RULES FOR
CLASSIFICATION OF

SHIPS

SPECIAL EQUIPMENT AND SYSTEMS
ADDITIONAL CLASS

PART 6 CHAPTER 11

HULL MONITORING SYSTEM

JANUARY 2003
This booklet includes the relevant amendments and corrections shown in the January 2004 version of Pt.0 Ch.1 Sec.3.

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CHANGES IN THE RULES

General

This booklet is a reprint of the previous edition and apart from clarifications of text and the inclusion of amendments and corrections, published in the July 2002 edition of Pt.0 Ch.1 Sec.3, no other changes have been made.

This chapter is valid until superseded by a revised chapter. Supplements will not be issued except for an updated list of minor amendments and corrections presented in Pt.0 Ch.1 Sec.3. Pt.0 Ch.1 is normally revised in January and July each year.

Revised chapters will be forwarded to all subscribers to the rules. Buyers of reprints are advised to check the updated list of rule chapters printed in Pt.0 Ch.1 Sec.1 to ensure that the chapter is current.

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SECTION 1
GENERAL REQUIREMENTS

A. Classification

A 100 Rule application

101 These rules are applicable to ships where an instrumentation system for monitoring of hull behaviour is arranged. The system will give warning when stress levels and the frequency and magnitude of ship accelerations approach levels which require corrective action.

Guidance note:

The monitoring system is intended as an aid to the Master's judgement and not as a substitute for it. Accordingly, any failure of the system does not detract from the Master's absolute responsibility to take correct action in operating the ship. The basic rule requirements of this system are in accordance with IMO Recommendations for the Fitting of Hull Stress Monitoring Systems. (MSC/Circ.646)

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A 200 Class notations

201 Ships complying with these Rules may be assigned one of the following class notations:

HMON-1 This notation will be assigned when the ship has been provided with a basic hull monitoring system in accordance with these rules.

HMON-2 This notation will be assigned when the ship has been provided with a comprehensive hull monitoring in accordance with these rules. This system will also incorporate instruments to measure the environmental conditions.

202 The class notation will be issued on the basis of plan approval and survey under construction.

A 300 Qualification of components

301 Sensors are to be approved or type approved by the Society.

302 Data processing units (signal conditioning units, amplifiers, computers, display units) including flow charts and formulae for calculations are to be certified according to Pt.4 Ch.9 Sec.1

A 400 Maintenance and instruction manuals

401 Instruction manuals are to be kept on board. The manuals are to contain necessary instructions on:

— operation
— testing
— identification of faults
— repairs
— emergency operation
— systematic maintenance and function testing
— interpretation of measuring results.

402 The plan for systematic maintenance and function testing is to show how components and systems are to be tested and what is to be observed during the tests.

B. Definitions

B 100 Terms

The terms described below are relevant in these rules.

101 *Course*. The horizontal direction of the vessel in which the vessel is sailing expressed as angular distance from the true north.

102 *Display*. Means by which a device presents visual information to the operator.

103 *Data Processing Unit(s)*. Device(s) designed to process data according to defined algorithms (e.g. signal conditioning units, amplifiers, computers, display units).

104 *Global Positioning System (GPS)*. A satellite system intended to provide highly accurate position and velocity information on a global basis.

105 *Log*. An instrument for measuring the speed and/or distance travelled by a vessel.

106 *Position*. The description of a place by its global co-ordinates i.e. latitude and longitude.

107 *RPM*. The revolutions per minute of the propulsor(s).

108 *Sensor*. A device which measures a physical quantity as strain, acceleration, pressure etc.

109 *Slamming*. The result of the interaction (relative velocity) between ship and waves leading to sudden impact on the ship structure.

110 *Speed*. The distance per unit time covered by the movement of the vessel through the sea.

111 *Strain*. Relative dimensional elongation and/or shortening caused by an applied force.

112 *Torque*. The torsional moment on the rotating propulsor shaft(s).

113 *Wave condition*. Wave height, wave period and dominant direction relative to the longitudinal ship axis.

114 *Wind condition*. The velocity, i.e. average speed and dominant direction of the wind relative to the longitudinal ship axis.

C. Documentation

C 100 Plans and particulars

101 The following control and monitoring systems shall be approved by the Society:

— environmental monitoring system for **HMON-1**
— vapour pressure monitoring system **HMON-2**, in addition to the requirements for **HMON-1**.

For requirements to documentation, see Pt.4 Ch.9.

