

# TÜRK LOYDU



## Chapter 25 – Machinery Condition Monitoring

**JULY 2019**

This latest edition incorporates all rule changes. The latest revisions are shown with a vertical line. The section title is framed if the section is revised completely. Changes after the publication of the rule are written in red colour.

Unless otherwise specified, these Rules apply to ships for which the date of contract for construction as defined in TL- PR 29 is on or after 1<sup>st</sup> of July 2019. New rules or amendments entering into force after the date of contract for construction are to be applied if required by those rules. See Rule Change Notices on TL website for details.

"General Terms and Conditions" of the respective latest edition will be applicable (see Rules for Classification and Surveys).

If there is a difference between the rules in English and in Turkish, the rule in English is to be considered as valid. This publication is available in print and electronic pdf version. Once downloaded, this document will become UNCONTROLLED. Please check the website below for the valid version.

<http://www.turkloydu.org>

All rights are reserved by Türk Loydu, and content may not be reproduced, disseminated, published, or transferred in any form or by any means, except with the prior written permission of **TL**.

## **TÜRK LOYDU**

### **Head Office**

Postane Mah. Tersaneler Cad. No:26 Tuzla 34944 İSTANBUL / TÜRKİYE

Tel : (90-216) 581 37 00

Fax : (90-216) 581 38 00

E-mail : [info@turkloydu.org](mailto:info@turkloydu.org)

<http://www.turkloydu.org>

### **Regional Offices**

#### **Ankara**

Eskişehir Yolu Mustafa Kemal Mah. 2159. Sokak No : 6/4 Çankaya - ANKARA / TÜRKİYE

Tel : (90-312) 219 56 34

Fax : (90-312) 219 68 25

E-mail : [ankara@turkloydu.org](mailto:ankara@turkloydu.org)

#### **İzmir**

Atatürk Cad. No :378 K.4 D.402 Kavalalılar Apt. 35220 Alsancak - İZMİR / TÜRKİYE

Tel : (90-232) 464 29 88

Fax : (90-232) 464 87 51

E-mail : [izmir@turkloydu.org](mailto:izmir@turkloydu.org)

#### **Adana**

Çınarlı Mah. Atatürk Cad. Aziz Naci İş Merkezi No:5 K.1 D.2 Seyhan - ADANA / TÜRKİYE

Tel : (90- 322) 363 30 12

Fax : (90- 322) 363 30 19

E-mail : [adana@turkloydu.org](mailto:adana@turkloydu.org)

**Machinery Condition Monitoring**

	<b>Page</b>
<b>Section 1 - General</b>	
A. General .....	1- 2
B. Application .....	1- 2
C. Documents to be Submitted .....	1- 4
D. Survey Arrangement .....	1- 5
E. Planned Maintenance System .....	1- 5
<b>Section 2 - Requirements for the Design of Condition Monitoring Systems</b>	
A. General Requirements .....	2- 2
B. Condition Monitoring (CM)	
C. Condition Based Maintenance (CBM)	
D. Requirements for Installation .....	2- 2
E. Requirements for Software .....	2- 3
F. Steps of Acceptance .....	2- 3
<b>Section 3 - Requirements for Operation</b>	
A. Operating Personnel .....	3- 2
B. Measurements .....	3- 2
C. Analysis .....	3- 2
D. Reporting .....	3- 3
E. Documents available on Board .....	3- 3
<b>Section 4 - Surveys</b>	
A. General .....	4- 2
B. Implementation Survey .....	4- 2
C. Final Approval .....	4- 2
D. Annual Audit .....	4- 2
E. Non-periodical Surveys .....	4- 2
<b>Annex A - Examples for Application</b>	
A. Scope .....	A- 2
B. Cranktrain Bearings of Low-speed Diesel Engines .....	A- 2
C. Centrifugal Pumps .....	A- 2
D. Accumulator Battery .....	A- 4
<b>Annex B - Standards for Lubricating Oil Analysis</b>	
A. Test Methods .....	B- 2

**SECTION 1****GENERAL****Page**

<b>A. GENERAL</b> .....	<b>1- 2</b>
1. Application	
2. Purpose	
3. Structure of Condition Monitoring Systems	
4. Equivalence	
<b>B. DEFINITIONS</b> .....	<b>1- 2</b>
1. Baseline Data	
2. Condition Based Maintenance	
3. Condition Based Survey	
4. Condition Monitoring	
5. Condition Monitoring Equipment	
6. Condition Monitoring System	
7. Condition Monitoring Method	
8. Machinery Component	
9. Machinery System	
10. Planned Maintenance System (PMS)	
11. Reference Conditions	
12. Reference Values	
13. Trend Analysis	
14. Diagnostic	
<b>C. DOCUMENTS TO BE SUBMITTED</b> .....	<b>1- 4</b>
1. General	
2. Scope of Documentation	
<b>D. SURVEY ARRANGEMENT</b> .....	<b>1- 5</b>
<b>E. PLANNED MAINTENANCE SYSTEM</b> .....	<b>1- 5</b>

**A. General****1. Application**

**1.1** These requirements apply to the approved Condition Monitoring and Condition Based Maintenance schemes where the condition monitoring results are used to influence the scope and/or frequency of Class survey.

**1.2** This scheme may be applied to components and systems covered by Continuous Machinery Survey (CMS), and other components and systems as requested by the owner. The extent of Condition Based Maintenance and associated monitoring equipment to be included in the maintenance scheme is decided by the Owner.

