INTERNATIONAL STANDARD

ISO 10437

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Petroleum and natural gas industries — Special-purpose steam turbines for refinery service

Industries du pétrole et du gaz naturel — Turbines à vapeur d'usage spécial pour service en raffinerie

Reference number
ISO 10437:1993(E)

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.

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.

International Standard ISO 10437 was prepared by the American Petroleum Institute (API) (as STD 612, 3rd edition) and was adopted, under a special "fast-track procedure", by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum and natural gas industries*, in parallel with its approval by the ISO member bodies.

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Introduction

International Standard ISO 10437:1993 reproduces the content of API STD 612, 3rd edition, 1987. ISO, in endorsing this API document, recognizes that in certain respects the latter does not comply with all current ISO rules on the presentation and content of an International Standard. Therefore, the relevant technical body, within ISO/TC 67, will review ISO 10437:1993 and reissue it, when practicable, in a form complying with these rules.

This standard is not intended to obviate the need for sound engineering judgement as to when and where this standard should be utilized and users of this standard should be aware that additional or differing requirements may be needed to meet the needs for the particular service intended.

Standards referenced herein may be replaced by other international or national standards that can be shown to meet or exceed the requirements of the referenced standards.

Appendices A and C to E form an integral part of the requirements of this standard.

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Petroleum and natural gas industries — Special-purpose steam turbines for refinery service

1 Scope

This International Standard specifies the minimum requirements for special-purpose steam turbines for use in petroleum refinery service.

2 Requirements

Requirements are specified in:

> "API Standard 612 (Std 612), Third Edition, November 1987, *Special-Purpose Steam Turbines For Refinery Services*",

which is adopted as ISO 10437.

For the purposes of international standardization, however, modifications shall apply to specific clauses and paragraphs of publication API Std 612. These modifications are outlined below.

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Subclause 1.5.1

The referenced standards listed hereafter are available under the following ISO references:

API Std 611 as ISO 10436
API Std 613 as ISO 13711 (at present under study)
API Std 614 as ISO 10438
API Std 671 as ISO 10441 (at present under study)

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Special-Purpose Steam Turbines For Refinery Services

API STANDARD 612
THIRD EDITION, NOVEMBER 1987

American Petroleum Institute
1220 L Street, Northwest
Washington, D.C. 20005

Special-Purpose Steam Turbines for Refinery Services

SECTION 1—GENERAL

1.1 Scope

1.1.1 This standard covers the minimum requirements for special-purpose steam turbines for refinery services. These requirements include basic design, materials, and related lube-oil systems, controls, and auxiliary equipment.

Note: A bullet (●) at the beginning of a paragraph indicates that a decision by the purchaser is required. These decisions should be indicated on the data sheets (see Appendix A); otherwise they should be stated in the quotation request or in the order.

1.1.2 Steam turbines are classified general-purpose or special-purpose according to service requirements as described in 1.1.2.1 and 1.1.2.2.

1.1.2.1 General-purpose turbines are those horizontal or vertical turbines used to drive equipment that is usually spared, is relatively small in size (power), or is in noncritical service. They are intended for applications where steam conditions will not exceed 600 pounds per square inch gauge (41 bar gauge) pressure or 750°F (400°C) inlet temperature, or both, and where speed will not exceed 6000 revolutions per minute. Requirements for general-purpose turbines are defined in API Standard 611.

1.1.2.2 Special-purpose turbines are those horizontal turbines used to drive equipment that is usually not spared, is relatively large in size (power), or is in critical service. This category is not limited by steam conditions or turbine speed.

1.2 Alternative Designs

The vendor may offer alternative designs. Equivalent metric dimensions, fasteners, and flanges may be substituted as mutually agreed upon by the purchaser and the vendor.

1.3 Conflicting Requirements

In case of conflict between this standard and the inquiry or order, the information included in the order shall govern.

1.4 Definition of Terms

Terms used in this standard are defined in 1.4.1 through 1.4.23.

