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Gas turbine applications — Safety

Applications des turbines à gaz — Sécurité

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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 21789 was prepared by Technical Committee ISO/TC 192, *Gas turbines*.

Introduction

This document is a type C standard as stated in ISO 12100 (all parts). A type C standard is “a standard dealing with the detailed safety requirements for a particular machine or group of machines”.

The machinery concerned and the extent to which hazards, hazardous situations and hazardous events are covered are indicated in the Scope of this International Standard.

When provisions of this type C standard are different from those that are stated in type A or B standards, the provisions of this type C standard take precedence over the provisions of the other standards for machines that have been designed and built according to the provisions of this type C standard.

The extent of the applicability of the references may be limited by the context of the text within ISO 21789. Where a dated standard is specified this does not preclude the use of later versions provided that the requirements continue to meet the safety issues and identified hazards detailed in this standard. Where a reference is made to a specific clause in a standard only the text of that clause and references therein apply.[1)]

In addition to covering the relevant safety requirements, this International Standard has also been produced to assist designers, manufacturers and others by providing methods of compliance with the relevant, essential safety requirements of the following European Legislation for gas turbine applications without prejudicing compliance with this International Standard outside the European Union:

— Machinery Directive (2006/42/EC);

— ATEX (Equipment) Directive (94/9/EC);

— Pressure Equipment Directive (97/23/EC).

Methods are also provided as far as practical and where relevant for compliance with the relevant, essential safety requirements of the following European Legislation:

— ATEX (Workplace) Directive (1999/92/EC);

— Low Voltage Directive (2006/95/EC);

— Electromagnetic Compatibility Directives (91/236/EEC – 92/31/EEC – 93/68/EEC – 2004/108/EC);

— Integrated Pollution Prevention and Control Directive (96/61/EC);

— Environmental Noise Directive (2002/49/EC);

— Chemical Agents Directive (98/24/EC);

— Classification, Packaging, and Labelling of Dangerous Substances Directive (97/69/EC).

1) References within Notes are provisions but not normative provisions of this document and are listed in the Bibliography.

Gas turbine applications — Safety

1 Scope

This International Standard covers the safety requirements for gas turbine applications using liquid or gaseous fuels and the safety related control and detection systems and essential auxiliaries for all types of open cycles (simple, combined, regenerative, reheat, etc.) used in onshore and offshore applications including floating production platforms.

This International Standard applies to driven machinery only where it is an integral part of the gas turbine (e.g. a gearbox integral to the gas turbine), or is located within the gas turbine enclosure and forms part of the enclosure hazardous area classification (e.g. a generator within the gas turbine enclosure), or where the driven machinery has a direct effect on the operational safety of the gas turbine.

This International Standard details the anticipated significant hazards associated with gas turbines and specifies the appropriate preventative measures and processes for reduction or elimination of these hazards. This International Standard addresses the risks of injury or death to humans and risks to the environment. Equipment damage without risk to humans or the environment is not covered.

Gas turbine packages are generally specified using International Standards and national standards. Achieving safety is promoted by using additional safety codes and standards, which are shared by gas turbines with other technologies. It is necessary to recognize that local legislation in the country in which the equipment is to be put to use may not be covered by this International Standard.

This International Standard approaches gas turbine safety from an international perspective based on the content of existing, recognized ISO and IEC standards to the greatest extent possible. Where no ISO or IEC standard exists, other codes or standards (such as EN, NFPA, etc.) have been included. Where local or national legislation accepts other established codes or standards, or an alternative international or national standard providing equivalent requirements for achieving the desired tolerable level of risk, the use of these alternative codes or standards in place of the references provided in Clause 2 is permissible.

This International Standard excludes gas turbines used primarily for direct and indirect propulsion, special heat source applications and in research and development programmes. It also excludes gas turbines for closed-cycle and semi-closed cycle applications, and compressed-air energy storage plants. Where appropriate, this International Standard can be used to give general guidance in such applications.

This document is not applicable to machinery or safety components that were manufactured before the date of its publication as an International Standard.

