Special Purpose Steam Turbines For Petroleum, Chemical, and Gas Industry Services

API STANDARD 612 .
FOURTH EDITION, JUNE 1995

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

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Manufacturing, Distribution and Marketing Department

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FOREWORD

The primary purpose of this standard is to establish minimum electromechanical requirements. This limitation in scope is one of charter as opposed to interest and concern. Energy conservation is of concern and has become increasingly important in all aspects of equipment design, application, and operation. Thus, innovative energy-conserving approaches should be aggressively pursued by the manufacturer and the user during these steps. Alternative approaches that may result in improved energy utilization should be thoroughly investigated and brought forth. This is especially true of new equipment proposals, since the evaluation of purchase options will be based increasingly on total life costs as opposed to acquisition cost alone. Equipment manufacturers, in particular, are encouraged to suggest alternatives to those specified when such approaches achieve improved energy effectiveness and reduced total life costs without sacrifice of safety or reliability.

This standard requires the purchaser to specify certain details and features. Although it is recognized that the purchaser may desire to modify, delete, or amplify sections of this standard, it is strongly recommended that such modifications, deletions, and amplifications be made by supplementing this standard, rather than by rewriting or incorporating sections thereof into another complete standard.

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Suggested revisions are invited and should be submitted to the director of the Manufacturing, Distribution and Marketing Department, American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005.

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SECTION 1—GENERAL

1.1 Scope

1.1.1 This standard covers the minimum requirements for special purpose steam turbines for petroleum, chemical, and gas industry 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 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 Appendix A); otherwise it 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 conditions will not exceed 48 bar gauge (700 pounds per square inch gauge) pressure or 400°C (750°F) 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 conflicting requirements 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 1.4.37.

1.4.1 The *alarm point* is a preset value of a parameter at which an alarm is actuated to warn of a condition that requires corrective action.

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

1.4.3 The *control mechanism* includes all of the equipment between the speed governor and the governor-controlled valve(s) (that is, linkages, pilot valves, power servos, and so forth).

1.4.4 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.

1.4.5 *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 the following:

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.
d. Using prewired shorting plugs.
e. Using authorized controlled access.

1.4.6 A *gauge board* is an enclosed bracket or plate used to support and display gauges, switches, and other instruments.

1.4.7 The *governor-controlled valve(s)* controls the flow of steam into or out of the turbine in response to the speed governor.

1.4.8 *Hydrodynamic bearings* are bearings that use the principles of hydrodynamic lubrication. Their surfaces are oriented so that relative motion forms an oil wedge to support the load without journal-to-bearing contact.

1.4.9 *Local* refers to a device mounted on or near the equipment or console.

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

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

1.4.12 *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.

1.4.13 *Maximum allowable working pressure* is the maximum continuous pressure 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 temperature.

1.4.14 *Maximum continuous speed* (revolutions per minute) is the speed at least equal to 105 percent of rated operating speed (see Figure 7).

1.4.15 *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.

Note: The turbine casing will be subjected to the maximum temperature and pressure under these conditions. The manufacturer's classification determines the maximum safety relief valve setting.

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

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

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

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

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

1.4.21 A *mechanical running test* is a test of a steam turbine to demonstrate mechanical integrity of the turbine package and functionality of the instrumentation. This test is normally performed uncoupled and under no load.

1.4.22 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 the performance is within the tolerances stated in this standard.

1.4.23 A *panel* is an enclosure used to mount, display, and protect gauges, switches and other instruments.

1.4.24 *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 (that is, larger or additional) nozzles and, possibly, with a larger governor-controlled valve or valves.

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

1.4.26 *Rated operating speed* is the greatest speed required by any of the specified operating conditions.

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

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

1.4.29 *Remote* refers to a device located away from the equipment or console, typically in a control room.

1.4.30 The *shutdown point* is a preset value of a parameter at which automatic or manual shutdown of the system is required.

1.4.31 *Slow roll* is the speed recommended by the vendor (typically 400–500 revolutions per minute) for warm-up and initial check of equipment integrity prior to full operation.