102 Details of any modification to the approved hull monitoring system is to be submitted for approval.

SECTION 2
COMPONENT DESIGN

A. Component Requirements

A 100 General

101 All components and systems are to be designed and installed in accordance with the requirements given in Pt.4 Ch.9 Sec.5.

102 All components are to be replaceable and designed for easy maintenance.

103 Accelerations are to be measured over a range of - 20 m/s^2 to + 20 m/s^2. The measurement uncertainty of the acceleration is to be less than 2% of the measured value, or 0,10 m/s^2, whichever is the greater.

104 Each strain gauge is to measure the strain which is characteristic for the structural response considered. The type and installation are in general to exclude the effects of local stress concentrations.

105 Each strain gauge is to be temperature compensated and the measured uncertainty is to be less than 3% of the measured value or 20 micro-strain, whichever is the greater. Relative changes of 10 micro-strain are to be detected. The linear range of each strain gauge is to be in excess of the full range of expected still-water and dynamic stress variation.

106 The monitoring system (hull monitoring and slamming measurements devices including sensors, cabling, amplifiers and computing devices) is to record the physical quantities within the specified uncertainties in the frequency range 0 to 5 Hz and 0 to 100 Hz for slamming respectively.

A 200 Electrical equipment

201 All electrical equipment associated with the hull monitoring system located in hazardous areas is to be of a type permitted in Pt.4 Ch.8 Sec.9 and applicable class notation(s) for Special Service and Type.

SECTION 3
SYSTEM DESIGN

A. Indication and Monitoring System

A 100 General

101 The hull monitoring system is to consist of at least the functions as given in Table D1.

102 The hull monitoring system is to provide real-time information to the bridge of the measured values while at sea and during loading and unloading operations.

103 The system is to include sensor(s) for measuring accelerations of the ship. By analysing the frequency ranges of the signals, slamming information and warning against sea water on the deck are to be provided based on the bow mounted accelerometer.

104 The strain gauges monitoring hull girder bending are to give information on the wave induced stresses and the mean value of still water stress.

105 Sudden changes from the trend in the dynamic response values or significant offsets from the static (mean) values, indicating for instance water ingress, are to give visual and audible alarm on the bridge.

106 The system is to include a computer that can process sensor signals and compare these with pre-set threshold levels. Values exceeding these pre-set threshold levels are to give visual and audible alarm on the bridge.

The threshold values for the global hull girder bending stresses shall be approved by the Society.

In order not to include diurnal temperature stresses in the global strain sensor signals, the low frequency diurnal temperature variations and the mean value of the measured signals shall be filtered out and replaced with the still water stress values calculated by the loading computer at the position of the global strain sensors.

107 The system is to have a minimum recording capability for the purpose of verifying that all sensors are working under sea-going conditions and during loading and unloading operations.

108 The system is to have a display suitable for the presentation sensor information.

109 An electronic data storage device suitable for accumulating statistical information for feed-back purposes is to be used.

110 In order to verify intermediate and final stages of loading and unloading operations, the hull monitoring system is to have a link to the loading computer. The calculated forces and moments from the loading computer are to be converted to stresses for comparison with the measured hull girder stresses.

In order to process the measured global hull girder stress signals for comparison with the approved threshold values, still water loading computer data are to be fed to the hull monitoring computer upon completion of loading or ballast operations at the beginning of each voyage.

B. Primary Elements

B 100 General

101 Sensors are to be protected against mechanical damage, humidity (water), exposure to excessive high or low temperatures and damage from local vibration sources.

B 200 Strain gauges

201 The position of the strain gauges is to take account of the structural configuration of the ship and its mode of operation.

Guidance note:

The strain gauges for measuring vertical hull girder bending should be located in such a way that the system monitors global strain (port + starboard) in the deck structure as near as practicable to amidships and in addition at the quarterly lengths (± L/4 from midship for vessels with L > 180 metres). See Table D1.

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B 300 Accelerometers

301 One accelerometer for measuring vertical accelerations at the bow is to be installed. On type B to D ships as defined in Table D1, also an accelerometer measuring transverse acceleration is to be installed at a suitable position in the midship area.

B 400 Position indicator HMON-2

401 A global position system (GPS) is to be installed.

B 500 Wave sensors HMON-2

501 An arrangement to monitor wave condition is to be used.

B 600 Wind sensors HMON-2

601 An anemometer giving speed and dominant direction of the wind is to be used.

B 700 Speed monitoring

701 The speed of the vessel may be taken from the GPS system or the speed log.

B 800 Course monitoring

801 The course of the vessel may be taken from the GPS system or the speed log.

C. Data Processing and Output Devices

C 100 General

101 The parameters given in Table D1 are to be processed and displayed in a suitable format.

102 The displays are to enable the values produced by the hull monitoring system to be visually compared with the classification threshold values.

