in Table 5.3.2 for equipment operation based on the condition monitoring of the tank cleaning equipment:

Table 5.3.2

No.	Function category	Alarming state	Assistant decision-making function
1.	Tank cleaning water pressure monitoring & alarming and assistant decision-making	Tank cleaning water pressure monitoring & alarming	In the process of tank cleaning, the system monitors the inlet or pipeline pressure of tank cleaning water in real time. If the pressure exceeds the set threshold, the system is to send an alarm and prompt the crew to stop the tank cleaning and check the tank cleaning pump or the stop valve of the tank cleaning machine (if applicable).
2.	Tank cleaning water temperature monitoring & alarming and assistant decision-making	Tank cleaning water temperature monitoring & alarming	In the process of tank cleaning, the system monitors the temperature of the tank cleaning water in real time. If the temperature exceeds the set threshold, an alarm is to be given to prompt the crew to stop the tank cleaning and check the tank cleaning water heater.
3.	Tank cleaning equipment working condition monitoring & alarming and assistant decision-making	Tank cleaning pump failure alarming	In the process of tank cleaning, the system monitors the temperature of pump bearing and pump shell in real time. If the temperature exceeds the set threshold, the system is to release an alarm and prompt the crew to stop the tank cleaning and check the tank cleaning pump.
		Tank cleaning machine failure alarming	In the process of tank cleaning, the system monitors the working state of the tank cleaning machine in real time. If the rotation of the tank cleaning machine is abnormal, the system is to release an alarm and prompt the crew to stop the tank cleaning and check the tank cleaning machine.

5.3.3 The intelligent tank cleaning system is to be able to monitor the cleaning status of the cargo tank in real time, including at least:

(1) Pressure of cargo tank;

(2) Temperature of cargo tank;

(3) Concentration of combustible gas in the cargo tank;

(4) Concentration of toxic gas in the cargo tank (if applicable);

(5) Concentration of oxygen in the cargo tank;

(6) Status of drainage system in the cargo tank.

5.3.4 The intelligent tank cleaning system is to be able to at least propose the assistant decision-making suggestions listed in Table 5.3.4 for equipment operation based on the monitoring of the cleaning condition of the cargo tank:

Table 5.3.4

No.	Function category	Function name	Description of function
1.	Cargo tank pressure monitoring & alarming and assistant decision-making	Cargo tank low pressure early warning	In the process of tank cleaning, the system monitors the pressure of the cargo tank in real time. If the pressure of the cargo tank is low, it is to give an early warning and to alert the crew to check the cargo tank.
		Cargo tank low pressure alarming	In the process of tank cleaning, the system monitors the pressure of the cargo tank in real time. If the pressure of the cargo tank approaches negative pressure, it is to release

			an alarm and prompt the crew to stop the tank cleaning operation.
2.	Cargo tank oxygen content monitoring, alarming and assistant decision-making	Oxygen content detection early warning before tank cleaning	Before cleaning the cargo tank, the oxygen content in the cargo tank is to be monitored and detected. If the oxygen content exceeds the threshold, the crew is to be prompted to carry out inert gas supply operation.
		Oxygen content detection early warning during tank cleaning	In the process of tank cleaning, the system monitors the oxygen content of the cargo tank in real time. If the oxygen content of the cargo tank rises, the system is to give an early warning and prompt the operation of inert gas supply.
		Oxygen content detection alarming during tank cleaning	In the process of tank cleaning, the system monitors the oxygen content of the cargo tank in real time. If the oxygen content of the cargo tank rises close to the threshold, the crew is to be prompted to stop the tank cleaning operation and carry out inert gas supply operation.
3.	Cargo tank cleaning system monitoring, alarming and assistant decision-making	Liquid level alarming	In the process of tank cleaning, if the liquid level reaches the threshold during the tank cleaning, an alarm is to be released to prompt the crew to stop the tank cleaning operation.
4.	Tank cleaning water discharge assistant decision-making	Discharge standard monitoring and alarming	The current condition is to be automatically identified as ship in navigation. Real-time monitoring of the discharge standards (Reg.13.2.1 in Chapter 5 of Annex II of MARPOL) is to be carried out for ships which comply with the discharge requirements of Chapter 5 of Annex II of MARPOL: If the standards are complied with, the crew is to be prompted to carry out the discharge operation; If the standards are not complied with, the crew is to be reminded and the discharge operation is to be stopped automatically.

5.4 Assessment of tank cleaning results

5.4.1 The intelligent cargo management system is to be able to assess the results of tank cleaning and provide relevant suggestions, which are to at least include:

(1) Assessment of tank cleaning quality: The intelligent tank cleaning system is to automatically judge the quality of cargo tank cleaning through the assessment of tank cleaning water quality or other approved methods, and provide suggestions on completion of tank cleaning, repeat tank cleaning and other operations;

(2) Assessment of tank cleaning safety: The intelligent tank cleaning system is to be able to determine the concentration of combustible and/or toxic gases in the cargo tank through real-time monitoring or other approved methods, and provide suggestions on ventilation and other operations.

