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Condition monitoring and diagnostics of machines — Data processing, communication and presentation —

Part 1:
General guidelines

Surveillance et diagnostic d'état des machines — Traitement, échange et présentation des données —

Partie 1: Lignes directrices générales

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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 13374-1 was prepared by Technical Committee ISO/TC 108, *Mechanical vibration and shock*, Subcommittee SC 5, *Condition monitoring and diagnostics of machines*.

ISO 13374 consists of the following parts, under the general title *Condition monitoring and diagnostics of machines — Data processing, communication and presentation*:

— *Part 1: General guidelines*

— *Part 2: Data-processing requirements*

— *Part 3: Communication requirements*

— *Part 4: Presentation requirements*

Introduction

The various computer software programs written for condition monitoring and diagnostics of machines that are currently in use cannot easily exchange data or operate in a plug-and-play fashion without an extensive integration effort. This makes it difficult to integrate systems and provide a unified view of the condition of machinery to users. The intent of ISO 13374 is to provide the basic requirements for open software specifications which will allow machine condition monitoring data and information to be processed, communicated and displayed by various software packages without platform-specific or hardware-specific protocols.

Extensible Markup Language (XML) is a project of the World Wide Web Consortium (W3C), and the development of the specification is being supervised by their XML Working Group. XML is a public format written in the Standard Generalized Markup Language (SGML) (see ISO 8879[1] for details) for defining descriptions of the structures of different types of electronic documents. The version 1.0 specification was accepted by the W3C as a Recommendation in 1998. A W3C Recommendation indicates that a specification is stable, contributes to Web interoperability, and has been reviewed by the W3C membership, who are in favour of supporting its adoption by academic, industry and research communities. It is designed to improve the functionality of the Web by providing more flexible and adaptable information identification.

Condition monitoring and diagnostics of machines — Data processing, communication and presentation —

Part 1: General guidelines

1 Scope

This part of ISO 13374 establishes general guidelines for software specifications related to data processing, communication, and presentation of machine condition monitoring and diagnostic information.

NOTE Later parts of ISO 13374 (under preparation) will address specific software specification requirements for data processing, communication and presentation.

2 Data processing

2.1 Overview

Relevant data processing and analysis procedures are required to interpret the data received from condition monitoring activities. A synergistic combination of technologies should establish the cause and severity of possible faults and provide the justification for operations and maintenance actions in a pro-active manner.

A data processing and information flow of the type shown in Figure 1 is recommended either on a manual or automatic basis, in order to implement condition monitoring successfully. The data flow begins at the top, where monitoring configuration data are specified for the various sensors monitoring the equipment, and finally results in actions to be taken by maintenance and operations personnel. As the information flow progresses from data acquisition to advisory generation, data from the earlier processing blocks need to be transferred to the next processing block and additional information acquired from or sent to external systems. Similarly, as the data evolve into information, both standard technical displays and simpler graphical presentation formats are needed. The flow progresses from data acquisition to complex prognostic tasks, ending in the issuance of advisories and recommended actions (one of which may be a modification of the monitoring process itself).

2.2 Data-processing blocks

2.2.1 Machine condition assessment processing blocks

Machine condition assessment can be broken into six distinct, layered processing blocks. The first three blocks are technology-specific, requiring signal processing and data analysis functions targeted to a particular technology. The following are some of the most commonly used technologies in condition monitoring and diagnostics of machines:

— shaft displacement monitoring;

— bearing vibration monitoring;

— tribology-based monitoring;

— infrared thermographic monitoring;

— performance monitoring;

— acoustical monitoring;

— motor current monitoring.