**1.3** These requirements can be applied only to vessels operating on approved PMS survey scheme.

**1.4** The scheme may be applied to any individual items and systems. Any items not covered by the scheme shall be surveyed and credited in accordance with the requirements of TL- R Z18 and / or TL- R Z20.

**1.5** These Guidelines can be applied to new ships and to existing ships. For already existing ships, for which a Survey Arrangement CM will be requested, special considerations concerning their actual wear and tear condition have to be undertaken.

**1.6** These Guidelines apply in addition to the **TL** Rules for Classification and Construction.

**1.7** If a Condition Monitoring System is used in the frame of a monitoring and control system and/or a safety system, the respective **TL** Rules for monitoring and control systems and/or for safety systems shall be applied, see in particular Chapter 5 – Electrical Installation, Section 9, B.

**1.8** For propeller shafts running within the stern tube in oil under special conditions the intervals between shaft withdrawals may be prolonged and the Class Notation **CM-PS** may be assigned, see Chapter 2 –

Machinery, Section 5, C.

**2. Purpose**

**2.1** The purpose of Condition Monitoring Systems is to detect ongoing deterioration, especially wear and tear, of Machinery Components or parts of them. For this purpose values of significant parameters are to be collected with the aid of an adequate measurement chain. The values shall be suitable to show an obvious trend of the monitored deterioration over a period of time.

**2.2** Condition Monitoring Systems shall be capable of producing relevant data trends from the values collected and compare them with pre-defined acceptance criteria (e.g. limit curves).

**2.3** Condition Monitoring for a Machinery Component, or parts of it, will be accepted by **TL**, if it is capable of producing reliable and trustworthy information for determining the actual condition of the Machinery Component, or parts of it.

**2.4** The condition determination of a Machinery Component or parts of it, achieved from a **TL** accepted Condition Monitoring System, will be considered equivalent to condition determination by direct inspection, compare Section 4.

**3. Structure of Condition Monitoring Systems**

Condition Monitoring Systems are distinguished in three categories:

- fixed installed systems
- systems with portable measurement equipment
- sampling systems, e.g. for oil sampling

**4. Equivalence**

Condition Monitoring Systems deviating from these Guidelines in their type, equipment or some of their parts may be accepted, provided that they are found to be equivalent to the **TL** requirements.

## B. Definitions

The following definitions are used in this Guideline.

### 1. Baseline Data

Baseline Data are generally obtained during operation on board, where the performance of the component is considered to meet the initial condition.

Baseline Data are measured or observed Reference Values defining the initial condition of a Machinery Component or parts of it, during operation under Reference Conditions.

### 2. Condition Based Maintenance

Maintenance performed as governed by condition monitoring programmes.

It is recommended to include the so-called Condition Based Maintenance actions into the Planned Maintenance System.

### 3. Condition Based Survey

A Condition Based Survey for Machinery Components operating under Condition Monitoring is a survey where the TL Surveyor primarily checks the Condition Monitoring Reports defined in Section 3, D. If such reports are giving evidence to the Surveyor that the Component or part of it, is in an acceptable running condition, he may grant a waiver from dismantling of the Component for direct inspection.

### 4. Condition Monitoring

Acquisition and processing of information and data that indicate the state of a machine over time. The machine state deteriorates if faults or failures occur.

Within the scope of these Guidelines a clear distinction is made between Condition Monitoring and monitoring for control or safety systems (see A.1.5).

### 5. Condition Monitoring Equipment

Condition Monitoring Equipment is any equipment used

to carry out Condition Monitoring measurements.

### 6. Condition Monitoring System

Condition Monitoring System is a system used to detect the condition of a component. It consists of Condition Monitoring Equipment, procedures, schedules as well as methods for data collection and analysis procedures including trend estimation.

### 7. Condition Monitoring Method

The condition Monitoring Method describes the technique for the collection and evaluation of information about the condition of components or parts of it. Examples are vibration monitoring, oil analysis, performance monitoring, thermography or motor current signature analysis.

### 8. Machinery Component

Machinery Components are units, such as diesel engines, generators, pumps, compressors, fans. Machinery Components consist of machinery parts, such as bearings, rotors, etc.

### 9. Machinery System

A Machinery System is a group of Machinery Components, providing specific functions for the operation of the ship's machinery and/or cargo refrigerating installation. Examples for Machinery Systems are fuel oil systems, cooling systems, ventilation systems, etc.

### 10. Planned Maintenance System (PMS)

PMS is a computerized system that organises maintenance and overhaul activities of machinery and electrical plant components according to manufacturers', Owners' and/or Classification Societies' requirements. The system includes maintenance intervals, maintenance instructions, lists of required spare parts, measurement records and other relevant information.

For the requirement of such a system see Classification and Surveys, Section 3, A 4.5.

## 11. Reference Conditions

Reference Conditions are operating and/or ambient conditions during recording of Condition Monitoring data, e.g. operating conditions of the monitored component (e.g. speed, temperatures, pressures), operating conditions of surrounding systems, operating conditions of the ship (e.g. speed, draft) and relevant ambient conditions (e.g. temperature, barometric pressure, sea state, wind).

Reference Conditions are described by respective reference parameters.

Reference Conditions should be reproducible during normal operation.

## 12. Reference Values

Reference values are values of the measurement parameters or descriptors that define the condition of a Machinery Component or part of it, which is in an acceptable running condition. With respect to Trend Analysis, Reference Values are also referred to as Baseline Data.

