

Guide to

Steam turbine procurement

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British Standard

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National foreword

This British Standard has been prepared under the direction of the Machinery and Components Standards Policy Committee and is the English language version of EN 60045-1:1993 *Steam turbines — Part 1: Specifications*, published by the European Committee for Electrotechnical Standardization (CENELEC). It is identical with IEC 45-1:1991 published by the International Electrotechnical Commission (IEC) and supersedes BS 132:1983 *Guide for steam turbines procurement*, which is withdrawn.

For graphical symbols, and letter symbols and signs approved by the IEC for general use, readers are referred to:

- IEC Publication 27: *Letter symbols to be used in electrical technology*;
- IEC Publication 617: *Graphical symbols for diagrams*.

The symbols and signs contained in the present publication have either been taken from IEC Publications 27 or 617, or have been specifically approved for the purpose of this publication.

For general terminology, readers are referred to IEC Publication 50: *International Electrotechnical Vocabulary (IEV)*, which is issued in the form of separate chapters each dealing with a specific field, the General Index being published as a separate booklet. Full details of the IEV will be supplied on request.

The terms and definitions contained in the present publication have either been taken from the IEV or have been specifically approved for the purpose of this publication.

EN 60045-1 was produced as a result of international discussion in which the United Kingdom took an active part.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the EN title page, pages 2 to 26, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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Descriptors: Turbogenerator, turbine, steam under pressure, generator, specification, operating characteristic

English version

Steam turbines Part 1: Specifications

(IEC 45-1:1991)

Turbines à vapeur
Partie 1: Spécifications
(CEI 45-1:1991)

Dampfturbinen
Teil 1: Anforderungen
(IEC 45-1:1991)

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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
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Foreword

The CENELEC questionnaire procedure, performed for finding out whether or not the International Standard IEC 45-1:1991 could be accepted without textual changes, has shown that no common modifications were necessary for the acceptance as European Standard.

The reference document was submitted to the CENELEC members for formal vote and was approved by CENELEC as EN 60045-1 on 9 December 1992.

The following dates were fixed:

- latest date of publication of an identical national standard (dop) 1993-12-01
- latest date of withdrawal of conflicting national standards (dow) 1993-12-01

For products which have complied with the relevant national standard before 1993-12-01, as shown by the manufacturer or by a certification body, this previous standard may continue to apply for production until 1998-12-01.

Annexes designated “normative” are part of the body of the standard. In this standard, Annex A and Annex ZA are normative.

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Introduction

The first edition of IEC 45 was issued in 1931. Subsequent revisions were made, the last being in 1970. Since then, intensive development has resulted in the availability of more highly-rated turbines.

The development of turbines suitable for use with water-cooled nuclear reactors has proceeded in parallel, resulting in the production of large turbines for use with steam which is initially dry-saturated or slightly wet.

The demands made upon turbine control systems have increased simultaneously with the development of new control technologies, such as electro-hydraulic systems. Increased reliability, higher standards of dynamic performance, suitability for two-shift operation, and increased attention to health and safety are among the aspects now requiring high standards of achievement.

It has therefore become necessary to specify a turbine in more detail than was formerly needed. In consequence, this part of IEC 45 has been completely re-written, and is accordingly more comprehensive than earlier editions.

Wherever practicable, this part of IEC 45 takes into account the scope for applying to smaller turbines developments originally intended for larger machines, without implying that such applications would always be necessary or advantageous.

1 Scope and object

This part of International Standard IEC 45 is applicable primarily to steam turbines driving generators for electrical power services. Some of its provisions are relevant to turbines for other applications.

The purpose of this part is to make an intending purchaser aware of options and alternatives which he may wish to consider, and to enable him to state his technical requirements clearly to potential suppliers.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 651:1979, *Sound level meters*.

IEC 953-1:1990, *Rules for steam turbine thermal acceptance tests — Part 1: Method A*.

IEC 953-2:1990, *Rules for steam turbine thermal acceptance tests — Part 2: Method B*.

ISO 2372:1974, *Mechanical vibration of machines with operating speeds from 10 to 200 rev/s. Basis for specifying evaluation standards*.

ISO 7919-1:1986, *Mechanical vibration of non-reciprocating machines — Measurements on rotating shafts and evaluation — Part 1: General guidelines*.

