



DPC: 24/30482061 DC

BSI Group Headquarters

389 Chiswick High Road London W4 4AL

Tel: +44 (0)20 8996 9000

Fax: +44 (0)20 8996 7400

www.bsigroup.com

Date: 14 November 2024

Origin: International

Latest date for receipt of comments: 07 January 2025

Project No. 2023/02524

Responsible committee: GME/21/7 Mechanical vibration, shock and condition monitoring - Condition monitoring

Interested committees:

Title: Draft BS ISO 13379-1 Condition monitoring and diagnostics of machines — Data interpretation and diagnostics techniques.
Part 1: General guidelines.

Please notify admin.start@bsigroup.com if you are aware of any keywords that might assist in clarifying or identifying the standard or of the content of this standard:

- i) has any issues related to 3rd party IPR, patent or copyright
- ii) affects other national standard(s)
- iii) requires additional national guidance or information

WARNING: THIS IS A DRAFT AND MUST NOT BE REGARDED OR USED AS A BRITISH STANDARD. THIS DRAFT IS NOT CURRENT BEYOND 07 January 2025

This draft is issued to allow comments from interested parties; all comments will be given consideration prior to publication. No acknowledgement will normally be sent. **See overleaf for information on the submission of comments.**

No copying is allowed, in any form, without prior written permission from BSI except as permitted under the Copyright, Designs and Patent Act 1988 or for circulation within a nominating organization for briefing purposes. Electronic circulation is limited to dissemination by e-mail within such an organization by committee members.

Further copies of this draft may be purchased from BSI Shop <http://shop.bsigroup.com> or from BSI Customer Services, Tel: +44(0) 20 8996 9001 or email cservices@bsigroup.com. British, International and foreign standards are also available from BSI Customer Services.

Information on the co-operating organizations represented on the committees referenced above may be obtained from <https://standardsdevelopment.bsigroup.com/>.

E-mail: admin.start@bsigroup.com

Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

UK Vote

Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

Submission of Comments

- **Annotated drafts are not acceptable and will be rejected.**
- All comments should be submitted online at <https://standardsdevelopment.bsigroup.com/>. You will need to register in order to comment.

Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
------------------	------------------------

1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



DRAFT International Standard

ISO/DIS 13379-1

Condition monitoring and diagnostics of machines — Data interpretation and diagnostics techniques —

Part 1: General guidelines

*Surveillance et diagnostic d'état des machines — Interprétation
des données et techniques de diagnostic —*

Partie 1: Lignes directrices générales

ICS: 17.160

ISO/TC 108/SC 5

Secretariat: **SA**

Voting begins on:
2024-11-14

Voting terminates on:
2025-02-06

This document is circulated as received from the committee secretariat.

THIS DOCUMENT IS A DRAFT CIRCULATED FOR COMMENTS AND APPROVAL. IT IS THEREFORE SUBJECT TO CHANGE AND MAY NOT BE REFERRED TO AS AN INTERNATIONAL STANDARD UNTIL PUBLISHED AS SUCH.

IN ADDITION TO THEIR EVALUATION AS BEING ACCEPTABLE FOR INDUSTRIAL, TECHNOLOGICAL, COMMERCIAL AND USER PURPOSES, DRAFT INTERNATIONAL STANDARDS MAY ON OCCASION HAVE TO BE CONSIDERED IN THE LIGHT OF THEIR POTENTIAL TO BECOME STANDARDS TO WHICH REFERENCE MAY BE MADE IN NATIONAL REGULATIONS.

RECIPIENTS OF THIS DRAFT ARE INVITED TO SUBMIT, WITH THEIR COMMENTS, NOTIFICATION OF ANY RELEVANT PATENT RIGHTS OF WHICH THEY ARE AWARE AND TO PROVIDE SUPPORTING DOCUMENTATION.