Reference Values are valid only for predefined Reference Conditions. They can be obtained by measurement or observation of a component or part of it, which is proven to be free of failure or by rules and standards.

## 13. Trend Analysis

A Trend Analysis presents time histories of measurement parameters or descriptors to evaluate the extent and progress of deterioration and the trends for the future.

## 14. Diagnostic

Examination of symptoms and syndromes to determine the nature of faults or failures.

### C. Documents to be Submitted

#### 1. General

The required drawings, documents, calculations and supporting documentation are to be submitted in

Turkish or English language. This shall be done at a sufficiently early date before the Condition Monitoring System is installed on the ship. For prototype systems special agreements may be considered.

## 2. Scope of Documentation

If the TL approval for a Condition Monitoring System is requested with the aim to conclude a Survey Arrangement CM (see D.) the following documentation has to be submitted to TL Head Office for approval.

### 2.1 Listing of Machinery Components to be covered

A list and description of the Machinery Components to be covered by Condition Monitoring shall be provided.

### 2.2 Condition Monitoring System

Descriptions of the complete Condition Monitoring System to be used specifying the following items:

- overview of the system
- functional description, including user manual, parameter definition, data collection method, data handling, data analysis method
- local arrangement including location and orientation of measuring points
- sampling method and sampling points, if applicable
- wiring diagram, if applicable
- power supply scheme, if applicable
- parts list including sensors (model, type, manufacturer, technical data sheet, attachment method) and data collection instruments (model, type, manufacturer, technical data sheet)
- TL approval for the Condition Monitoring System (see Section 2, D.), if already existing
- TL approval, if already existing, for installation of the measuring device (e.g. sensors, cables etc.)

on the respective Machinery Component based on the agreement of the Component manufacturer

- Procedure for changes to software system and CM parameters
- Listing of equipment to be included in the scheme
- Listing of acceptable condition monitoring parameters
- Description of CBM scheme
- Listing, specifications and maintenance procedures for condition monitoring equipment
- Baseline data for equipment with condition monitoring
- Qualification of personnel and company responsible for analysing CM results

### 2.3 Details about Machinery Components

For each Machinery Component covered by Condition Monitoring the following items shall be specified:

- actual condition of each Component, e.g. information about running hours, etc.
- procedure of Baseline Data collection, including specification of Reference Condition(s)
- procedure and schedule for collection of actual operating data
- procedure and schedule for data analysis (including applied acceptance criteria for parameters) and reporting the results.
- procedure and schedule for calibration and functional tests of Condition Monitoring Equipment
- agreement of Component manufacturer to the

Condition Monitoring parameters, Condition Monitoring Method, Reference Values, etc.

### 2.4 Further Documents

TL reserves the right to demand other documents where these submitted are not adequate to provide an evaluation of the system.

### 2.5 Modifications/extensions of Machinery Components or Condition Monitoring Systems

Major modifications of the Machinery Components and/or the Condition Monitoring System which may affect the functioning of the approved Condition Monitoring System on a ship under construction or at sea are also subject to approval by TL. Documents are to be submitted in due time before conversion.

### D. Survey Arrangement

1. Where Machinery Components subject to Class Surveys are covered by Condition Monitoring, a Survey Arrangement CM can be agreed between the owner/operator of the ship and TL.

2. The Survey Arrangement CM shall follow the relevant requirements defined in the following Sections.

3. Machinery Components covered by the Survey Arrangement CM will be listed in the Approval Certificate.

### E. Planned Maintenance System

The Condition Monitoring System shall be used in the framework of a computerized Planned Maintenance System (PMS). The elements of the PMS considering the Machinery Components or part of them covered by Condition Monitoring shall be approved by TL according to the TL Rules Classification and Surveys, Section 3, A 4.5.



**SECTION 2****REQUIREMENTS FOR THE DESIGN OF CONDITION MONITORING SYSTEMS****Page**

<b>A. GENERAL REQUIREMENTS</b> .....	<b>2- 2</b>
1. Ambient Conditions	
2. Interference to Machinery Control	
<b>B. CONDITION MONITORING (CM)</b>	
<b>C. CONDITION BASED MAINTENANCE (CBM)</b>	
<b>D. REQUIREMENTS FOR INSTALLATION</b> .....	<b>2- 3</b>
1. General	
2. Equipment and System Requirements	
3. Portable Systems	
4. Fixed Installed Systems	
5. Central Recording and Processing Computer	
6. Onboard Responsibility	
<b>E. REQUIREMENTS FOR SOFTWARE</b> .....	<b>2- 4</b>
1. Data Measurement	
2. Data Analyses	
<b>F. STEPS OF ACCEPTANCE</b> .....	<b>2- 4</b>
1. Design Approval	
2. Type Approval for Components of Condition Monitoring Systems	
3. Case by Case Approval of a Condition Monitoring System	
4. Type approval of Condition Monitoring Systems	
5. Approval Validity	

**A. General Requirements****1. Ambient conditions**

The Condition Monitoring System has to operate under the ambient conditions of ship machinery installations as defined in the TL Rules Chapter 4 – Machinery, Section 1, C. The degree of protection of electric/electronic components against the ingress of foreign bodies and water according to TL Rules Chapter 5 – Electrical Installation, Section 1, K is to be considered.

**2. Interference to machinery control**

Data acquisition from machinery control and monitoring systems for Condition Monitoring purposes has to be free of reactive effects.

