CHARTING THE FUTURE

ClassNK

Guidelines for Hull Monitoring (Edition 2.0)

[English]

Introduction

In recent years, efforts to utilise hull monitoring as means for enhancing ship safety have become more widespread due to improvements in sensing and simulation technologies as well as developments in ship-to-shore communication and big data analysis technology.

The **Rules for Hull Monitoring Systems** established by ClassNK in 2002 summarised technical requirements based on the hull monitoring system technologies prevalent at the time for the purpose of assisting relevant ship personnel in making judgments by displaying hull response data obtained from onboard sensors as specific numerical values. The scope of the aforementioned rules, however, is limited and covers only certain systems and also does not reflect the latest technologies and the systems developed over the years.

For this reason, ClassNK established the **Guidelines for Digital Smart Ships** in 2020, outlining requirements for ships equipped with digital technologies such as various monitoring systems and autonomous navigation. In 2021, as an extension of said guidelines, ClassNK established this **Guidelines for Hull Monitoring** so as to comprehensively establish technical requirements for systems that enhance the safety of hull structures and support operations based on hull structure monitoring utilising digital technologies.

In this revision, technical requirements have been specified for systems that support decision making related to loading with improved loading efficiency and operations based on specific loading conditions as a further application of monitoring and digital technologies.

This Guidelines consist of a main section and three appendices: the main section defines the overall hull structure monitoring system, requirements for its components and survey procedures; Appendix A outlines the requirements for hull maintenance management functions that incorporate measurement data and fatigue strength evaluation methods; Appendix B specifies the requirements for navigation support functions in rough weather based on measurement data; and Appendix C establishes the requirements for functions support decision making of loading and the operation based on it utilising measurement data and simulation technologies. These appendices will be revised or expanded as necessary in response to future technological advancements and industry needs.

ClassNK hopes that this Guidelines will be a positive contribution to current efforts being undertaken worldwide by the maritime industry not only for improving current ship operations but also for furthering the development of innovative technologies.

November 2025
Nippon Kaiji Kyokai (ClassNK)

Guidelines for Hull Monitoring (Edition 2.0)
Contents

1. General

1.1 General

1 This "Guidelines for Hull Monitoring" (hereafter referred to as "the Guidelines") specifies the requirements that the hull monitoring system is to satisfy to achieve its intended purpose.

2 The objectives of the hull monitoring system envisioned by the Guidelines include supporting the maintenance and management of the hull structure, assisting in navigation and cargo loading decisions, and contributing to the enhancement of ship safety and operational efficiency.

3 The users of the hull monitoring system are assumed to vary depending on its purpose. In addition to onboard users such as ship personnel, land-based users responsible for operating the system are also considered.

4 The information provided by the hull monitoring system is not to be a substitute for the judgment and the responsibility of ship personnel.

5 In addition to the requirements stipulated in the Guidelines compliance with relevant rules by the Society (e.g. **Part C** and **Part X of the Rules for the Survey and Construction of Steel Ships**), international conventions and regulations for the flag state are to be satisfied.

6 Where deemed appropriate by the Society, ISO standards, IEC standards and other industrial standards may be considered for the hull monitoring system, its subsystems and its equipment.

1.2 Application

1 The Guidelines is applicable to ships that are registered by the Society that are equipped with a hull monitoring system for which an application for affixing class notation indicating that the ship is equipped with a hull monitoring system to its classification character has been made.

2 For a hull monitoring system to which the Guidelines is not applicable, it may be taken as compliant with the Guidelines when deemed equivalent by the Society based upon the general principles of the Guidelines.

1.3 Functional Requirements

1 Necessary information related to the hull structure is to be collected through measurements, simulations equivalent to measurements or a combination of both. Based on the collected information, quantitative analyses and assessments are to be conducted, and useful information is to be provided to users for the purposes of the hull monitoring system, such as enhancing the safety of the ship and supporting loading condition assessment.

2 In addition to the main section, the relevant appendices are to be satisfied according to the intended purpose of the ship.

3 In applying **-1** above, a hull monitoring system based only on simulations and forecast instead of measurements is to be as deemed appropriate by the Society.

1.4 Class Notations

For ships equipped with a hull monitoring system, class notations are to be affixed to the classification characters of the ships according to Appendices A, B and C.

1.5 Termination of Class Notation

The Society will delete relevant class notation in cases where a smart system in accordance with the Guidelines is not properly maintained. Compliance with the Guidelines, however, is optional and not a condition of class maintenance.

1.6 Terms and Definitions

The terms used in the Guidelines mean as follows:

(1) Hull monitoring system

A system that monitors and evaluates the condition of the hull as specified in each appendix by collecting information through measurement sensors. This also includes systems based on simulation technology designed to assist or substitute for measurement-based information collection. Depending on the purpose of the hull monitoring system, it may incorporate subsystems that provide users with information and alerts.

(2) Subsystem

A distinct component of the hull monitoring system that possesses specific functions.

(3) Programmable Device

A physical component equipped with software.

2. Hull Monitoring Systems

2.1 System Requirements

2.1.1 General

1 The requirements of **1.3** are to be satisfied.

2 Components that constitute the hull monitoring system such as subsystems, communication devices and equipment (including programmable devices) are to operate properly under the anticipated environmental conditions.

3 All sensors and components of the hull monitoring system installed in hazardous areas are to be intrinsically safe and explosion proof.

4 In case of abnormalities detected in the hull monitoring system, the design of the said system is to be based on the assumption that data from analysis, evaluation and judgment based on the requirements in each appendix are not to be used.

5 The hull monitoring system, as specified in **Appendix C**, with functions to support loading with improved efficiency and operation of the said loading condition is to satisfy the requirements of **Part X of the Rules for the Survey and Construction of Steel Ships**. Where the said system is classified as Category I, a risk assessment to assess the consequence on the hull and the operations is to be conducted and documented as a risk assessment report in accordance with **3.4.3-4, Part X of the Rules for the Survey and Construction of Steel Ship**.

2.1.2 System Stability

1 The hull monitoring system is to be connected to the main source of electrical power in order to ensure stable power supply.

2 The hull monitoring system is to include a function that enables the user to detect power supply loss.

3 The hull monitoring system is to include a function that enables the user to detect when the system is unable to record data due to a failure of the system, sensors, wires, subsystems, etc.

4 The hull monitoring system is to be equipped with an uninterruptible power system unit that enables the system to operate for at least ten *minutes* even when the supply of power stops.

5 When the supply of power is recovered, the hull monitoring system is to be able to be restarted to normal operation without fail.

