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Gas turbines — Data acquisition and trend monitoring system requirements for gas turbine installations

Turbines à gaz — Exigences relatives aux systèmes d'acquisition des données et de surveillance des tendances pour les installations à turbine à gaz

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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.

ISO 19860 was prepared by Technical Committee ISO/TC 192, *Gas turbines*.

Introduction

The International Organization for Standardization (ISO) draws attention to the fact that it is claimed that compliance with this document may involve the use of a patent concerning data processing systems and diagnostic systems for technical/power plants.

The specific patents declared include the following:

EP 0 643 345:	Data processing device for the monitoring of the operating states of a technical plant
US 5,625,574	Method and data processing system for monitoring operating states of a technical plant
EP 0 667 013	Diagnostic system for a plant
US 5,734,567	Diagnosis system for a plant
KR 299811	Diagnostic system for a plant
IN 179026	Diagnosis system for a power plant

The ISO takes no position concerning the evidence, validity and scope of this patent right.

The holder of this patent right has assured the ISO that he is willing to negotiate licences under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statement of the holder of this patent right is registered with the ISO. Information may be obtained from:

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

Investors who acquire gas turbine engines insist more and more on having their installations equipped with trend-monitoring systems (TMS) of varying abilities. A rigorous employment of TMS in general allows projects to run with increased cost effectiveness as well as to improve the operation in the future. These statements are tempting enough to encourage retrofitting existing equipment with TMS in order to increase cost-effectiveness and reliability as well as to reduce maintenance intervals and risk of outages. The complexity of TMS can be determined by quoting chapters of this International Standard that are agreed by contract.

Trend-monitoring systems can also enable the following benefits:

— investigate reasons for outages;

— analyse the actual condition, enabling the preparation of maintenance in advance and only if the need arises.

Trends during recent years show that in the foreseeable future no gas turbine is likely to be sold without a TMS. There is also a tendency to integrate the TMS closely with the control systems of the gas turbines.

One reason for this lies in the use of the operating data available in the control system and needed for control as well as for the TMS. On the other hand, the control system can respond rapidly to critical situations detected by TMS. Therefore the direct connection of both systems offers the best solution.

Many independent, as well as integrated, systems are commercially available but they are based on different philosophies. Correspondingly, their performances can differ. Certain terms are often used with conflicting meanings and can mislead expectations.

TMS offers important benefits in the following areas:

- minimize fuel consumption;
- optimize maintenance costs in line with actual requirements (e.g. availability);
- minimize impact on the environment;
- predict possible failure and minimize subsequent damage and/or loss;
- improve reliability and availability.

Use of the same system will allow the manufacturer to

- determine the actual (not the theoretical) thermodynamic data;
- data and performance verification;
- determine gas-turbine ageing;
- improve service interval scheduling;
- optimize compressor cleaning.

Together, both operator and manufacturer will be able to

- interpret the short- and long-term trends established;
- perform a status analysis;
- identify and potentially reduce failures;

which in turn will enable future automated diagnostic systems to be extended still further.

As more and more new systems emerge, it is convenient to classify the technical terms and to define them. The intention is to set up certain guidelines on the subject of trend-monitoring systems to provide a basis for comparison of the various systems, their features, their performances and to help in the process of decision-making.

Gas turbines — Data acquisition and trend monitoring system requirements for gas turbine installations

1 Scope

This International Standard applies to data-acquisition and trend-monitoring systems for gas turbine installations and associated systems. It classifies and defines monitoring systems and their technical terms. It establishes a system for conversion and validation of measured quantities in order to enable a comparison of the various systems, their features and their performances.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2314:1989, *Gas turbines — Acceptance tests*

ISO 3977-2:1997, *Gas turbines — Procurement — Part 2: Standard reference conditions and ratings*

ISO 13373-1:2002, *Condition monitoring and diagnostics of machines — Vibration condition monitoring — Part 1: General procedures*

3 Terms, abbreviated terms and definitions

For the purposes of this document, the following definitions apply.

NOTE “Gas turbine” as used in this International Standard means the gas turbine and its associated systems.

3.1
combustion-monitoring system
CMS
equipment to acquire operating data and allow a judgement on the quality of the combustion process

3.2
data acquisition system
DA
equipment to collect and store a selection of data enabling a description of the condition of the gas turbine engine and its associated systems

3.3
diagnosis system
DS
equipment to determine the condition of the gas turbine installation using information acquired by DA and TMS

NOTE In addition, the DS can display the reason for the actual situation. In an advanced version, it can offer suggestions or guidance on actions required.