Reference number
ISO/DIS 13379-1:2024(en)

Full document details: 24/30482061 DC

© ISO 2024  **Documents**
Document Sharing Hub



COPYRIGHT PROTECTED DOCUMENT

© ISO 2024

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Diagnostics and its relation to condition monitoring	1
5 Condition monitoring set-up and diagnostics requirements	2
5.1 General	2
5.2 Establishing diagnostics needs	2
5.3 Failure mode symptoms analysis	3
5.3.1 General	3
5.3.2 Guide for usage	4
5.3.3 Guide for rating	4
5.4 Diagnostics requirements report	7
6 Elements used for diagnostics	7
6.1 Condition monitoring data	7
6.1.1 Measurements	7
6.1.2 Descriptors	8
6.1.3 Symptoms	8
6.1.4 Fault	9
6.1.5 Operational parameters	9
6.2 Machine system data	10
6.3 Machine system history	10
7 Diagnostic approaches and methods	10
7.1 Types of approaches	10
7.2 General guidelines for selecting a diagnostic approach	10
7.3 Data-driven approach	12
7.3.1 List of methods	12
7.3.2 Strengths and weaknesses of the data-driven approach	12
7.3.3 Statistical data analysis and case-based reasoning	13
7.3.4 Neural networks	13
7.3.5 Classification trees	15
7.3.6 Random forests	16
7.3.7 Logistic regression (LR)	17
7.3.8 Support vector machines (SVM)	17
7.4 Knowledge-based approach	18
7.4.1 Fault-symptom diagnostic method	18
7.4.2 Causal tree diagnostic method	20
7.4.3 First principle models	22
7.5 Confidence factor determination	23
Annex A (informative) Failure mode and symptoms analysis (FMSA)	24
Annex B (informative) Effectiveness of the diagnostics system	26
Annex C (informative) Comparative analysis of diagnostic models	28
Annex D (informative) Most commonly used diagnostic models by monitoring technique	29
Annex E (informative) Example of diagnostic report	30
Annex F (informative) Example of causal tree modelling: bearing spalling	32
Annex G (informative) Example of diagnosis confidence level determination	34
Bibliography	35

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 13379-1 was prepared by *Technical Committee ISO/TC 108, Mechanical vibration, shock and condition monitoring, Subcommittee SC 5, Condition monitoring and diagnostics of machines*.

This second edition of ISO 13379-1 cancels and replaces the previous edition, ISO 13379:2012, which has been technically revised.

ISO 13379 consists of the following parts, under the general title *Condition monitoring and diagnostics of machine systems — Data interpretation and diagnostics techniques*:

- *Part 1: General guidelines*
- *Part 2: Data-driven applications*

Introduction

This part of ISO 13379 contains general procedures that can be used to determine the condition of a machine system relative to a set of baseline parameters. Changes from the baseline values and comparison to alarm criteria are used to indicate anomalous behaviour and generate alarms; this is usually designated as condition monitoring. Additionally, procedures that identify the cause(s) of the anomalous behaviour are given to assist in determining the proper corrective action; this is usually designated as diagnostics.

Condition monitoring and diagnostics of machines — Data interpretation and diagnostics techniques —

Part 1: General guidelines

1 Scope

This part of ISO 13379 gives guidelines for the data interpretation and diagnostics of machine systems. It is intended to

- allow the users and manufacturers of condition monitoring and diagnostics systems to share common concepts in the fields of machine system diagnostics;
- enable users to prepare the necessary technical characteristics that are used for the further diagnosis of the condition of the machine system;
- give an appropriate approach to achieving a diagnosis of machine faults.

Since these are general guidelines, a list of the machine systems addressed is not included. However, the machine systems covered by this part of ISO 13379 typically include industrial machines such as turbines, compressors, pumps, generators, electrical motors, blowers, gearboxes, fans, and components and auxiliaries that support the actions and works of these machines.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. The latest edition of the referenced document (including any amendments) applies for undated references.

ISO 13372, *Condition monitoring and diagnostics of machines — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13372 apply.