2.1.3 Signal Incoherence

When signals of multiple sensors are to be transmitted through the same line, care is to be taken to prevent interference between the sensors.

2.1.4 Functions for Detecting Anomalies

1 The hull monitoring system is to include a function for checking at least once every 24 *hours* whether measurement data contains any anomalies (e.g. measurement data omissions).

2 The hull monitoring system is to include a function for appropriately indicating detected anomalies on a user interface and logging said anomalies in the data recorder.

2.1.5 Time Synchronisation

1 When multiple subsystems with different set times are to be used together, time synchronisation of

measured data is to be appropriately performed.

2 Time synchronisation is, in principle, to be done in Coordinated Universal Time (UTC).

3 For data measured by the hull monitoring system, time synchronisation is to be performed with an error not exceeding one second from the UTC.

2.1.6 Storage Function

1 The hull monitoring system is to store measured data appropriately in the data recorder.

2 The hull monitoring system is to have sufficient capacity to store measured data.

3 The hull monitoring system is to be equipped with a measured data backup function.

4 If an onboard server is to be used, the data format is to comply with **ISO 19847** and **19848**, as amended.

2.1.7 Subsystems Based on Simulation Technology

For ships equipped with subsystems based on simulation technology, such subsystems are to have sufficient computational accuracy to achieve its intended objectives.

2.1.8 Linkage with Voyage Data Recorder (VDR)

1 The hull monitoring system is to include an output port intended to transmit the information specified in **IMO Resolution MSC.333(90)** to a voyage data recorder (VDR) in cases where the VDR is directly connected to the hull monitoring system.

2 The output port specified in **-1** above is to satisfy **IEC 61162**.

2.1.9 Thermal stress

The hull monitoring system is to appropriately take thermal stress into account according to the intended purpose.

2.2 Components of Hull Monitoring Systems

2.2.1 General

This section specifies requirements for representative devices that constitute the hull monitoring system. Components that do not affect the functionality of the system need not satisfy the requirements of this section.

2.2.2 Strain Gauges

2.2.2.1 General

1 Strain gauges are to be suitable for measuring the target structural responses of hull structures. Where performing measurements targeting hull girder stress, multiple strain gauges are to be used and the effects of stress components other than the target one are to be excluded.

2 When strain gauges are unable to exclude the effects of other stress components in accordance with in **-1** above, said effects are to be excluded using some other appropriate method.

3 For the sensing part of the strain gauge, the hysteresis (history effect) for the strain of the hull, long-term stability performance and environmental resistance performance are to be verified, and data confirming these properties is to be available.

2.2.2.2 Resolution

Strain gauges are to be capable of measuring strain with accuracy of at least 10 μST. In addition, the

measurement range of the strain gauge is to cover the range of expected stress in the fluctuating stress due to waves and is to cover the entire range taking into account static stress when necessary. However, this does not apply if static stress is estimated by means other than the strain gauges.

2.2.2.3 Frequency Response Characteristics

Strain gauges are to have frequency response characteristics with which strain fluctuating in a range from 0 to 5 *Hz* can be measured.

2.2.2.4 Temperature Characteristics

Strain gauges are to be capable of correcting temperature effects on hull structures.

2.2.2.5 Environmental Resistance

Strain gauges are to be sufficiently durable according to the installation environment.

2.2.3 Accelerometers

2.2.3.1 General

For the sensing part of the accelerometer, the sensitivity characteristics, long-term stability performance and environmental resistance performance are to be verified, and data confirming these properties is to be available.

2.2.3.2 Resolution

Accelerometers are to be capable of measuring acceleration with accuracy of at least 0.01 *G*. In addition, the measurement range of the accelerometer is to be capable of measuring fluctuating acceleration within a range from −2 *G* to 2 *G*.

2.2.3.3 Frequency Response Characteristics

1 Accelerometers are to have frequency response characteristics capable of measuring acceleration fluctuating in a frequency range from 0.01 to 5 *Hz*.

2 Accelerometers installed in the bow for slamming measurement in the vertical direction are to have frequency response characteristics capable of measuring acceleration in a frequency range from 0.01 to 100 *Hz*.

2.2.3.4 Environmental Resistance

1 Accelerometer durability is to be sufficient for the installation environment.

2 Accelerometer impact resistance is to be sufficient for the installation environment.

2.2.4 Signal Processors

2.2.4.1 General

1 Important programs and data essential for achieving the objectives of the hull monitoring system are not to be lost in the event of a temporary power supply interruption.

2 The computers used for the hull monitoring system are to be configured so that power can be promptly restored according to the predetermined procedures after power supply stops.

2.2.4.2 Environmental Resistance

1 Signal processor durability is to be sufficient for the installation environment.

2 The signal processor is to be protected from overvoltage that may enter the system from input/output terminals.

2.2.5 Data Recorders

2.2.5.1 Environmental Resistance

Data recorder durability is to be sufficient for the installation environment.

2.2.5.2 Data Protection

Data stored in data recorders is to be protected from becoming degraded even when power supply is lost.

2.2.6 Uninterruptible Power System Units

Uninterruptible power system unit durability is to be sufficient for the installation environment.

2.2.7 Wiring

Cables used for wiring are to be sufficiently durable for the installation environment.

2.2.8 Other

Other components (subsystems, communication equipment, programmable devices, etc.) composing the hull monitoring system are to be discussed with the Society, and the requirements to be applied are to be determined. When there are no relevant requirements by the Society, industrial or other standards may be applied.

3. Installation of Hull Monitoring Systems

3.1 Installation of Hull Monitoring Systems

3.1.1 Installing Sensors

The influence of the installation method on a sensor's long-term stability performance and environmental resistance performance are to be verified in advance.

3.1.2 Initial Set-up of Strain Gauge and Accelerometer

1 Strain gauges for measuring the hull girder stress are to be initially set to the stress value corresponding to the results of calculations carried out using a loading computer or a loading manual for the loading conditions approved by the Society. This setting may be done using a method of resetting the stress value to zero under the known loading conditions, a method of correcting temperature effects, such as sunlight etc.

2 The initial set-up for the accelerator is to be made in accordance with specifications submitted to the Society.

3.1.3 Installation Location

When installing a sensor, care is to be taken to prevent its location from affecting other functions provided on the ship.

3.2 System Performance Verification of Hull Monitoring Systems

After installation, system operations are to be tested in order to confirm the hull monitoring system operates well in accordance with the documents specified in **4.2.2-2(2)**.