3 Terms and definitions

For the purposes of this part, the following terms and definitions apply:

3.1 Turbine type

superheat turbine

a turbine whose initial steam is significantly superheated

wet-steam turbine

a turbine whose initial steam is saturated or nearly so (Also referred to as saturated-steam turbine.)

reheat turbine

a turbine from which the steam is extracted part-way through the expansion, reheated (one or more times) and readmitted to the turbine

non-reheat turbine

a turbine in which the steam is not reheated

mixed-pressure turbine

a turbine provided with separate inlets for steam supplied at two or more pressures

back-pressure turbine

a turbine whose exhaust heat will be used to provide process heat, and whose exhaust is not directly connected to a condenser. The exhaust pressure will normally be above atmospheric pressure (Also referred to as a non-condensing turbine.)

condensing turbine

a turbine whose exhaust is directly connected to a condenser. The exhaust pressure will normally be below atmospheric pressure

regenerative-cycle turbine

a turbine from which some of the steam is extracted part-way through the expansion in order to heat feed water

extraction turbine

a turbine in which some of the steam is extracted part-way through the expansion in order to provide process steam. If the turbine includes means for controlling the pressure of the extracted steam, it is called a controlled (or automatic) extraction turbine

combined cycle

a combination of boiler, steam turbine and gas turbine, in which the gas turbine exhaust normally contributes to the heat input to the steam cycle

single-line combined-cycle

a combined-cycle plant in which the steam turbine and gas turbine both drive the same generator. It is not possible to segregate the separate outputs of the steam turbine and the gas turbine; and definitions, such as those of heat rate or output given later in this standard, no longer apply

NOTE The terms in 3.1 may be combined to define the features of any particular unit.

3.2 Methods of initial steam admission**full-arc**

all of the governing (control) valves supply steam uniformly to the admission inlet belt of the first stage

partial-arc

the inlet belt to the first stage is divided into discrete arcs of admission, steam being supplied separately to each arc through, normally, one governing valve; governing valves operate wholly or partially in sequence

3.3 Conditions**terminal conditions**

the terminal conditions for a steam turbine or turbine-generator are the conditions imposed on the plant at their terminating points of the contract. These may typically comprise:

- initial and hot reheat steam conditions;
- cold reheat pressure;
- final feed water temperature;
- exhaust pressure;
- power output;
- speed;
- extraction requirements.

specified or rated terminal conditions

the conditions at the terminating points of the turbine or turbine-generator contract, with which specified output and/or heat rate shall be stated and/or guaranteed. Note that some nuclear steam generators supply steam at a pressure which increases as load reduces, and the turbine design must allow for this

steam conditions

the conditions which define the thermodynamic state of steam, normally (static) pressure and temperature or dryness fraction (or quality). Steam pressure should always be quoted in absolute units, not as gauge pressure

initial steam conditions

the steam conditions at inlet to the main stop valves

maximum steam conditions

the highest steam conditions at which the turbine is required to operate continuously

NOTE The highest steam conditions should not exceed those permitted by 6.2 a) and 6.2 b).

induction steam conditions

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

dual steam conditions

the combination of initial and induction steam conditions appropriate to a mixed-pressure turbine

reheat steam conditions

the steam conditions at the inlet to the reheat stop valves (Also referred to as hot reheat steam conditions.)

cold reheat steam conditions

the steam conditions at the outlet of the turbine preceding the reheater

extraction steam conditions

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

exhaust conditions

the steam conditions at the exhaust connection from the turbine

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

3.4 Speeds**rated speed**

the speed at which the turbine is specified to operate at its rated output

maximum continuous speed

the upper limit of the operating speed of the turbine for continuous service

overspeed trip setting

the speed at which the overspeed trip is set to operate

temporary speed rise

the transient increase in turbine speed following a load rejection, with the speed governing system in operation. The rated temporary speed rise applies if the rated output is rejected at the rated speed

maximum transient speed

maximum rotational speed following rejection of maximum capability by disconnecting the generator from the electric system (with auxiliary supplies previously disconnected) and the speed governing (control) system in operation

permanent speed rise

the final steady-state increase in turbine speed following a load rejection, with normal governor control

maximum speed rise

the transient increase in turbine speed following a load rejection, with the speed governing system inoperative and the overspeed trip operative. The rated maximum speed rise applies if the rated output is rejected at rated speed

3.5 Powers

NOTE All these powers or outputs refer to operation of the turbine at rated terminal conditions (except where stated otherwise).

power

the power supplied by the turbine or its driven machine. The definition should state the position of measurement and any deductions for losses or auxiliary power (Also referred to as output or load.)

net power at coupling

the power at the turbine coupling, less the power supplied to turbine auxiliaries if driven separately

generator output

power at the generator terminals, after the deduction of any external excitation power

maximum continuous rating (MCR) (electrical generating set)

the power output assigned to the turbine-generator by the supplier, at which the unit may be operated for an unlimited time, not exceeding the specified life, at the specified terminal conditions. This is the rating which will normally carry a guarantee of heat rate. The governing (control) valves will not necessarily be fully open (Also referred to as rated output, rated power, or rated load.)

