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Guidelines for Condition Based Maintenance (CBM)

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CHAPTER 1 GENERAL

Section 1 General

101. Application

1. This guidelines provides specific application methods of condition monitoring and condition-based maintenance procedure specified in **Pt 1, Annex 1-8 of the Rules**.
2. This guidelines is applicable to ships which an approved preventive maintenance system(PMS) has been applied.
3. This guidelines describe the requirements for how to apply condition monitoring and condition-based maintenance.
4. For the application of condition monitoring and condition-based maintenance, a sufficient level of information should be retained to extend the overhaul survey with information collected through condition monitoring devices and other means.
5. Refer to **Figure 1** for determining the survey method including condition-based maintenance.

102. Definition of Terms

Definitions of terms are in accordance with the Rules for the Classification of Steel Ships, except as otherwise provided herein.

1. **Planned Maintenance System(hereinafter referred to as "PMS")** is a system that maintains the state of the machinery/equipment through overhaul survey and replacement of parts according to the survey schedule approved by the Society on the basis of a certain period. In principle, overhaul survey period does not exceed 5 years.
2. **Time-based maintenance(hereinafter referred to as "TBM")** is a method of survey and maintenance for a certain period of time or at regular intervals based on the operating time regardless of the state of the device.
3. **Condition Monitoring(hereinafter referred to as "CM")** is the process of collecting and processing information and data indicating the machine status over time through sensors and equipment approved by the Society.
4. **Diagnosis** is examining symptoms and signs to determine the cause of a defect or malfunction.
5. **Condition based maintenance(hereinafter referred to as "CBM")** is a method of diagnosing the condition of equipment and performing maintenance at an appropriate time based on the operation data of the machine/equipment acquired through condition monitoring.

Section 2 Maintenance Method

201. Maintenance Method

In general, the following maintenance methods can be considered.

1. Breakdown Maintenance

Breakdown Maintenance is a maintenance method for recovery after a failure can reduce the cost of equipment inspection, but since maintenance is performed after a failure occurs, downtime is unavoidable. In this case, downtime may be prolonged if replacement parts are not readily available. In

addition, failures may affect other components of the device, resulting in additional cost.

2. Preventive Maintenance

Preventive Maintenance is carried out according to a predetermined plan before a failure occurs. This maintenance includes time based maintenance(TBM) and condition based maintenance(CBM).

(1) Time Based Maintenance (TBM)

The advantage of TBM is that it avoids time lost due to equipment failure and makes it easier to schedule maintenance. However, since the inspection and maintenance cycle of the TBM is set with a margin based on past operation records, the life of the device remains, so it can be operated without any problems even at the time of maintenance. In addition, the possibility of malfunction due to an unintended problem after maintenance cannot be excluded even if the device operated without problems before the overhaul inspection.

(2) Condition Based Maintenance (CBM)

CBM generally reduces related costs and time because overhaul inspection and replacement of parts are performed at an optimal time compared to TBM. In addition, it is possible to reduce maintenance costs and time by minimizing the number of replacement parts by performing inspection and maintenance before a failure occurs. On the other hand, in order to perform CBM, it should be considered that the initial cost for a costly sensor, condition monitoring and diagnosis device is generally required. In addition, there is a need for knowledge to set baseline data to be measured and reference values to evaluate the need for inspection and maintenance to perform diagnosis.

Table 1. Comparison of maintenance methods

Method	Advantages	Disadvantages
Breakdown Maintenance	1. Inspecting cost saving	1. Downtime occurs 2. Actual repair cost may be higher than preventive maintenance cost
Time Based Maintenance (TBM)	1. Prevention of time loss due to breakdown 2. Easy to schedule maintenance	1. Relatively frequent open inspection and/or replacement of parts 2. Possibility of unintended malfunctions after scheduled maintenance
Condition Based Maintenance (CBM)	1. Prevention of time loss due to breakdown 2. Reduce inspection time 3. Reduce maintenance costs by using the parts of the machine up to the full lifespan	1. System required for status monitoring and diagnosis 2. CBM can be applied only to equipment for which diagnostic technology has already been developed.