Chapter 6 Drawings and Documents

6.1 Basis of examination

6.1.1 Chapters 1 and 2, PART SEVEN of ISC Rules for Classification of Sea-going Steel Ships.

6.1.2 Chapter 6 of ISC Rules for Intelligent Ships and the Guidelines.

6.2 List of drawings and documents

6.2.1 Ships applying for ISC class notation for intelligent cargo management are to submit the following applicable drawings and documents to ISC, as shown in Table 6.2.1(1) and Table 6.2.1(2).

List of drawings and documents for ship plan examination Table 6.2.1(1)

No.	Drawings and documents to be submitted	Ship plan examination
1	Intelligent cargo management system arrangement plan	Approval
2	Power system diagrams of Intelligent cargo management system	Approval
3	Intelligent cargo management system monitoring, early warning/alarm and assistant decision-making item table	Approval
4	Instructions for ship intelligent cargo management system	Used for information
5	Instructions for procedures and plans for cargo/tank monitoring, early warning/alarm and assistant decision-making	Used for information

List of drawings and documents for ship survey Table 6.2.1(2)

No.	Drawings and documents to be submitted	Main contents and requirements
1	Test program for on board tests	Chapter 7 of the Guidelines
2	On board test report	Chapter 7 of the Guidelines
3	Updated software registry form	Chapter 7 of the Guidelines
4	Software modification effect analysis record and test report	Chapter 7 of the Guidelines
5	Procedures and schedules for calibration of monitoring devices/sensors	Periodic calibration mechanism, calibration method, personnel arrangement, relevant implementation records, etc.
6	System installing procedure (if any)	Environmental control and installation of computer, network equipment, sensors and other equipments, and cable laying process requirements.

Chapter 7 Class Notation Survey

7.1 Initial survey

7.1.1 The relevant requirements for survey during construction in 6.9.1 of Chapter 6 of the Rules for Intelligent Ships are to be met.

7.1.2 The following documents are to be kept on board:

(1) Ship drawings and documents approved by ISC;

(2) Product certificate of the system;

(3) Calibration records/certificates of monitoring devices/sensors;

(4) Evaluation report (if any) provided by the service supplier of the intelligent cargo management system.

7.1.3 Onboard survey and test

(1) Tests are to be carried out in accordance with the approved onboard test program, which may be divided into two parts, the mooring test and the sea trial, and is to include at least the following:

① verifying the integrity and accuracy of the monitoring and display data required by each system;

② verifying that the early warning and alarm function of the monitoring alarm system is normal. The set values of the system early warning point and alarm point parameters determined by the test meeting the requirements of the Guidelines are to be recorded and kept on board for information. The modification of the early warning and alarm set values is to be authorized to prevent arbitrary modification;

③ verifying that the system is running normally and meets the design function according to the system configuration and function specifications. Software functions can be verified through simulation operation. The system is to be able to analyze the detected data and provide operational guidance;

④ verifying that training and operating procedures for the intelligent cargo management system are established on board.

The test items are to include at least the contents of Table 7.1.3.

Checklist of initial test **Table 7.1.3**

No.	Test items	Requirements for test result	Remarks
1	Inspection of appearance, identification and completeness	To confirm that there is no damage of the appearance of product, the identification is clear and modules of product are complete.	
I. General functions			
2	Inspection of tamper-proofing function	Protective measures are to be provided to prevent the operator from making unwitting or unauthorized modification to the procedure; the update of procedures or software is to be recorded.	
3	Inspection of data communication failure alarming function	The system is to be capable of making continuous self-monitoring of communication lines and alarm is to be initiated once abnormal situation occurs (such as loss of data, data error).	
4	Inspection of the data acquisition function	To verify the completeness and accuracy of the data to be monitored and indicated.	To provide data acquisition interfaces with access to standard signal (e.g. temperature signal, pressure signal, flux signal) and to observe the data indication; data acquisition interfaces of the same type may be verified by sampling if the number of interfaces is large.