**B. Condition Monitoring (CM)**

1. Where an approved condition monitoring system is fitted, credit for survey may be based on acceptable condition monitoring results. The condition monitoring results are to be reviewed during the annual audit.

2. Limiting parameters are to be based on the Original Equipment Manufacturers guidelines (OEM), or a recognised international standard.

3. The condition monitoring system is to provide an equivalent or greater degree of confidence in the condition of the machinery to traditional survey techniques.

4. The condition monitoring system shall be approved in accordance with subsection F.

5. A condition monitoring system may be used to provide a greater understanding of equipment condition, and a condition based maintenance scheme may be used to obtain maintenance efficiency. Class approval is required where owners wish to change the survey cycle based on CM/CBM.

6. Software systems can use complex algorithms, machine learning and knowledge of global equipment populations/defect data in order to identify acceptability for continued service or the requirement for maintenance. These systems may be independent of the OEM recommended maintenance and condition monitoring suggested limits. Approval of this type of software is to be based on OEM recommendations, industry standards and TL experience.

7. TL retains the right to test or open-up the machinery, irrespective of the CM results, if deemed necessary.

**C. Condition Based Maintenance (CBM)**

1. Where an owner wishes to base their equipment maintenance on a CBM approach, this is to meet the requirements of the ISM Code.

2. Where an agreed planned maintenance and CBM scheme is in operation, the CMS and other survey intervals may be extended based on OEM maintenance recommendations and acceptable condition monitoring results.

3. Limiting parameters (alarms and warnings) are to be based on the OEM guidelines, or a recognised international standard.

4. The CBM scheme is to provide an equivalent or greater degree of confidence in the condition of the machinery to traditional maintenance techniques.

5. The scheme shall be approved in accordance with subsection F.

6. Software systems can use complex algorithms, machine learning and knowledge of global equipment populations/defect data in order to identify acceptability for continued service or the requirement for maintenance. These systems may be independent of the OEM recommended maintenance and condition monitoring suggested limits. Approval of this type of software is to be based on OEM recommendations, industry standards and TL experience.

## D. Requirements for Installation

### 1. General

1.1 Correct functioning and accuracy in measurement of all measurement devices shall be assured by individual functional tests and regular calibration procedures. They have to be documented. Equipment for functional tests of the measurement devices shall be available on board.

1.2 The manufacturer of a Machinery Component to be included in the Condition Monitoring System has to give his agreement to the installation of the measuring device on the Component as well as to the Condition Monitoring Method to be introduced for the Component. On the basis of this agreement **TL** can approve the above mentioned installation and the Condition Monitoring Method.

1.3 All parts of the Condition Monitoring System have to be installed in a way to enable accessibility for survey, maintenance, repair and calibration.

1.4 If parts of Machinery Components or even Components as a whole, which influence the design and/or operation of the Condition Monitoring System, have to be changed/renewed, it shall be ensured that the Condition Monitoring System is still functioning reliably.

1.5 In principle, Machinery Components already in service can only be included in a Condition Based Maintenance scheme, if evidence is given that the Components are in a condition close to their initial condition. In any case, an initial survey is mandatory.

1.6 It is recommended that the implementation process is assisted by an expert familiar with the Condition Monitoring System and with the respective Machinery Component.

### 2. Equipment and System Requirements

2.1 CM equipment and systems shall be approved in accordance with subsection F.

2.2 The CM/CBM scheme and its extent, are to be approved by **TL**.

2.3 The CBM scheme is to be capable of producing a condition report, and maintenance recommendations.

2.4 A system is to be provided to identify where limiting parameters (alarms and warnings) are modified during the operation of the scheme.

2.5 Where CM and CBM schemes use remote monitoring and diagnosis (i.e. data is transferred from the vessel and analysed remotely), the system is to meet the applicable standards for Cyber Safety and Security. The system shall be capable of continued onboard operation in the event of loss of the communication function.

2.6 CBM schemes are to identify defects and unexpected failures that were not prevented by the CM system.

2.7 Systems shall include a method of backing up data at regular intervals.

### 3. Portable systems

Portable measurement devices are used for such systems.

The position of the measurement points, and in case of directed values, the measurement direction, shall be marked permanently. The coupling of the sensor to the measurement point shall be designed in an adequate way to avoid any human influences.

### 4. Fixed Installed Systems

4.1 The measuring devices shall be fixed installed at the Machinery Components to be monitored.

4.2 The cables for data transfer shall comply with the requirements of the **TL** Rules Chapter 5 – Electrical Installation, Section 12.

4.3 The Condition Monitoring System has to be equipped with a directly connected central recording and processing unit.

4.4 Disturbed data collection shall be indicated and recorded in a log file.

## 5. Central recording and processing computer

**5.1** The provided central recording and processing computer shall be capable of running the necessary analysis programs. The storage capacity shall be suitable to keep the data used for the Annual Condition Monitoring Reports (see Section 3, D.2) at minimum since the last Annual Survey.

**5.2** Computers in systems to be type approved shall meet the requirements defined in Chapter 5 – Electrical Installation, Section 10.

**5.3** The computer system has to be only accessible for authorized operating personnel, see Section 3, A.

## 6. Onboard Responsibility

**6.1** The chief engineer shall be the responsible person on board in charge of the CM and CBM.

**6.2** Documentation on the overhaul of items covered by CM and CBM schemes shall be reported by the chief engineer.

**6.3** Access to computerized systems for updating of the maintenance documentation and maintenance program shall only be permitted by the chief engineer or other authorized person.