1.4.32 The *speed governor* includes those elements which are directly responsive to speed and which "position" or influence the action of other elements of the governing system to maintain the operating speed within the specified limits.

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

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

1.4.35 *Turbine manufacturer* refers to the company that designs, manufactures, tests, and provides service support for the equipment.

1.4.36 *Trip speed* (expressed in revolutions per minute) is the speed at which the independent overspeed shutdown system operates to shut down a prime mover. Trip speed shall be at least 110 percent of the maximum continuous speed (see Figure 5).

1.4.37 *Unit responsibility* refers to the responsibility for coordinating the technical aspects of the equipment and all auxiliary systems included in the scope of the order. Responsibility for such factors as the power requirements, speed, rotation, general arrangement, couplings, dynamics, noise, lubrication, sealing system, material test reports, instrumentation, piping, and testing of components shall be reviewed.

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 referenced 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]

Y14.2M *Line Conventions and Lettering*

API

Manual of Petroleum Measurement Standards (MPMS), Chapter 15, "Guidelines for the Use of the International System of Units (SI) in the Petroleum and Allied Industries"

RP 500 *Classification of Locations for Electrical Installations in Petroleum Facilities*

RP 520 *Sizing, Selection, and Installation of Pressure-Relieving Systems in Refineries, Part I—Sizing and Selection and Part II—Installation*

Std 526 *Flanged Steel Safety Relief Valves*

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 660 *Shell-and-Tube Heat Exchangers for General Refinery Services*

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

Std 671 *Special Purpose Couplings for Refinery Services*

ASME[2]

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

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

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

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*

B16.47 *Large Diameter Steel Flanges (NPS 26 through NPS 60)*

B17.1 *Keys and Keyseats*

B31.3 *Chemical Plant and Petroleum Refinery Piping*

PTC 1 *General Instructions*

PTC 6 *Steam Turbines*

ASTM[3]

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

A 105 *Carbon Steel Forgings for Piping Components*

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

A 153 *Zinc Coating (Hot-Dip) on Iron and Steel Hardware*

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

A 193 *Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service*

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

A 197 *Cupola Malleable Iron*

A 247 *Evaluating the Microstructure of Graphite in Iron Castings*

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 338 *Malleable Iron Flanges, Pipe Fittings, and Valve Parts for Railroad, Marine, and Other Heavy Duty Service at Temperatures up to 650°F (345°C)*

A 358 *Electric-Fusion-Welded Austenitic Chromium-Nickel Alloy Steel Pipe for High-Temperature Service*

A 395 *Ferritic Dectile 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*

[1]American National Standards Institute, 11 West 42nd Street, New York, New York 10036.

[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 19103-1187.

A 515 *Carbon Steel Pressure Vessel Plates for Intermediate- and Higher-Temperature Service*
A 536 *Ductile Iron Castings*
B 127 *Nickel-Copper Alloy (UNS N00400) Plate, Sheet, and Strip*
E 94 *Guide for Radiographic Testing*
E 125 *Reference Photographs for Magnetic Particle Indications on Ferrous Castings*
E 142 *Method for Controlling Quality of Radiographic Testing*
E 709 *Practice for Magnetic Particle Examination*

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

ISA[5]
S18.1 *Annunciator Sequences and Specifications*

ISO[6]
3448 *Standard Industrial Lubricants-ISO Viscosity Classification*

MSS[7]
SP-44 *Steel Pipeline Flanges*

NEMA[8]
Pub 250 *Enclosures for Electrical Equipment (1000 volts maximum)*

SM 23 *Steam Turbines for Mechanical Drive Service*

NFPA[9]
70 *National Electric Code*
496 *Purged Enclosures for Electrical Equipment in Hazardous Locations*

SSPC[10]
SP 6 *Commercial Blast Cleaning*

TEMA[11]
Standards of Tubular Exchanger Manufacturers Association

1.5.2 The purchaser and 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.

1.6 Unit Conversion

The factors in API MPMS, Chapter 15, have been used to convert from U.S. Customary to SI units. The resulting SI units have been rounded off to the nearest nominal sizes available.

