INTERNATIONAL STANDARD

ISO 14661

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Thermal turbines for industrial applications (steam turbines, gas expansion turbines) — General requirements

Turbines thermiques pour applications industrielles (turbines à vapeur, turbines à dilatation de gaz) — Prescriptions 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 3.

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 International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 14661 was prepared by Technical Committee ISO/TC 208, *Thermal turbines for industrial application (steam turbines, gas expansion turbines)*.

Annex B is a normative part of this International Standard. Annexes A and C are for information only.

Introduction

This International Standard is a basic standard. Therefore the users of this International Standard should be aware that additional or differing requirements may be needed to meet the needs for the particular service intended.

It is intended to add later, by means of an amendment, an annex containing data sheets appropriate to the text at hand.

Thermal turbines for industrial applications (steam turbines, gas expansion turbines) — General requirements

1 Scope

This International Standard specifies general requirements intended to facilitate the procurement and supply of steam turbines and gas expansion turbines primarily for industrial applications.

This International Standard should serve as a basis for any application although, for special applications, supplementary specifications may also be required, for example for general and special purpose industrial steam turbines used in the petroleum and natural gas industries.

This International Standard is applicable to axial- and radial-flow industrial-type turbines (steam turbines and gas expansion turbines). It specifies the basic requirements for single-stage and multi-stage impulse or reaction turbines, which are not spared or are in critical service. In addition, this International Standard also specifies some requirements for driven machines, gear units, lubrication and sealing systems, controls, instrumentation and auxiliary units for turbine plants.

Exceptions to the requirements laid down in this International Standard may be agreed between the purchaser and supplier.

NOTE 1 Which standard is to be applied in the individual case is the decision of the purchaser. For instance, the purchaser of a generator-driving turbine connected to the public network will generally be responsible for complying with the technical requirements of the public network regardless which standard is specified. If the purchaser of a generator-driving turbine is also the operator of the public network or if he/she is the supplier of an independent power producer (IPP), he/she usually specifies the application of IEC 60045-1.

NOTE 2 Further standards on industrial steam turbines for the Petroleum and Natural Gas Industries are ISO 10436 and ISO 10437. Information on other relevant International Standards is given in the bibliography.

NOTE 3 A bullet ● at the edge of the text indicates that either a decision is required or further information is to be provided by the purchaser. This information should be indicated on the data sheets (see "Introduction") otherwise it should be stated in the quotation request or in the tender.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 261, *ISO general-purpose metric screw threads — General plan.*

ISO 263, *ISO inch screw threads — General plan and selection for screws, bolts and nuts — Diameter range 0.06 to 6 in.*

ISO 1122-1, *Glossary of gear terms — Part 1: Geometrical definitions.*

ISO 1127, *Stainless steel tubes — Dimensions, tolerances, and conventional masses per unit length.*

ISO 1925, *Mechanical vibration — Balancing —Vocabulary.*

ISO 1940-1, *Mechanical vibration — Balance quality requirements of rigid rotors — Part 1: Determination of permissible residual unbalance.*

ISO 1940-2, *Mechanical vibration — Balance quality requirements of rigid rotors — Part 2: Balance errors.*

ISO 2041, *Vibration and shock — Vocabulary.*

ISO 3304, *Plain end seamless precision steel tubes —Technical conditions for delivery.*

ISO 4200, *Plain end steel tubes, welded and seamless — General tables of dimensions and masses per unit length.*

ISO 4572, *Hydraulic fluid power — Filters — Multi-pass method for evaluating filtration performance.*

ISO 6708, *Pipe components — Definition and selection of DN (nominal size).*

ISO 7005-1, *Metallic flanges — Part 1: Steel flanges.*

ISO 7268, *Pipe components — Definition of nominal pressure.*

ISO 7919-1, *Mechanical vibration on non-reciprocating machines — Measurements on rotating shafts and evaluation criteria — Part 1: General guidelines.*

ISO 7919-2, *Mechanical vibration on non-reciprocating machines — Measurements on rotating shafts and evaluation criteria — Part 2: Guidelines for large land-based steam turbine generator sets.*

ISO 7919-3, *Mechanical vibration on non-reciprocating machines —- Measurements on rotating shafts and evaluation criteria — Part 3: Coupled industrial machines.*

ISO 8068, *Petroleum products and lubricants — Petroleum lubricating oils for turbines (categories ISO-L-TSA and ISO-L-TGA) — Specifications.*

ISO 9084, *Calculation of load capacity of spur and helical gears — Application to high speed gears and gears of similar requirements.*