**6.4** All personnel involved in CM and CBM shall be appropriately qualified.

*Note: CM does not replace routine surveillance or the chief engineer's responsibility for taking decisions in accordance with his judgement.*

## E. Requirements for Software

The software for the central recording and processing computer shall meet the requirements defined in Chapter 5 – Electrical Installation, Section 10. In addition, the following requirements shall be fulfilled.

### 1. Data Measurement

**1.1** Reference Values for the parameters to be monitored shall be accepted by the manufacturer of the

monitored Machinery Component, the Condition Monitoring System provider and require approval by TL.

**1.2** The Reference Values shall be displayed together with the trend curves.

**1.3** Reference parameters defining Reference Conditions and Condition Monitoring data shall be measured within an adequate time window to ensure that the values belong to the same operating conditions.

**1.4** The sampling rate of the data acquisition shall be adequate for the respective duty of the Condition Monitoring method.

**1.5** The evaluation rate shall be adequate to ensure detection of failures at the Machinery Components in time.

**1.6** In fixed installed systems all data which define the Reference Conditions of the Machinery Component shall be made available.

## 2. Data analyses

### 2.1 Monitoring and diagnosis

The Condition Monitoring System used to evaluate a component's condition shall provide adequate monitoring and diagnosis functions. These functions shall enable a clear evaluation of the actual condition of the component or parts of it.

### 2.2 Trend analysis

A trend analysis has to be established for the time development of the measurement values. For this the measurement values are to be presented over the operation time considering the Reference Conditions. From this presentation it shall be possible to derive the consequences for necessary actions.

## F. Steps of Acceptance

If an owner/operator of a ship requests a Survey Arrangement CM as defined in Section 1, D. the following steps of technical acceptance have to be executed:

### 1. Design Approval

The documentation as defined in Section 1, C. has to be submitted to **TL** Head Office and checked to achieve the design approval.

### 2. Type approval for components of Condition Monitoring Systems

All essential components of a Condition Monitoring System have to be type approved. For detailed requirements see **TL** Rules, Additional Rules and Guidelines, Guidelines for the Performance of Type Approvals, and Chapter 5 – Electrical Installation, Section 10.

### 3. Case by Case Approval of a Condition Monitoring System

**3.1** For an approval of a Condition Monitoring System designed for a special, singular application on board of a ship the components of the Condition Monitoring System shall be type approved according to 2.

**3.2** After installation of the complete fixed or portable system on board of the ship, tests will be made in presence of **TL** representatives considering the overall functioning during the sea trials and after an operating time of successful operation – the length of which will be defined according to scope and complexity of the system – the Condition Monitoring System is approved.

### 4. Type approval of Condition Monitoring Systems

**4.1** It is possible to get – on request – also type approval for a complete, fixed installed Condition Monitoring System. In this case the components shall be type approved according to 2. and the overall functioning of the system has to be proven by suitable tests.

After successful testing, a Type Approval Certificate will be issued with the remark that a successful check of the application on board is still pending.

**4.2** If a system with a Type Approval Certificate according to 4.1 is installed on board of a ship, after the sea trials and after an operating time of successful operation – the length of which will be defined according to scope and complexity of the system – the Type Approval Certificate will get the remark that the application on board has been successful.

### 5. Approval Validity

**5.1** An Annual Audit shall be carried out to maintain the validity of the CM/CBM scheme.

**5.2** The survey arrangement for machinery under CM/CBM can be cancelled by **TL** if the scheme is not being satisfactorily carried out either from the maintenance records or the general condition of the machinery.

**5.3** The case of sale or change of management of the ship or transfer of class shall cause the approval to be reconsidered.

**5.4** The ship owner may, at any time, cancel the survey arrangement for machinery under the scheme by informing **TL** in writing and for this case the items which have been inspected under the scheme since the last annual Audit can be credited for class at the discretion of the attending surveyor.

**SECTION 3****REQUIREMENTS FOR OPERATION**

	<b>Page</b>
<b>A. OPERATING PERSONNEL</b> .....	<b>3- 2</b>
<b>B. MEASUREMENTS</b> .....	<b>3- 2</b>
1. Intervals	
2. Baseline Data	
3. Reference Conditions	
4. Documentation of Results	
5. Significant Failures and Defects	
<b>C. ANALYSIS</b> .....	<b>3- 2</b>
1. Documentation	
2. Reference Values	
3. Special Analysis Methods	
<b>D. REPORTING</b> .....	<b>3- 3</b>
1. Immediate Reports	
2. Annual Condition Monitoring Report	
<b>E. DOCUMENTS AVAILABLE ON BOARD</b> .....	<b>3- 3</b>

## A. Operating Personnel

1. The chief engineer shall be the responsible person on board in charge of the Condition Monitoring Systems.
2. The operation of Condition Monitoring Systems is to be carried out only by assigned personnel.
3. The qualification of the operating personnel has to be proven by adequate documents, compare Section 4, B.2.

Such documents may relate to existing experience with Condition Monitoring and/or suitable training received/planned for the Condition Monitoring System installed on the ship.

## B. Measurements

### 1. Intervals

Measurements for Condition Monitoring purposes shall be taken at defined intervals. The length of the intervals depends on the individual monitoring task and has to be defined for each individual task and each component.

### 2. Baseline Data

**2.1** Baseline Data shall be taken at Reference Conditions. The conditions have to be documented during measurements and shall be adjusted during the period of successful operation according to Section 2, D.3. and D.4.