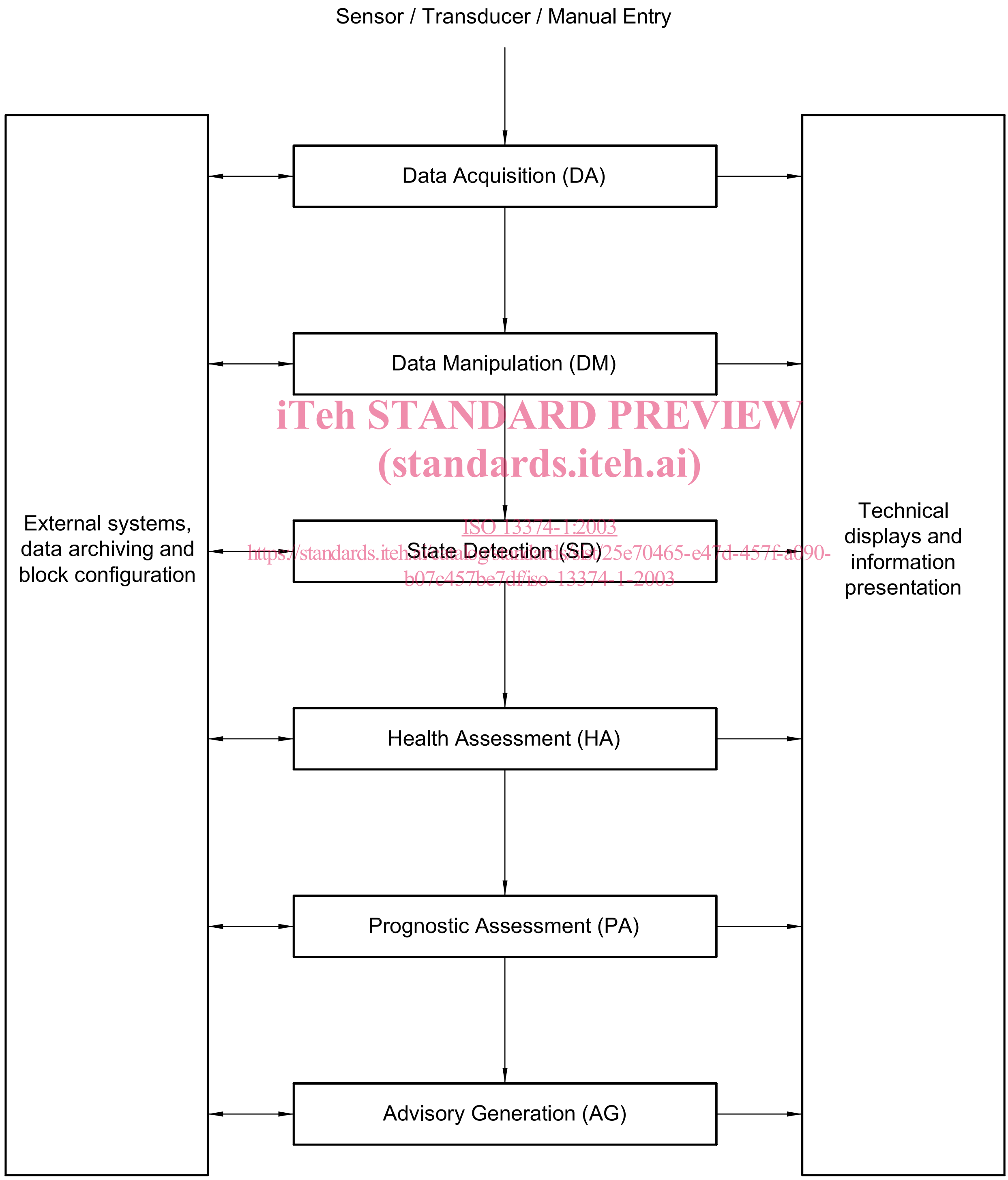

Figure 1 — Data-processing and information-flow blocks

The technology-specific blocks and the functions they should provide are as follows.

a) **Data Acquisition (DA) block**: converts an output from the transducer to a digital parameter representing a physical quantity and related information (such as the time, calibration, data quality, data collector utilized, sensor configuration).

b) **Data Manipulation (DM block)**: performs signal analysis, computes meaningful descriptors, and derives virtual sensor readings from the raw measurements.

c) **State Detection (SD block)**: facilitates the creation and maintenance of normal baseline "profiles", searches for abnormalities whenever new data are acquired, and determines in which abnormality zone, if any, the data belong (e.g. "alert" or "alarm").