103 Audible and visual alarms are to be provided on the bridge to indicate when the current values exceed the classification threshold values.

104 For the purpose of verifying that all sensors are working under sea-going conditions the system is to have a minimum recording capability. This requires that a semi-permanent data storage medium is to be used to record, at least once per month and whilst the ship is at sea, the following information, processed over a period of 30 minutes:

— maximum peak to peak value of stress/acceleration
— mean value of stress/acceleration
— standard deviation of stress/acceleration
— average zero crossing period of stress/acceleration
— time reference.

105 Automatic post-processing of data on-board or ashore is to be available in order to enable the recorded data to be examined.

106 The monitoring system is to be powered through an Uninteruptible Power Supply (UPS). In case of failure of the main input voltage the battery capacity is to be sufficient to maintain normal operation of the monitoring system for at least 10 minutes.

107 Failure of any power supply to the system is to initiate an audible and visual alarm.

108 The programs and data held in the data recording system are to be protected from corruption by loss of power. In case of power failure the monitoring system is to automatically recover to full functionality when power is supplied.

109 The system is to be able to record and display on the bridge the following three sets of data for each strain gauge and accelerometer:

a) The peak value of the longitudinal hull girder bending stress or vertical acceleration.

b) The mean value of the longitudinal hull girder bending stress or vertical acceleration.

c) The standard deviation of the longitudinal hull girder bending stress or vertical acceleration.

Display (a) is to be the default displays of the system.

110 The number of acceleration peak exceeding a pre-set acceleration level, indicating a slam in the bow area within a one hour period are to be recorded and displayed.

111 Vertical and horizontal hull bending are to be measured in terms of normal stress (strain) at the locations given in Table D1.

112 Lateral loads are preferably to be measured in terms of normal stress (strain) at the structure on which the pressure is acting, e.g. lateral loads are to be measured as normal stress on longitudinal(s).

C 200 Trend predictions

201 The sensor readings are to be displayed in a manner that enables the trends in the data over the last 4 hours to be seen. The system is also to present a forecast trend prediction based on at least the last 4 hours of the response parameters. Each update of the display is to be based on statistics of the last 30 minutes of the recorded data.

202 When the sensor signal exceeds 80 % of the threshold value, visual and audible alarms are to be given at the bridge. At the same time the expected time to reach the threshold level is to be clearly displayed.

C 300 Response spectra

301 The recordings from selected accelerometers and strain sensors are to be processed using a type of cycle count method (e.g. "rainflow" method) to produce response histograms (spectra). The stress spectra may be used as basis for fatigue life predictions.

D. Extent of Monitoring

D 100 Extent of monitoring

101 The extent of monitoring is shown in Table D1.

Table D1 Parameters to be monitored for the various types of vessels			
Parameter	**HMON-1**	**HMON-2**	*Remarks*
Vertical accelerations at forward perpendicular (≤0,01L) at centre line	A, B, C, D	A, B, C, D	
Transverse acceleration in the 0,4L midship area	B, C, D	B, C, D	To monitor inertia loading on sensitive cargo. Sudden change in response may indicate irregular situations such as ingress of water in holds or at vehicle decks.
Vertical hull bending (L/2) amidships (port and starboard)	A, B, C, D[1]	A, B, C, D[1]	[1] For vessels with hull girder sectional modulus < 1,5 Z_{rule}.
Vertical hull bending ±L/4 from midship (port or starboard side)	A[2], B[2], C[2], D[3]	A[2], B[2], C[2], D[3]	[2] For vessels with length L>180 m. [3] For vessels with hull girder sectional modulus < 1,5 Z_{rule} and with length L>180 m.
Horizontal hull bending (L/2) amidships (port and starboard)	B[4], C[5]	B[4], C[5]	[4] Longitudinal stresses (L/2) amidships below the neutral axis, e.g. at bilge area. Only for ships with large openings in deck, for example open hatch carriers. [5] Longitudinal stresses (L/2) amidships below neutral axis, e.g. at bilge area.
Double bottom bending		B[6]	[6] For Bulk Carriers with class notation **HC, HC-E** or **HC-EA**, one strain sensor in inner bottom of each hold.
Bending/shear stress in pillar bulkheads		C[7]	[7] For vessels with operational limits with respect to draught with empty holds.
Lateral loads at bottom at near forward perpendicular		A, B, C, D[8]	[8] If slamming in the forebody may occur (ballast).
Lateral loads at side		A, B, C, D	Dynamic stress histogram => Fatigue indicator.
Lateral loads at the bow door		D[9]	[9] For Ro-Ro Vessels only. Measuring of relevant parameters i.e. stresses or pressures.
Loading computer system	A, B, C, D	A, B, C, D	
Position, speed/course		A[10], B, C, D	[10] Not relevant for Oil Production and Storage Vessels.
RPM and torque of propulsor(s)		A[11], B, C, D	[11] Not relevant for Oil Production and Storage Vessels.
Speed (log)	A[12], B, C, D	A[12], B, C, D	[12] Not relevant for Oil Production and Storage Vessels.
Wave condition		A, B, C, D	
Wind condition		A, B, C, D	
A: Oil Carriers, Chemical Carriers, Liquefied Gas Carriers and Oil Production and Storage Vessels B: Bulk Carriers and Ore Carriers C: Container Vessels D: General Cargo Ships, Ro-Ro Vessels, Passenger Vessels and other Vessels			