4 Diagnostics and its relation to condition monitoring

Condition monitoring involves continuous or scheduled measurement of machine system parameters, processing these measurements into data, and usually also the presentation and storage of the processed data. The diagnostic process is generally triggered by detecting an anomaly during routine condition monitoring, routine analysis, random analysis or human perception. This detection is carried out by making a comparison between the present descriptors of a machine system and reference values (generally called baseline values or data) chosen from experience, from the manufacturer's specifications, from commissioning tests or computed from statistical data (e.g. long-term average for a particular operational state).

The diagnostic process is a systematic approach used to identify the root cause of the anomaly and has an essential role in decision-making for operation and maintenance tasks. It typically involves the following steps:

- Anomaly validation:** At the start of the process, it should be ensured that the malfunction of a transducer or any other part of the condition monitoring system does not cause the anomaly.

- b) **Data collection:** The process continues with the gathering of relevant elements provided in [Clause 6](#), including measurements, descriptors derived from measurements, symptom and fault characteristics, and specific information that describes machine system construction, history and operational parameters.
- c) **Data analysis:** The collected elements are analysed to identify patterns, trends and deviations from the baseline values. The exact data analysis procedure depends on a selected diagnostic approach. The diagnostic approaches and the most used diagnostic methods and models are described in [Clause 7](#), together with guidelines for their selection.
- d) **Hypotheses formulation:** Potential causes of the anomaly are hypothesised based on the outputs of data analysis. In formulating the hypotheses, consideration should be given to the factors outlined in [Clause 5](#).

NOTE The hypothesis that no fault is present should always be considered.

- e) **Hypotheses testing:** Hypotheses are tested through additional actions, such as targeted measurements, tests, inspections or simulations. The tested hypothesis can be rejected, failed to reject or accepted.
- f) **Diagnosis or prognosis synthesis:** The diagnosis or prognosis is formulated in a space of hypotheses that were not rejected, or those that were accepted if a higher confidence level is required. [Clause 7.4](#) and [Annex G](#) give further information on determining diagnosis confidence.
- g) **Recommendation:** Based on the diagnosis or prognosis, recommendations for corrective actions are formulated. Such actions can include maintenance tasks such as refurbishments, repairs and replacements, adjustments of operating parameters or further monitoring. To develop recommendations, the diagnostician should be familiar with the machine system in accordance with [Clause 5](#).
- h) **Follow-up:** After implementing the recommended corrective actions, the machine system should be further monitored to assess whether normal operation has been restored or additional actions are required.

The diagnostic process is iterative and may require multiple cycles through individual steps to arrive at an accurate diagnosis or prognosis. The exact procedure can depend on constraints, such as financial, temporal and organisational, and external dependencies, which influence the feasibility of the individual steps. However, stakeholders should be made aware that skipping any of the steps listed above may reduce the accuracy of the diagnosis or prognosis and, consequently, the confidence in the outputs of the diagnostic process.

5 Condition monitoring set-up and diagnostics requirements

5.1 General

Diagnostics have an essential role in decision making for operation and maintenance tasks. To be effective, diagnostics procedures should be set up according to the faults that can occur in the machine or its auxiliaries. Therefore, it is strongly recommended that a preliminary study be carried out when preparing the requirements for the condition monitoring and diagnostics system of a particular machine system.

5.2 Establishing diagnostics needs

The principle of the preliminary study is shown in [Figure 1](#). The V-shape has been intentionally chosen to represent the high-level concerns (maintenance: machine, risk assessment) and the low-level ones (measurements: monitoring, periodical tests, data processing).

The left branch corresponds to the preliminary study, which prepares, for a particular machine system, the necessary data for condition monitoring and diagnostics. The right branch of the sketch corresponds to the condition monitoring and diagnostic activities that are normally undertaken after the machine system has been commissioned. Each layer consists of a preparatory design phase (left) and a usage phase (right).

