DNV·GL

CLASS GUIDELINE

DNVGL-CG-0052 Edition December 2015

Survey arrangement for machinery condition monitoring

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FOREWORD

DNV GL class guidelines contain methods, technical requirements, principles and acceptance criteria related to classed objects as referred to from the rules.

Any comments may be sent by e-mail to *rules@dnvgl.com*

CHANGES – CURRENT

This is a new document.

CONTENTS

SECTION 1 INTRODUCTION

1 General

This classification guideline is a supplement to the applicable rules for the alternative survey arrangement machinery condition monitoring (machinery CM). The information in this classification guideline shall be considered mandatory unless otherwise stated.

It is recognized that the most common condition monitoring methods are vibration measurements and analysis together with applicable lubrication- and hydraulic oil analysis. Typically these 2 methods are carried out jointly and are considered as standard for rotating machinery. In case of application of other methods it is recommended to contact the Society at an early stage to determine the possibility and scope of approval.

2 Application

All components in the class machinery and drilling list can be subject of condition monitoring. Additional information for replacement of separate surveys by condition monitoring (e.g. propulsion thrusters) can be found in the Appendix.

3 Definitions

Table 1 Definitions of terms

Term	*Definition*
Condition based maintenance (CBM)	CBM is a predictive maintenance form, based on and utilizing the information of an established condition monitoring programme
Condition monitoring programme (CM programme, also CM manual)	A CM programme is the result of an evaluation of what and how machinery shall be monitored. It contains comprehensive information about all relevant parameters, components and personnel, related to condition monitoring.
Condition monitoring (CM)	CM is the acquisition and processing of information and data with the help of CM methods to determine the condition of machinery over time.
Condition monitoring method (CM method)	The method by which data/information is obtained. There are several recognized CM methods available, mostly applied are vibration- and oil analysis.
Condition monitoring system (CM system)	In general CM systems can be distinguished in — fixed installed systems (online) — systems with portable measurement equipment (offline) — sampling systems (e.g. oil sampling)

4 References

References to the approval process, terminology and additional information can be found in

— *DNV GL rules for classification – Ships* RU SHIP Pt.7 Ch.1 Sec.7 [3.3]
— *DNV GL Rules for classification – Offshore units* RU OU-0101 Ch.3 Sec.7 [2.5]
— *Class programme* CP 0279 *- Service suppliers engaged in condition monitoring of machinery onboard ships and mobile offshore units*

— ISO 13372 *Condition monitoring and diagnostics of machines — Vocabulary*
— ISO 17359 *Condition monitoring and diagnostics of machines — General guidelines*
— ISO 18436-2 *Condition monitoring and diagnostics of machines — Requirements for qualification and assessment of personal*

SECTION 2 CONDITION MONITORING PROCESS

1 General

The approval of the survey arrangement machinery CM is based on

— an approved and implemented survey arrangement machinery planned maintenance system (MPMS)
— successful approval of the manager's CM programme (management/vessel)
— initial survey onboard the applicable vessel(s).

In general the CM programme is reflecting the scope and extent of condition monitoring that shall be submitted by the management for approval.

For the application of CM methods where the Society has approved service supplier according to the Society's document DNVGL CP 0279, the approval process will directly reflect their involvement.

2 Preparation of CM program

2.1 CM programme prepared by an approved service supplier (AoSS)

If an approved service suppliers (acc. to CP 0279) is commissioned to perform a combination of vibration measurements and oil sampling, and the analysis of both (see Sec.3), they will be responsible for developing the CM programme together with the manager.

The manager is responsible for submitting the final documentation. It shall be evident that the service supplier is a contributing third party. All recommendations and conditions during installation and operation given to the manager by the service supplier shall be implemented and documented.

The necessary approval steps in this case are:

— management approval (see Sec.3 [2])
— vessel approval (see Sec.3 [3]).

2.2 CM programme prepared by a non-approved third party/manager

In case of the utilization of a non-approved third party, a CM method not following a developed industry standard, a newly developed CM system, or an 'in-house' application by the manager, a case-by-case approval will be carried out.

The manager is responsible for submitting the final documentation.

The necessary approval steps in this case are:

— management approval (see Sec.3 [2])
— CM system approval (if applicable, see Sec.3 [2.1])
— CM programme approval (see Sec.3 [2.2])
— vessel approval (see Sec.3 [3]).

3 Initial Survey

An initial survey will be carried out by a surveyor after a successful vessel approval, however, earliest 6 months after performed baseline measurements. Provided the initial survey is carried out with satisfactory results, the survey arrangement machinery CM will be granted and subsequent annual surveys shall be carried out (ref. fleet in service rules).

The manager is responsible for submitting the final documentation.

4 Re-approval

Any change of management/service supplier results in cancellation of the arrangement and is subject to re-approval if the vessel is to stay on the arrangement.

Any modification to an already approved CM system/related equipment or monitored machinery/component shall be communicated to the Society for review and may be subject to re-approval.