4. Surveys

4.1 General

4.1.1 Kinds

Systems are to be subjected to the following surveys:

(1) Surveys for registration (hereafter referred to as "Registration Surveys")

(2) Surveys for maintaining registration (hereafter referred to as "Registration Maintenance Surveys"), which are as follows:

  (a) Annual Surveys

  (b) Occasional Surveys

4.1.2 Timing

1 Registration Surveys are to be carried out at the time of application for registration.

2 Registration Maintenance Surveys are to be carried out at the following intervals:

(1) Annual Surveys are to be carried out at those times stipulated in **1.1.3-1(1)** to **(3), Part B of the Rules for the Survey and Construction of Steel Ships.**

(2) Notwithstanding **(1)** above, Occasional Surveys are to be carried out for any of the following cases, independently of Annual Surveys.

  (a) When an important part of the hull monitoring system has been damaged, repaired or renewed.

  (b) When the hull monitoring system is modified or altered.

  (c) When a survey is considered necessary by the Society.

4.1.3 Surveys Carried Out in Advance

Annual Surveys may be carried out in advance of their due dates in accordance with **1.1.4, Part B of the Rules for Survey and Construction of Steel Ships**.

4.1.4 Preparations

1 All preparations considered necessary for surveys are to be made by and are the responsibility of survey applicants. Necessary arrangements are also to be made by survey applicants to ensure persons knowledgeable about the requirements of the survey supervise its preparation.

2 Society surveyors may suspend surveys in the following cases:

  (1) Necessary preparations have not been made.

  (2) An appropriate attendant is not present.

  (3) The surveyor considers that the safe execution of the survey is not ensured.

4.1.5 Disposition when Repairs are Considered Necessary as the Result of a Survey

In cases where repairs are deemed necessary as the result of a survey, Society surveyors will notify survey applicants of their findings. Survey applicants, upon receiving such notification, are to obtain Society surveyor verification after carrying out all necessary repairs.

4.2 Registration Surveys

4.2.1 General

During Registration Surveys, the performance, installation and initial set-up of hull monitoring systems

are to be examined in detail in order to ascertain that they satisfy the Guidelines.

4.2.2 Submission of Plans and Documents

1 The following plans and documents are to be submitted for hull monitoring systems to be registered to confirm the system complies with **Chapters 2** and **3**.

(1) Document explaining the functions and operation of the hull monitoring system.

(2) Document demonstrating the functionality of the subsystems that make up the hull monitoring system, including the validity of the computational mechanisms and simulation techniques contained within the subsystems.

(3) General arrangements and section drawings of ships showing cable arrangements and positions of any strain gauges, accelerometers and main components of hull monitoring systems.

(4) Block diagram illustrating hull monitoring system operation.

(5) Document regarding the manufacturer names, types, accuracy, measurements, range, frequency response characteristics, temperature characteristics and environmental resistance of sensors.

(6) Document regarding the data content, recording methods and data storage device capabilities.

(7) Operation manual for the hull monitoring system.

(8) Any other documents deemed necessary by the Society.

2 The following plans and documents are to be submitted in addition to the plans and documents specified in **-1** above.

(1) Document that shows the installing procedures, adjustment method and calibration method for each sensor.

(2) Document that shows the method for a simulation test for the hull monitoring system.

(3) Document that shows the procedures for verification of initial set-up in **4.2.4-2(2)**.

(4) Any other documents deemed necessary by the Society.

4.2.3 Simulation Tests

After the hull monitoring system is installed on the ship, processing functions of systems are to be tested in the presence of a Society surveyor in order to confirm that the said system are satisfactory. Simulation tests are to be conducted using simulated input signals in accordance with those simulation test procedures submitted prior to such tests. Values produced by systems are to be compared with those values calculated using simulated input signals.

4.2.4 Surveys for Installation and Initial Set-up

1 After the hull monitoring system is installed on the ship, it is to be ascertained, in the presence of a surveyor, that the sensors and other devices of the said systems are installed and set up according to plan.

2 Initial set-up and its verification are to be carried out as follows:

(1) Strain gauges are to be initially set in ballast conditions or light weight conditions in accordance with the requirements given in **3.1.2-1**.

(2) Verification of the initial set-up specified in **(1)** above is to be carried out under conditions deemed appropriate by the Society. During such verification, stress levels obtained from strain gauges are to be compared with outputs of any loading instruments or calculations using loading manuals. The differences are, in general, to be within 10 % of the allowable stress.

4.3 Registration Maintenance Surveys

4.3.1 Annual Surveys

During Annual Surveys, the following examinations and confirmations of systems are to be carried out:

(1) It is to be ascertained that the hull monitoring system is in good order in accordance with those procedures submitted prior to the survey.

(2) It is to be ascertained that current calibration certificates for sensors, including strain gauges, accelerometers and so on are kept on board. The sensors are to be recalibrated every five *years* in general. However, this does not apply when the sensor is deemed to be in good condition based on past calibration records and usage history. When the sensor manufacturer recommends calibration is less than five *years*, recalibration according to the said recommendation is to be conducted. Where deemed necessary, the Society surveyor-in-charge may instruct that the sensors to be recalibrated at shorter intervals.

(3) Operation manuals of the hull monitoring system are to be verified as being on board.

4.3.2 Occasional Surveys

During Occasional Surveys, inspections, tests or investigations are to be carried out on necessary items according to those cases specified in **4.1.2-2(2)** in order to ascertain that the hull monitoring system complies with the Guidelines.

Appendix A Assistance for Ship Maintenance

A1. Purpose

This Appendix A specifies the incorporating of a hull maintenance support function based on the utilisation of stress measurement data and fatigue strength evaluation methods to assess the condition of the hull structure.

A2. Class Notations

The class notations shown in **Table A1** are to be affixed to the classification characters of ships satisfying the main section and this Appendix of the Guidelines.

Table A1 Class Notation and Abbreviations

Target Hull Structural Strength	Class Notation and Abbreviation
(A)-1 Hull girder	Digital Smart Ship(Hull Monitoring(Fatigue)) Abbreviation: DSS(HM(F))
(A)-2 Hull girder (with ship-to-shore communication capability)	Digital Smart Ship(Hull Monitoring(Fatigue+Shore)) Abbreviation: DSS(HM(F+S))
(B)-1 Hull girder + local member(s)	Digital Smart Ship(Hull Monitoring(Fatigue+Local)) Abbreviation: DSS(HM(F+L))
(B)-2 Hull girder + local member(s) (with ship-to-shore communication capability)	Digital Smart Ship(Hull Monitoring(Fatigue+Local+Shore)) Abbreviation: DSS(HM(F+LS))

A3. Evaluations and Measurement Locations

A3.1 Hull Girder Stress Occurring in the Hull Structure

Critical areas where high stress occurs are to be considered evaluation points. The following locations are to be considered standard measurement points:

(1) Strength deck on both sides amidship.
(2) Strength deck on one side at a position 1/4 L from the fore peak. (L: Length of ship)
(3) Strength deck on one side at a position 1/4 L from the aft peak. (L: Length of ship)
(4) Other locations deemed necessary by the Society.

