

JIS

JAPANESE INDUSTRIAL STANDARD

**Specification for
steam turbines**

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In the event of any doubt arising,
the original Standard in Japanese is to be final authority.

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JAPANESE INDUSTRIAL STANDARD
Specification for steam turbines

J I S
B 8101-1991

1. Scope

This Japanese Industrial Standard specifies general specifications for steam turbines for power generation hereafter referred to as "turbines".

Further, this Standard may be applied to steam turbines for other uses.

Remarks 1. Applicable Standards to this Standard are shown in the following:

JIS B 0127-Glossary of Terms for Thermal Power Plant (Steam Turbines, Geothermal Power Plant and Auxiliary Equipment)

JIS B 0130-Glossary of Terms for Thermal Power Plant (General)

JIS B 8102-Rules for Acceptance Test of Steam Turbines

JIS C 1502-Sound Level Meters

2. Corresponding International Standard to this Standard is shown in the following.

IEC Publication 45 Specification for steam turbines

2. Definitions

For the purposes of this Standard main definitions are in accordance with JIS B 0127, JIS B 0130 and JIS B 8102, and further the following definitions apply.

(1) turbine and cycle types

- (a) superheat turbine The turbine of which main steam is superheat steam.
- (b) wet-steam turbine The turbine of which main steam is saturated or near thereto steam. This is called also the "saturated-steam turbine".
- (c) reheat turbine The turbine in which the steam is taken out in the midway of expansion stage, reheated and returned to the turbine and further expands (Refer to JIS B 0127).
- (d) non-reheat turbine The turbine in which in midway of expansion stage the reheating of steam is not carried out (Refer to JIS B 0127).

- (e) mixed-pressure turbine The turbine of such structure that steams different in pressure are entered in the same turbine to work (Refer to JIS B 0127).
- (f) back-pressure turbine The turbine of which exhaust steam is utilized for factory steam and others, and the turbine to discharge it to atmosphere. It is called also non-condensing turbine (Refer to JIS B 0127).
- (g) condensing turbine The turbine of which exhaust steam is condensed by a condenser to obtain high vacuum and the steam is expanded in turbine until sufficient low pressure (Refer to JIS B 0127).
- (h) regenerative turbine The turbine to extract steam from the intermediate stage of turbine and to utilize for feed-water heating (Refer to JIS B 0127).
- (i) extraction turbine The turbine to extract steam from the intermediate stage of turbine and to use this for factory or others.

In the case of controlling the pressure of extraction steam, it is called "controlled extraction turbine" or "automatic extraction turbine".

- (j) combined cycle The cycle intended to improve the thermal efficiency by connecting the gas turbine cycle and steam turbine cycle.

This is constituted by gas turbine, exhaust heat recovery boiler, and steam turbine and the exhaust heat of gas turbine is utilized as entering heat of steam cycle.

- (k) single-line combined-cycle The combined cycle of which steam turbine and gas turbine drive the same generator.

Remarks: Because the outputs of steam turbine and gas turbine can not be separated individually, the definitions of output and heat rate of this Standard are not applied.

- (1) multi-line combined cycle The combined cycle of which steam turbine and gas turbine drive each individual generator.

Remarks: Definitions described in (1), in the case where the definition of special unit constitution is required those may be combined.

(2) steam inlet system

- (a) full-arc admission The system to spray steam from all control valves (Refer to JIS B 0127).
- (b) partial-arc admission The system to feed steam only a part of nozzle group in nozzle cutout governing type turbine (Refer to JIS B 0127).

(3) plan conditions

- (a) terminal conditions Conditions to be satisfied on the plan of power plant at the terminal point on contract.

Remarks: Main conditions to be satisfied on the plan are shown in the following:

Initial steam, high temperature reheat steam conditions

Cold reheat steam conditions

Final feed water temperature

Exhaust steam pressure

Output

Rotating speed

Requiring of extraction steam

- (b) specified terminal conditions; rated terminal conditions Conditions to be described clearly in the contract with both output and heat rate, and further to be guaranteed.