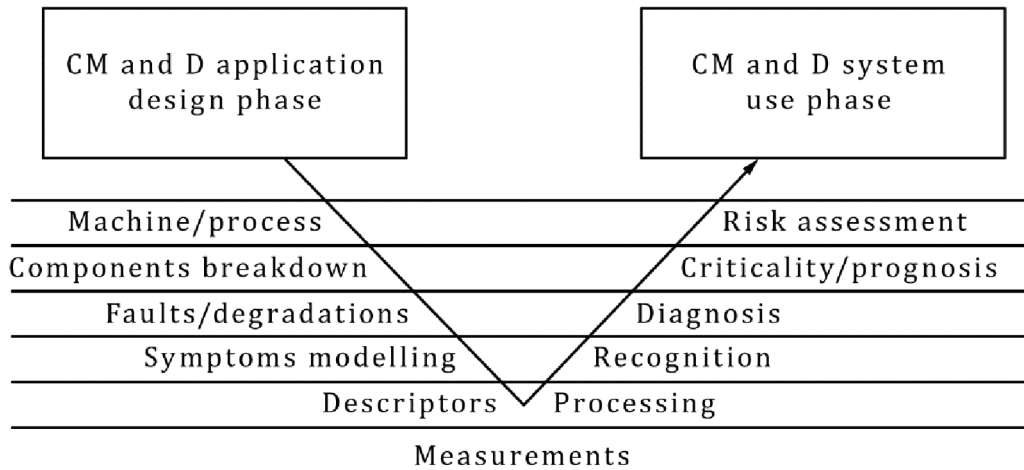


Figure 1 — Condition monitoring and diagnostics (CM and D) cycle: design and use of the application on a machine system

The generic steps of the preliminary study include the following:

- analyse the machine system availability, maintainability and criticality with respect to the whole process;
- list the major components and auxiliaries and their functions;
- analyse the failure modes and their causes as component faults;
- express the criticality, taking into account the significance (safety, availability, maintenance costs, production quality) and the likelihood of occurrence;
- decide accordingly which faults should be covered by diagnostics (“diagnosable”);
- analyse under which operating conditions the different faults can be best observed and define reference conditions;
- express the symptoms that can serve in assessing the condition of the machine system and that are used for diagnostics;
- list the descriptors that are used to evaluate (recognize) the different symptoms;
- identify the necessary measurements and transducers from which the descriptors are derived or computed.

The steps given in a), b), c) and d) may be followed using maintenance optimization such as *failure modes and effects analysis* (FMEA) or *failure mode effects and criticality analysis* (FMECA). They also may be accomplished within a more general process of maintenance optimization, such as *reliability-centred maintenance* (RCM).

NOTE 1 The FMEA and FMECA procedures are outlined in IEC 60812^[6].

NOTE 2 Guidelines for developing failure management policies using RCM are provided in IEC 60300-3-11.

The steps given in c), d), e), f), g), h) and i) may be followed using the *failure mode symptoms analysis* methodology explained in [Clause 5.3](#).

5.3 Failure mode symptoms analysis

5.3.1 General

The aim of the failure mode symptoms analysis (FMSA) is to select monitoring techniques, technologies and strategies that maximize the confidence level in the diagnosis and prognosis of any given failure mode.

This analysis is designed to assist with the selection of monitoring techniques that provide the greatest sensitivity to the detection and rate of change of a given symptom. Where the confidence in a technique's sensitivity and resulting diagnosis or prognosis accuracy is questionable, the use of additional techniques for further correlation is recommended.

The FMSA is essentially a modification of an FMECA with a focus on the symptoms produced by each failure mode identified and the subsequent selection of the most appropriate detection and monitoring techniques and strategies. This analysis should be used in conjunction with any existing FMECA that has already identified and ranked possible failure modes.

5.3.2 Guide for usage

This process is best represented by [Table A.1](#). The essential items are as follows:

- listing the components and auxiliaries involved;
- listing the possible failure modes for each component or auxiliary;
- listing the effects of each failure mode;
- listing the causes of each failure mode;
- listing the symptoms produced by each failure mode;
- listing the most appropriate monitoring technique;
- listing the estimated frequency of monitoring;
- ranking each failure mode by detection, severity, diagnosis confidence and prognosis confidence resulting in a monitoring priority number (MPN);
- listing the most appropriate correlation techniques;
- listing the frequency of monitoring for the correlation techniques.