A3.2 Local Stress Occurring in the Hull Structure

1 In cases that correspond to (B)-1 and (B)-2 in **Table A1**, in addition to the locations specified in **A3.1**, critical areas where high stress occurs are to be considered as measurement targets.

2 Measurement and evaluation locations are to be determined based on discussions with the Society.

A4. Evaluation Method

A4.1 Measurement Locations

1 Cumulative fatigue damage for the location subject to evaluation is to be calculated using measurement data and using an appropriate method.

2 The calculation method specified in **-1** above is to be determined through discussions with the Society based on documents submitted in accordance with **A6.1.1-1(2)**, **A.6.1.1-2(2)**, **A.6.1.1-3(2)** or **A.6.1.1-4(2)**.

A4.2 Non-measured Locations

1 Where a non-measured location is to be evaluated, the cumulative fatigue damage is to be estimated through estimation of the stress in the member at a location subject to evaluation other than the location being monitored.

2 The estimation method specified in **-1.** above is to be determined based on discussions with the Society and documents submitted in accordance with **A6.1.1-3(2)** or **A6.1.1-4(2)**.

A5. Requirements

A5.1 Hull Monitoring Systems

A5.1.1 Redundancy

The hull monitoring system is to be capable of storing a log of periods during which any omissions of data measurement occur.

A5.2 Hull Monitoring System Components

A5.2.1 Data Recorders

The data recorder is to be capable of recording the following information at least every hour for a period of one year or more.

(1) Date and time (UTC)

(2) Cumulative fatigue damage

A5.2.2 Ship-to-Shore Communication

1 To acquire the additional notation “DSS(HM(F+S))”, the hull monitoring system is to be capable of communicating the evaluation results obtained in **A4.1** or **A4.2** to shore in an appropriate manner.

2 The communication function specified in **-1** above is to be determined based on discussions with the Society and documents submitted in accordance with **A6.1.1-2(5)**.

3 To acquire the additional notation “DSS(HM(F+LS))”, the hull monitoring system is to be capable of communicating the evaluation results obtained in **A4.1** or **A4.2** to shore in an appropriate manner.

4 The communication function specified in **-3** above is to be determined based on discussions with the Society and documents submitted in accordance with **A6.1.1-4(5)**.

A6. Surveys

A6.1Registration Surveys

A6.1.1 Documents

1 For a hull monitoring system that is to undergo a Registration Survey for the additional notation "DSS(HM(F))" in accordance with this Appendix, the following documents are to be submitted to confirm system compliance.

(1) Document that describes the concept of the hull monitoring system.
(2) Document that describes the method for calculating the cumulative damage at the location subject to evaluation.
(3) Document that describes the adequacy of the method for calculating the cumulative damage at the location subject to evaluation.
(4) Document explaining system functions.
(5) Other documents deemed necessary by the Society.

2 For a hull monitoring system that is to undergo a Registration Survey for the additional notation "DSS(HM(F+S))" in accordance with this Appendix, the following documents are to be submitted to confirm system compliance.

(1) Document that describes the concept of the hull monitoring system.
(2) Document that describes the method for calculating the cumulative damage at the location subject to evaluation.
(3) Document that describes the adequacy of the method for calculating the cumulative damage at the location subject to evaluation.
(4) Document explaining system functions.
(5) Document that describes the details of the onshore communication function.
(6) Other documents deemed necessary by the Society.

3 For a hull monitoring system that is to undergo a Registration Survey for the additional notation "DSS(HM(F+L))" in accordance with this Appendix, the following documents are to be submitted to confirm system compliance.

(1) Document that describes the concept of the hull monitoring system.
(2) Document that describes the method for calculating the cumulative damage at the location subject to evaluation.
(3) Document that describes the adequacy of the method for calculating the cumulative damage at the location subject to evaluation.
(4) Document explaining system functions.
(5) Other documents deemed necessary by the Society.

4 For a hull monitoring system that is to undergo a Registration Survey for the additional notation "DSS(HM(F+LS))" in accordance with this Appendix, the following documents are to be submitted to confirm system compliance.

(1) Document that describes the concept of the hull monitoring system.
(2) Document that describes the method for calculating the cumulative damage at the location subject to evaluation.
(3) Document that describes the adequacy of the method for calculating the cumulative damage at the location subject to evaluation.
(4) Document explaining system functions.
(5) Document that describes the details of the onshore communication function.
(6) Other documents deemed necessary by the Society.

A6.2 Registration Maintenance Surveys

A6.2.1 Annual Surveys

Each function of the hull monitoring system specified in this Appendix is to be verified in accordance with the procedures submitted beforehand to ensure it is in a normal state.

A6.2.2 Occasional Surveys

During Occasional Surveys, according to **4.1.2-2(2)**, a survey, test or investigation of necessary matters is to be conducted to confirm that the hull monitoring system is in a state where it complies with this Appendix.

Appendix B Assistance for Ship Operation in Rough Conditions

B1. Purpose

This Appendix B specifies the equipping of hull monitoring systems with an adverse weather navigation support function, utilising the measurement data of longitudinal bending stress and acceleration for hull structure condition monitoring.

B2. Class Notation

The class notations shown in **Table B1** are to be affixed to the classification characters of ships satisfying the main section and this Appendix of the Guidelines.

Table B1 Class Notation and Abbreviations

Functions for assisting ship operation	Class Notation and Abbreviation
(A)-1 Real-time (on board)	Digital Smart Ship(Hull Monitoring(Operation)) Abbreviation: DSS(HM(O))
(A)-2 Real-time (on board + shore)	Digital Smart Ship(Hull Monitoring(Operation+Shore)) Abbreviation: DSS(HM(O+S))
(B)-1 Real-time + Forecast (on board)	Digital Smart Ship(Hull Monitoring(Operation+Prediction)) Abbreviation: DSS(HM(O+P))
(B)-2 Real-time + Forecast (on board + shore)	Digital Smart Ship(Hull Monitoring(Operation+Prediction+Shore)) Abbreviation: DSS(HM(O+PS))

B3. Functions for Assisting Ship Operation

B3.1 Real-time (on board)

For ships corresponding to (A)-1 in **Table B1**, the hull monitoring system is to be capable of providing real-time measurement data to assist onboard users with ship operations.