Table 2. Maintenance procedure comparison

Survey Procedure	Continuous Machinery Survey (CMS)	Planned Maintenance System (PMS)	Condition Based Maintenance (CBM)
Maintenance Method	TBM		CBM
Overhaul Inspection Interval	Interval not exceeding 5 years	Interval not exceeding 5 years (Other intervals based on running hours are applicable if recommended by the manufacturer and approved by the Society)	If an abnormality is found through condition monitoring and diagnosis, and an overhaul inspection is deemed necessary
The need for a computer system	–	Planned maintenance system	Planned maintenance system and condition monitoring system

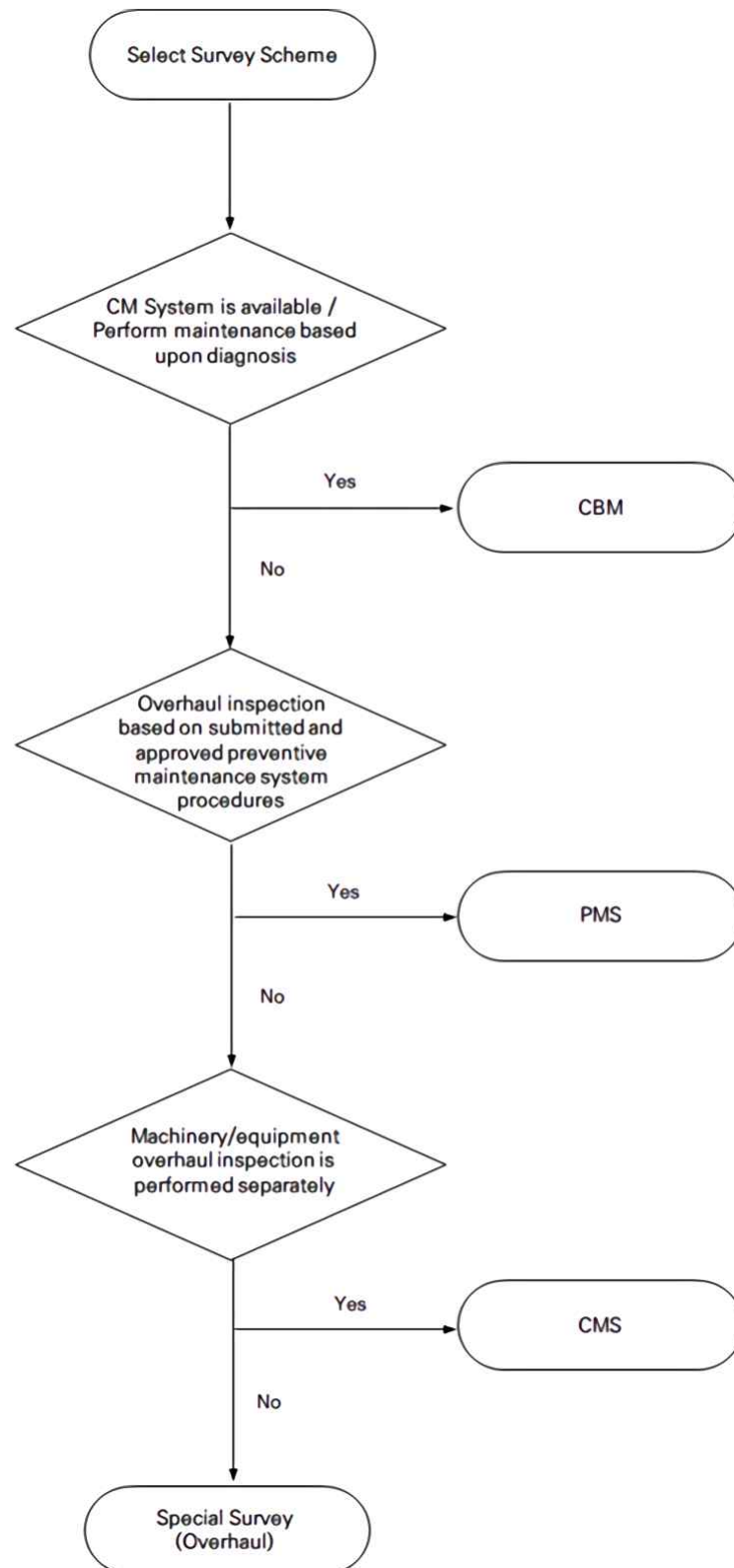


Figure 1 Selection of survey scheme for machinery/equipment

CHAPTER 2 Condition Based Maintenance (CBM)

Section 1 Application for CBM

101. Application

1. Select a list of machinery to which CBM is to be applied.
2. Submit the CBM application and the following documents to the Society.