3.4
emission-monitoring system
EMS
equipment to store data, indicating the output of emissions that are produced by the combustion process of the gas-turbine installation

3.5
maintenance-on-condition
MOC
procedure whereby maintenance work is done only if requested by the monitoring system

3.6
mechanical-monitoring system
MMS
equipment to acquire data on the condition of the gas turbine installation that are of importance for the lifetime of the mechanical design

3.7
monitoring system
MS
equipment used in the same manner as for surveillance

NOTE This is considered as the generic term for all systems that perform a surveillance of the gas turbine and installations.

3.8
performance-monitoring system
PMS
equipment to take data and display the performance of the gas turbine

NOTE The parameters involved are essentially power, efficiency, exhaust-gas temperature and exhaust-gas flow and can include engine-component-condition assessment.

3.9
trend
approximation of an x-y correlation within an acceptable correlation coefficient on the basis of data that are eventually validated and normalized

NOTE The variable x is most often “time”, and trends are usually evaluated as functions of operating time or operating cycles.

3.10
trend-monitoring system
TMS
equipment to acquire operating data describing the condition of the gas-turbine installation that are used for the computation of short-term and long-term trends for selected parameters

3.11
validation
detection and elimination and/or replacement of wrong values among the measured data

3.12
vibration-monitoring system
VMS
equipment for monitoring the mechanical vibrations of the rotor(s) and the casing(s) of a gas turbine installation

4 Monitoring systems and their characteristics

4.1 General features

In applications where aspects of safety are extremely important (i.e. for aircraft engines), the analysis of the condition of complex systems has already attained a high level. The positive influence on the maintenance effort that accompanies the introduction of monitoring systems (MSs), as well as the possibility of preventing failures, more and more raises the interest in applying such systems to large power plants where the safety requirements are less stringent. The economic performance of a plant can be improved by such monitoring systems.

Projects carried out in recent years show trends in the operation of gas turbines that predict the need for the application of such a monitoring system. Furthermore, it can be observed that the values measured for the MSs are mostly those already being acquired by the available control system. To an increasing extent, MSs are combined with the control system of the gas turbine and the governing system leading an entire complex. MSs are considered as an integral part operating in the background.

Integration of the monitoring system and the control system has both advantages and disadvantages.

a) Joining control and monitoring systems is advantageous because

  1) the control system already contributes essential information on the condition of the cycle;

  2) the MS can use the control system to execute actions required in the process;

  3) the distributed systems and/or remote systems are becoming more popular.

b) The disadvantages include

  1) the system design and validation become much more complicated at the development phase;

  2) the possibility of introducing unexpected error to another system might be higher at a later modification phase.

There are already many independent, as well as integrated, systems commercially available, which differ in design concepts, operating philosophies and performance. As new systems emerge continuously, it is convenient to classify and define the technical terms. Beyond that, guidelines will be developed to allow comparisons among MSs in the future (see Annex A) and to enable decision-making according to requirements.

MSs may be grouped into three levels (see Figures 1 and 2 and Figure B.1), where the complexity and the information increase with the level. Depending on the application in the field, overlapping of the standards appears regularly.

4.2 Data-acquisition systems

All systems are based on DAs and therefore they shall be considered as the basic component leading to all further extensions. DA is essentially restricted to measurement or acquisition and limited storage of system and operating conditions.