1.4.1 The *normal operating point* is the point at which usual operation is expected and optimum efficiency is desired. This point is usually the point at which the vendor certifies that performance is within the tolerances stated in this standard.

1.4.2 *Rated* applies to the greatest turbine power specified and the corresponding speed. It includes all the margin required by the specifications of the driven equipment.

1.4.3 *Maximum continuous speed* (in revolutions per minute) is the speed at least equal to 105 percent of the highest speed required by any of the specified operating conditions.

1.4.4 *Maximum allowable speed* (in revolutions per minute) is the highest speed at which the manufacturer's design will permit continuous operation.

1.4.5 *Trip speed* (in revolutions per minute) is the speed at which the independent emergency overspeed device operates to shut down a prime mover. Trip speed shall be at least 110 percent of the maximum continuous speed.

1.4.6 *Maximum inlet pressure and temperature* refer to the highest inlet steam pressure and temperature conditions at which the turbine is required to operate continuously.

1.4.7 *Minimum inlet pressure and temperature* refer to the lowest inlet steam pressure and temperature conditions at which the turbine is required to operate continuously.

1.4.8 *Maximum exhaust pressure* is the highest exhaust steam pressure at which the turbine is required to operate continuously.

1.4.9 *Minimum exhaust pressure* is the lowest exhaust steam pressure at which the turbine is required to operate continuously.

1.4.10 *Maximum exhaust casing pressure* is the highest exhaust steam pressure that the purchaser requires the casing to contain, with steam supplied at maximum inlet conditions.

1.4.11 *Maximum allowable working pressure* is the maximum pressure for which the manufacturer has designed the equipment when operating at the maximum allowable temperature.

1.4.12 *Axially split* refers to casing joints that are parallel to the shaft centerline.

1.4.13 *Radially split* refers to casing joints that are transverse to the shaft centerline.

1.4.14 The use of the word *design* in any term (such as design power, design pressure, design temperature, or design speed) should be avoided in the purchaser's specifications. This terminology should be used only by the equipment designer and the manufacturer.

1.4.15 *Heat rate* is a prime mover's energy consumption per unit of work. It is expressed in British thermal units (Btu) per horsepower-hour or Btu per kilowatt-hour, based on the lower heating value of the fuel.

1.4.16 *Steam rate* is the quantity of steam required by the turbine per unit of power output measured at the output shaft of the turbine. It is expressed in pounds of steam per horsepower-hour or in kilograms of steam per kilowatt-hour.

1.4.17 *Maximum allowable temperature* is the maximum continuous temperature for which the manufacturer has designed the equipment (or any part to which the term is referred) when handling the specified fluid at the specified pressure.

1.4.18 *Maximum sealing pressure* is the highest pressure expected at the seals during any specified static or operating conditions and during startup and shutdown.

1.4.19 *Minimum allowable speed* (in revolutions per minute) is the lowest speed at which the manufacturer's design will permit continuous operation.

1.4.20 *Potential maximum power* is the approximate maximum power to which the turbine can be uprated at the specified normal speed and steam conditions when it is furnished with suitable (larger or additional) nozzles and, possibly, with a larger governor-controlled valve or valves.

1.4.21 The *pressure casing* is the composite of all stationary pressure-containing parts of the unit, including all nozzles and other attached parts.

1.4.22 *Standby service* refers to a normally idle or idling piece of equipment that is capable of immediate automatic or manual startup and continuous operation.

1.4.23 *Field changeable* refers to a design feature that permits alteration of a function after the equipment has been installed. The alteration may be accomplished by (a) soldering jumper leads to terminal pins especially provided for this purpose, (b) employing circuit-board-mounted switches or potentiometers, (c) using a shorting or diode-pin-type matrix board, or (d) using prewired shorting plugs.

1.5 Referenced Publications

1.5.1 The editions of the following standards, codes, and specifications that are in effect at the time of publication of this standard shall, to the extent specified herein, form a part of this standard. The applicability of changes in standards, codes, and specifications that occur after the inquiry shall be mutually agreed upon by the purchaser and the vendor.