(1) CBM Scheme

The following documents are required for equipment applied by CBM scheme.

- (A) Functions of the condition monitoring system
- (B) Condition monitoring and diagnostic procedures
- (C) Handling procedures in case abnormality is found (including maintenance records and reporting procedures to the Society)
- (D) Procedures to identify defects and failures that cannot be prevented by condition monitoring and diagnostics and to revise the CBM scheme accordingly

(2) Survey schedule table

This table is to include the following items for the classification survey.

(A) Annual audit items

For the annual audit, the condition monitoring record and maintenance record are presented to the surveyor, and the procedure to show that the condition monitoring system is functioning properly, etc., is to be described.

(B) Occasional survey (damage and repair) related items

If abnormality is found as a result of condition monitoring and diagnosis or abnormality occurs in the relevant machinery, the abnormality is to be reported to the Society and recorded. The Society reviews the report, if necessary, conducts occasional survey. In addition, when replacing part due to breakdown, the replaced part should be stored on the ship as much as possible and confirmed by the surveyor.

(3) Description of functions such as condition monitoring system

The following items should be included in the functional description of the condition monitoring system, etc.

(A) Condition monitoring system components

Computers that collect and process information via sensors, and communications facilities that transmit data to onshore facilities for analysis must be arranged for use on board ships.

(B) Condition monitoring system function description

There should be sufficient functional description for use by the chief engineer. If the measured value obtained from a sensor other than those provided by the condition monitoring system is required for condition monitoring and diagnosis, it should be possible to input the measurement method and measurement result.

(C) Condition monitoring system maintenance manual

Sufficient maintenance manuals are to be provided for use by the chief engineer.

(4) Functional description of the maintenance management system

Based on the information of the condition monitoring system, it should be possible to manage the inspection, maintenance, importance, and inspection schedule for each machine/equipment and its components. This function can also be integrated into a condition monitoring system.

(5) Condition monitoring record

Condition monitoring record should be submitted. The form is to include the signatures of the Chief Engineer and the Class Surveyor.

(6) Baseline data and limiting parameters used for condition monitoring and diagnosis

The value of the parameter indicating the degree of abnormality is called "baseline data" and

the limit value of the abnormality judgment is called “threshold parameter”. Threshold parameter should be determined according to manufacturer recommendations or international standards for each machine/equipment. If this value is determined on the basis of data measured during operation, it should be submitted to the Society prior to the implementation survey.

(7) Organizational Responsibilities for CBM

Monitoring and diagnosis by the condition monitoring system does not replace the responsibility of the chief engineer to conduct regular inspections or make decisions based on the judgment of the chief engineer. Examples of responsibilities to CBM are shown in **Table 1**.

Table 1 Examples of responsibilities to CBM

		Master	Chief Engineer
Task		<ul style="list-style-type: none"> – Responsibility for the safety of ships 	<ul style="list-style-type: none"> – Responsible for implementing CBM – Authority and responsibility for condition monitoring of machines /equipment and verification of diagnosis results – When an abnormality is found, report the details to the captain and manager and request assistance if necessary
Role	In case of equipment status diagnosis on board	Providing support necessary for ship's CBM implementation such as spare parts investigation, management, and request	
	In case of equipment condition diagnosis on shore	Regularly share the ship's diagnosis results with the shore, and immediately share with the shore when an abnormality is identified	

Section 2 Implementation of CBM

201. Survey and Audit

1. Installation Survey

It should be verified that the condition monitoring and maintenance system is installed and operating properly. Also, it is to be confirmed the documents in **101. 2.** are available onboard. In the case of newbuilding, it is generally assumed that the survey is conducted during the mooring test or the sea test, but some survey items such as sensor installation can be carried out in advance at the shop test of the relevant machinery/equipment. Documents such as CBM scheme should be prepared prior to survey. In addition, it is advisable to prepare in advance because design modifications or other additional work may be required when installing sensors and computers.

