TÜRK LOYDU

Chapter 25 – Machinery Condition Monitoring
2015

Unless otherwise specified, these Rules apply to ships for which the date of contract for construction as defined in IACS PR No.29 is on or after 01st January 2015. 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).

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Machinery Condition Monitoring

SECTION 1

GENERAL

A. General

1. Scope

1.1 These Guidelines for Machinery Condition Monitoring apply to the machinery of ships, which are classified by **TL**, and for which a Survey Arrangement CM has been concluded between the owner/operator of the ship and **TL**.

1.2 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.

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

1.4 The Guidelines set out **TL**'s general requirements regarding Condition Monitoring, which are the basis for the acceptance of Condition Monitoring with respect to Condition Based Survey.

1.5 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.

1.6 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

Condition Based Maintenance is a form of preventive maintenance which uses the information from a Condition Monitoring System as additional input to adjust the planned activities according to the actual wear and tear condition of a Machinery Component.

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

Condition Monitoring comprises actions collecting regularly information about machinery condition to detect failures or deterioration of machinery condition. Measurements or observations shall be carried out during operation under defined Reference Conditions.

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.

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

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

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. 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. 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.

3. Fixed installed systems

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

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

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

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

4. Central recording and processing computer

4.1 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.

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

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

C. 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.

D. 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.

SECTION 3

REQUIREMENTS FOR OPERATION

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:

- 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

SECTION 4

SURVEYS

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.

B. Implementation Survey

1. An Implementation Survey has to be carried out in presence of a **TL** Surveyor after installation of the Condition Monitoring System on board to verify that the Condition Monitoring System is implemented in accordance with the approved documents and is functioning as intended. See also Section 3, B.

2. Documents suitable to prove adequate qualification of the assigned operating personnel have to be checked, see Section 3, A.3.

3. For retrofit of a Condition Monitoring System, the actual condition of the respective Machinery Component or part of it shall be verified on a case by case basis.

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 Survey

1. The Annual Survey will be carried out to maintain the validity of the Survey Arrangement CM. It is recommended to carry it out together with the annual Class Survey of the ship and has to prove that the Condition Monitoring System is operated as intended. All documents listed in Section 3, E. shall be available for the attending **TL** Surveyor.

2. The Surveyor has to verify that the approved Condition Monitoring procedures are met and that the Condition Monitoring System is correctly operated. The Surveyor will review the Annual Condition Monitoring Report, compare Section 3, D.2.

3. During the survey, the Surveyor will verify that on board personnel assigned to perform Condition Monitoring tasks is familiar with the Condition Monitoring System, especially with the data collection and processing units.

4. Recorded data and data trends will be examined and it will be checked if necessary maintenance actions have been carried out.

5. At the discretion of the Surveyor, function tests on components covered by Condition Monitoring, and inspections (e.g. dismantling of components) shall be carried out as far as practicable and reasonable, e.g. with respect to condition monitoring data.

6. For the year where Class Renewal of the ship is due, the same Annual Survey as defined above will be executed.

E. Non-periodical Surveys

1. Damage and Repair Surveys

Damage and repair surveys fall due whenever the Condition Monitoring System or Machinery Components covered by Condition Monitoring have suffered a damage, which might affect the validity of the Survey Arrangement CM.

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

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 - lubrication oil pressure
	Impeller, casing, casing wear ring, mechanical seal		- pressure difference between discharge and suction side - power output - leakage control at mechanical seal
	Electrical motor		- current - insulation resistance
Accumulator battery		- load	- 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

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 Condition 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^2/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

Abbreviations :

ISO : The International Organisation for Standardisation
ASTM : American Society for Testing and Materials
DIN : Deutsches Institut für Normung
AFNOR : Association Francaise de Normalisation
JIS : Japan Industry Specification
FTIR : Fourier transform infrared

Notes :

1. *Oil change intervals prescribed by Diesel engine makers have strongly to be observed.*
2. *The use of test methods other than mentioned above requires approval of **TL**.*