B3.2 Real-time (on board + shore)

For ships corresponding to (A)-2 in **Table B1**, the hull monitoring system is to be capable of providing real-time measurement data to assist onboard and onshore users with ship operations.

B3.3 Real-time + Forecast (on board)

For ships corresponding to (B)-1 in **Table B1**, the hull monitoring system, in addition to capability specified in **B3.1**, is to be capable of providing forecasts based on data (measurement data, wave forecast data, etc.) to assist onboard users with ship operations.

B3.4 Real-time + Forecast (on board + shore)

For ships corresponding to (B)-2 in **Table B1**, the hull monitoring system, in addition to the capability

specified in **B3.2**, is to be capable of providing data-based forecasts (measurement data, wave forecast data, etc.) to assist onboard and onshore users with ship operations.

B4. Evaluations and Measurement Locations

B4.1 Strain Gauges

The following locations are to be considered as standard measurement and evaluation points:

(1) Strength deck on both sides amidship.
(2) Strength deck on one side at a position 1/4 *L* from the fore peak. (*L*: Length of ship)
(3) Strength deck on one side at a position 1/4 *L* from the aft peak. (*L*: Length of ship)
(4) Other locations deemed necessary by the Society.

B4.2 Accelerometers

The following locations are to be considered as standard measurement and evaluation points:

(1) One location along the ship's centreline as far forward as possible from the bow (assuming the acceleration in the vertical direction).
(2) Other locations deemed necessary by the Society.

B5. Evaluation Method

B5.1 Real-time Evaluation

1 The hull monitoring system is to be capable of notifying the operator when the measured stress and acceleration values exceed pre-defined threshold values.

2 The alarming index specified in **-1** above is to be determined through discussions with the Society based on the documents submitted in accordance with **B7.1.1-1(3)**, **B7.1.1-2(3)**, **B7.1.1-3(4)** or **B7.1.1-4(4)**.

B5.2 Evaluation including Forecast

1 In cases corresponding to (B)-1 and (B)-2 of **Table B1**, in addition to the function specified in **B5.1**, the hull monitoring system is to be capable of predicting future stress and acceleration by using measured data such as stress, acceleration, and wave forecast data, and of supporting manoeuvring through appropriate methods.

2 The estimation methods specified in **-1** above are to be determined through discussions with the Society based on the documents submitted in accordance with **B7.1.1-3(2)** or **B7.1.1-4(2)**.

B6. Requirements

B6.1 Display

1 The system is to appropriately display the real-time stress and acceleration values obtained in **B5.1** as well as the alarm index.

2 In cases corresponding to (B)-1 and (B)-2 of **Table B1**, in addition to the function specified in **B6.1**, the system is to appropriately display on the monitor the future stress and acceleration obtained in **B5.2**, as well as information contributing to the support of ship operation.

B6.2 Ship-to Shore Communication

1 To acquire the additional notation "DSS(HM(O+S))", the hull monitoring system is to be capable of

communicating the evaluation results obtained in **B5.1** to shore in an appropriate manner.

2 The communication function specified in **-1** above is to be determined through discussion with the Society based on the documents submitted in accordance with **B7.1.1-2(5)**.

3 To acquire the additional notation "DSS(HM(O+PS))", the hull monitoring system is to be capable of communicating the evaluation results obtained in **B5.2** to shore in an appropriate manner.

4 The communication function specified in **-3** above is to be determined through discussions with the Society based on the documents submitted in accordance with **B7.1.1-4(6)**.

B7. Surveys

B7.1 Registration Surveys

B7.1.1 Documents

1 For a hull monitoring system that is to undergo a Registration Survey for the additional notation "DSS(HM(O))" in accordance with this Appendix, the following documents are to be submitted to confirm system compliance.

(1) Document that describes the concept of the hull monitoring system.

(2) Document that describes the method for calculating the stress and acceleration at the measurement location.

(3) Documents demonstrating the validity of pre-defined thresholds in relation to **(2)** above.

(4) Document explaining system functions.

(5) Other documents deemed necessary by the Society.

2 For a hull monitoring system that is to undergo a Registration Survey for the additional notation "DSS(HM(O+S))" in accordance with this Appendix, the following documents are to be submitted to confirm system compliance.

(1) Document that describes the concept of the hull monitoring system.

(2) Document that describes the method for calculating the stress and acceleration at the measurement location.

(3) Documents demonstrating the validity of pre-defined thresholds in relation to **(2)** above.

(4) Document explaining system functions.

(5) Document that describes the details of the onshore communication function.

(6) Other documents deemed necessary by the Society.

3 For a hull monitoring system that is to undergo a Registration Survey for the additional notation "DSS(HM(O+P))" in accordance with this Appendix, the following documents are to be submitted to confirm system compliance.

(1) Document that describes the concept of the hull monitoring system.

(2) Document that describes the method for estimating future stress and acceleration.

(3) Document that describes the function for assisting ship operation using the stress and acceleration obtained in **(1)** above.

(4) Documents demonstrating the validity of pre-defined thresholds in relation to **(3)** above.

(5) Document explaining system functions.

(6) Other documents deemed necessary by the Society.

4 For a hull monitoring system that is to undergo a Registration Survey for the additional notation "DSS(HM(O+PS))" in accordance with this Appendix, the following documents are to be submitted to

confirm system compliance.

(1) Document that describes the concept of the hull monitoring system.
(2) Document that describes the method for estimating future stress and acceleration.
(3) Document that describes a function for assisting ship operation using the stress and acceleration obtained in **(1)** above.
(4) Documents demonstrating the validity of pre-defined thresholds in relation to **(3)** above.
(5) Document explaining system functions.
(6) Document that describes the details of the onshore communication function.
(7) Other documents deemed necessary by the Society.

B7.2 Registration Maintenance Surveys

B7.2.1 Annual Surveys

Each function of the hull monitoring system specified in this Appendix is to be verified, in accordance with the submitted procedures beforehand, to ensure it is in a normal state.

B7.2.2 Occasional Surveys

During Occasional Surveys, according to **4.1.2-2(2)**, a survey, test or investigation of necessary matters is to be conducted to confirm that the hull monitoring system is in a state where it complies with this Appendix.

Appendix C Function for assisting cargo loading designed to improve loading efficiency and for supporting the operation under such loading conditions

C1. General

1 This Appendix specifies necessary requirements under specified conditions for functions assisting decision making with respect to improved loading efficiency and functions supporting operations under said loading condition.