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 3977-1:1997, *Gas turbines — Procurement — Part 1: General introduction and definitions*

ISO 3977-3:2004, *Gas turbines — Procurement — Part 3: Design requirements*

ISO 3977-9:1999, *Gas turbines — Procurement — Part 9: Reliability, availability, maintainability and safety*

ISO 4413:1998, *Hydraulic fluid power — General rules relating to systems*

ISO 4414:1998, *Pneumatic fluid power — General rules relating to systems*

ISO 4871:1996, *Acoustics — Declaration and verification of noise emission values of machinery and equipment*

ISO 6183:1990, *Fire protection equipment — Carbon dioxide extinguishing systems for use on premises — Design and installation*[2)]

ISO 10441:2007, *Petroleum, petrochemical and natural gas industries — Flexible couplings for mechanical power transmission — Special-purpose applications*

ISO 10494:1993, *Gas turbines and gas turbine sets — Measurement of emitted airborne noise — Engineering/survey method*

ISO 11086:1996, *Gas turbines — Vocabulary*

ISO 12100-1:2003, *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology*

ISO 12100-2:2003, *Safety of machinery — Basic concepts, general principles for design — Part 2: Technical principles*

ISO 12499:1999, *Industrial fans — Mechanical safety of fans — Guarding*

ISO/TR 13387-7:1999, *Fire safety engineering — Part 7: Detection, activation and suppression*

ISO 14001:2004, *Environmental management systems — Requirements with guidance for use*

ISO 14118:2000, *Safety of machinery — Prevention of unexpected start-up*

ISO 14120:2002, *Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards*

ISO 14121-1:2007, *Safety of machinery — Risk assessment — Part 1: Principles*

ISO 14123-1:1998, *Safety of machinery — Reduction of risks to health from hazardous substances emitted by machinery — Part 1: Principles and specifications for machinery manufacturers*

ISO 14520-1:2006, *Gaseous fire-extinguishing systems — Physical properties and system design — General requirements*

ISO 14691:1999, *Petroleum and natural gas industries — Flexible couplings for mechanical power transmission — General purpose applications*[2)]

ISO 19353:2005, *Safety of machinery — Fire prevention and protection*

IEC 60079-0:2007, *Explosive atmospheres — Part 0: Equipment — General requirements*

IEC 60079-4:1975, *Electrical apparatus for explosive gas atmospheres — Part 4: Method of test for ignition temperature*, amended by IEC 60079-4-AM:1995

IEC 60079-10, *Electrical apparatus for explosive gas atmospheres — Part 10: Classification of hazardous areas*

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2) Replaced by ISO 14691:2008, *Petroleum, petrochemical and natural gas industries — Flexible couplings for mechanical power transmission — General-purpose applications*.

IEC 60079-14:2007, *Explosive atmospheres — Part 14: Electrical installations design, selection and erection*

IEC 60079-17:2007, *Explosive atmospheres — Part 17: Electrical installations inspection and maintenance*

IEC/TR 60079-20:1996, *Electrical apparatus for explosive gas atmospheres — Part 20: Data for flammable gases and vapours, relating to the use of electrical apparatus*

IEC 60079-29-1:2007, *Explosive atmospheres — Part 29-1: Gas detectors — Performance requirements of detectors for flammable gases*

IEC 60079-29-2:2007, *Explosive atmospheres — Part 29-2: Gas detectors — Selection, installation, use and maintenance of detectors for flammable gases and oxygen*

IEC 60204-1:2005, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*

IEC 60204-11:2000, *Safety of machinery — Electrical equipment of machines — Part 11: Requirements for HV equipment for voltages above 1 000 V a.c. or 1 500 V d.c. and not exceeding 36 kV*

IEC 60529:2001, *Degrees of protection provided by enclosures (IP Code)*

IEC 60695-1-1:1999, *Fire hazard testing — Part 1-1: Guidance for assessing the fire hazard of electrotechnical products — General guidelines*

IEC/TR 61000-5-1:1996, *Electromagnetic compatibility (EMC) — Part 5: Installation and mitigation guidelines — Section 1: General considerations — Basic EMC publication*

IEC/TR 61000-5-2:1997, *Electromagnetic compatibility (EMC) — Part 5: Installation and mitigation guidelines — Section 2: Earthing and cabling*

IEC 61000-6-2:2005, *Electromagnetic compatibility (EMC) — Part 6: Generic standards — Section 2: Immunity for industrial environments*

IEC 61000-6-4:2006, *Electromagnetic compatibility (EMC) — Part 6: Generic standards — Section 4: Emission standard for industrial environments*

IEC 61508-1:1998, *Functional safety of electrical/electronic/programmable electronic safety related systems — Part 1: General requirements*

IEC 61511-1:2003, *Functional safety — Safety instrumented systems for the process industry sector — Part 1: Framework, definitions, system, hardware and software requirements*

EN 1127-1:2007, *Explosive atmospheres — Explosion prevention and protection — Part 1: Basic concepts and methodology*

EN 13463-1:2001, *Non-electrical equipment for potentially explosive atmospheres — Part 1: Basic method and requirements*

EN 50272-2:2001, *Safety requirements for secondary batteries and battery installations — Stationary batteries*

NFPA 12:2008, *Standard on Carbon Dioxide Extinguishing Systems*

NFPA 13:2007, *Installation of Sprinkler Systems*

NFPA 15:2007, *Water Spray Fixed Systems for Fire Protection*

NFPA 68:2007, *Standard on Explosion Protection by Deflagration Venting*

NFPA 750:2006, *Standard on Water Mist Fire Protection Systems*

NFPA 2001:2008, *Clean Agent Fire Extinguishing systems*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 3977-1:1997, ISO 3977-3:2004, ISO 3977-9:1999, ISO 11086:1996 and ISO 12100-1:2003 and the following apply.