ANSI[1]

B1.1 *Unified Inch Screw Threads (UN and UNR Thread Form)*

B16.1 *Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800*

B16.5 *Pipe Flanges and Flanged Fittings, Steel, Nickel Alloy and Other Special Alloys*

B16.11 *Forged Steel Fittings, Socket-Welding and Threaded*

B16.42 *Ductile Iron Pipe Flanges and Flanged Fittings, Class 150 and 300*

B17.1 *Keys and Keyseats*

Y14.2M *Line Conventions and Lettering*

API

RP 520 *Recommended Practice for the Design and Installation of Pressure-Relieving Systems in Refineries, Part I—Design* and *Part II—Installation*

Std 526 *Flanged Steel Safety Relief Valves*

RP 550 *Manual on Installation of Refinery Instruments and Control Systems*

Std 611 *General-Purpose Steam Turbines for Refinery Services*

Std 613 *Special-Purpose Gear Units for Refinery Services*

Std 614 *Lubrication, Shaft-Sealing, and Control-Oil Systems for Special-Purpose Applications*

Std 615 *Sound Control of Mechanical Equipment for Refinery Services*

Std 670 *Vibration, Axial-Position, and Bearing-Temperature Monitoring Systems*

Std 671 *Special-Purpose Couplings for Refinery Services*

Std 678 *Accelerometer-Based Vibration Monitoring System*

ASME[2]

Boiler and Pressure Vessel Code, Section VIII, "Rules for Construction of Pressure Vessels," and Section IX, "Welding and Brazing Qualifications"

B1.20.1 *General Purpose (Inch) Pipe Threads*

B31.3 *Chemical Plant and Petroleum Refinery Piping*

PTC 6 *Steam Turbines*

ASTM[3]

A 53 *Zinc-Coated Welded and Seamless Black and Hot-Dipped Steel Pipe*

A 106 *Seamless Carbon Steel Pipe for High-Temperature Service*

A 192 *Seamless Carbon Steel Boiler Tubes for High-Pressure Service*

A 194 *Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service*

[1]American National Standards Institute, 1430 Broadway, New York, New York 10018.

[2]American Society of Mechanical Engineers, 345 East 47th Street, New York, New York 10017.

[3]American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.

A 269 *Seamless and Welded Austenitic Stainless Steel Tubing for General Service*
A 278 *Gray Iron Castings for Pressure-Containing Parts for Temperatures Up to 650°F (345°C)*
A 307 *Carbon Steel Externally Threaded Standard Fasteners*
A 312 *Seamless and Welded Austenitic Stainless Steel Pipe*
A 358 *Electric-Fusion-Welded Austenitic Chromium-Nickel Alloy Steel Pipe for High-Temperature Service*
A 395 *Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures*
A 418 *Method for Ultrasonic Inspection of Turbine and Generator Steel Rotor Forgings*
A 472 *Test Method for Heat Stability of Steam Turbine Shafts and Rotor Forgings*
A 515 *Carbon Steel Pressure Vessel Plates for Intermediate- and Higher-Temperature Service*
A 536 *Ductile Iron Castings*
B 127 *Nickel-Copper Alloy (UNS N004400) Plate, Sheet, and Strip*
E 125 *Reference Photographs for Magnetic Particle Indications on Ferrous Castings*
E 709 *Practice for Magnetic Particle Examination*

AWS[4]
D1.1 *Structural Welding Code—Steel*

NEMA[5]
SM 23 *Steam Turbines for Mechanical Drive Service*

NFPA[6]
70 *National Electrical Code*
496 *Purged Enclosures for Electrical Equipment in Hazardous Locations*

OSHA[7]
Occupational Safety and Health Standards of the U.S. Department of Labor

● **1.5.2** The purchaser and the vendor shall mutually determine the measures that must be taken to comply with any federal, state, or local codes, regulations, ordinances, or rules that are applicable to the equipment.

SECTION 2—BASIC DESIGN

2.1 General

2.1.1 The equipment (including auxiliaries) covered by this standard shall be designed and constructed for a minimum service life of 20 years and at least 3 years of uninterrupted operation. It is recognized that this is a design criterion.