2 This Appendix specifies necessary requirements for support functions that allow pre-defined values regarding vertical still water bending moment under specified conditions (i.e. allows using values other than the permissible values specified in **Part C of the Rules for the Survey and Construction of Steel Ships** (hereinafter referred to as **Part C of the Rules**) and for a hull monitoring system with said function. It is assumed that any restriction conditions, e.g. draught, other than the said permissible values do not change.

3 Support functions focused on restriction conditions other than the permissible values of vertical still water bending moment are to be discussed with the Society.

C2. Class Notation

1 The class notation corresponding to functions assisting decision making with respect to improved load efficiency and functions supporting operations under said loading condition shown in **Table C1** is to be affixed to the classification characters of ships satisfying the main section and this Appendix of the Guidelines.

2 When the hull monitoring system is not properly maintained, the notation specified in **-1** above is to be withdrawn. In that case, decision making with respect to loading and operation under said loading condition in accordance with the standard specified in this Appendix are not to be carried out.

Table C1 Class Notation and Abbreviations

Function for Assisting Loading	Class Notation and Abbreviation
(C) Function Assisting Loading with Improved Efficiency and Function Supporting Operation under Said Loading condition	Digital Smart Ship(Hull Monitoring (Loading with improved efficient)) Abbreviation: DSS(HM(L-IE))

C3. Hull Monitoring Systems

C3.1 General

1 The hull monitoring system is to include at least a subsystem evaluating the state of the hull on the planned route before departure (hereinafter called the “loading support system”), and a subsystem monitoring the state of the hull and evaluating said state during voyage (hereinafter called the “condition monitoring system”).

2 The loading support system specified in **-1** above is to be capable of estimating the vertical wave bending moments that may occur on the planned route and then be capable of calculating the permissible values of vertical still water bending moment on the planned route based on calculation results from such

estimates.

3 The condition monitoring system specified in **-1** above is to be capable of measuring vertical bending moments in real time, newly estimating such moments on the planned route based on information updated during the voyage and confirming that such moments are within the range of pre-defined values. When the hull monitoring system is installed on a container carrier, the elastic response component is to be considered in addition to the wave component.

4 The hull monitoring system is to be capable of appropriately and promptly conveying to any users, including ship operators, through a subsystem (hereinafter referred to as the "display system"), the information obtained through the functions specified in **-2** and **-3** above, and is to be capable of conveying such information by alerts if necessary.

5 Shipyards are to prepare safety measures that are appropriate in the event of an alert so that the ship operator can easily implement such measures.

C3.2 Loading Support Systems

C3.2.1 Estimating Vertical Wave Bending Moments on Planned Routes

1 The loading support system is to be capable of estimating the vertical wave bending moment $M_{WV\_pre}(t)$ (t means time on the planned route, and t=0 at the time of departure) occurring on the planned route based on an appropriate simulation technology and the forecast of waves (wave height, period, and direction) on the planned route.

2 The simulation technology specified in **-1** above is to be capable of estimating the value corresponding to M_{WV_rt} as specified in **C3.3.1**. In addition, for said estimation, the appropriate loading conditions and ship speeds are to be considered.

3 For the wave forecast in **-1** above, information provided by a suitable organisation or company is to be utilised. In addition, attention is to be paid to the definitions of wave height and period, and an operation manual is to be prepared so that any user, including ship operators, does not input parameters of different definitions into the hull monitoring system.

C3.2.2 Calculating Permissible Values of Vertical Still Water Bending Moments

1 The loading support system is to be capable of calculating the permissible values of the vertical still water bending moment $M_{SV\_max\_dt}$ based on $M_{WV\_pre}(t)$ as estimated in **C3.2.1** and the vertical bending moment specified in **4.3, Part 1, Part C** or **4.2, Part 2-1, Part C of the Rules**, and $M_{SV\_max\_dt}$ is to be as follows:

For $|M_{WV\_pre}(t)| \leq |M_{WV\_dt}|$:

For hogging, $M_{SV\_max\_dt} = C_{EL-h} \cdot M_{SV\_max}$

For sagging, $M_{SV\_max\_dt} = C_{EL-s} \cdot M_{SV\_min}$

$M_{WV\_pre}(t)$: As specified in **C3.2.1**: the value for hogging is positive, and the value for sagging is negative.

M_{WV_dt}: Reference value of the vertical wave bending moment for $M_{SV\_max\_dt}$, as shown in the following formulae:

For hogging, $M_{WV\_dt} = M_{WV-h} - (C_{EL-h} - 1.0)M_{SV\_max} - M_{safety}$

For sagging, $M_{WV\_dt} = M_{WV-s} - (C_{EL-s} - 1.0)M_{SV\_min} - M_{safety}$

C_{EL-h}: Coefficient determined by the shipyard for the hogging moment. The coefficient is to

be determined in consideration of the safety measures specified in **C4**. The standard for container carriers is that the coefficient be more than 1.0 but not exceed 1.2, whereas the coefficient tor other ship types is to be determined as deemed appropriate by the Society.

C_{EL-s}: Coefficient determined by the shipyard for the sagging moment that is to be determined in consideration of the basis of the safety measures specified in **C4**. The standard for container carriers is that the coefficient be more than 1.0 but not exceed 1.2, whereas the coefficient for other ship types is to be determined as deemed appropriate by the Society.

M_{WV-h}, M_{WV-s}: Vertical wave bending moments specified in **4.3.2.3, Part 1** or **4.2.2.3, Part 2-1, Part C of the Rules**

M_{SV_max}, M_{SV_min}: Vertical still water bending moments specified in **4.3.2.2, Part 1** or **4.2.2.2, Part 2-1, Part C of the Rules**. A combination with M_{WV-h} or M_{WV-s} is to be in accordance with the load case specified in **4.3.2.5, Part 1** or **4.2.2.5, Part 2-1, Part C of the Rules**.

M_{safety}: Safety margin, which is to be greater than the following formulae for container carriers. For other ship types, it is to be discussed with the Society. M_{safety} is not to exceed M_{WV-h} (M_{WV-s} for sagging) for any ship:

For hogging, $M_{safety} = M_D \left[\left(3.65 - 3\frac{C_{EL-h}M_{SV\_max}}{M_D}\right)/12\right]^{0.85}$

For sagging, $M_{safety} = M_D \left[\left(3.65 - 3\frac{C_{EL-s}M_{SV\_min}}{M_D}\right)/12\right]^{0.85}$

M_D: As given by the following formulae:

For hogging, $M_D = M_{SV\_max} + M_{WV-h}$

For sagging, $M_D = M_{SV\_min} + M_{WV-s}$

For $|M_{WV\_pre}(t)| > |M_{WV\_dt}|$:

For hogging, $M_{SV\_max\_dt} = M_{SV\_max}$

For sagging, $M_{SV\_max\_dt} = M_{SV\_min}$

2 The loading corresponding to the vertical still water bending moment $M_{SV\_max\_dt}$ calculated in **-1** above is to be described in the loading manual. In addition, the maximum value $C_{EL-h-env}$ of C_{EL-h} and the maximum value $C_{EL-s-env}$ of C_{EL-s} are to be described in the loading manual.