2. Implementation Survey

The implementation survey should be carried out after the operating period of 6 months, and no later than the first periodic survey. Confirm that the CBM is operated according to the CBM scheme, and check that the baseline data and limiting parameters for parameters are entered into the condition monitoring system. Wherever possible, the limiting parameters should be determined

prior to the implementation survey. Upon completion of the implementation survey, the Society issues CBM certificate.

3. Annual Audit

Annual audits should be performed concurrently with periodical survey. During the annual audit, it is necessary to confirm that the CBM is in place according to the approved CBM scheme, including confirmation on proper operation of the condition monitoring and maintenance system and its condition monitoring and maintenance records. In addition, a general survey is performed on all machinery/equipment to which the CBM is applied. When surveyor found a potential abnormality while confirming the related records, etc., the surveyor may request an overhaul inspection of the relevant machinery/equipment and, if necessary, additional measurements may be carried out through the condition monitoring system.

4. Occasional Survey

When machinery/equipment is damaged or an abnormality affecting safe operation of the vessel is detected by the condition monitoring system, it should be reported to the Society and, if deemed necessary, occasional survey should be carried out. Occasional survey confirms that the abnormality or damage has been repaired. Circumstances reported to the Society are to be specified in the CBM scheme. In addition, repair to be performed for the safe operation of the vessel does not need to wait for the surveyor to attend, but the replaced parts should be kept on board where possible until confirmed by the surveyor.

5. Cancellation of CBM

In case of serious damage to the machinery/equipment despite the implementation of CBM, the Society may partially or fully cancel the CBM approval. Serious damage means that threatens the safety of crew members or impedes the safe navigation of the vessel. All machinery/equipment for which the CBM is canceled are converted to other survey schemes such as CMS, and the next overhaul inspection date should be within 5 years from the date of the occasional survey to confirm that the machinery has recovered from damage. However, if it is determined that the CBM can be safely applied after all necessary modifications, such as the detection method or limiting parameters of the condition monitoring system, are made, it is not necessary to cancel it. Also, in principle, when the ship's management company is changed, the CBM will be cancelled. Therefore, when the new management company wants to apply the existing CBM scheme or the new CBM scheme, it should be approved by the Society.