Remarks: The steam to be fed by nuclear reactor steam generator, in some cases, following the decrease of load the pressure rises and it shall be permitted on turbine design, and therefore cautions are required.

- (c) steam conditions Collection of steam pressure (static pressure), temperature, dry degree, etc. (Refer to JIS B 0130).

Remarks: The steam pressure is usually expressed by absolute pressure, but may be expressed by gauge pressure.

- (d) initial steam conditions The steam conditions at inlet of main stop valve.

- (e) maximum steam conditions The permissible value of maximum steam conditions capable of continuous running of turbine.

- (f) induction steam conditions Steam conditions of low pressure steam to be entered turbine at any pressure lower than the initial steam pressure.

- (g) dual steam conditions The steam conditions combined with the main steam and low pressure indraught steam suitable for mixed pressure turbine.

- (h) reheat steam conditions The steam conditions at reheat-steam stop-valve inlet.

- (i) cold reheat steam conditions The steam conditions at turbine outlet at reheater up-stream side.

- (j) extraction steam conditions The steam conditions at turbine take-out point of steam for feed water heating, factory, etc.
- (k) exhaust conditions The steam conditions at outlet of turbine.

(4) speed

- (a) rated speed The plan rotating speed
- (b) maximum continuous speed The upper limit value of rotating speed capable of continuous running.
- (c) over speed trip setting The rotating speed for working of emergency governor.
- (d) instantaneous maximum speed Under the condition when at an optional load, the governor of turbine running at specified conditions and rated speed is working normally, the rotating speed to attain instantaneously the load cut off rapidly, immediately after (Refer to JIS B 0127).

Remarks: The instantaneous maximum speed in the case where at the rated speed the rated load is cut-off is called the rated instantaneous maximum speed.

- (e) permanent speed rise Under the condition where the governor of turbine is working normally, when the load is cut-off, the turbine rotating speed at the finally stabilized condition (Refer to JIS B 0127).

(5) power; output

- (a) power; output The power generated by the turbine driven or the appliance driven by turbine. It is called also the load.

Remarks 1. Relating to a dealing of measuring point, each type loss and power for auxiliary machine shall be defined clearly.

2. The power herein, unless particularly specified, means that relating to turbine at instructed terminal conditions.

- (b) net power at coupling The power at turbine coupling (shaft joint part), except the power for turbine auxiliary machine not driven directly by the turbine.
- (c) generator output The output at terminal of generator.
- (d) maximum continuous rating (MCR) The guarantee maximum continuous power at generator terminal in the case where the turbine is driven under the specific conditions.

It is also called the rated output, rated power, or rate load.

Remark: In the case of other than generator driving, evaluate the power by turbine shaft joint or driven machine side joint determined by agreement.

- (e) maximum capability The maximum capable output when the main steam control valve is made full open under the specified initial steam conditions.

It is called also the values-wide-open capability.

- (f) most economical continuous rating (ECR) The output in the case where the heat rate or steam rate becomes minimum.
- (g) net electrical power The electrical power of output of generator terminal subtracted by auxiliary machine power.
- (h) electrical auxiliary power The electrical power for auxiliary machines of turbine and generator not driven directly by main machine.

Remarks 1. Generally, this power includes all powers required for exciting electric power, control, lubrication, generator cooling, generator seal, etc.

2. The auxiliary machine to be included as auxiliary power shall be agreed between the parties concerned with delivery.

(6) steam flow rate and steam rate

- (a) initial steam flow rate The steam flow rate under the turbine initial stem conditions. It includes the supply steam to valve stem, gland, and balance piston and the supply steam to plant auxiliary machine such as the turbine for driving of feed water pump, steam/steam heater, ejector, etc.
- (b) steam rate The steam consumption rate per 1 kWh (Refer to JIS B 0127).

(7) Heat rate

- (a) heat rate The heat consumption rate per 1 kWh (Refer to JIS B 0130).
- (b) guarantee heat rate The heat rate guaranteed based on the contract. The calculation formula defined with the heat rate is to be described in the contract specifications.
- (c) uncorrected test heat rate The heat rate to be obtained by entering the test results in the calculation formula described in contract specifications.
- (d) fully-corrected heat rate The heat rate to be obtained in the conditions where all environmental conditions such as terminal conditions are in the specified condition of guaranteed performance.