● **2.1.2** The purchaser will specify the equipment's normal operating point on the data sheets.

2.1.3 Turbines shall be capable of the following:

a. Operation at normal power and speed with normal steam conditions. The steam rate (heat rate) certified by the manufacturer shall be at these conditions.
b. Delivering rated power at its corresponding speed with coincident minimum inlet and maximum exhaust conditions as specified on the data sheets.

Note: To prevent oversizing and/or to obtain higher operating efficiency, it may be desirable to limit maximum turbine capability by specifying normal power or a selected percentage of rated power instead of rated power at the conditions specified.

c. Continuous operation at maximum continuous speed and at any other speed within the range specified.
d. Continuous operation at rated power and speed with maximum inlet steam conditions and maximum or minimum exhaust steam conditions.
● e. Continuous operation at the lowest speed at which maximum torque is required with minimum inlet and maximum exhaust conditions. The purchaser will specify both the speed and torque values required.
f. Continuous operation at conditions agreed upon between the purchaser and the vendor for extraction or induction or both.
g. Operation with variations from rated steam conditions per NEMA SM 23.
h. Operation uncoupled with maximum inlet steam conditions. (Governing instability may occur and require action such as throttling of inlet pressure.)

2.1.4 Equipment shall be designed to run without damage to the trip speed and relief valve settings.

2.1.5 After installation, the combined performance of the machine and its driven equipment shall be the joint responsibility of the purchaser and the vendor. The units shall perform on the test stand and on their permanent foundation within the specified acceptance criteria.

● **2.1.6** Many factors (such as piping loads, alignment at operating conditions, supporting structure, handling during ship-

[4]American Welding Society, 550 N.W. LeJeune Rd., Miami, Florida 33135.
[5]National Electrical Manufacturers Association, 2101 L Street, N.W., Washington, D.C. 20037.
[6]National Fire Protection Association, Batterymarch Park, Quincy, Massachusetts 02269.
[7]Occupational Safety and Health Administration, U.S. Department of Labor, Washington, D.C. 20210.

ment, and handling and assembly at the site) may adversely affect site performance. To minimize the influence of these factors, the vendor shall review and comment on the purchaser's piping and foundation drawings, and the vendor's representative shall observe a check of the piping performed by parting the flanges. The vendor's representative shall check alignment at the operating temperature and, when specified, shall be present during the initial alignment check.

2.1.7 The arrangement of the equipment, including piping and auxiliaries, shall be developed jointly by the purchaser and the vendor. The arrangement shall provide adequate clearance areas and safe access for operation and maintenance.

2.1.8 All equipment shall be designed to permit rapid and economical maintenance. Major parts such as casing components and bearing housings shall be designed (shouldered or doweled) and manufactured to ensure accurate alignment on reassembly.

2.1.9 Oil reservoirs and housings that enclose moving lubricated parts (such as bearings, shaft seals, highly polished parts, instruments, and control elements) shall be designed to minimize contamination by moisture, dust, and other foreign matter during periods of operation or idleness.

2.1.10 Unless otherwise specified, cooling water systems shall be designed for the following conditions:

Velocity over heat exchange surfaces	5–8 ft/s	1.5–2.5 m/s
Maximum allowable working pressure	≥75 psig	≥5.2 bar (ga)
Test pressure	≥115 psig	≥7.9 bar (ga)
Maximum pressure drop	15 psi	1 bar
Maximum inlet temperature	90 °F	32 °C
Maximum outlet temperature	120 °F	49 °C
Maximum temperature rise	30 °F	17 °C
Minimum temperature rise	20 °F	11 °C
Fouling factor on water side	0.002 hr-ft² - °F/Btu	0.35 m² • K/kW

Provision shall be made for complete venting and draining of the system.

Note: The vendor shall notify the purchaser if the criteria for minimum temperature rise and velocity over heat exchange surfaces result in a conflicting design. The criterion for velocity over heat exchange surfaces is intended to minimize water-side fouling; the criterion for minimum temperature rise is intended to minimize the use of cooling water. The purchaser will approve the final selection.