3 For cases to which **-1** above is not applicable (e.g. cases where M_{SV_min} is 0 or a positive value), the determination of permissible values is to be as deemed appropriate by the Society.

C3.3 Condition Monitoring Systems

C3.3.1 Measuring Vertical Bending Moments in Real Time

1 The condition monitoring system is to be capable of estimating the vertical bending moment M_{WV_rt} based on measurement data obtained during voyage. For container carriers, said system is to be capable of estimating $M_{WV\_whip\_rt}$.

2 The standard locations to be measured are as follows:

(1) Strength deck on both sides amidship

(2) Other locations deemed necessary by the Society

3 For M_{WV_rt} specified in **-1** above, the measured vertical wave bending moment or the maximum expected value calculated based upon the standard deviation of said measured values in a certain period, whichever is greater (whichever is smaller for negative values), is to be considered.

4 The $M_{WV\_whip\_rt}$ specified in **-1** above, both the elastic response component and the wave component are to be considered. Moreover, the measured values or the maximum expected values calculated based upon the standard deviation of the measured values for a certain period, whichever is greater (whichever is smaller for negative values), is to be considered.

5 An estimation method for the M_{WV_rt} and $M_{WV\_whip\_rt}$ specified in **-1** above is to be determined based on discussions with the Society and the documents submitted in accordance with **C7.1.1(4)**.

C3.3.2 Updating Estimation Values of Vertical Wave Bending Moments for the Remaining Planned Route

1 When utilising a condition monitoring system during the voyage, wave forecast information is to be updated at intervals of 12 *hours* or less, and the $M_{WV\_pre}(t)$ from the current position of ship to its destination is to be updated accordingly. The definitions of $M_{WV\_pre}(t)$ is to be in accordance with **C3.2.1**.

2 Where the route is changed, $M_{WV\_pre}(t)$ is to be updated based upon wave forecast information for the new planned route.

3 For ships not provided with safety measures related to the standards specified in **C4-4(2)** and **C4-5(2)**, the calculation method for $M_{WV\_pre}(t)$ is to be determined based on discussions with the Society, notwithstanding **-1** and **-2** above.

C3.3.3 Confirming in Real Time that Vertical Bending Moments are within Pre-defined Values

1 The condition monitoring system is to be capable of confirm in real time that M_{WV_rt} (as specified in **C3.3.1**) and $M_{WV\_pre}(t)$ (as specified in **C3.3.2**) satisfy the following formula. Where M_{WV_rt} and $M_{WV\_pre}(t)$ are positive values, M_{WV_dt} is to be the value for hogging. Where M_{WV_rt} and $M_{WV\_pre}(t)$ are negative values, M_{WV_dt} is to be the value for sagging:

$$\max\left(\left|M_{WV\_rt}\right|, \left|M_{WV\_pre}(t)\right|\right) \leq \left|M_{WV\_dt}\right|$$

M_{WV_rt}: As specified in **C3.3.1**.

$M_{WV\_pre}(t)$: As specified in **C3.3.2**.

M_{WV_dt}: As specified in **C3.2.2**.

2 For container carriers, the condition monitoring system is to be capable of confirming that $M_{WV\_whip\_rt}$ (as specified in **C3.3.1**) satisfies the following formula:

$$C_U M_{WV\_whip\_rt} \leq M_{WV\_whip\_dt}$$

$M_{WV\_whip\_dt}$: As given by the following formulae:

$$M_{WV\_whip\_dt} = M_U - M_{SV\_max\_dt}$$

M_U: Hull girder ultimate strength, as given by M_{U_DB} specified in **5.4.3, Part 2-1, Part C of the Rules**.

C_U: Safety factor determined by the shipyard to consider the uncertainties of measured values, including elastic vibration. The value is to be 1.0 or greater.

C3.4 Display Systems and Alerts

1 The display system is to be capable of displaying the latest information on the following **(1)** to **(6)**

parameters in chronological order.

(1) The permissible values for the vertical still water bending moment on the planned route, $M_{SV\_max\_dt}$

(2) The reference value for the vertical wave bending moment, M_{WV_dt}

(3) The vertical wave bending moment for the planned route, $M_{WV\_pre}(t)$

(4) The measurement values for the vertical wave bending moment in real time, M_{WV_rt}

(5) The reference value for the vertical wave bending moment, including the elastic vibration component, $M_{WV\_whip\_dt}$

(6) The measurement values for the vertical wave bending moment, including the elastic vibration component in real time, $M_{WV\_whip\_rt}$ (only for container carriers)

(7) The vertical still water bending moment water calculated by a loading instrument

2 Alert information and corresponding safety measures are to be displayed in an appropriate way when necessary. The alert is to not only be visible but also audible.

3 The display system is to be capable of allowing all users, including ship operators, to view the information in **-1** and **-2** above.

4 In applying **-1** above, where some or all of the parameters are displayed on equipment or systems other than the hull monitoring system, e.g. loading instrument, it is to be determined based on discussions with the Society.

C3.5 Communications

1 Where subsystems composing the hull monitoring system are connected either directly or via public means of communication (e.g. the Internet), the hull monitoring system is to be designed in such a way that the loss of communication or some other failure do not directly pose a risk to the hull structure.

2 The safety measures specified in **C4** are to take into account cases where the loss of communication or some other failure can occur.

C3.6 Redundancy

1 The hull monitoring system is to be capable of notifying users of alerts and other information indicating the need for appropriate safety measures to be taken when an abnormality is detected because of a failure of a device constituting the hull monitoring system.

2 The system is to be designed to prevent the failure of a single device from directly posing a risk to the hull structure. For the safety measures specified in **C4**, potential risks are to be considered.

3 The hull monitoring system is to be capable of retaining logs when periods of missing data are recorded.

C3.7 Data Recorders

1 The onshore and onboard data storage devices are to be capable of recording the information specified in the following **-2** to **-4** for a period of one *year* or more.