SECTION 3 APPROVAL STEPS

1 General

All applicable approval steps, as outlined in Sec.2, shall be successfully carried out before the initial survey onboard each vessel can be requested.

2 Management approval

The management approval shall verify that the chosen CM programme is implemented into the existing planned maintenance- and document handling system. The management's maintenance strategy shall reflect the programme and support compliance towards class. The following documentation shall be submitted for review:

- description of roles and responsibilities with regards to the CM programme (onboard and onshore)
- description of training and qualifications of personnel involved in CM activities (qualifications shall, as far as applicable, follow ISO 18436).

2.1 Approval of condition monitoring system

CM systems, which do not follow a common industry standard or where only limited experience is available, shall be approved on a case-by-case basis. The approval is largely depending on the technical documentation, applied method(s), documented experience and qualifications and evident possibility to predict maintenance tasks/trend conclusive data over time.

Demonstration of the system and/or field test(s) can be part of this approval.

It is recommended to contact the Society at an early stage to determine the possibility and scope of approval.

2.2 Approval of condition monitoring programme

The applicable programme shall be approved for each individual vessel and shall be prepared by the manager. It shall contain (but is not limited to) the following information:

- all machinery/components to be monitored
- component information and CM contributing parameter(s) (e.g. forcing frequencies for vibration monitoring)
- measurement method(s)
- measurement points (drawings, sketches & unique marking)
- sampling points (drawings & unique marking)
- all applicable equipment used for monitoring purposes, including installation diagrams
- how and when baseline data is obtained
- reference conditions/values
- measurement/sampling intervals
- warning- and alarm levels
- work procedure(s) for all relevant CM tasks
- analysis responsibilities
- follow up of analysis results - responsibilities

3 Vessel approval

The vessel approval shall verify that the CM programme is implemented onboard a dedicated vessel successfully. It shall be carried out for each individual vessel of an approved manager. After a successful vessel approval the applicable initial survey can be requested.

The vessel specific CM programme (see Sec.3 [2.2]) shall contain all relevant information and shall be submitted by the manager for approval. If prepared by an approved service supplier, it shall be evident that the programme is part of the manager's documentation handling system onboard. In addition the following documentation shall be submitted for review:

- implementation in the onboard PMS (intervals and work descriptions for CM related tasks, i.e. measurements (offline system) and sampling)
- roles and responsibilities onboard related to CM tasks
- qualification of personnel related to CM tasks (offline system)
- procedure for handling of results of the CM tasks (offline system)
- procedure for handling of results of the applicable analysis (warning- and alarm limits)
- a minimum of 2 recent reports, containing relevant information about the condition of the monitored machinery
- description of the central recording and processing (online system).

4 Approval of service supplier (AoSS)

For the CM methods vibration - and oil analysis, the Society has approved service suppliers to carry out condition monitoring activities according to Society's document CP 0279. Whenever these methods are applied exclusively, an approved service supplier shall preapare the applicable condition monitoring programme and carry out the analysis (see the Society's website for a list of approved service supplier). In cases where no approved service suppliers is commissioned, a case by case approval will be considered.

SECTION 4 OPERATIONAL REQUIREMENTS

1 General

During the operation of a vessel the maintenance will typically be carried out as a mix of predictive and preventive maintenance. Predictive maintenance is only recognized and accepted by the Society if the vessel is on an approved survey arrangement machinery CM. In addition, to the following shall be adhered.

2 Intervals

All in the CM programme predefined measurement intervals shall be followed and documented in the onboard PMS. Typically only offline systems require CM related tasks to be carried out periodically (e.g. manual vibration measurements, oil sampling, etc.). These intervals need to be adjusted to the function (e.g. main propulsion vs. position keeping) and operational profile (e.g. low load over long periods) and shall not exceed 3 months in any case.

The monitoring interval shall reflect the expected type of fault, its rate of progression and the rate of change of the relevant parameters. The lead time to failure (LTTF, time between detection of fault and actual failure) shall be sufficient to plan and carry out maintenance.

3 Calibration

Regular calibration of CM equipment (sensors, handhelds, etc.) shall be carried out according to maker's specifications, as a class requirement at least every 2nd year. Any deviations from the calibration requirement shall be documented by the maker.

4 Measurements

All measurements shall be carried out by qualified personnel (see Sec.3 [2]).

It is essential that the periodic (vibration) measurements are carried out under load conditions as close as possible to the reference conditions defined in the CM programme (e.g. propeller rpm and pitch, the load on the drive motor, rotational speed, etc.).

If the reference conditions cannot be reached the actual condition and reasons shall be recorded and forwarded to the analysing party (which might require additional measurements).

5 Reporting requirements

The responsible party for the analysis shall compile a report/overview of the monitored machinery at least quarterly. The results of the analysis shall be made accessible to the crew onboard in an easy manner and shall include all relevant information about the condition of the monitored machinery.

All relevant recommendations shall be clear with regards to fault detection, action required and possible consequences. Trending of data shall be made available upon request.