● **2.1.11** Control of the sound pressure level (SPL) of all equipment furnished shall be a joint effort of the purchaser and the vendor. Unless otherwise specified, the equipment furnished by the vendor shall conform to the requirements of API Standard 615 and to the maximum allowable sound pressure level specified by the purchaser.

● **2.1.12** Electrical components and installations shall be suitable for the area classification (class, group, and division) specified by the purchaser on the data sheets and shall meet the requirements of NFPA 70, Articles 500 and 501, as well as local codes specified and furnished by the purchaser.

● **2.1.13** The purchaser will specify whether the installation is indoors (heated or unheated) or outdoors (with or without a roof), as well as the weather and environmental conditions in which the equipment must operate (including maximum and minimum temperatures and unusual humidity or dust problems). The unit and its auxiliaries shall be suitable for operation under these specified conditions. For the purchaser's guidance, the vendor shall list in the proposal any special protection that the purchaser is required to supply.

2.1.14 Spare parts for the machine and all furnished auxiliaries shall meet all the criteria of this standard.

2.1.15 The vendor shall assume responsibility for the engineering coordination of the equipment and all auxiliary systems included in the scope of the order.

2.2 Pressure Casings

2.2.1 All pressure parts shall be at least suitable for operation at the most severe conditions of coincident pressure and temperature expected with the specified steam conditions.

2.2.2 The hoop-stress values used in the design of the casing shall not exceed the maximum allowable stress values in tension specified in Section VIII, Division I, of the ASME Code at the maximum operating temperature of the material used.

2.2.3 The maximum allowable working pressure of the casing shall be at least equal to the specified relief valve setting. For condensing turbines the maximum allowable working pressure of the exhaust casing shall be full vacuum and at least 10 pounds per square inch gauge.

Note: Normally a full-capacity safety relief valve is required in the exhaust piping between each exhaust connection and exhaust block valve to prevent overpressure and possible rupture of the turbine casing.

2.2.4 The turbine casing shall be axially split. Turbine casings may also be split radially between high-pressure and low-pressure portions. If the casing must be split into two or more pressure levels, the vendor shall define the physical limits and the maximum allowable working pressure of each part of the casing.

2.2.5 Radially and axially split casings shall use a metal-to-metal joint (with a suitable joint compound) that is tightly maintained by suitable bolting. Gaskets (including string type) shall not be used. Confined gaskets may be used on the packing-box-to-casing joints.

2.2.6 Each axially split casing shall be sufficiently rigid to allow removal and replacement of its upper half without disturbing rotor-to-casing running clearances.

2.2.7 Casings and supports shall be designed to have sufficient strength and rigidity to limit any change of shaft alignment at the coupling flange, caused by the worst combination of allowable pressure, torque, and piping forces and moments, to 0.002 inch (50 micrometers). Supports and alignment bolts shall be rigid enough to permit the machine to be moved by the use of its lateral and axial jackscrews.

2.2.8 Jackscrews, guide rods, and casing alignment dowels shall be provided to facilitate disassembly and reassembly. When jackscrews are used as a means of parting contacting faces, one of the faces shall be relieved (counterbored or recessed) to prevent a leaking joint or an improper fit caused by marring of the face. Guide rods shall be of sufficient length to prevent damage to the internals or casing studs by the casing during disassembly and reassembly. Lifting lugs or eyebolts shall be provided for lifting only the top half of the casing. Methods of lifting the assembled machine shall be specified by the vendor.

2.2.9 The steam chest and casing shall be provided with connections to ensure complete drainage. Drain connections shall be 1 inch minimum pipe size.

2.2.10 Tapped holes in pressure parts shall be kept to a minimum. To prevent leakage in pressure sections of casings, sufficient metal, in addition to the allowance for corrosion, shall be left around and below the bottom of drilled and tapped holes. Through bolting is preferred in areas of the casing where the temperature may exceed 775 °F (413 °C).