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 5 years of uninterrupted operation. It is recognized that this is a design criterion.

2.1.2 The vendor shall assume unit responsibility for all equipment and all auxiliary systems included in the scope of the order.

● **2.1.3** The purchaser will specify the equipment's normal operating point and any other operating points on the data sheets.

2.1.4 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 or to obtain higher operating efficiency or both, 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

[4]American Welding Society, 550 N.W. LeJeune Road, Miami, Florida 33135.
[5]Instrument Society of America, P.O. Box 12277, Research Triangle Park, North Carolina 27709.
[6]International Organization for Standardization. ISO publications are available from the American National Standards Institute, 11 West 42nd Street, New York, New York 10036.
[7]Manufacturers Standardization Society of the Valve and Fittings Industry, 127 Park Street, N.E., Vienna, Virginia 22180.
[8]National Electrical Manufacturers Association, 2101 L Street, N.W., Washington, D.C. 20037.
[9]National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02269-9101.
[10]Steel Structures Painting Council, 4400 Fifth Avenue, Pittsburgh, Pennsylvania 15213-2683.
[11]Tubular Exchanger Manufacturers Association, 25 North Broadway, Tarrytown, New York 10591.

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 and steam purity limits per NEMA SM 23.

h. Operation uncoupled with maximum inlet steam conditions.

Note: Governing instability and high acceleration rates may occur and require action such as throttling of inlet pressure. Care should be taken when operating uncoupled or no load for generator sets. Consideration should be made for the high exhaust and extraction steam temperatures that would result during light or no-load operation.

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

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

● **2.1.7** Many factors (such as piping loads, alignment at operating conditions, supporting structure, handling during shipment, 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.

2.1.8 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.

2.1.9 All equipment shall be designed to permit rapid and economical maintenance. Major parts such as casing components and bearing housings shall be designed and manufactured using shoulders or cylindrical dowels to ensure accurate alignment on reassembly.

2.1.10 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.

2.1.11 Unless otherwise specified, cooling water systems shall be designed for the conditions specified in Table 1. 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 surface 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.

● **2.1.12** Control of the sound pressure level (SPL) of all equipment furnished shall be a joint effort of the purchaser and the vendor. The equipment furnished by the vendor shall conform to the maximum allowable sound pressure level specified. The vendor shall provide the expected noise level.

● **2.1.13** Motors, electrical components, and electrical 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, 501, and 502, as well as local codes specified and furnished by the purchaser.

● **2.1.14** 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, 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.

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

2.2 Pressure Casings

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

Table 1—Design Criteria and Specifications for Cooling Water Systems

	Specifications	
Criteria	Metric	U.S. Customary
Velocity over heat exchange surfaces	1.5–2.5 m/s	5–8 ft/s
Maximum allowable working pressure	≥5.2 bar (ga)	≥75 psig
Test pressure	≥7.9 bar (ga)	≥115 psig
Maximum pressure drop	1 bar	15 psi
Maximum inlet temperature	32°C	90°F
Maximum outlet temperature	49°C	120°F
Maximum temperature rise	17°C	30°F
Minimum temperature rise	11°C	20°F
Fouling factor on water side	$0.35 m^2 \times K/kW$	$0.002 hr\text{-}ft^2\text{-}°F/Btu$
Shell corrosion allowance	3.2 mm	0.125 in.

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 II, Part D, of the ASME Code at the maximum operating temperature of the material used.

Note: Turbine casings are not ASME code pressure vessels.

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 0.7 bar (ga) (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 50 micrometers (0.002 inch). 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 cylindrical 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 The use of tapped holes in pressure parts shall be minimized. To prevent leakage in pressure sections of casings, metal equal in thickness to at least half the nominal bolt diameter, in addition to the allowance for corrosion, shall be left around and below the bottom of drilled and tapped holes. The depth of the tapped holes shall be at least 1.5 times the stud diameter. Through bolting is preferred in areas of the casing where the temperature may exceed 410°C (775°F).