ISO 10816-1, *Mechanical vibration — Evaluation of machine vibration by measurements on non-rotating parts — Part 1: General guidelines*

ISO 10816-2, *Mechanical vibration — Evaluation of machine vibration by measurements on non-rotating parts — Part 2: Large land-based steam turbine sets in excess of 50 MW.*

ISO 10816-3, *Mechanical vibration — Evaluation of machine vibration by measurements on non-rotating parts — Part 3: Industrial machines with nominal power above 15 kW and nominal speeds between 120 r/min and 15 000 r/min when measured in situ.*

ISO 11342, *Mechanical vibration — Methods and criteria for the mechanical balancing of flexible rotors.*

ISO/TR 13989-1, *Calculation of scuffing load capacity of cylindrical, bevel, and hypoid gears — Part 1: Flash temperature method.*

ISO/TR 13989-2, *Calculation of scuffing load capacity of cylindrical, bevel, and hypoid gears — Part 2: Integral temperature method.*

IEC 60045-1, *Steam turbines — Part 1: Specifications.*

IEC 60079 (all parts), *Electrical apparatus for explosive gas atmospheres.*

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

IEC 60584 (all parts), *Thermocouples.*

IEC 60751, *Industrial platinum resistance thermometer sensors.*

IEC 61515, *Mineral insulated thermocouple cables and thermocouples.*

3 Terms and definitions

For the purposes of this International Standard, the terms and definitions given in ISO 1122-1 (for geometrical definitions), ISO 1925 (for balancing definitions), ISO 2041 (for vibration and shock definitions) and the following apply.

NOTE Use of the word "design“ with respect to any steam conditions, power output, speed, etc. should be avoided in contract documents. This terminology should only be applied by the equipment designer and the manufacturer to the values used in design calculations such as the design pressure for pressure vessel.

3.1 Turbines

3.1.1
steam turbine
thermal power unit with rotating components in which the enthalpy drop of steam is converted into mechanical energy in one or several stages

3.1.2
industrial-type steam turbine
steam turbine which is used for industrial purposes.

NOTE In addition to mechanical energy it is typical that, by the use of the turbine, steam can be exported for various production fields. This steam can be extracted from the turbine anywhere during or at the end of expansion.

3.1.3
extraction turbine
turbine in which some of the steam is extracted part-away through the expansion in order to provide process steam

NOTE If the turbine includes means for controlling the pressure of the extracted steam, it is called a controlled (or automatic) extraction turbine.

3.1.4
mixed pressure turbine
turbine where the working fluid enters the turbine at two or more pressures through separate inlet openings

3.1.5
gas expansion turbine
thermal power unit with rotating components, in which the enthalpy drop of a gaseous medium is converted into mechanical energy in one or several stages

NOTE The gas expansion turbine differs from the gas turbine in that it has neither its own associated compression nor combustion system.

3.2 Power output, heat rate and steam rate

3.2.1
rated power output
P_r
maximum power output at the turbine coupling or at the generator terminals, as specified by the purchaser, including the relevant conditions

NOTE The governing valves will not necessarily be fully open.

3.2.2
maximum power output
P_{max}
maximum available power output at the turbine coupling or at the generator terminals, as stated by the manufacturer, including the relevant conditions

3.2.3
heat rate
φ
ratio of the absorbed heat between the motive fluid inlet(s) and outlet(s) to the power output at the coupling or at the generator terminals, considering the specified operating conditions:

$$\varphi = \frac{Q_s - Q_r}{P}$$

where Q_s and Q_r are the heat supplied and the heat returned

NOTE 1 The dimensions are kilojoules per kilowatt second [kJ/(kW·s)] or the equivalent in a coherent unit system to obtain a dimensionless ratio.

NOTE 2 The relationship between the heat rate and the thermal efficiency η_t is

$$\varphi = \frac{1}{\eta_t}$$

3.2.4
steam rate
s
ratio of the steam mass flow rate, q_m, at the inlet of the turbine to the power output at the coupling or at the generator terminals, considering the specified operating conditions:

$$s = \frac{q_m}{P}$$

NOTE 1 The dimensions are kilogram per kilowatt second [kg/(kW·s)] or kilogram per kilowatt hour [kg/(kW·h)] or the equivalent in a coherent unit system.

NOTE 2 The relationship between the steam rate and the thermodynamic efficiency η_{td} and the isentropic drop Δh_s is

$$s = \frac{1}{\eta_{td} \cdot \Delta h_s}$$

where η_{td} is the value of the power output divided by the isentropic power capacity.