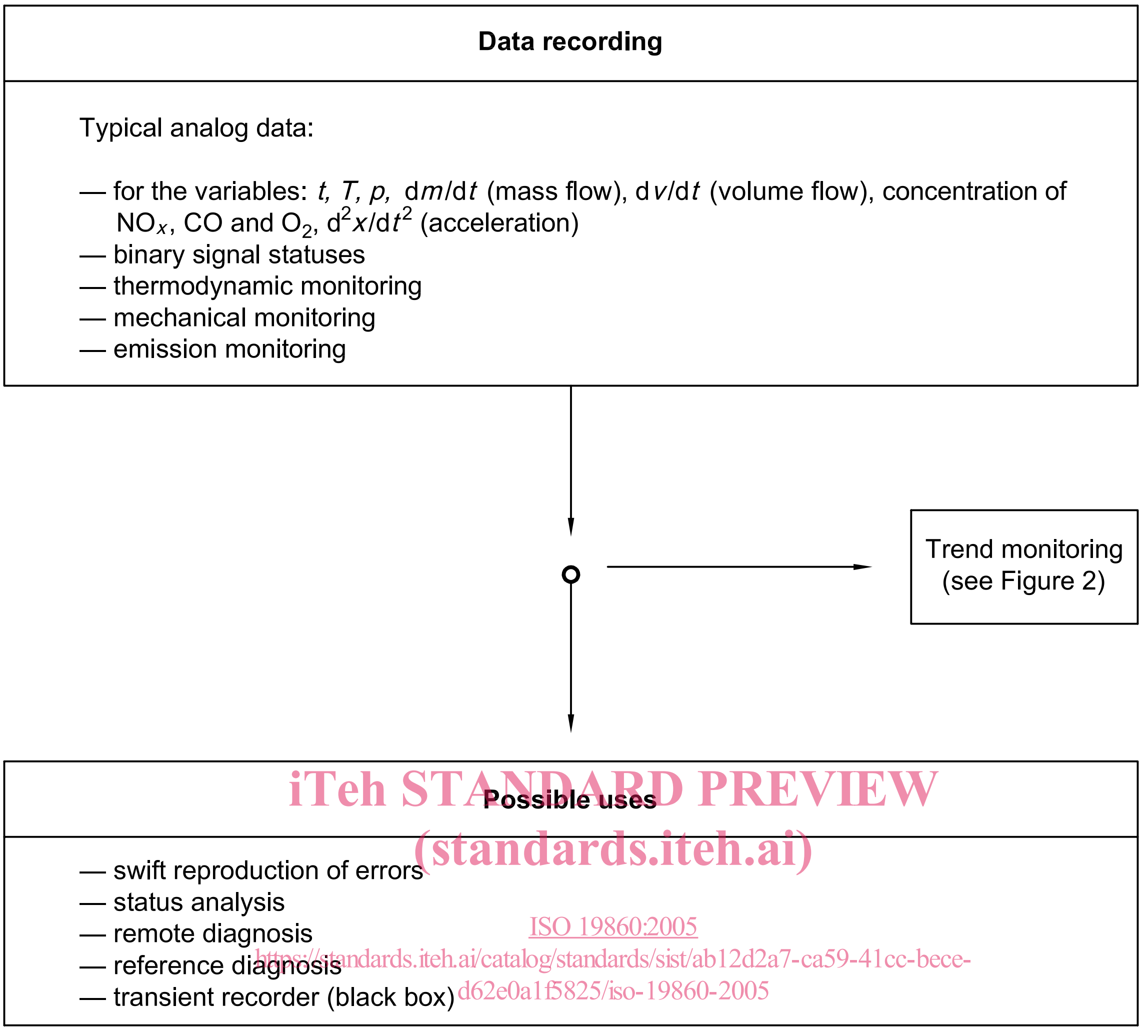

Figure 1 — Data acquisition

DAs usually require a high level of technical knowledge and experience as well as knowledge of the system. Therefore, their use remains restricted to experienced personnel.

4.3 Trend-monitoring systems

TMSs (Figure 2) evaluate short-term and long-term trends in the performance, the exhaust emissions and the mechanical behaviour of gas turbine installations. In contrast to DAs, the data the variables corresponding to the thermodynamic state are normalized to ISO standard conditions[1)] (see ISO 3977-2) and can be archived in long-term storage.

Intentional deviations of the reference conditions from the ISO standard conditions shall be agreed upon between the contract partners. Often, when the measured values do not correspond to standard conditions (ISO 3977-2), TMSs do not give the usual analysis of trends (e.g. deviation of specific fuel consumption) and do not extrapolate for upcoming consequences (e.g. NO_x emissions).

TMSs shall also provide validation of the experimental data as well as the logic for the selection of elements from the acquired data and the numerical algorithms from which to construct the trends. Wrong measurements shall be eliminated and spurious data shall be identified and discarded.

1) $p = 101,3$ kPa; $T = 288,15$ K; $\varphi = 60$ % relative humidity in the ambient air.