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 1.5 times the major diameter of the stud; the first 1.5 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 2.2.12.6.

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

2.2.12.2 Studs shall be supplied on the main casing joint of axially split turbines unless cap screws are specifically approved by the purchaser.

2.2.12.3 Stud markings shall be located on the nut end of the exposed stud.

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

2.2.12.5 Internal socket-, slotted-nut-, or spanner-type bolting shall not be used unless specifically approved by the purchaser.

2.2.12.6 The material limits for pressure bolting based upon the actual bolting temperature shall be as specified in ASME B31.3, Paragraph 309. Nuts shall conform to ASTM A 194, Grade 2H (or ASTM A 307, Grade B, case-hardened, where space is limited).

2.2.13 The machined finish of the mounting surface shall be 3–6 micrometers (125–250 microinches) 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.

2.2.14 The equipment feet shall be provided with vertical jackscrews and shall be drilled with pilot holes that are accessible for use in final doweling.

2.3 Casing Appurtenances

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

2.3.2 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).

2.4 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 2.11.3.5).

2.4.3 Casing openings for piping connections shall be at least NPS $^3/_4$ and shall be flanged or machined and studded. Where flanged or machined and studded openings are impractical, threaded openings in NPS $^3/_4$ through $1^1/_2$ 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 150 millimeters (6 inches) long, shall be screwed into the threaded opening.

2.4.3.2 Pipe nipples shall be a minimum of Schedule 160 seamless for NPS 1 and smaller and a minimum of Schedule 80 for NPS $1^1/_2$.

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; however, seal welding is not permitted on cast iron equipment, for instrument connections, or where disassembly is required for maintenance. Seal-welded joints shall be in accordance with ASME B31.3.

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

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

2.4.4 Openings for NPS $1^1/_4$, $2^1/_2$, $3^1/_2$, 5, 7, and 9 shall not be used.

2.4.5 Tapped openings not connected to piping shall be plugged with solid, round-head steel plugs furnished in accordance with ANSI B16.11. As a minimum, these plugs shall meet the material requirements of the casing. Plugs that may later require removal shall be of corrosion-resistant material. A lubricant that meets the proper temperature specification shall be used on all threaded connections. 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 ASME 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 ASME B16.1 for sizes 8 inches and smaller.

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

2.4.6.3 Flanges that are thicker or have a larger outside diameter than that required by ASME B16.5, ASME B16.47, or MSS SP-44 are acceptable. Non-standard thicknesses and outside diameters shall be dimensioned on certified outline drawings for purchaser's use in selecting bolt lengths and gaskets and avoiding dimensional interferences.

2.4.6.4 Connections other than those covered by ASME B16.5, ASME B16.47, or MSS SP-44 require the purchaser's approval. Unless otherwise specified, these nonstandard 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 ASME 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 2. Milled flange surfaces require the purchaser's approval.

2.4.7 Machined and studded connections shall conform to the facing and drilling requirements of ASME B16.1, B16.5, or B16.42. Studs and nuts shall be furnished installed. The first $1^1/_2$ threads at both ends of each stud shall be removed. Connections larger than those covered by ASME shall meet the requirements of 2.4.6.4.

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 260°C (500°F) or steam

Table 2—Finish Requirements for Flange Contact Surfaces

		Finish (R_a)	
Flange Type	Service	Micrometers	Microinches
Ring joint	All	1.5	<63
	Vacuum	1.5–3	63–125
Flat and raised face	All	3–15	125–500

pressures above 2,800 kPa gauge (400 pounds per square inch 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 127 percent of rated operating speed at normal temperature.

2.6.1.2 Rotors shall be capable of safe operation at momentary speeds up to 127 percent of the rated operating speed at normal operating temperature.

2.6.1.3 The purchaser's approval is required for built-up rotors when blade tip velocities exceed 250 meters per second (825 feet per second) at maximum continuous speed or when stage inlet steam temperatures exceed 440°C (825°F).