Measurements of Baseline Data have to be carried out to the satisfaction of **TL**.

**2.2** For retrofit of a Condition Monitoring System, special consideration has to be given regarding the definition of the Reference Values of each component subject to Condition Monitoring. This has to be done on a case by case basis.

### 3. Reference Conditions

Measurements for Condition Monitoring purposes shall be taken at Reference Conditions. The Reference Conditions have to be documented. In case that

Reference Conditions cannot be established at the time of the measurements, the measured values shall be converted to Reference Conditions, applying suitable conversion algorithms.

### 4. Documentation of results

To facilitate the comparison of the actual measurement results with the Baseline Data, Baseline Data shall be displayed or noted together with the documented results.

### 5. Significant failures and defects

Significant failures and defects of the Condition Monitoring System which cause that trends of the measured data cannot be controlled, have to be repaired promptly.

## C. Analysis

### 1. Documentation

Measurement results shall be documented in tables or graphs. The trend of the measured data versus time has to be documented and is in general the relevant information to judge the condition of the monitored Machinery Component.

### 2. Reference Values

**2.1** Reference Values shall be presented together with the documented results. A comparison of the measured values with the Reference Values provides the basis for the assessment of the condition status.

**2.2** Reference Values may be reconsidered, taking into account the operation experience with the individual machinery on board the ship. See also Section 2, C.1.1.

### 3. Special analysis methods

The requirements for special analysis methods, like the periodical analysis of liquids, will be defined case by case depending on the application.

**D. Reporting****1. Immediate reports**

1.1 Any modifications of the Condition Monitoring System, its procedures and/or schedules have to be reported to TL's Head Office for approval.

1.2 TL's Head Office shall be informed, if scheduled Condition Monitoring measurements cannot be performed due to failures/defects defined in B.5.

**2. Annual Condition Monitoring Report**

An Annual Condition Monitoring Report has to be submitted to TL's Head Office at least four weeks prior to the annual survey onboard the ship. It shall contain:

- a list of all Machinery Components covered by Condition Monitoring with the condition status of each component and the respective trend curves stated. The status and the trend curves are to be based on all results including the latest measurements.
- a summary list of all Machinery Components covered by Condition Monitoring that has been modified, repaired, and/or maintained unscheduled, together with a description of the causes
- a description of any changes made regarding the Condition Monitoring System, including a statement of the reason
- failures and defects experienced with the Condition Monitoring System

For the year where Class Renewal of the ship is due, the same Annual Report as defined above has to be submitted.

**E. Documents available on Board**

The following documentation shall be available on board:

- relevant manuals for all Condition Monitoring Systems

- records of measurements including Baseline Data taken, sample analyses results received, as well as corresponding data trends for the machinery covered by Condition Monitoring
- calibration protocols and functional tests protocols for the Condition Monitoring Equipment
- reports of modifications on a component, repairs or unscheduled maintenance, including the analysis of the reasons
- records of training in the use of the Condition Monitoring Equipment on board, or similar means to prove adequate qualification for each person assigned to carry out Condition Monitoring procedures
- all reports concerning Condition Monitoring for at least the last five years of operation
- All clauses in Section 1 C.2.2 in an up-to-date fashion
- Maintenance instructions (manufacturer's and shipyard's)
- Condition monitoring data including all data since last opening of the machine and the original base line data
- Reference documentation (trend investigation procedures etc.)
- Records of maintenance including repairs and renewals carried out
- Records of changes to software systems and parameters
- Sensors calibration records / certification / status



**SECTION 4****SURVEYS**

	<b>Page</b>
<b>A. GENERAL</b> .....	<b>4- 2</b>
1. Avoidance of Direct Survey	
2. Direct Survey	
3. Installation Survey	
<b>B. IMPLEMENTATION SURVEY</b> .....	<b>4- 2</b>
<b>C. FINAL APPROVAL</b> .....	<b>4- 2</b>
<b>D. ANNUAL AUDIT</b> .....	<b>4- 2</b>
<b>E. NON-PERIODICAL SURVEYS</b> .....	<b>4- 2</b>
1. Damage and Repair Surveys	
2. Conversion Surveys	
3. Change of Ownership or Management	

**A. General****1. Avoidance of direct survey**

Information derived from Condition Monitoring of a Machinery Component or parts of it, can be accepted by **TL** as equivalent to direct inspection, if the information are giving evidence that the Component or part of it, is in an acceptable running condition.

In this case, for the particular Machinery Component or parts of it, which are covered by Condition Monitoring, the Surveyor may grant a waiver from dismantling of the Component for direct inspection.

**2. Direct survey**

Any item of a component not covered by Condition Monitoring shall be surveyed and credited in the conventional way.

**3. Installation Survey**

**3.1** Condition monitoring equipment is to be installed and surveyed in accordance with these rules, and a set of base line readings is to be taken.

**B. Implementation Survey**

**1.** The Implementation Survey shall be carried out by **TL**'s surveyor no earlier than 6 months after installation survey and no later than the first Class annual survey.

**2.** During the Implementation survey the following shall be verified by a surveyor:

- the CM/CBM scheme is implemented according to the approval documentation, including a comparison with baseline data;
- the scheme is producing the documentation required for the Annual Audit and the requirements of surveys and testing for the maintenance of class are complied with;

- the onboard personnel are familiar with operating the scheme.

- records of any limiting parameters (alarms and warnings) that have been modified during the operation of the scheme.