NOTE 3 For mixed pressure and for extraction steam turbines it is necessary to declare in addition to the numerical value of the steam rate the associated specific conditions for induction and for extraction steam. These are:

a) for mixed pressure turbines: induction steam

- mass flow,
- pressure,
- temperature;

b) for extraction turbines: extraction steam

- mass flow.

3.3 Connection points

3.3.1
inlet connections
inlet connecting point of the stop valve or casing connecting points for intake and additional induction steam stop valves

3.3.2
outlet connections
outlet connecting point of casing for controlled or uncontrolled extractions or exhaust

3.4 Steam or gas conditions

3.4.1
steam or gas conditions
conditions which define the thermodynamic state of steam or gas, normally (static) pressure and temperature or dryness fraction (or quality)

NOTE Steam or gas pressure should always be quoted in absolute units, not as gauge pressure.

3.4.2
initial steam or gas conditions
steam or gas conditions at the inlet to the stop valves

3.4.3
maximum operating steam or gas conditions
highest steam or gas conditions at which the turbine is required to operate continuously

NOTE The steam conditions should not exceed those permitted by IEC 60045-1.

3.4.4
maximum steam or gas conditions
most severe steam or gas conditions at which the turbine is required to operate continuously

NOTE If the pressure and/or temperature are limited by protecting devices (set values) to protect any component of the turbine's steam or gas system, these set values define the maximum steam or gas condition.

3.4.5
minimum operating steam or gas conditions
least severe steam or gas conditions at which the turbine is required to operate continuously

3.4.6
induction steam conditions
conditions of any additional steam entering the turbine at any pressure lower than the initial pressure

3.4.7
extraction steam conditions
conditions at the extraction connections of the turbine, of steam extracted for feed-heating or process purposes

3.4.8
exhaust conditions
steam or gas conditions at the exhaust connection from the turbine

3.5 Wetness

3.5.1
gas wetness
ratio of the actual mass of vapour and steam droplets contained in a defined gas volume and the total mass of the defined volume

3.5.2
steam wetness
ratio of the actual mass of water in a defined steam volume and the total mass of the defined volume (steam/water mixture)

3.6 Mass flow

3.6.1
steam or gas flow
steam or gas mass flow which the turbine, including the turbine shaft-driven auxiliary equipment, requires to produce the specified power output at the coupling or generator terminals for the different operating points under the specified conditions

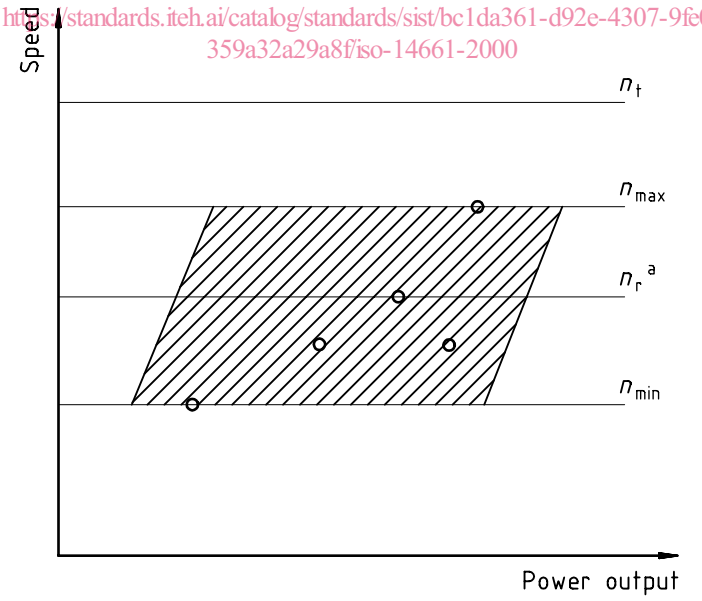
NOTE The requirements for auxiliary steam and power should be agreed upon between the purchaser and the supplier.

3.6.2
extraction or bleed mass flow
steam or gas mass flow extracted from the turbine at a pressure below the inlet pressure but above the outlet pressure

3.6.3
exhaust steam or exhaust gas mass flow
steam or gas mass flow which passes through the casing into the back pressure system or the condensing plant

3.6.4
induction mass flow
steam or gas mass flow induced to the turbine at a pressure below the inlet pressure

3.7 Speeds (see Figure 1)



o = specified operating points

//// = specified operating range for turbines with variable operating speed

a For generator drives, all operating points are situated on this line.