2.2.11 Studded connections shall be furnished with studs installed. Blind stud holes should be drilled only deep enough to allow a preferred tap depth of 1½ times the major diameter of the stud; the first 1½ threads at both ends of each stud shall be removed.

2.2.12 Bolting shall be furnished as specified in 2.2.12.1 through 2.2.12.4.

2.2.12.1 The details of threading shall conform to ANSI B1.1.

2.2.12.2 Studs are preferred to cap screws.

2.2.12.3 Adequate clearance shall be provided at bolting locations to permit the use of socket or box wrenches.

2.2.12.4 Socket-, slotted-nut-, or spanner-type bolting shall not be used unless specifically approved by the purchaser.

2.2.12.5 ANSI B31.3, Paragraph 309, shall govern the material limits for pressure bolting based upon the actual bolting temperature. Nuts shall conform to ASTM A 194, Grade 2H (or ASTM A 307, Grade B, casehardened, where space is limited).

2.2.13 The machined finish of the mounting surface shall be 125–250 microinches (3.2–6.4 micrometers) arithmetic average roughness (R_a). Hold-down or foundation bolt holes shall be drilled perpendicular to the mounting surface or surfaces and spot faced to a diameter three times that of the hole.

2.3 Casing Appurtenances

2.3.1 NOZZLES AND DIAPHRAGMS

2.3.1.1 All nozzle rings shall be replaceable. Nozzle rings welded to the case are acceptable only when approved in advance by the purchaser.

2.3.1.2 All other stationary blading shall be mounted in replaceable diaphragms or blade carriers. Nozzles or blading welded to the diaphragm is preferred (see 2.11.3.1).

• 2.3.2 SENTINEL WARNING VALVE

When specified, a sentinel warning valve shall be supplied on the turbine casing. It shall be set at 5 pounds per square inch gauge (0.35 bar gauge) on condensing turbines. For noncondensing turbines it shall be set at either 10 pounds per square inch gauge (0.7 bar gauge) or 10 percent above the maximum exhaust pressure, whichever is greater.

Note: A sentinel warning valve is only an audible warning device and is not a pressure-relieving device.

2.4 Casing Connections

• **2.4.1** Inlet and outlet connections shall be flanged or machined and studded, oriented as specified in the data sheets, and suitable for the maximum allowable working pressure at the maximum allowable temperature.

2.4.2 Connections welded to the casing shall meet the material requirements of the casing, including impact values, rather than the requirements of the connected piping (see 2.11.3.6).

2.4.3 Casing openings for piping connections shall be at least ¾ inch nominal pipe size and shall be flanged or machined and studded. Where flanged or machined and studded openings are impractical, threaded openings in sizes, ¾ inch through 1½ inches nominal pipe size are permissible. These threaded openings shall be installed as specified in 2.4.3.1 through 2.4.3.7.

2.4.3.1 A pipe nipple, preferably not more than 6 inches (152 millimeters) long, shall be screwed into the threaded opening.

2.4.3.2 Pipe nipples shall be a minimum of Schedule 160 seamless for sizes 1 inch and smaller and a minimum of Schedule 80 for a size of 1½ inches.

2.4.3.3 The pipe nipple shall be provided with a welding-neck or socket-weld flange.

2.4.3.4 The nipple and flange materials shall meet the requirements of 2.4.2.

2.4.3.5 The threaded connection shall be seal welded in accordance with 3.6.1.8.

2.4.3.6 Tapped openings and bosses for pipe threads shall conform to ANSI B16.5.

2.4.3.7 Pipe threads shall be taper threads conforming to ASME B1.20.1.

2.4.4 Openings for pipe sizes of 1¼, 2½, 3½, 5, 7, and 9 inches shall not be used.

2.4.5 Tapped openings not connected to piping shall be plugged with solid steel plugs furnished in accordance with ANSI B16.11. Plugs that may later require removal shall be of corrosion-resistant material. Threads shall be lubricated. Tape shall not be applied to threads of plugs inserted into oil passages. Plastic plugs are not permitted.