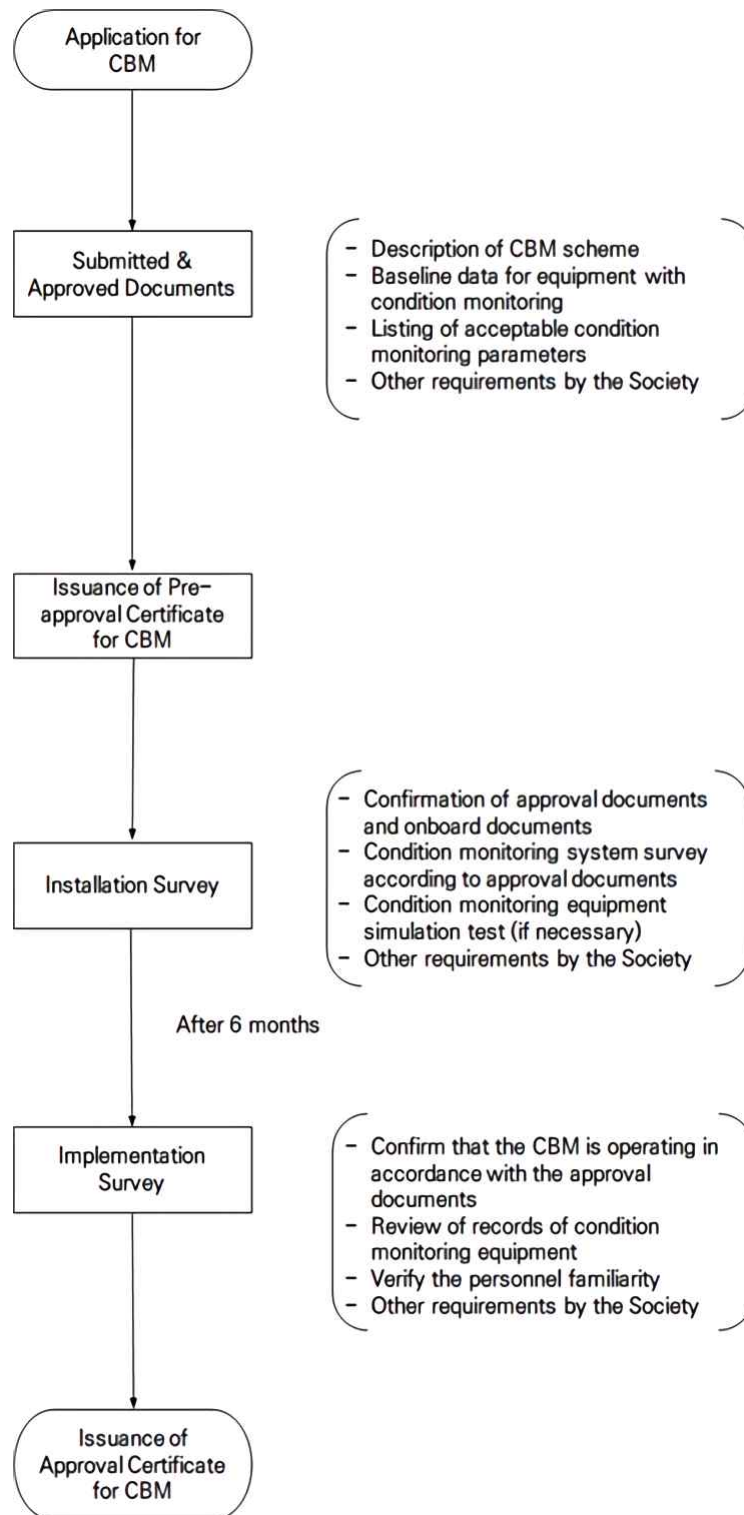


Figure 2 CBM Procedure

Section 3 Condition Monitoring System

301. Condition Monitoring System

1. It is assumed that status monitoring and diagnosis are carried out through the following methods.
 - (1) Computers on board for condition monitoring
 - (2) Transmission of data from ship to shore
 - (3) Combination of paragraphs (1) and (2)
2. In the case of using 1. (1), it is judged that it is not practical to continuously deploy a crew member with expertise in data analysis on board, so the relevant system should be made available to those who do not have expert knowledge. In this case, not only the functional processing of measurement data, but also the need to integrate anomaly detection and diagnosis logic into the condition monitoring system itself should be considered.
3. During the approval of the condition monitoring system, the system is surveyed to determine whether the condition monitoring and diagnosis of the related machinery/equipment can be performed. This survey is carried out according to documents such as the technical background of abnormality detection and diagnosis and/or other data confirming whether the condition monitoring system can detect abnormality through simulation or actual measurement data. Ownership of diagnostic technology can be considered, and the method of survey is determined by agreement between the applicant and the Society.
4. The hardware used in the condition monitoring system should comply with the following Rules.
 - (1) Sensor: **Ch 3 Sec 23 of the Guidance for Approval of Manufacturing Process and Type Approval, Etc** (Automatic and Remote Control Systems)
 - (2) Computer: **Pt 6, Ch 2, Sec 4. 403. 4 of the Rules.** ⚓

Annex 1 Approval of PMS/CBM Software

101. Application

1. Applies to approval of PMS / CBM software only if there is an application from the shipowner or manufacturer. However, the requirements of 3. (4) does not apply to software not used for CBM.
2. Documents

The following data are to be submitted to the Society with the application for approval.

- (1) Software: 1 copy (if an installation-only program is required, the corresponding program is also attached)
- (2) Instruction manual detailing the following: 3 copies (1 copy in the case of an electronic manual)
 - (A) Operating environment (Central processing unit, OS, required storage and memory capacity, etc.)
 - (B) Procedures for installation and deletion
 - (C) Function
 - (D) How it works
- (3) Other materials deemed necessary by the Society

3. Functional requirements

- (1) Planned maintenance function

The software should have the following functions.

