ISO/FDIS 3977-9:2023(E)

ISO/TC 192/WG 4

Secretariat: ANSI

Date: 2023-12-012024-xx

Gas turbineturbines — Procurement —

Part 9: Reliability, availability and maintainability

Turbines à gaz — Spécifications pour l'acquisition —

Partie 9: Fiabilité, disponibilité, maintenance

FDIS stage

Style Definition ...

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

Published in Switzerland

Formatted: Font: 11 pt, Bold
Formatted: Font: 11 pt, Bold
Formatted: Font: Bold
Formatted: HeaderCentered
Formatted: Right: 1.5 cm, Bottom: 1 cm, Gutter: 0 cm, Header distance from edge: 1.27 cm, Footer distance from edge: 0.5 cm
Commented [eXtyles1]: The reference is to a withdrawn standard which has been replaced

ISO 20344, Personal protective equipment — Test methods for footwear

Formatted: Default Paragraph Font
Formatted: Indent: Left: 0 cm, Right: 0 cm, Space Before: 0 pt, No page break before, Adjust space between Latin and Asian text, Adjust space between Asian text and numbers
Formatted: French (Switzerland)
Formatted: French (Switzerland)
Formatted: French (Switzerland)
Formatted: FooterPageRomanNumber

Formatted: Font: 11 pt
Formatted: Font: 11 pt
Formatted: HeaderCentered, Left, Space After: 0 pt, Line spacing: single
Formatted: Adjust space between Latin and Asian text, Adjust space between Asian text and numbers

Contents

Formatted: FooterPageRomanNumber

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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents.www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.htmlwww.iso.org/iso/foreword.html.

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

This second edition cancels and replaces the first edition (ISO 3977-9:1999), which has been technically revised.

The main changes are as follows:

— safety aspects of the document were removed since this is a procurement standard.

A list of all parts in the ISO 3977 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.htmlwww.iso.org/members.html.

Formatted: Font: 11 pt, Bold
Formatted: Font: 11 pt, Bold
Formatted: Font: Bold
Formatted: HeaderCentered
Formatted: Adjust space between Latin and Asian text, Adjust space between Asian text and numbers
Formatted: English (United Kingdom)
Formatted: Default Paragraph Font
Formatted: Default Paragraph Font
Formatted: Default Paragraph Font
Formatted: Default Paragraph Font
Formatted: Adjust space between Latin and Asian text, Adjust space between Asian text and numbers, Tab stops: Not at 0.7 cm + 1.4 cm + 2.1 cm + 2.8 cm + 3.5 cm + 4.2 cm + 4.9 cm + 5.6 cm + 6.3 cm + 7 cm
Commented [eXtyles2]: Invalid reference: "ISO 3977 series"
Formatted: Default Paragraph Font
Formatted: Default Paragraph Font
Formatted: Default Paragraph Font
Formatted: Adjust space between Latin and Asian text, Adjust space between Asian text and numbers
Formatted: FooterPageRomanNumber

Formatted: Font: 11 pt

Formatted: Font: 11 pt

Formatted: HeaderCentered, Left, Space After: 0 pt, Line spacing: single

Introduction

This is a procurement standard developed for the aspects of reliability, availability and maintainability of gas turbines.

Formatted: FooterPageRomanNumber

Gas turbines — Procurement —

Part 9:
Reliability, availability and maintainability

1 Scope

This document provides a basis for exchange of information about reliability, availability and maintainability between gas turbine manufacturers, users, consultants, regulatory bodies, insurance companies and others. It defines terms and definitions and also describes component life expectancy, repairs and criteria for determining overhaul intervals.

This document is applicable to all elements of the gas turbine and auxiliaries.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

<std>ISO 3977-1, Gas turbines — Procurement — Part 1: General introduction and definitions</std>

<std>ISO 3977-3, Gas turbines — Procurement — Part 3: Design requirements</std>

<std>ISO 11086, *Gas turbines — Vocabulary*</std>

<std>ISO 11086, *Gas turbines — Vocabulary*

ISO 19859, Gas turbine applications — Requirements for power generation</std>

<std>ISO 12100, Safety of machinery — General principles for design — Risk assessment and risk reduction</std>

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 3977-1, ISO 3977-3, ISO 11086, ISO 19859, 12100 and ISO 12100 19859, and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/https://www.electropedia.org/

3.1
ageing
loss of *performance* (3.21) of a gas turbine due to wear and tear experienced in normal operation which is not recoverable by compressor cleaning, turbine cleaning, filter cleaning, etc.