maximum continuous rating (MCR) (other than electrical generator drives)

the power output assigned to the turbine by the supplier, at which the unit may be operated for an unlimited time, not exceeding the specified life, at the specified terminal conditions. This is the rating which will normally carry a guarantee of heat rate. The governing (control) valves will not necessarily be fully open. The power shall be that delivered at the turbine coupling, or the coupling of the driven machine, as may be agreed (Also referred to as rated output, rated power, or rated load.)

maximum capability

the power output that the turbine can produce with the governing (control) valves fully open and at the specified terminal conditions (Also referred to as valves-wide-open capability.)

maximum overload capability

the maximum power output that the unit can produce with the governing (control) valves fully open, and with the terminal conditions specified for over-load, e.g. with final feed water heater bypassed, or with increased initial steam pressure

most economical continuous rating (ECR)

the output at which the minimum heat rate or steam rate is achieved at the specified terminal conditions

net electrical power

the generator output (with external excitation power deducted) minus the electrical auxiliary power

electrical auxiliary power

power taken by turbine and generator auxiliaries not driven by the turbine. This will normally include all power used for control, lubrication, generator cooling and sealing. It may also include additional auxiliaries such as motor-driven boiler feed pumps. The purchaser and contractor should agree on which additional auxiliaries should be included

3.6 Steam flow rate and steam rate**initial steam flow rate**

the flow rate of steam at initial conditions to the turbine, including any steam supplied to valve stems, glands, or balance pistons, and any steam supplied to auxiliary plant such as boiler feed pump turbines, steam/steam reheaters, ejectors, etc.

steam rate

the ratio of initial steam flow rate to power output

3.7 Heat rates

(See also IEC 953, where the definitions are given in greater detail)

heat rate

the ratio of external heat input to the cycle to power output. It is the reciprocal of thermal efficiency

guarantee heat rate

the heat rate upon which the guarantee or offer is based for a stated output with the rated terminal conditions, and for the cycle described in **19.1**. Any assumption with regard to extraneous flows, make-up, heat addition or removal, shall be stated. In all cases, the formula used to define the heat rate shall be stated in the contract

uncorrected test heat rate

the heat rate obtained by inserting test results in the formula stated in the contract

fully-corrected heat rate

the heat rate which would have been achieved during the test if the terminal conditions had been as specified, and all ancillary plant outside the supplier's responsibility had performed exactly in accordance with its guarantee

3.8 Efficiency

thermal efficiency

the reciprocal of heat rate, and therefore defined as the ratio of power output to external heat input to the cycle. If guaranteed, the definition of thermal efficiency shall be stated in the contract

3.9 Operational regimes (modes)

base-load operation

operation at maximum continuous rating (MCR) or a high fraction of this throughout a prolonged period

two-shift operation

operation at MCR or a high fraction of this for about 16 h or less out of 24 h per day, the remaining time being shut down

one-shift operation

operation at MCR or a high fraction of this for about 8 h out of 24 h per day, the remaining time being shut down

load cycling

operation alternating between high and low levels of load on a regular basis

peak-load operation

operation at high load for short periods, typically 1 h to 3 h, at times of peak demand. The number of peaks per day is not implied. The remaining time is spent shut down

NOTE Although the above definitions are of a general nature, they may be made more specific by stating whether the turbine is or is not subject to periodic shutdown, which might typically be categorized as a 36 h shutdown or a 48 h shutdown.

3.10 Methods of load variation

constant-pressure operation

operation in which the initial steam pressure is maintained sensibly constant, and where load is reduced by gradually closing the governing (control) valves either in parallel (full-arc admission) or in sequence (partial-arc admission)

sliding-pressure operation

operation in which load is changed by variation of the initial steam pressure; the governing (control) valves, which operate in parallel, all remaining at their fully-open position

modified sliding-pressure

operation in which load changes in the range from 100 % to about 90 % of rated output are achieved by operating all the governing (control) valves in parallel, the initial steam pressure remaining constant; below about 90 % of rated output changes of load are, where practicable, achieved by variations of the initial steam pressure, while the governing (control) valves remain near the position corresponding to 90 % of rated output

hybrid operation

operation of a partial-arc admission machine in which load is reduced by sequential closing of the governing (control) valves to a value corresponding to the minimum allowable number of governing (control) valves remaining fully open, the initial steam pressure remaining constant; further reduction of load is achieved by reduction in initial steam pressure while those governing (control) valves are open remain at or near their fully-open position

throttle governing

the governing (control) valves operate in parallel, or nearly so, this being the normal control mode of a full-arc admission turbine in constant-pressure operation

nozzle governing

the governing (control) valves close in sequence, this being the normal control mode of a partial-arc admission turbine in constant-pressure operation

3.11 Operational life

calendar age

the total elapsed life of the plant, expressed in months or years, measured from first synchronization