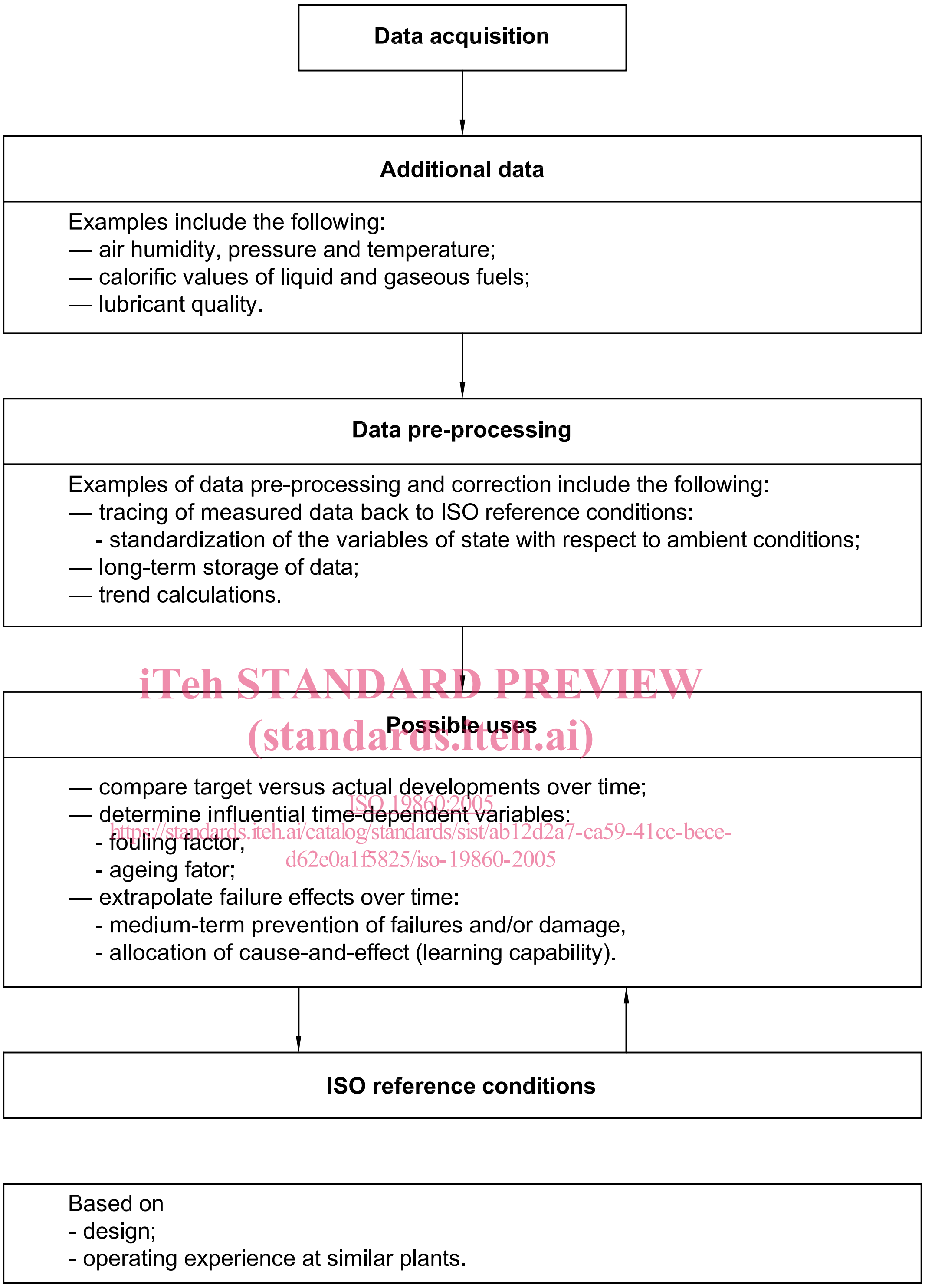

Figure 2 — Trend-monitoring system (TMS)

Normalizing the thermodynamic state of the plant requires the acquisition of all ambient operating parameters, including the following:

— ambient pressure;

— temperature;

— humidity;

— heating value;

— exhaust-gas pressure loss.

It is convenient to compare actual values with target values that can be provided by the cycle analysis for actual conditions from integrated systems. The cycle is computed analytically from measured parameters, or, if data are missing, empirically through the use of the charts or tables that are provided by the manufacturer of the plant. Performing a cycle analysis requires data that might not always be known to the operator of the plant.

In this way, it is possible to determine deviations from the design or reference values which are persistent over time (e.g. for efficiency), to check values related to operating costs (e.g. specific fuel consumption) and to follow the evolution of disturbances or failures.

Advanced systems might also be able to provide diagnosis and advice to non-specialist maintainers and operators.

Key areas for application in connection with gas turbines are as follows:

a) all properties of DAs and, in addition, trend-monitoring over medium and long periods of

   — performance results,

   — emissions-monitoring and reporting,

   — mechanical operating parameters;

b) analysis of trends for

   — identification of developing faults,

   — prediction of failures,

   — optimization of operating and maintenance,

   — improvement of availability by maintenance-on-condition (MOC).

4.4 Comparison of the systems

TMSs are capable of performing the same tasks as DAs, but also validate and normalize measured data. In addition, information to date is stored in a databank from which all values are extracted to determine short- and long-term trends.

When using a DA, the personnel can compare formerly registered data with current registered data and decide whether values are abnormal and might, eventually, lead to difficulties. More advanced systems analyse the trends and predict when the parameters will reach an established range limit. Appropriate alerts can be signalled to the operator.

The TMS performs this task and indicates values that might be abnormal and that might lead to disturbances or failures that could damage the plant. On top of that, the TMS might contain the necessary rules as well as experience to recommend necessary precautions as an output.

Finally, a very sophisticated MS will be similar to a DS, which indicates risks, consequences of failures and the required action to be taken to change a situation identified as being unfavourable. At this level of development, all functions indicated in Figure B.1 are available.