The final three blocks normally attempt to combine monitoring technologies in order to assess the current health of the machine, predict future failures, and provide recommended action steps to operations and maintenance personnel. These three blocks and the functions they should support are as follows.

d) **Health Assessment (HA) block**: diagnoses any faults and rates the current health of the equipment or process, considering all state information.

e) **Prognostic Assessment (PA) block**: determines future health states and failure modes based on the current health assessment and projected usage loads on the equipment and/or process, as well as remaining useful life predictions.

f) **Advisory Generation (AG) block**: provides actionable information regarding maintenance or operational changes required to optimize the life of the process and/or equipment.

2.2.2 Technical displays

To facilitate analysis by qualified personnel, relevant technical displays showing data such as trends as well as associated abnormality zones are necessary. These displays should provide the analyst with the data required to identify, confirm or understand an abnormal state.

2.2.3 Information presentation

It is important that the data be converted to a form that clearly represents the information necessary to make corrective-action decisions. This may be done in a written format, numerically in order to demonstrate magnitudes, graphically in order to show trends, or a combination of all three.

The information should include pertinent data describing the equipment or its components, the failure type or fault, an estimate of the severity, a projection of condition and, finally, recommended action. Cost and risk factors may also be displayed.

2.2.4 External systems

Retrieval of previous work histories from the maintenance system and previous operational data (starts/stops/loads) from a process-data historian is important in the assessment of machinery health. After a health assessment is made, the maintenance action to be taken may range from increasing the frequency of inspection to repair or replacement of the damaged machinery or component. The effect on operations may be an adjustment of operating procedures or a request to shutdown the equipment immediately. This need for rapid communication to the maintenance and operational system requires software interfaces to maintenance management systems and operational control systems. These interfaces are useful in order to communicate recommended actions in the form of maintenance work requests and operational change requests.

2.2.5 Data archiving

Data archiving is an important feature during all blocks of a machine condition monitoring program. Previous data trends can be analysed for statistical relevance. Previous health assessments should be audited for accuracy, and root cause information added upon its discovery.

2.2.6 Block configuration

Each data-processing block requires configuration information, some of which may be static information and other data may be dynamically changed by the system during operation. For example, the configuration of the Data Acquisition block may include identification of measurement monitoring locations, orientation and relative transducer position, monitoring polling rates, sensor set-up data and calibration parameters.

2.3 Conceptual information schema guidelines

2.3.1 Overview

The conceptual information schema is a single integrated definition of the relative machinery and condition monitoring information, which is unbiased toward any single application of data and is independent of how the data are physically stored or accessed. The primary objective of the conceptual schema is to provide a consistent definition of the meanings and interrelationship of data, which can be used to integrate, share and manage the integrity of data. This information schema is a blueprint of the location of various data elements. There are various forms of information schema.

The file description schema format has been used for years in the scientific programming community. It maps the format for ASCII or binary data files, which can be exported from a computer system or imported into a computer system. A complete record format description is published which specifies the data fields contained in the file, their exact location in relation to the other data fields, whether the fields are in ASCII or binary format, and the exact data format (scientific floating point, integer, character, varying character string) of each field.

The relational information schema format is the definition language for relational database management systems. The relational method is analogous to a blue-print drawing which defines the following:

- various “room names” (or tables) where data will be stored;
- the data “contents” (or columns) in the rooms;
- each data column's exact data format (scientific floating point, integer, varying character string, etc.);
- whether or not a data column can be empty or not (not null);
- each data row's unique “key” (primary key) which uniquely identifies it.