3.1
auto-ignition temperature
AIT
lowest temperature in degrees Celsius of a heated surface at which the ignition of a combustible substance in the form of gas or vapour mixture with air can occur

NOTE AIT is also referred to as ignition temperature, minimum ignition temperature or self-ignition temperature in other standards and in the literature (see 5.16.4.4).

3.2
drain valve
valve that is intended to remove liquids from a pipework system, and that normally drains to atmospheric pressure

3.3
extinction safety time
maximum allowable period of time between the direct or indirect detection of loss of combustion and cessation of the fuel supply

3.4
foreseeable lifetime
foreseeable lifetime includes all phases of life of a part or a system, for example, but not limited to, construction, transportation, commissioning, use, operation, cleaning, trouble-shooting, maintenance, decommissioning, dismantling, final disposal, etc.

3.5
ignition safety time
maximum allowable period of time between the opening of the fuel supply valve, which permits fuel to flow, and cessation of the fuel supply, in the absence of confirmation that combustion has commenced (e.g. unsuccessful ignition)

3.6
interlock
interlocking device
mechanical, electrical or other type of device, the purpose of which is to prevent the operation of machine elements under specified conditions by an inhibit command from the interlocking device that

a) directly interrupts the energy supply or directly disconnects parts from the equipment, or

b) is introduced into the control system so that interruption of the energy or disconnection of parts from the equipment is triggered by the control system

3.7
lower explosive limit
LEL
volume concentration of flammable gas or vapour in air, below which the mixture is not explosive

NOTE The terms “explosive limit” and “flammable limit” are equivalent.

3.8
operator
person or organization having responsibility for the operation of the equipment

3.9
original equipment manufacturer
OEM
person or company having design responsibility for the equipment or for parts of it

NOTE This may be the manufacturer/packager of the equipment.

3.10
packager
supplier(s) having responsibility for integrating the technical aspects of the equipment and all auxiliary systems included in the scope of the supply

3.11
purchaser
person or company having authority to specify and to buy the equipment

NOTE This, in some cases, may designate the operator.

3.12
relief valve
safety device used for over-pressure protection and which does not operate under normal running conditions

3.13
safety device
all elements that are used to measure, limit or control safety relevant process variables, for processing safety relevant signals or for activation of automatic or manual safety related interventions

3.14
safety related system
systems/components whose primary failure is shown by the failure analysis as likely to cause a hazard and can require special measures in order to achieve an acceptably low probability of occurrence

3.15
spill valve
control valve that is intended to divert a portion of the liquids during normal running conditions

3.16
tolerable risk
risk that is accepted within a given context based on the current values of society

NOTE See IEC 61511-3 and/or ISO/IEC Guide 51.

3.17
valve pressure proving
system to check the effective closure of automatic shut-off valves by detecting leakage

3.18
vent
opening intended to discharge gases, fumes or mists except the exhaust gas of the gas turbine, the latter being called the exhaust system

4 List of significant hazards

Anticipated significant hazards are listed in broad outline in Annex A, which indicates the significant corresponding preventative measures and which should be used in conjunction with Clauses 5, 6, and 7 to reduce or eliminate these hazards.

5 Safety requirements

5.1 General

The overall objective of the safety requirements is to ensure that equipment is designed and maintained throughout its life to attain an appropriate level of safety for its intended application.

To achieve this, the safety management process shall consist of the following three levels, applied in the order shown:

— design for safety with passive means;

— apply active measures (e.g. automatic protection intervention if preset limit values are exceeded);

— communicate the residual risk to the operator by instructions to reduce the risk to a tolerable level.

For relevant hazards which are not dealt with by this International Standard, the machinery should be assessed in accordance with the principles of ISO 12100-1 and ISO 12100-2.

The content of this International Standard should not prejudice technical advances in the field of gas turbine safety or be used to inhibit innovation that can lead to increased safety.

5.2 Risk assessment

Risk assessments shall be performed to determine whether the gas turbine and associated equipment can cause injury to people or pose a threat to people's lives, or to the environment, or can cause significant collateral damage. The results of the assessments shall be documented. Where risk reduction measures are undertaken it is essential to ensure that additional measures do not introduce additional hazards. Risks identified during risk assessment should be eliminated but, where this is not possible, risks shall be reduced to a tolerable level for the associated consequence. Risk assessment is the overriding principal that should, where applicable, be applied to all the requirements of this International Standard.