Figure 1 — Definitions of speeds

3.7.1
rated speed
n_r
speed at the rated operating point

3.7.2
minimum continuous operating speed
n_{min}
minimum speed in the specified speed range

NOTE For generator drives this is equal to the rated speed n_r, taking into account a certain variation in network frequency.

3.7.3
maximum continuous operating speed
n_{max}
maximum speed in the specified operating speed range

3.7.4
trip speed
n_t
speed at which the turbine is tripped automatically by the independent overspeed device

NOTE Further details on speeds are given in 10.2 and annex A. Terms concerning speed governing are given in annex B.

3.8 Operating points

3.8.1
normal operating point
point at which usual operation is expected and where optimal efficiency is desired

3.8.2
guarantee point(s)
normal operating point and/or other specified operating points at which guarantee values must be met

3.8.3
rated point
operating point at which the maximum power is produced at the corresponding speed

3.9 Miscellaneous

3.9.1
purchaser
company or corporation which places the order with the supplier

3.9.2
supplier
company or corporation which accepted the order of the purchaser

3.9.3
witnessed inspection or test
inspection or test carried out with the purchaser or his/her representative in attendance

NOTE In this case a hold is applied to the production schedule to ensure that the purchaser can attend.

3.9.4
observed inspection or test
inspection or test carried out after the purchaser has been informed of the timing

NOTE In this case the inspection or test is performed as scheduled and if the purchaser or his/her representative is not present, the supplier may proceed to the next step.

3.9.5
special tools
tools which cannot be found in the catalogues of tooling suppliers

4 Symbols and abbreviations

A	Amplitude
F	Amplification factor
L_v	Vibration limit
MSR	Maximum speed rise
P	Power output
P_m	Maximum power output at which zero extraction or induction is permitted
P_{max}	Maximum available power output
P_r	Rated power output
Q_s	Heat supplied
Q_r	Heat returned
S	Separation margin
SV	Speed variation
U	Input unbalance for rotor response analysis
U_{max}	Maximum allowable residual unbalance
W	Journal static weight load
h	Enthalpy
Δh_s	Isentropic enthalpy drop
n	Speed
n_c	Rotor critical speed
n_m	Speed at maximum power output with zero extraction or induction
n_{max}	Maximum continuous operating speed
n_{min}	Minimum continuous operating speed
n_r	Rated speed
n_s	Set point of speed
n_t	Trip speed
Δn	Difference in speeds
q_m	Mass flow rate of steam
s	Steam rate
δ	Steady-state speed regulation
δ_i	Incremental steady-state speed regulation

η_t Thermal efficiency

η_{td} Thermodynamic efficiency

φ Heat rate

5 Enquiry and tender

5.1 General

5.1.1 Because of the long delivery time for turbines, the last but one sentence in the introductory phrase to clause 2 is to read as follows: If not otherwise agreed, the edition of the normative document valid at the moment of order placement, shall apply.

5.1.2 The data sheets for industrial turbines are part of the inquiry or of the order. If there is any contradiction of this International Standard in the inquiry, then the statements in the inquiry take precedent. With an order, the information of the order overrules that given in this International Standard.

Documents which are part of the inquiry, the quotation or the order shall not be passed to a third party, except if this is necessary for setting up the quotation or for the execution of the order.

Documents which have been submitted to the purchaser and which are approved by him shall be incorporated in the order information.The approval does not release the supplier and the purchaser from their contractual obligations.

The responsibility for the coordination of the turbine and the driven machine shall be clarified before the contract is agreed.

5.2 Enquiry

The purchaser shall complete the data sheets for industrial turbines as far as is possible. In the data sheets all statements shall be made which are necessary for the supplier to make a tender. Where the standard requires the purchaser to make a decision, he should make an unequivocal statement.

The purchaser shall state any exceptions and deviations from this International Standard, which are to be considered by the supplier.

● In this enquiry the purchaser shall specify all spare parts, which he/she requires to be taken into account within the tender. The supplier may amend this list with his/her own proposals.

The purchaser shall provide the supplier with all information concerning legislative authority regulations which shall be valid for the turbine and its appurtenances, e.g. noise emission, air pollution, water pollution, fire protection, etc.

The purchaser and the supplier shall agree on any exceptions and deviations from this International Standard.

5.3 Tender

The supplier shall complete the data sheets for industrial turbines and include them as part of the tender documentation. He shall provide additional information where necessary to describe the scope of supply.

In addition, the supplier shall provide the following minimum level of documentation with the tender:

a) arrangement or outline drawings;

b) schematic drawings for the operating fluid systems, control and lubrication oil systems, and overall control systems;