No.	Test items	Requirements for test result	Remarks
5	Inspection of the signal loss alarming function	The system is to be capable of giving an alarm if the signal to be collected is lost.	
6	Inspection of the format of monitoring parameters	The record of monitoring parameter is at least to include the following information: (1) basic information of monitored equipment; (2) method for processing measuring data; (3) Date and time information.	
7	Inspection of the data storage function	The measured data is to be capable of being recorded in a standard format and stored periodically; the history data may be checked from the stored data and the contents of data are to be consistent with the original inputted data.	
8	Inspection of data backup capability	Equipment necessary for database backup is to be provided and verified effective.	
9	Power shifting function	The system is to be capable of shifting automatically to the backup power in the case of power loss during normal power supply. The storage battery maybe used as backup power and the capacity is to maintain the power supply for at least 30 minutes.	
10	Power failure alarming	Audio and visual alarms are to be initiated while the system power failure occurs.	
II. Cargo/cargo tank monitoring, early warning/alarming and assistant decision-making systems			
11	Trend analysis and handling of monitoring data	The system is to be capable of implementing the trend analysis of real-time data and comparative analysis and handling of history data, and indicate visually the results.	
12	Assistant decision-making system function	The system is to initiate the early warning and alarms for the results of data analysis and handling and provide operation and handling suggestion.	
13	History data query function	Assistant decision-making system is to facilitate the query of history data and output relevant records necessary for surveys.	
III. Intelligent stowage system			
14	Knowledge base function	The knowledge base of cargoes fit for carriage is to be established for the system, and the knowledge base is to be updated and improved continuously with the accumulation of experience in system operation and the update of knowledge.	
15	Intelligent cargo stowage function	The system is to be capable of utilizing sensing devices such as sensors to collect all data in relation to cargo handling and ballast water transfer, considering various restraining factors, making real-time calculation and analysis and giving optimized stowage plan and loading/unloading sequence.	
16	Loading/unloading process simulation function	The system is to be capable of simulating and controlling related components and equipment to complete cargo loading/unloading operation according to the optimized stowage plan and based on the data of cargo and ship loading/unloading equipment.	
17	History data query function	The system is to facilitate the query of history data and output relevant records necessary for surveys.	
IV. Automatic cargo loading/unloading system			
18	Cargo loading/ unloading file system function	The system is to have the function of automatically operating the necessary documents and reports in the process of cargo loading/unloading operation of the ship and the port.	
19	Autonomous decision-making capability	The system is to be capable of achieving autonomous calculation, analysis and decision-making based on monitored data and restraining conditions and giving optimized stowage plan and operation plan.	
20	Automatic control function	The system is to complete the cargo loading/unloading process automatically according to the optimized stowage	

No.	Test items	Requirements for test result	Remarks
		and operation plan: (1) automatic control of the start and stop of cargo pump, automatic adjust the rotate speed or displacement; (2) automatic control of the start and stop of ballast pump and valve switch and opening degree; (3) automatic control of cargo loading/unloading, such as cargo capacity, ballast water of ballast tank, maximum still water bending moment and shear force. Also to be capable of emergency handling and control according to the unexpected equipment failure or external environmental change so as to prevent damage to the ship or pollution of the environment.	
21	History record query function	The system is to facilitate the query of history automatic cargo handling records and the records of handing and control of unexpected situation and output relevant records necessary for surveys.	
V. Intelligent tank cleaning system			
22	Knowledge base function	The knowledge base of cargo tank cleaning data is to be established for the system, and the knowledge base is to be updated and improved continuously with the accumulation of experience in system operation and the update of knowledge.	
23	Function of generating tank cleaning plan	The system is to be capable of utilizing sensing devices such as sensors to collect all data in relation to tank cleaning, considering various restraining factors, making calculation and analysis and giving optimized tank cleaning plan.	
24	Assistant decision-making function	According to the tank cleaning plan, the system is to be capable of monitoring the tank cleaning process, analyzing and processing the data related to the tank cleaning, initiating the early warnings and alarms, evaluating the tank cleaning results and providing operation and handling suggestions.	
25	History data query function	The system is to facilitate the query of history data and output relevant records necessary for surveys.	

7.2 Implementation survey

7.2.1 For ships assigned with the class notation for the first time, the implementation survey is to be carried out in accordance with the requirements in Chapter 1 of the Rules for Intelligent Ships.

7.3 Survey after construction

7.3.1 The relevant requirements of survey after construction of 6.9.2 in Chapter 6 of the Rules for Intelligent Ships are to be met. Survey after construction is to be carried out in conjunction with the annual survey for ship class as specified in Section 2, Chapter 5, PART ONE of the Rules for Classification of Sea-going Steel Ships. The items of intermediate and special surveys are the same as those of annual survey.

7.3.2 The survey contents include:

(1) Confirming that there are no changes of the intelligent cargo management system since the last survey;

(2) Confirming that operators are familiar with system operation;

(3) Checking the maintenance, repair and replacement records of equipment and system since the last survey;

(4) Checking all monitoring data (including original benchmark data) and early warning and alarm records of monitored items since the last survey;

(5) Confirming that the equipment and system have been in normal operation since the last survey and checking all kinds of alarms using simulation methods as practical as possible;

(6) Calibration records/certificates of monitoring equipment/sensors;

(7) Evaluation report (if any) provided by the service supplier of the intelligent cargo management system.

7.3.3 Occasional survey

7.3.3.1 When the equipment (such as computers, programmable controllers, etc.) and the system are repaired or updated, the ship owner is to notify ISC and apply for occasional survey and test

to verify that the function of the equipment and the system at least comply with the technical requirements for the original equipment and system.

7.3.3.2 Software change or version upgrade of the system is to be made by the manufacturer or the representative designated by the manufacturer and the record of such change is to be included in the updated software registry form. The modification records, software modification impact analysis records and test report are to be submitted to the ISC surveyor for information.