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

2.6.1.5 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. The surface finish of the coupling fit area, bearing areas, and at sealing areas for carbon-ring packing shall not exceed 0.8 micrometer (32 microinches) R_a. On builtup rotors, the surface finish of areas under the wheel shrink fit shall not exceed 0.8 micrometer (32 microinches) 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 (both radial vibration and axial position) shall be free from stencil and scribe marks or any other surface discontinuity, such as an oil hole or a keyway, for a minimum of one probe-tip diameter on each side of the probe. These areas shall not be metallized, sleeved, or plated. The final surface finish shall be from 0.4–0.8 micrometer (16–32 microinches) 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 25 percent of the maximum allowed peak-to-peak vibration amplitude or the following value, whichever is greater:

a. For areas to be observed by radial-vibration probes, 6 micrometers (0.25 mil).
b. For areas to be observed by axial-position probes, 13 micrometers (0.5 mil).

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 couplings shall conform to API Standard 671.

2.6.2.6 To prevent the buildup of harmful potential voltage, magnetic flux density of any part of the rotating element shall not exceed 0.0003 tesla (3 gauss).

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 or Goodman diagrams or both shall be provided to the purchaser. Blades shall be designed to withstand operation at resonant frequencies during normal warm-up.

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 Unless otherwise specified, outer glands shall be sealed with replaceable labyrinth packing.

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 50 meters per second (160 feet per second) at maximum continuous speed. The number of carbon rings shall be determined by the service and venting requirements, with 170 kPa (25 pounds per square inch) 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 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** Unless otherwise specified, 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.

2.7.6 All piping and components of shaft seal and vacuum systems shall be sized for not less than 300 percent of the calculated new clearance leakage.

2.8 Dynamics

Rotor dynamics logic diagrams showing lateral and torsional analysis requirements are shown in Appendix C.

2.8.1 CRITICAL SPEEDS

2.8.1.1 When the frequency of a periodic forcing phenomenon (exciting frequency) applied to a rotor-bearing support system corresponds to a natural frequency of that system, the system may be in a state of resonance.

2.8.1.2 A rotor-bearing support system in resonance will have its normal vibration displacement amplified. The magnitude of amplification and the rate of phase-angle change are related to the amount of damping in the system and the mode shape taken by the rotor.

Note: The mode shapes are commonly referred to as the first rigid (translatory or bouncing) mode, the second rigid (conical or rocking) mode, and the (first, second, third, . . ., *n*th) bending mode.

2.8.1.3 When the rotor amplification factor (see Figure 1), as measured at the shaft radial vibration probes, is greater than or equal to 2.5, the corresponding frequency is called a *critical speed,* and the corresponding shaft rotational frequency is also called a critical speed. For the purposes of this standard, a critically damped system is one in which the amplification factor is less than 2.5.

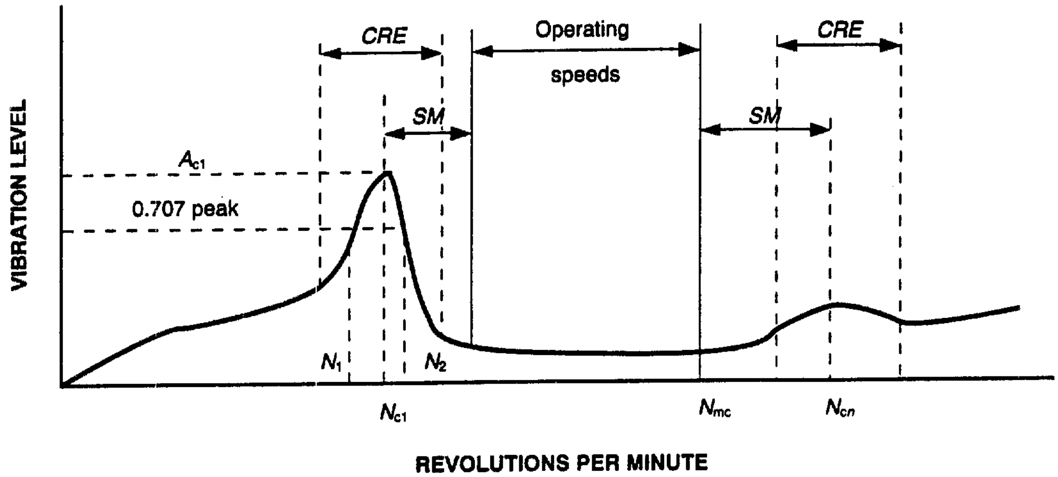
2.8.1.4 Critical speeds and their associated amplification factors shall be determined analytically by means of a damped unbalanced rotor response analysis and shall be confirmed during the running test and any specified optional tests.