- (A) Being able to register not only the items to be inspected as prescribed by PMS and CBM, but also all devices that require maintenance.
- (B) It is possible to designate the maintenance period or operation time of machinery, equipment and their components.
- (C) At least the following items should be displayed in a list. In addition, the list is to be displayed in a tree structure, etc. by appropriately classifying the registered machinery, equipment and its components.
 - (a) Names of machinery, equipment and its components;
 - (b) Maintenance items
 - (c) Maintenance period (indicate next inspection date or operating hours)
 - (d) Maintenance schedule (in which inspection dates can be entered directly or calculated from maintenance period)
 - (e) Maintenance person in charge
- (D) The maintenance interval is, in principle, planned within the range of not exceeding 5 years. In addition, work to be performed within an arbitrarily designated period can be displayed in a list.
- (E) When there is maintenance work that has passed maintenance time, it can be easily identified.

- (2) Maintenance record function

The software shall have the following maintenance recording functions.

- (A) Being able to manage and record the results of maintenance work carried out in accordance with (1). Management and recording items should include at least the following:
 - (a) Names of machinery, equipment and their components
 - (b) Contents and results of work (including replacement of parts);
 - (c) the date of completion of the work;
 - (d) total running hour
 - (e) the next inspection date;
 - (f) Measurement data (including design dimensions and allowable values. However, it is limited to the case of measurement.)
 - (g), if any, the circumstances and methods of repair;

- (B) Able to display a list of maintenance work performed within a specified period and within that period. The list should include the names of machinery, equipment and their components, the contents of the work, and the date of completion of the work.
- (C) Able to display a list of past histories related to maintenance by arbitrarily selecting machinery, equipment and their components.
- (3) Spare parts management function

The software should be capable of managing spare parts of machinery, devices and their components.
- (4) Condition monitoring function
 - (A) Software should have the function of monitoring the status of machinery, devices and their components as necessary. Such status monitoring should be capable of analysis such as trend analysis if necessary. When trend analysis is applied, the following requirements should be met.
 - (a) When measurement data changes due to the influence of temperature, engine speed, load, etc., such data can be standardized and trend analysis can be performed on the index. However, exceptions are made in the case of performing trend display by collecting measurement data during normal operation.
 - (b) The upper and lower limits of the limiting parameters of the measurement data should be determined by the manufacturer's recommendations. However, it can also be determined by statistical processing based on the reference data, and in this case, it should be possible to automatically calculate the limiting parameters based on the accumulated data. But this limit may be determined by other methods recognized by the Society.
 - (c) The trend of measurement data can be displayed along with the limit value by simple operation.
 - (B) Software can be used diagnostic techniques, such as complex algorithms, machine learning and statistical knowledge, obtained from machinery data installed on other ships, etc. The software does not have to follow the maintenance guidelines recommended by the machine manufacturer or use the limiting parameters specified by the manufacturer. However, in this case, the software should be approved in accordance with the recommendations of manufacturers registered with the Society, industry standards and history of use.
 - (C) Maintenance based on the condition monitoring specified in (A) above shall be in accordance with the following.
 - (a) Planned maintenance
 - (i) machinery, equipment and their components subject to condition monitoring can be registered separately from those subject to regular overhaul inspection.
 - (ii) The registration of machinery, equipment and their components subject to condition monitoring shall include the following items.
 - ① Names of machinery, equipment and their components
 - ② Type of signal to be measured
 - ③ Measurement interval
 - ④ Limited parameter (set for each type of signal to be measured)
 - (b) processing and recording at the time of measurement
 - (i) To record the date of measurement and the value of the measurement.
 - (ii) Being able to record the results of maintenance work as in 3. (2) above, when overhaul inspection is performed.

4. Software management

- (1) Revision

Manufacturers and system administrators should properly manage the revision of software following system changes, and identification information regarding revision should be available from the main screen or menu.
- (2) Back-up

Manufacturers and system managers should specify appropriate procedures for back-up the maintenance data they manage.

5. Installation survey

After reviewing the attached data in **2**, in principle, the Society is to conduct confirmation tests for the functional requirements in **3**. The test can be conducted on the ship in the actual operating condition. However, an exception is made when the function can be confirmed by the submitted software. ↓

GUIDLINES FOR CONDITION BASED MAINTENANCE (CBM)

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