A table can be related to another table by including a “reference” (foreign key) to it.

Extensible Markup Language (XML) is a project of the World Wide Web Consortium (W3C) and the development of the specification is being supervised by their XML Working Group. XML is a public format written in the Standard Generalized Markup Language (SGML) (see ISO 8879[1] for details) for defining descriptions of the structures of different types of electronic documents. It is called extensible because it is not a fixed format like Hypertext Markup Language (HTML), which is a single, predefined markup language. Instead, XML is actually a “meta-language” (a language for describing other languages) which allows one to design customized markup languages for limitless different types of documents. XML uses the internationally standardized 31-bit character repertoire specified in ISO 10646[2], which covers most human (and some non-human) languages. This is currently congruent with Unicode and is planned to be superset of Unicode. XML is intended to make it easy and straightforward to use SGML on the Web: easy to define document types, easy to author and manage SGML-defined documents, and easy to transmit and share them across the Web. It defines an extremely simple dialect of SGML, which is completely described in the XML Specification. The goal is to enable generic SGML to be served, received and processed on the Web in the way that is now possible with HTML. For this reason, XML has been designed for ease of implementation, and for interoperability with both SGML and HTML.

In 2001, the W3C issued XML Schema as a W3C Recommendation. XML Schemas define shared markup vocabularies, the structure of XML documents, which use those vocabularies, and provide hooks to associate semantics with them. By bringing datatypes to XML, XML Schemas increase XML's utility to the developers of data interchange systems. XML Schemas allow the author to determine which parts of a document may be validated, or identify parts of a document where a schema may apply. Furthermore, as XML Schemas are XML documents themselves, they may be managed by XML authoring tools.

A software object information schema is now becoming widely used in the computer industry. Software "objects" are defined using an object definition language, including their external characteristics and operations, unique keys, data attributes available, data types, relationships, etc. The Unified Modelling Language (UML) has emerged as the software industry's dominant modelling language. The Object Management Group (OMG) adopted UML as its standard modelling language.

NOTE The OMG has submitted the UML specification to ISO as a Publicly Available Specification (PAS).

2.3.2 Information schema requirements

Regardless of which information schema format is chosen, the schema will define a minimum set of data elements that should be included in the schema for compliance. In addition, a list of optional elements will be included.

To support data communication between multiple condition monitoring modules supplied by various vendors, a vendor-independent, open machine condition monitoring information schema architecture is required as an underlying framework. This framework can be utilized in various communication implementations.

Vendor independence is vital. Many vendors and users have implemented various methods of machine condition monitoring data storage. An open information schema allows for the integration of many sources of machinery information, supports peer-to-peer databases, allows user-defined lookup entries, and utilizes standardized timestamps and engineering units. The schema should support unique site identifiers and site database or data source identifiers to differentiate data taken at different physical locations. The schema should also support unique, system-wide identifiers for plant segments containing machinery (service segment locations) in a parent-child hierarchy. Also the schema should support a unique asset-specific identifier to allow individual component monitoring and tracking in a parts hierarchy. The basic framework of storing sites, site databases, process or machine segment information, asset nameplate data, model or part information, measurement locations, data measurement sources, transducers, ordered lists, and alarms should be specified in the schema. At a data level, the schema should support formats for communicating historical single-valued numeric data, Fast-Fourier Transform (FFT) spectra data, constant percentage band (CPB) spectra, time waveforms, sample-based test data, thermographic images, and binary large objects. The schema should support a date/time notation that references back to a specific instance in time, using the Gregorian (Common Era or CE) calendar, with a lexical representation based upon ISO 8601[3].

In order to communicate common machinery equipment types, measurement location types, orientations, etc., a standard set of reference entries should contain a set of common codes and associated text in various languages as required. The architecture should allow for each database to create and maintain additional reference table entries to allow maximum flexibility. An example of a publicly available XML Schema that supports this architecture is given in Annex A.