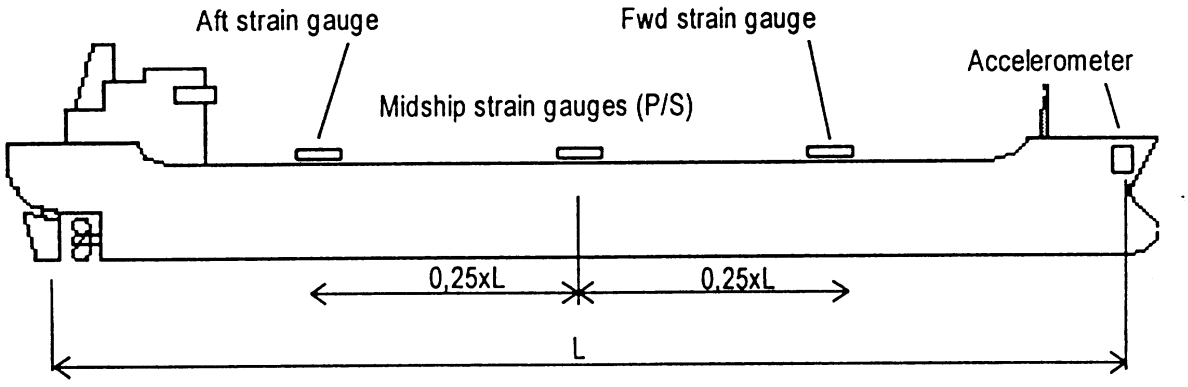

Fig. 1
Typical location of sensors, class notation HMON-1

SECTION 4
INSTALLATION AND TESTING

A. General

A 100 Calibration certificate

101 Calibration certificates for all the relevant components of the monitoring system are to be delivered.

A 200 Operations manual

201 An operations manual written in English and in a language appropriate for the ship's crew is to be on board.

A 300 Monitoring system

301 Each strain gauge is initially to be set to a stress calculated in an agreed loading condition. This calculated stress is to be compatible with the output of the loading instrument and calculations made using the loading manual. The set-up is not to be carried out when dynamic stresses are present and are to be made when temperature effects are minimised and in absence of large gradients.

302 Information on how to interpolate the values at the strain gauge settings is to be included in the computer programme of the system so that the loading instrument readings can be used for setting and checking the system.

303 The initial read out of the sensor is to be checked against a subsequently agreed loading condition in calm water, with the attendance of a surveyor from the Society. In the event that differences greater than 5% of the approved value or 10 N/mm^2 occur, whichever is the greater, the set-up and subsequent checking procedure is to be repeated.

304 The calibration is to be verified by a surveyor from the Society. Recommendations and certificates of calibration, signed by an authorised person are to be kept on board the ship.

B. Approval and Testing Procedure

B 100 General

101 The processing functions of the hull monitoring system are to be tested using simulated input signals. A spectrum of harmonic signals is to be used covering the ranges of the individual sensors. The values produced by the hull monitoring system are to be compared with separate calculations based on the knowledge of the simulated signals. The proposed simulation test programme is to be submitted for approval prior to the test.

102 The operation of the hull monitoring system is to be verified upon installation by a surveyor from the Society:

— to ensure that the value of the stress as defined is compatible with the output of the loading instrument for the current condition
— examination of the recorded data for compliance with the requirements.