The greatest difficulty arises in establishing the correct terms for *failure modes*, *effects*, and *causes*. In the FMECA, there are areas of overlap between the terms used for the *failure modes*, *effects* and *causes*. An item may appear as a *cause of failure* in one line when considering a component and as a *failure mode* in another. A term may also appear as an *effect* in one line when dealing with a component and as a *failure mode* when dealing with an assembly. This also remains true for the FMSA.

Care shall be taken to avoid duplication of failure mode and cause on the same line. For each item, the failure mode, effect, and cause shall read logically across the page. It may be helpful to use the following form:

- a *failure mode* can result in an *effect* due to a *cause*.

When considering monitoring strategies, the following form can also be used:

- a *failure mode* produces *symptoms*, which are best detectable by a *primary monitoring technique* resulting in a high diagnosis and prognosis confidence when monitored at a given *monitoring frequency*;
- increased diagnosis and prognosis confidence can be gained by using *correlation techniques* when monitored at a given *monitoring frequency*.

5.3.3 Guide for rating

5.3.3.1 General

Ratings which estimate the likelihood of detection (DET), the degree of severity of failure (SEV) and confidence levels of diagnosis (DGN) and prognosis (PGN) are assigned to each failure mode. It is important to note that there is no universal definition for individual ratings, as the scale for each rating depends on specific needs of the user of this standard. It is recommended to use a scale with the same range for each

rating to ensure that all ratings hold equal weight when establishing the MPN. For guidance, this standard provides an example for each rating that utilizes a scale of 1 to 5.

5.3.3.2 Rating detection (DET)

The likelihood of detection is designed to reflect the overall detectability of a failure mode irrespective of the following accuracy of diagnosis or prognosis. This rating is designed to highlight failure modes which:

- produce symptoms that are detectable but unrepeatable;
- produce symptoms that are undetectable;
- produce symptoms that are not measurable in practice; or
- produce symptoms that may be masked by other failure mode symptoms.

An example of the DET rating using a scale of 1 to 5 is given below:

- 1 means “There is a REMOTE LIKELIHOOD that this failure mode will be detected.”
- 2 means “There is a LOW LIKELIHOOD that this failure mode will be detected.”
- 3 means “There is a MODERATE LIKELIHOOD that this failure mode will be detected.”
- 4 means “There is a HIGH LIKELIHOOD that this failure mode will be detected.”
- 5 means “It is VIRTUALLY CERTAIN that this failure mode will be detected.”

5.3.3.3 Severity of failure (SEV)

This ranking should reflect any previous FMECA analysis and is designed to rank individual failure modes by severity for the worst-case scenario.

An example of the SEV rating using a scale of 1 to 5 is given below:

- 1 means “Any event which could cause degradation of system performance function(s) resulting in negligible damage to either system or its environment, and no damage to life or limb.”
- 2 means “Any event which degrades system performance function(s) without appreciable damage to either system or its environment, and no damage to life or limb.”
- 3 means “Any event which degrades system performance function(s) resulting in minor damage to either system or its environment, and negligible hazard to life or limb.”
- 4 means “Any event which could potentially cause the loss of primary system function(s) resulting in significant damage to the said system or its environment, and minor hazard to life or limb.”
- 5 means “Any event which could potentially cause the loss of primary system function(s) resulting in significant damage to the system or its environment, and/or cause the loss of life or limb.”

5.3.3.4 Diagnosis confidence (DGN)

The confidence level of the diagnosis is designed to identify failure modes with:

- detectable, but unrepeatable, symptoms;
- unknown symptoms; or
- symptoms that are not distinguishable from other failure mode symptoms.

An example of the DGN rating using a scale of 1 to 5 is given below:

- 1 means “There is a REMOTE LIKELIHOOD that this failure mode diagnosis will be accurate.”