2.4.6 Flanges shall conform to ANSI B16.1, B16.5, or B16.42 as applicable, except as specified in 2.4.6.1 through 2.4.6.6.

2.4.6.1 Cast iron flanges shall be flat faced and shall have a minimum thickness of Class 250 per ANSI B16.1 for sizes 8 inches and smaller.

2.4.6.2 Flat-faced flanges with full raised-face thickness are acceptable on cases other than cast iron.

2.4.6.3 Flanges that are thicker or have a larger outside diameter than that required by ANSI are acceptable.

● **2.4.6.4** For the purpose of manufacturing mating parts, when connections larger than those covered by ANSI are supplied, the vendor shall supply turbine flange details to the purchaser. When specified, the mating parts shall be furnished by the vendor.

2.4.6.5 The concentricity of the bolt circle and the bore of all casing flanges shall be such that the area of the machined gasket-seating surface is adequate to accommodate a complete standard gasket without protrusion of the gasket into the fluid flow.

2.4.6.6 The finish of all steel flanges and nozzles shall conform to ANSI B16.5 except for flange finish roughness requirements. The arithmetic average roughness (R_a) of flange contact surfaces shall conform to the values given in Table 1. Milled flange surfaces are acceptable with the purchaser's approval.

2.4.7 Machined and studded connections shall conform to the facing and drilling requirements of ANSI B16.1, B16.5, or B16.42. Studs and nuts shall be furnished installed. Connections larger than those covered by ANSI shall meet the requirements of 2.4.6.4.

Table 1—Finish Requirements for Flange Contact Surfaces

		Finish (R_a)	
Flange Type	Service	Microinches	Micrometers
Ring joint	All	<63	1.6
	Vacuum	63–125	1.6–3.2
Flat and raised face	All	125–500	3.2–12.7

2.4.8 All of the purchaser's connections shall be accessible for disassembly without the machine being moved.

2.4.9 Unless otherwise specified, pipe-flange gaskets shall be spiral-wound metal or metal-jacketed with nonhazardous filler for steam temperatures above 500°F (260°C) or steam pressures above 400 pounds per square inch gauge (28 bar gauge). The manufacturer's standard gasket can be used below these limits.

2.5 External Forces and Moments

Turbines shall be designed to withstand external forces and moments at least equal to the values calculated in accordance with NEMA SM 23. In some cases, these allowable forces and moments can be increased after considering such factors as location and degree of turbine support, nozzle length and degree of reinforcement, and casing configuration and thickness.

2.6 Rotating Elements

2.6.1 ROTORS

2.6.1.1 Rotors (other than integrally forged shafts and disks) shall be assembled so that movement of the disk relative to the shaft is prevented when operating at any speed up to 110 percent of trip speed at normal temperature.

2.6.1.2 Rotors shall be capable of safe operation at momentary speeds up to 110 percent of the trip speed at normal operating temperature.

2.6.1.3 The purchaser's approval is required for built-up rotors when blade tip velocities exceed 825 feet per second (250 meters per second) at maximum continuous speed or when stage inlet steam temperatures exceed 825°F (441°C).

2.6.1.4 Each rotor shall be clearly marked with a unique identification number. The number shall be visible, preferably on a shaft end, when the uncoupled rotor is enclosed by the casing.

● **2.6.1.5** When specified, provisions shall be made for ready access (not requiring removal of the case) for field balancing between the bearings. The number and location of these points shall be mutually agreed upon by the purchaser and the vendor.

2.6.2 SHAFTS

2.6.2.1 Shafts shall be accurately finished throughout their entire length and shall be ground at coupling and bearing areas and at sealing areas for carbon-ring packing. The finish of these ground surfaces shall not exceed 32 microinches (0.8 micrometer) R_a. On built-up rotors, the surface finish of areas under the wheel shrink fit shall not exceed 32 microinches (0.8 micrometer) R_a.