- Records of any failures of monitored equipment are to be reviewed to ensure that the condition monitoring scheme is effective / sufficient.

**3.** When this survey is carried out and the implementation is found in order, a report describing the scheme shall be submitted to **TL** and the scheme may be put into service.

**C. Final Approval**

Final approval of the Condition Monitoring System implemented on board is achieved after a period of probation of at least six months. During this period the Condition Monitoring System has to prove its fitness under normal operating conditions. **TL** is to be informed of any required modifications.

**D. Annual Audit**

**1.** An annual audit of the CM and CBM scheme shall be carried out by **TL**'s surveyor concurrently with the Class annual survey.

**2.** The purpose of this audit shall be to verify that the scheme is being correctly operated and that the machinery has been functioning satisfactorily since the previous audit. This is to include any limiting parameters (alarms and warnings) that have been modified since the last audit. A general examination of the items concerned shall be carried out.

**3.** The performance, condition monitoring and maintenance records shall be examined to verify that the machinery has functioned satisfactorily since the previous survey, or action has been taken in response to machinery operating parameters exceeding acceptable tolerances.

4. Written details of break-down or malfunction shall be made available.
5. At the discretion of the surveyor, function tests, confirmatory surveys and random check readings, where Condition Monitoring / Condition Based Maintenance equipment is in use, shall be carried out as far as practicable and reasonable.
6. The familiarity of the chief engineer and other personnel involved with the CM system shall be verified.
7. Calibration status of sensors and equipment shall be verified.
8. Verification that the suitability of the CM/CBM scheme has been reviewed following defects and failures shall be carried out.

#### **E. Non-periodical Surveys**

##### **1. Damage and Repair Surveys**

- 1.1 Damage to components or items of machinery is to be reported to **TL**. The repairs of such damaged components or items of machinery are to be carried out to the satisfaction of the Surveyor.

**1.2** Details of repairs and maintenance carried out shall be examined. Any machinery part, which has been replaced by a spare one, due to damage, is to be retained on board where possible until examined by the **TL's** Surveyor.

**1.3** Defect and failure data is to be reviewed in order to ensure the system output is appropriate. Where necessary, following review of the failure data, there is to be a method of amending the CM and CBM scheme.

##### **2. Conversion Surveys**

In case of conversions of the Condition Monitoring System or Machinery Components covered by Condition Monitoring, surveys are to be conducted with a scope depending on the type and extent of the conversion and are to be decided case by case.

##### **3. Change of ownership or management**

In case of sale or change of management of the ship the Survey Arrangement CM shall be reconsidered regarding the assumptions on which the Condition Monitoring acceptance was based upon.

**ANNEX A****EXAMPLES FOR APPLICATION**

	<b>Page</b>
<b>A. SCOPE .....</b>	<b>ANNEXA -2</b>
<b>B. CRANKTRAIN BEARINGS OF LOW-SPEED DIESEL ENGINES.....</b>	<b>ANNEXA -2</b>
1. Description of Method	
2. Special Requirements	
3. Data to be Presented	
<b>C. CENTRIFUGAL PUMPS .....</b>	<b>ANNEXA -2</b>
1. Description of Method	
2. Special Requirements	
3. Data to be Presented	
<b>D. ACCUMULATOR BATTERY .....</b>	<b>ANNEXA -4</b>

**A. Scope**

1. The Condition Monitoring scope for a Machinery Component may be such that either the entire condition of the component can be evaluated or only the condition of a part of the component. As characteristic example, Table A.1 provides some typical Machinery Components with characteristic Condition Monitoring items and a range of relevant parameters that may be monitored.

2. The actual Condition Monitoring scope, the relevant parameters to be monitored and the limits and Reference Values for parameters are defined for each component on a case by case basis.

**B. Cranktrain Bearings of Low-speed Diesel Engines****1. Description of method:**

The position of the crosshead assembly is measured by two distance sensors for each cylinder compartment at bottom dead centre of the piston. If the surface of a target mounted at each guide shoe side of the crosshead enters the measuring range of the distance sensor, the lowest gap is evaluated and recorded. The values are compared with Reference Values agreed with the engine designer. In case of exceeding a limit value, a warning or an alarm can be triggered.

**2. Special requirements**

- The bearing monitoring system shall include enough data storage capacity to keep at minimum the trend curves of one class period of five years.
- The trend curve shall show a clear trend, i.e. that fluctuations caused by irregularities of the combustion process or by movements of the ship in rough sea state or by changes in engine speed should be smoothed or compensated.
- A crankcase inspection procedure published by the engine designer and approved by TL, shall exist. It shall contain clear instructions for inspection of respective parts of the cranktrain and for the corresponding time schedule.

**3. Data to be presented**

The following data has to be presented to the TL Surveyor:

- operating hours
- trend curve of distance values of the past year
- log file containing log statements for any warning or alarm including sensor failures if recognised
- protocols of crankcase inspections done by the chief engineer according to the engine designer's instructions
- documentation of maintenance and/or repair actions if done

**C. Centrifugal Pumps****1. Description of method:**

In most cases, centrifugal pumps consist of the casing with the impeller and the casing wear ring, the driving shaft with roller bearings and mechanical seal and the driving electric motor.

The condition of the roller bearings can be monitored by means of regular vibration measurements with a portable system at marked measurement locations. By evaluation of the vibration spectrum and the envelope spectrum, developing deterioration can be detected in an early stage and be allocated to the parts of the bearing, i.e. the inner or outer ring, the cage or the rolling elements.