Remarks: Details of definition of heat rate are in accordance with JIS B 8102.

(8) efficiency

- (a) thermal efficiency The ratio of entering heat in the cycle to discharge heat (output).

(9) operation system

- (a) base-load operation The operation system to be operated for a long time under the rated or near thereto load.
- (b) two-shift operation Such operation system that 16 h out of 24 h per day it is operated and for the remaining time are stopped.
- (c) one-shift operation Such operation system that 8 h out of 24 h per day it is operated at the rated or near thereto load and for the remaining time are stopped.
- (d) load cycling The operation system to carry out alternately the high load and low load.
- (e) peak-load operation The operation system to operate for a short time at high load as required for peak electric power and for other time to be stopped.

Remarks: The above-mentioned operation system indicates the representative example.

(10) load changing system

- (a) constant-pressure operation The operation system to keep the initial steam pressure at a constant and to change the load according to the change of opening degree of control valve.
- (b) sliding-pressure operation The operating system to be operated at initial steam pressure corresponding to the load in order to improve the thermal efficiency at low load (Refer to JIS B 0130).
- (c) modified sliding-pressure operation The operating system to perform the constant-pressure operation for the load not less than a certain load and to perform the sliding-pressure operation for the load not more than it.

That is the operation system, in the partial-arcadmission system sampler, to carry out the load changing (lowering) by throttling sequentially with keeping the main steam pressure at constant and with keeping the minimum limit control valve at fully opening as it is.

Further, in the case of lowering the load, it is operated by lowering the main steam pressure with the control valve maintained at nearly full opening keeping opening as it is.

- (d) throttle governing The governing the output by throttling the steam with controlling the opening degree of steam-control valve and changing the heat drop difference and steam flow rate (Refer to JIS B 0127).
- (e) nozzle governing With the effective heat drop difference at constant as it is, control the number of nozzles, control the number of nozzles to eject the steam, and by changing the flow rate to regulate the output (Refer to JIS B 0127).

(11) operating life

- (a) calendar age The total lapse of time of plant since the initial arranging in row on the calendar expressed by year or month.
- (b) running hours The total hours when the plant is loading operated.

(12) control and protection system

- (a) governing system The system to carry out the speed control, which regulates the steam flow rate by changing the opening degree of control valve so as to be specified rotating speed always independent of the fluctuation of load. At the time of parallel running, it is capable of increasing-decreasing of load. There are mechanical type and electrical type (Refer to JIS B 0127).
- (b) turbine-generator protection system The system general to be installed for protecting the turbine and generator from accident in power plant or series accidents with other power plants.
- (c) steady-state condition The running condition holding the rotating speed and load at constant.
- (d) stable operation The operation made steady-state condition after variation of rotating speed or load.
- (e) steady state speed regulation The value expressed by ratio of rotating speed change quantity when changed the turbine output from the rated load until no load without changing the setting of governing system.

It is called also the overall speed droop.

The steady state regulation R_s (%) is obtained according to the following formula (Refer to JIS B 0127).

$$R_s = \frac{n_0 - n_r}{n_r} \times 100$$

where n_0 : steady state speed (s^{-1})

n_r : rated speed (s^{-1})

- (f) incremental speed droop; incremental speed variation The incremental speed droop R_r (%) is to be obtained according to the following formula (Refer to JIS B 0127).

$$R_r = \frac{d_n}{d_p} \cdot \frac{P}{n_r} \times 100$$

where $\frac{d_n}{d_p}$: increment at an optional output point of output-speed characteristics (s^{-1}/kW)

P : rated output (kW)

n_r : rated speed (s^{-1})

- (g) dead band of the speed governing system The ratio of rotating speed changing quantity in the range of without changing of control-valve opening degree during rated speed operating to the rated rotating speed.