6 CBM actions

In case of a fault detection the analysis will contain recommendations for further treatment/handling of the relevant machinery/component. All these recommendations are considered mandatory when on the survey arrangement machinery CM and shall be carried out according to the applicable procedure (see Sec.3 [4]) and documented in the onboard PMS.

Guidance note:

CM is only a tool to determine the condition of the measured component; it does not replace routine surveillance or the chief engineer's responsibility for taking decisions in accordance with his judgement.

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7 Modifications and damages

Any modification on either CM equipment or monitored machinery shall be communicated to the Society and may be subject to re-approval (see Sec.2 [5]).

Any damages suffered on class machinery (irrespective of survey arrangement) shall be communicated to the Society immediately.

Information about all modifications and damages as well as changes in operational parameters shall be forwarded to the party responsible for the analysis.

8 Annual survey

All of the above ([1] to [6]) will be subject to review during the annual condition monitoring survey onboard each vessel. The approved CM programme shall be available onboard.

APPENDIX A MACHINERY CM

1 General

The CM arrangement for machinery is applicable for any machinery component in the Society's machinery list and can be based on a variety of CM methods. The machinery components and applicable methods shall be included and clearly identified in the CM programme.

2 Initial survey

An initial survey can be requested after a successful vessel approval and earliest 6 months after the baseline measurements have been carried out. The scope of this survey includes (but is not limited to) verification of:

— correct installation of CM equipment
— implementation in the onboard PMS (intervals and work descriptions for CM related tasks, i.e. measurements (offline system) and sampling)
— roles and responsibilities onboard related to CM tasks
— measurements carried out by onboard responsible acc. to CM programme (offline system)
— qualification of personnel related to CM tasks (offline system)
— procedure for handling of results of CM tasks (offline system)
— procedure for handling of results of the applicable analysis (warning- and alarm limits).

3 Annual survey

An annual survey will be carried out in order to verify that:

— onboard personnel is qualified (offline system)
— recommendations in the analyses of the last year have been implemented
— results of the analyses are available onboard
— equipment is calibrated acc. to requirements.

APPENDIX B THRUSTER CM (PROPULSION AND POSITION THRUSTERS)

1 General

The CM arrangement for thruster CM based on vibration measurements and lubrication- and hydraulic oil sampling, as outlined in RU SHIP Pt.7 Ch.1 Sec.5 [4] &[5], will replace the complete survey of thrusters. It is intended to monitor the condition of the mechanical power transmission train (i.e. bearings and gears) and may also be implemented for podded type thrusters, i.e. thrusters equipped with integrated electric drive motor, instead of gear transmission, to monitor shaft bearings and sealing condition.

Depending on the function of the monitored thruster, the oil sampling intervals shall be adjusted to a minimum:

— monthly oil sampling and -analysis of thrusters for propulsion
— quarterly oil sampling and -analysis of thrusters for position keeping.

2 Initial survey

An initial survey can be requested after a successful vessel approval and earliest 6 months after the baseline measurements have been carried out. The scope of this survey includes (but is not limited to) verification of:

— correct installation of CM equipment
— implementation in the onboard PMS (intervals and work descriptions for CM related tasks, i.e. measurements (offline system) and sampling)
— roles and responsibilities onboard related to CM tasks
— measurements carried out by onboard responsible acc. to CM programme (offline system)
— qualification of personnel related to CM tasks (offline system)
— procedure for handling of results of CM tasks (offline system)
— procedure for handling of results of the applicable analysis (warning- and alarm limits).

3 Annual survey

An annual survey will be carried out in order to verify that:

— onboard personnel is qualified (offline system)
— recommendations in the analyses of the last year have been implemented
— results of the analyses are available onboard
— equipment is calibrated acc. to requirements.

APPENDIX C CRANK TRAIN BEARING CM (BEARING WEAR MONITORING)

1 General

The CM arrangement for crank train bearings (of low-speed diesel engines) is based on distance measurements, water-in-oil and voltage monitoring. This arrangement is considered a CM system approval and consists of approval and field-test.

In addition, the CM programme focuses on the following:

— 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. fluctuations caused by irregularities of the combustion process or by movements of the ship in rough sea state or by changes in engine speed shall have no influence on the results
— a water-in-oil monitoring sensor shall be installed at the diesel engine system lubrication oil inlet pipe
— a shaft line earthing device with a monitoring system (mV-meter) shall be installed on the intermediate shaft with the monitoring system connected to the shaft by a separate slip ring.

2 Initial survey

An initial survey can be requested after successful approval and field-test, earliest 6 months after the baseline measurements have been carried out. The scope of this survey includes (but is not limited to) verification of:

— implementation in the onboard PMS (intervals and work descriptions for CM related tasks, i.e. measurements (offline system) and sampling)
— compliance of the monitoring systems (bearing wear, water-in-oil, shaft line earthing) with approved CM programme and relevant statement from the Society
— installation of the monitoring equipment
— test of alarm functionality.

3 Annual survey

An annual survey will be carried out in order to verify that:

— the condition of the monitoring systems is satisfactory
— test of alarm functionality.

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