2.6.2.2 The rotor shaft sensing areas to be observed by radial vibration probes shall be concentric with the bearing journals. All shaft sensing areas (radial and axial position) shall be free from stencil and scribe marks or any other surface discontinuity, such as an oil hole or a keyway. These areas shall not be metallized, sleeved, or plated. The final surface finish shall be from 16 to 32 microinches (0.4 to 0.8 micrometer) R_a, preferably obtained by honing or burnishing. These areas shall be properly demagnetized or otherwise treated so that the combined total electrical and mechanical runout does not exceed the following values:

a. For areas to be observed by radial-vibration probes, 25 percent of the maximum allowed peak-to-peak vibration amplitude or 0.25 mil (6 micrometers), whichever is greater.
b. For areas to be observed by axial-position probes, 0.5 mil (13 micrometers).

2.6.2.3 Keyways shall have fillet radii conforming to ANSI B17.1.

2.6.2.4 Shafts shall be protected by corrosion-resistant material under carbon-ring packing for casing end glands; the manufacturer's application method, the coating materials used, and the finished coating thickness shall be stated on the data sheets.

2.6.2.5 Shaft ends for coupling fits shall conform to API Standard 671 (see 3.1.2).

2.6.2.6 To prevent the buildup of potential voltage, magnetism of the rotating element shall not exceed 5 gauss (0.0005 tesla).

2.6.3 BLADING

2.6.3.1 For each blade row, the vendor shall verify by Campbell diagrams or their equivalent (corrected to actual operating temperatures and speeds) that excitation of in-phase tangential, out-of-phase tangential, axial, torsional, and any other high-response modes by multiples of up to 15 times running speed, by nozzle passing frequency, and by twice nozzle passing frequency does not occur within the specified operating speed range. If this is not feasible, blade-stress levels developed in any specified driven-equipment operation shall be low enough to ensure trouble-free operation if resonant vibration occurs within the operating range. This shall be verified by Goodman diagrams or their equivalent. Copies of Campbell and/or Goodman diagrams shall be provided to the purchaser. Blades shall be designed to withstand operation at resonant frequencies during normal warmup.

Note: Excitation sources can include but are not limited to fundamental and first harmonic passing frequencies of rotating buckets and stationary vanes upstream and downstream of each blade row, steam passage splitters, irregularities in vane pitch at horizontal casing flanges, the first four turbine speed harmonics, casing openings (exhaust or extraction), partial arc diaphragms or nozzle plates, internal struts and structural members in the inlet and exhaust casing or horizontal joints, and meshing frequencies in gear units.

2.6.3.2 All blades shall be mechanically suitable for operation (including for transient conditions) over the specified speed range. The vendor shall assume that torque varies as speed squared unless otherwise notified by the purchaser.

2.7 Shaft Seals

● **2.7.1** Outer glands shall be sealed with replaceable labyrinth packing unless carbon-ring packing is specified by the purchaser.

2.7.2 When carbon-ring packing is specified, it shall be used only when the rubbing speed at the shaft-sealing surface is less than 160 feet per second (49 meters per second). The number of carbon rings shall be determined by the service and venting requirements, with 25 pounds per square inch (1.72 bar) being the maximum average differential pressure per active sealing ring. Springs for carbon packing shall be nickel-chromium-iron alloy (heat-treated after cold coiling) or equivalent material. Consideration shall be given to operating steam-temperature variations in establishing cold clearances for packing rings.

2.7.3 Sealing of interstage diaphragms shall be by replaceable labyrinth packing.

2.7.4 Glands operating at less than atmospheric pressure shall be designed for admission of steam to seal against air leakage. Piping with relief valve, pressure gauges, regulators, and other necessary valves shall be provided to interconnect the end glands. The piping shall have one common connection to the purchaser's sealing steam supply. The admission of sealing steam shall be automatically controlled throughout the load range. The normal operating sealing steam supply shall preferably come from a positive pressure section of the turbine.

2.7.5 A separate vacuum device shall be furnished to reduce external leakage from the glands and possible contamination of the bearing oil (see 3.5). The device shall be mounted and connected when specified. Appendix B shows a typical gland vacuum system.