- (h) maximum load inaccuracy or non-linearity The maximum load inaccuracy of load-rotating speed curve from the straight line corresponding to the total speed regulation in the case of being operated under the specified condition.
- (i) governor environmental stability Stability of load due to change of main cause of load setting or other than rotating speed change. For main cause, there are time lapse, temperature, vibration, atmosphere, supply voltage·frequency to governing system, etc.
- (j) short-term stability Change of load command value after an elapse of short term (30 min) to the set load and rotating speed under the specified environmental conditions.
- (k) long-term stability Changer of the short-term stability after an elapse of a definite term (12 months) to the set load and rotating speed.

Further, at the time of both tests, the environmental conditions are not required to be the same, but must be in the specified range.

3. Guarantee

3.1 General matters The contract specifications may be described, as the guarantee items, with thermal efficiency, heat rate, or steam-rate, output, electrical auxiliary power, etc.

Further, the function of governing system, vibration, noise level, etc. may be made the guarantee item.

Further, for all guarantee items shall be described in contract specifications together with the calculation formula.

3.2 Thermal efficiency, heat rate or steam rate The guarantee of thermal efficiency, heat rate or steam rate shall be as follows:

- (1) The guarantee of thermal efficiency, heat rate or steam rate may be guaranteed to one or more loads according to the specification of JIS B 8102.

In the case where the thermal efficiency, heat rate or steam rate to a series loads are guaranteed by the weighted mean, the calculation formula of the weighted mean shall be agreed between the parties concerned with delivery and, described in contract specifications.

- (2) In the case where the feed-water pump is built-in between the feed-water heaters of feed-water series and further the pressure rise in pump and pump efficiency are not instructed by purchaser, the turbine manufacturer must describe the values based on the guarantee on the estimated letter and contract specifications.
- (3) In the case where the regenerative feed water heater or auxiliary turbine is built-in the main turbine and feed water heating series, the parties concerned with delivery discuss relating to the whole series diagram to be the base of guarantee of heat rate.

- (4) Relating to dealing with heat source and heat quantity required for correction of test results such as the heat quantity given from the cooler of steam spray type air extractor, the heat quantity to be lost by cooling of piping, etc., even though that is outside of supply range but is included at guarantee calculation time and due to the change, the agreement between the parties concerned with delivery is carried out and described on the contract specifications.
- (5) The correction of thermal efficiency, heat rate or steam rate due to difference of operation conditions and specified test conditions, unless otherwise instructed, is to be carried out according to the specification of JIS B 8102.
- (6) In case where the regenerative type feed water heater is outside the supply range of turbine manufacturer, the purchaser indicates preliminarily the required data for guaranteeing by turbine manufacturer such as heat rate. In the other way, the turbine manufacturer describes, in the written estimate and contract specifications relating to the number of units of feed-water heaters, arrangement, terminal temperature difference, pressure loss from the turbine until feed-water heater, etc. used for guaranteeing of heat efficiency, heat-rate, or steam rate. In the wet steam turbine, even in the case where the wet content separator and heater are outside the supply range of turbine manufacturer, make similarly.
- (7) The turbine manufacturer, in the case where the performances of facilities (for example, feed water heater, pump, valve, piping, etc.) of outside the supply range are different from the conditions to be performed with guarantee of thermal efficiency, heat rate or steam rate, in the step of contract, can readjust the content of guarantee or apply corrections agreed between the parties concerned with delivery to the delivery performance test results.

3.3 Rated output and inlet steam quantity The turbine shall be confirmed relating to rated output or inlet steam quantity according to terminal conditions described in contract specifications.

The test shall be executed according to the specifications of JIS B 8102.

3.4 Electrical auxiliary power In the case of performing the guarantee relating to electrical auxiliary power, relating to the objective appliance perform the agreement between the parties concerned with delivery and describe on the contract specifications.

Measure the consumption electric power of each facility under the specified terminal conditions at the specified output of turbine or under the specified conditions determined by agreement between the parties concerned with delivery.

3.5 Steam table The class of steam table to be used for guarantee and calculation of test results is in accordance with the international frame steam table, as appropriate, of the 1963 year, and shall be agreed between the parties concerned with delivery and be described on the contract specifications.