Formatted: Right: 1.5 cm, Bottom: 1 cm, Gutter: 0 cm, Section start: New page, Header distance from edge: 1.27 cm, Footer distance from edge: 0.5 cm

Formatted: Main Title 2, Adjust space between Latin and Asian text, Adjust space between Asian text and numbers

Formatted: Default Paragraph Font

Formatted: Default Paragraph Font

Formatted: Default Paragraph Font

Formatted: Default Paragraph Font

Formatted: Adjust space between Latin and Asian text, Adjust space between Asian text and numbers, Tab stops: Not at 0.7 cm + 1.4 cm + 2.1 cm + 2.8 cm + 3.5 cm + 4.2 cm + 4.9 cm + 5.6 cm + 6.3 cm + 7 cm

Formatted: Default Paragraph Font

Formatted: Default Paragraph Font

Formatted: Default Paragraph Font

Formatted: Default Paragraph Font

Formatted: Default Paragraph Font

Formatted: Default Paragraph Font

Formatted: Default Paragraph Font

Formatted ...

Formatted: Default Paragraph Font

Formatted: Default Paragraph Font

Formatted: Default Paragraph Font

Formatted ...

Formatted: Default Paragraph Font

Formatted: Default Paragraph Font

Formatted: Default Paragraph Font

Formatted: Default Paragraph Font

Formatted: Default Paragraph Font

Formatted: Default Paragraph Font

Formatted: Default Paragraph Font

Formatted: Default Paragraph Font

Formatted: Default Paragraph Font

Formatted: Default Paragraph Font

Formatted ...

Formatted ...

Formatted: Font: Italic

Note 1 to entry: It is normally the result of increased seal clearances due to vibration and wear, loss of profile and increased blade surface roughness due to corrosion, erosion, etc

3.2
available
state in which a unit is capable of providing service, whether or not it is actually in service, regardless of the capacity level that can be provided

3.3
coating
in general, a consumable and generally replaceable overlay provided to protect the base material against corrosion and/or erosion and/or act as a thermal barrier.

3.4
compressor surge
unstable condition characterized by low frequency fluctuations in mass flow of the working fluid in the compressor and in the connecting ducts

3.5
condition monitoring
assessment of the condition of a gas turbine or its components by measuring those parameters which, over time, have been established to correlate with an incipient failure condition, and where the monitoring action is non- intrusive with respect to the equipment

Note 1 to entry: Any subsequent maintenance activity which is based upon a diagnosis of parts condition over time and executed in accordance with the monitored degree of deterioration, is referred to as "on-condition maintenance".

3.6
corrosion
chemical reaction and change of the gas turbine material due to corrosive elements in the working fluid

3.7
equivalent operating hours
weighted operating events affecting the life of the machine forming an equivalent operating time to determine inspection intervals or life expectancy

3.8
erosion
abrasive wear of material by mechanical impact of solid particles in the working fluid

3.9
fired start
any start which achieves full ignition and applies heat to the gas path components

Note 1 to entry: For fired hours, see *service hours* ~~(3.36)~~.(3.26).

3.10
failure
sudden and unexpected ending of the ability of a component or equipment to fulfil its function

Formatted: Font: 11 pt, Bold
Formatted: Font: 11 pt, Bold
Formatted: Font: Bold
Formatted: HeaderCentered
Formatted: Adjust space between Latin and Asian text, Adjust space between Asian text and numbers, Tab stops: Not at 0.7 cm + 1.4 cm + 2.1 cm + 2.8 cm + 3.5 cm + 4.2 cm + 4.9 cm + 5.6 cm + 6.3 cm + 7 cm
Formatted: Adjust space between Latin and Asian text, Adjust space between Asian text and numbers
Commented [eXtyles3]: The term "compressor surge" has not been used anywhere in this document
Formatted: Adjust space between Latin and Asian text, Adjust space between Asian text and numbers
Formatted: Adjust space between Latin and Asian text, Adjust space between Asian text and numbers, Tab stops: Not at 0.7 cm + 1.4 cm + 2.1 cm + 2.8 cm + 3.5 cm + 4.2 cm + 4.9 cm + 5.6 cm + 6.3 cm + 7 cm
Formatted: Adjust space between Latin and Asian text, Adjust space between Asian text and numbers
Commented [eXtyles4]: The term "corrosion" is used only in terms and definitions section
Formatted: Adjust space between Latin and Asian text, Adjust space between Asian text and numbers
Commented [eXtyles5]: The term "erosion" is used only in terms and definitions section
Commented [eXtyles6]: The term "fired start" has not been used anywhere in this document
Formatted: Adjust space between Latin and Asian text, Adjust space between Asian text and numbers
Formatted: Adjust space between Latin and Asian text, Adjust space between Asian text and numbers, Tab stops: Not at 0.7 cm + 1.4 cm + 2.1 cm + 2.8 cm + 3.5 cm + 4.2 cm + 4.9 cm + 5.6 cm + 6.3 cm + 7 cm
Formatted: Adjust space between Latin and Asian text, Adjust space between Asian text and numbers
Formatted: FooterPageRomanNumber

3.118
failure to start
FS
inability to bring a unit through a qualifying starting attempt to the in-service state within a specified period due to equipment supplied in the contract

Note 1 to entry: Repeated failures within the specified period are to be counted as a single starting failure. Test starts and failures to start due to equipment not furnished under the contract shall not be counted as starting attempts, failures or successes.