2 The values of the following **(1)** to **(3)** parameters are to be recorded in chronological order within 60 *minutes*:

(1) The vertical wave bending moment for the planned route, $M_{WV\_pre}(t)$

(2) The permissible values for the vertical still water bending moment, $M_{SV\_max\_dt}$

(3) The vertical wave bending moment at the measurement locations, M_{WV_rt} and $M_{WV\_whip\_rt}$ ($M_{WV\_whip\_rt}$ is applicable only to container carriers)

3 The following **(1)** to **(2)** parameters are to be recorded:
(1) Safety margin, M_{safety}
(2) The safety factor C_U for which the uncertainty in measurement values, including elastic vibration, is considered. (applicable only to container carries)

4 History of implementing the safety measures in **C4-1**.

5 Where the criteria specified in **C3.3.3-1** or **C3.3.3-2** are not satisfied, the time-series data of the following parameters is to be recorded for the prior 48 *hours*:
(1) The vertical wave bending moment waves at the measurement locations, M_{WV_rt} and $M_{WV\_whip\_rt}$.($M_{WV\_whip\_rt}$ is applicable only to container carriers)
(2) Other parameters deemed necessary by the Society.

C4. Safety Measures

1 In preparation for a state in which M_{WV_rt} specified in **C3.3.1** and $M_{WV\_pre}(t)$ specified in **C3.3.2** do not satisfy the criteria specified in **C3.3.3** during voyage, safety measures for appropriately suppressing the vertical bending moment are to be implemented by shipyard so that ship operators can easily carry out the said measures. Such safety measures are to be determined based on discussions with the Society and the documents in **C7.1.1(8)**.

2 Information necessary to carry out the safety measures in **-1** above (e.g. the loading condition after the safety measures or the procedure for reaching said state) is to be known to all users, including ship operators, for each voyage.

3 For the safety measures in **-1** above, records of training for users (ship operators and onshore persons concerned) are to be stored in accordance with the documents specified in **C7.1.1(8)**.

4 Where the safety measures in **-1** above are determined, the vertical bending moment for which the elastic response component is not considered is to satisfy the following **(1)** or **(2)**, or both:
(1) The formula in **C3.3.3-1** is satisfied (depending on, for example, route change).
(2) The vertical still water bending moment is M_{SV_max} or less and M_{SV_min} or more.

5 Where the safety measures in **-1** above are determined, the vertical bending moment for which the elastic response component is considered is to satisfy the following **(1)** or **(2)**, or both:
(1) The formula in **C3.3.3-2** is satisfied (depending on, for example, route change).
(2) The vertical still water bending moment is M_{SV_max} or less and M_{SV_min} or more.

C5. Hull Strength

1 The arrangement and scantlings of the hull are to satisfy the related requirements of **Part C of the Rules**.

2 Depending on the function specified in **C3**, the following **(1)** to **(5)** are especially to be considered.
(1) Trim and stability (draught (bow and stern, and mean), metacentre height, etc.)
(2) Hull girder load in still water other than the vertical still water bending moment
(3) Vertical bending moment and vertical shear force in the harbour condition
(4) Vertical bending moment in the flooded condition
(5) Other items deemed necessary by the Society

C6. Safety Management System

For the decision making related to loading based on the $M_{SV\_max\_\mathrm{dt}}$ specified in **C3.2.1**, the operation

under said loading condition, the information on the safety measures (the loading condition after safety measures are implemented and the procedure for reaching said state) and the training specified in **C4-2** and **C4-3** are to be managed by the safety management system specified in the **Rules for the Audit and Registration of Safety Management Systems**.

C7. Surveys

C7.1 Registration Surveys

C7.1.1 Documents

1 For a hull monitoring system that is to undergo a Registration Survey for the additional notation "DSS(HM(L-IE))" in accordance with this Appendix, the following **(1)** to **(10)** documents are to be submitted to confirm system compliance.

(1) Documents that describe the concept of the hull monitoring system, including the concept on the operation in association with the system

(2) Documents that describe the estimation method and the accuracy for the vertical wave bending moment $M_{WV\_pre}(t)$ on the planned route. In addition, an outline of simulation technology to be used, various conditions on calculation, calculation methods of statistical values, margin set for factors not considered in the simulation, etc. is to be included.

(3) Documents that describe the method for setting the permissible value, $M_{SV\_max\_dt}$, of the vertical still water bending moment

(4) Documents that describe the calculation method, and its adequacy for the vertical wave bending moment, M_{WV_rt} and $M_{WV\_whip\_rt}$, at the measured locations. Said documents are to include measurement data processing methods such as frequency domain to be extracted, component separation and so on. ($M_{WV\_whip\_rt}$ is applicable only to container carriers.)

(5) Documents that describe the method for calculation of the following safety margin:

(a) Safety margin, M_{safety}

(b) The safety factor C_U for which the uncertainty in measurement values, including elastic vibration, is considered. (Applicable only to container carriers)

(6) Documents that describe results of related strength evaluation (e.g. shear force, strength evaluation results in harbour and flooded conditions)

(7) Documents related to loading manual for $M_{SV\_max\_dt}$

(8) Explanatory documents for the hull monitoring system, and operation manuals for onboard and onshore users

(a) Explanations and manuals for the entire hull monitoring system

(b) Documents that explain **(7)** above

(c) The safety measures and the procedure specified in **C4**

(d) Measures for device failure (including the procedures for executing safety measures as needed)

(9) Documents that describe risk assessment results for the hull monitoring system and the operations based on said system, and that describe reliability analysis results of longitudinal strength. (Said documents may be omitted when the hull monitoring system and the operations based on it are deemed to be equivalent to systems previously approved by the Society.)

(10) Other documents deemed necessary by the Society

C7.2 Registration Maintenance Surveys

C7.2.1 Annual Surveys

1 The functions specified in this Appendix are to be confirmed to be in a normal state by conducting a simulation test of the arithmetic device in the presence of a Society surveyor.

2 Simulation tests are to be conducted using simulated input signals in accordance with test procedures submitted beforehand. Values produced by hull monitoring systems are to be compared with those values calculated using simulated input signals in order to confirm that display systems and alerts are in their normal states.

3 Documents related to the training of ship operators are to be confirmed to be in accordance with the documents specified in **C7.1.1(8)**.

C7.2.2 Occasional Surveys

During Occasional Surveys, inspections, tests or investigations are to be carried out on necessary items in accordance with **4.1.2-2(2)** in order to ascertain that the system complies with this Appendix.

C7.3 Miscellaneous

C7.3.1 Safety Management System

The safety management system is to be periodically inspected in accordance with the **Rules for the Audit and Registration of Safety Management Systems**.

Guidelines for Hull Monitoring
(Edition 2.0)
[English]

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November 2025