The condition of the impeller, the casing and the casing wear ring can be monitored by driving the pump against the closed valve. The pressure difference between discharge side and suction side together with the power input can be recorded and compared to Reference Values, e.g. derived from the characteristic curve.

The condition of the shaft seal and of the coupling can be monitored by visual inspection.

A certain voltage and current should lead to defined pressure difference or medium flow.

The temperature of the electric motor should be in certain limits at defined loads.

The insulation resistance of the electric motor gives information about the conditions of the wiring insulation and dirt or wetness condition inside the motor.

## 2. Special requirements:

- The measurement locations shall be defined according to ISO 13373-1:2002 (Table A.1), ISO 10816-3:1998 and VDI Guidelines 3841: 2002.
- The measurement locations shall be marked permanently, e.g. with a glued steel pad for magnetic sensor coupling or with a mounted bayonet socket.
- The measurement chain shall be calibrated regularly, on the minimum once a year.
- The personnel has to be qualified for carrying out vibration measurements.
- The vibration measurements shall be carried out regularly, on the minimum once every three months, in case of yellow state, the interval shall be shortened according to expert advice.

- The performance tests shall be carried out regularly, on the minimum once a month.

## 3. Data to be presented

The following data has to be presented to the TL Surveyor:

- operating hours
- traffic light information from vibration measurements for all covered centrifugal pumps; in case of yellow or red state, trend curves of overall levels of vibration and envelope signal containing warning and alarm limits.
- trend curves for all covered pumps containing measured pressure difference and power input together with Reference Values
- protocols of visual inspections (esp. with respect to shaft seal and coupling)
- Reference Conditions during measurements according to Table A.1
- documentation of maintenance and/or repair actions, if done

**Table A.1 Examples for the scope of Condition Monitoring**

Machinery Components	Characteristic items to be Condition Monitored	Reference parameters (1)	Condition Monitoring parameters
Cranktrain bearings of low-speed diesel engines (2)	Main bearings, crankpin bearings, crosshead bearings	- engine speed	- displacement of crosshead at bottom dead centre position
Centrifugal pump (3)	Roller bearings	- speed	- bearing vibrations
	Impeller, casing, casing wear ring, mechanical seal		- lubrication oil pressure
	Electrical motor		- pressure difference between discharge and suction side
Accumulator battery		- load	- power output
			- leakage control at mechanical seal
			- current
			- insulation resistance
			- voltage
			- capacity
			- temperature

**Advantages :**

(1) *parameters describing the Reference Conditions.*

(2) *early detection of bearing wear.*

(3) *early detection of failures for a greater number of components with one portable system for a fleet where appropriate.*

**D. Accumulator Battery**

1. An algorithm for determining of the capacity and reserve time of the battery working under non-stationary regimes will be used for the actual type of battery. This process can be based on digital modeling.

The capacity can be determined by continuously scanning the following parameters:

- current of charge
- current of discharge
- voltage of the battery

The temperature of the battery can be monitored for critical values.

**2. Special requirements**

The personnel shall be qualified for maintaining batteries.

**3. Data to be presented**

The following data is to be presented to the TL Surveyor:

- age of battery
- trend curve of the remaining capacity including the minimum required capacity
- documentation of maintenance especially the filling and the acid condition and refilling, if done

**ANNEX B**

**STANDARDS FOR LUBRICATING OIL ANALYSIS**

**Page**

**A. TEST METHODS..... ANNEXB-2**



### A. Test Methods

1. The Table B.1 lists the necessary scopes and standardised test methods, which are accepted by TL for lubricating oil analyses in connection with Condi-

tion Monitoring. These standards may especially be used for Diesel engines and stern tube bearings. For propeller shafts running within the stern tube in oil the Class Notation **CM-PS** may be assigned, compare Chapter 4 – Machinery, Section 5, C.

**Table B.1 Proposed standards for lubricating oil analyses**

Test property	ISO Standard	Other test methods				Stern tube	Diesel engine
		ASTM	DIN	AFNOR	JIS		
Kin. viscosity [mm <sup>2</sup> /s]	3104	D 445	(DIN EN ISO) 3104	T 60100	K 2283	X	X
Base number [mg KOH/g]	3771	D 2896	(DIN EN) 3771		K 2501		X
Acid Number		D 664					X
Flash point Pensky-Martens [°C]	2719	D 93		MO 7919	K 2265		X
Water content [% vol]	3733	D 95	(DIN ISO) 3733	T 60113	K 2275	X	X
Pentane and toluene insolubles [%m(A/B)]		D 893	51365	T 60157			X
Ash content (oxide ash)		D 482					X
Diesel fuel dilution [%m]		D 3524					X
Chlorine content	no standard test method					X	
Oxidation and nitration	FTIR method					X	
Wear metal analysis Al, Cr, Cu, Fe, Mg, Mo, Na, Ni, Pb, Si, Sn and V		D 5185				X	X
<p><b>Abbreviations :</b></p> <p>ISO : The International Organisation for Standardisation</p> <p>ASTM : American Society for Testing and Materials</p> <p>DIN : Deutsches Institut für Normung</p> <p>AFNOR : Association Francaise de Normalisation</p> <p>JIS : Japan Industry Specification</p> <p>FTIR : Fourier transform infrared</p> <p><b>Notes :</b></p> <p>1. Oil change intervals prescribed by Diesel engine makers have strongly to be observed.</p> <p>2. The use of test methods other than mentioned above requires approval of TL</p>							