Note 2 to entry: Procedural errors that do not constitute equipment failure involving repair are not counted as failures-to-start.

Note 3 to entry: For calculation, FS = number of failures to start.

3.12
forced outage
FO
unplanned component *failure* (3.7) (immediate, delayed, postponed) or another condition that requires the unit to be removed from service immediately or before the next planned *shutdown* (3.28)

3.139
forced outage hours
FOH
time, in hours, during which the unit or a major item of equipment was unavailable due to forced (unplanned) outages

3.1410
combustion inspection
activity of determining the condition of the combustor section of the gas turbine (including the transition duct)

3.1511
hot corrosion
accelerated oxidation of metals in the presence of salts, e.g. sodium sulfate, leading to degradation

Note 1 to entry: The salts tend to dissolve the protective oxides on the metal, thus continuously consuming the base metal. Hot corrosion occurs mainly in the metal temperature range between 700 °C and 900 °C. In the presence of vanadium the hot corrosion will occur at even lower temperatures, down to 565 °C, by forming very corrosive and low melting phases of sodium vanadates.

3.16
hot gas path / section inspection
activity of determining the condition of the combustion system together with the turbine components of the gas turbine

3.1712
inspection
activity of determining the condition of a component or assembly and necessary replacement

3.1813
major inspection
activity of determining the condition of the entire gas turbine

Formatted: Font: 11 pt
Formatted: Font: 11 pt
Formatted: HeaderCentered, Left, Space After: 0 pt, Line spacing: single
Commented [eXtyles7]: The term "failure to start" has not been used anywhere in this document
Commented [eXtyles8]: The term "FS" is used only in terms and definitions section
Formatted: Adjust space between Latin and Asian text, Adjust space between Asian text and numbers
Formatted: Font: Italic
Formatted: Font: Italic
Commented [eXtyles9]: The term "hot corrosion" is used only in terms and definitions section
Commented [eXtyles10]: The term "hot gas path / section inspection" has not been used anywhere in this document
Formatted: Adjust space between Latin and Asian text, Adjust space between Asian text and numbers
Formatted: FooterPageRomanNumber

3.1914
maintenance
sum of all measures intended to determine the actual gas turbine condition, together with the measures required to preserve/restore the specified condition

~~$MR = e^{-\lambda t}$~~

3.2015
off--line
any activity whilst the machine is out of operation

3.2116
on-line
any simultaneous activity whilst the machine is in operation

3.2217
on-line inspection
any *inspection* (3.12) activity (e.g. of lubricating oil filter) carried out concurrent with the gas turbine being in operation

3.2318
on-line maintenance
any *maintenance* (3.14) activity (e.g. of the auxiliary pump or sensing device) carried out simultaneously with the gas turbine being in operation

3.2419
operating hour
accumulated period of time from *start* (3.29) initiation operation to full stop

3.2520
overhaul
act of dismantling, reconditioning, renewal and/or replacement of components or sub-assemblies of a gas turbine in preparation for continued operation Fin accordance with the manufacturer's guidelines

3.2621
~~**pattern factor**~~
~~**PF**~~
~~maximum deviation of the hot gas temperature from the average temperature, divided by the temperature increase in the combustion chamber:~~

~~$F_{PF} = (T_{TITmax} - \bar{T}_{TIT}) / (\bar{T}_{TIT} - T_{TVH})$~~

~~Where~~

- ~~F_{PF} is the pattern factor (PF)~~
- ~~T_{TITmax} is the maximal value of the turbine inlet temperature;~~
- ~~$\bar{T}_{TIT}$ is the average value of the turbine inlet temperature;~~
- ~~T_{TVH} is the average value of the compressor outlet temperature.~~

Formatted: Font: 11 pt, Bold
Formatted: Font: 11 pt, Bold
Formatted: Font: Bold
Formatted: HeaderCentered
Formatted: Adjust space between Latin and Asian text, Adjust space between Asian text and numbers
Commented [eXtyles11]: The term "off line" has not been used anywhere in this document
Formatted: Font: Italic
Commented [eXtyles12]: The term "on-line maintenance" has not been used anywhere in this document
Formatted: Font: Italic
Formatted: Font: Italic
Commented [eXtyles13]: The term "pattern factor" is used only in terms and definitions section
Commented [eXtyles14]: The term "PF" has not been used anywhere in this document
Formatted: FooterPageRomanNumber