The content of the risk assessment process should, as a minimum, address the safety issues raised within this International Standard considering reasonably foreseeable activities over the life cycle of the plant.

NOTE 1 Safety is achieved by reducing risk to a tolerable level. Tolerable risk is determined by the search for an optimal balance between the ideal of absolute safety and the demands to be met by a product, process or service and factors such as benefit to the user, suitability for purpose, cost effectiveness and conventions of the society concerned. It follows that it is necessary to review continually the tolerable level, in particular when developments, both in technology and in knowledge, can lead to economically feasible improvements to attain the minimum risk compatible with the use of the product, process or service.

Where this International Standard states that the risk of a potential hazard shall be reduced to a tolerable level, and that hazard is associated with a safety related control function in conjunction with the associated system components (as mentioned in 5.20.1), a qualitative or quantitative risk assessment method shall be applied for the events to define the corresponding safety requirements and/or safety integrity level (SIL) of the protection system.

NOTE 2 IEC 61511-3:2004, Annex B, outlines quantitative methods for risk assessment. IEC 61508-5:1998, Annexes D and E, outline qualitative methods for risk assessment for the purposes of determining SIL levels.

Where the reduction of potential hazards to a tolerable level of risk for components and/or equipment not associated with SILs is required, an appropriate quantitative or qualitative risk assessment or a mixture of both methods shall be used, where applicable, to ensure that a tolerable level of risk is achieved.

The general principles used for risk assessment shall comply with ISO 14121-1:2007.

NOTE 3 In addition to the references in NOTE 2, detailed guidance on the risk assessment process and some of the techniques that can be used are given in IEC 60812:2006, IEC 61025:1990, IEC 61882:2001 and ANSI B11.TR3-2000.

The level of risk obtained shall assume that the requirements of this International Standard are being considered and that the operation and maintenance procedures ensure that the obtained levels of risk are maintained.

For quantitative risk assessments associated with the gas turbine(s) and the associated plant, it is recommended that common practice be followed in setting the maximum tolerable level of individual risk of fatality at 10^{-3} per year for employees and 10^{-4} for the public and the broadly acceptable level of individual risk to 10^{-6} per year. Risks in the tolerable region should be identified as controlled and as low as reasonably practicable (ALARP) considerations applied. To achieve these levels of risk, an allowance should be applied to the risk levels achieved for each separate risk identified in this International Standard that can cause a fatality, such that the above levels are achieved for the gas turbine(s) and the associated plant when other sources of risk are considered by the plant operator.

NOTE 4 IEC 61511-3:2004, Annex A, provides an overview of the concepts of tolerable risk and ALARP. IGE/SR/15, Edition 4, Section 3, provides guidance on exposure to several hazards at one location.

For qualitative risk assessments care should be taken to ensure that the parameters used are clearly defined so that objective judgements can be made, and that the values used for each parameter are appropriately calibrated to ensure that they are valid for the assessment being undertaken.

NOTE 5 IEC 61511-3:2004, D.3, outlines the calibration process in the context of a risk graph and the principles described equally apply to other qualitative methodologies.

NOTE 6 Further guidance on individual levels of risk can be found in IGE/SR/15, Edition 4, Section 3.

Any residual risks shall be communicated to the operator who shall take additional mitigation action as necessary.

If new information that significantly affects a risk assessment becomes available, operators of affected equipment shall be advised.

5.3 Modifications and replacement parts

All modifications and updates/upgrades to protection systems and safety relevant components shall be implemented to achieve the required tolerable level of risk. Replacements of components beyond the requirements of normal maintenance as well as modifications and upgrades of equipment to newer technology require that a risk assessment be performed to ensure that the resulting level of risk remains tolerable.

5.4 Foreseeable misuse

Equipment and protective systems shall be designed and manufactured after due analysis of possible operating faults to preclude dangerous situations due to the consequences of reasonably foreseeable misuse.

5.5 Lifetime

Life predictions for safety related systems/components, including safety protection systems and components, shall be performed to establish that the gas turbine can be operated with a tolerable level of risk throughout its foreseeable lifetime.

Periodic maintenance of protection systems and safety relevant components shall be scheduled to ensure the safety of the plant. The redundancy of protection systems as designed shall be maintained during the lifetime of the plant.

5.6 Hazard combinations

Where the potential exists for gases, vapours, mists and liquids to mix and cause a hazardous situation or affect the operation of a safety device, appropriate measures shall be taken to mitigate the risk to a tolerable level.