2.8.1.5 An exciting frequency may be less than, equal to, or greater than the rotational speed of the rotor. Potential exciting frequencies that are to be considered in the design of rotor-bearing systems shall include but are not limited to the following sources:

a. Unbalance in the rotor system.
b. Oil-film instabilities (whirl).
c. Internal rubs.
d. Blade, vane, nozzle, and diffuser passing frequencies.
e. Gear-tooth meshing and side bands.
f. Coupling misalignment.
g. Loose rotor-system components.
h. Hysteretic and friction whirl.
i. Boundary-layer flow separation.
j. Acoustic and aerodynamic cross-coupling forces.
k. Asynchronous whirl.

2.8.1.6 Resonances of structural support systems may adversely affect the rotor vibration amplitude. Therefore, resonances of structural support systems that are within the vendor's scope of supply and that affect the rotor vibration amplitude shall not occur within the specified operating speed range or the specified separation margins (see 2.8.2.5) unless the resonances are critically damped.

2.8.1.7 The vendor who is specified to have unit responsibility shall determine that the drive-train (turbine, gear, and motor) critical speeds (rotor lateral, system torsional, and blading modes) will not excite any critical speed of the machinery being supplied. The vendor shall also determine that the entire train is suitable for the specified operating speed range, including any starting-speed detent (hold-point) requirements. A list of all undesirable speeds from zero to trip shall be submitted



N_{c1} = Rotor first critical, center frequency, cycles per minute.
N_{cn} = Critical speed, *n*th.
N_{mc} = Maximum continuous speed, 105 percent.
N_1 = Initial (lesser) speed at 0.707 × peak amplitude (critical).
N_2 = Final (greater) speed at 0.707 × peak amplitude (critical).
$N_2 - N_1$ = Peak width at the half-power point.
AF = Amplification factor.
$= \frac{N_{c1}}{N_2 - N_1}$
SM = Separation margin.
CRE = Critical response envelope.
A_{c1} = Amplitude at N_{c1}.
A_{cn} = Amplitude at N_{cn}.

Note: The shape of the curve is for illustration only and does not necessarily represent any actual rotor response plot.

Figure 1—Rotor Response Plot

to the purchaser for his review at the vendor coordination meeting and included in the operating and maintenance manuals for his guidance (see Appendix E, Item 40).

2.8.2 LATERAL ANALYSIS

2.8.2.1 The vendor shall provide a damped unbalanced response analysis for each machine to ensure acceptable amplitudes of vibration at any speed from zero to trip. A logic diagram of the lateral analysis requirements is shown in Figure C-1.

2.8.2.2 The damped unbalanced response analysis shall include, but shall not be limited to, the following considerations:

a. Support (base, frame, and bearing-housing) stiffness, mass, and damping characteristics, including effects of rotational speed variation. The vendor shall state the assumed support system values and the basis for these values (for example, tests of identical rotor support systems and assumed values).
b. Bearing lubricant-film stiffness and damping changes due to speed, load, preload, oil temperatures, accumulated assembly tolerances, and maximum to minimum clearances.
c. Rotational speed, including the various starting-speed detents, operating speed and load ranges (including agreed-upon test conditions if different from those specified), trip speed, and coast-down conditions.
d. Rotor masses, including the mass moment of coupling halves, stiffness, and damping effects (for example, accumulated fit tolerances, fluid stiffening and damping, and frame and casing effects).
e. Asymmetrical loading (for example, partial arc admission, gear forces, side streams, and eccentric clearances).

● **2.8.2.3** When specified, the effects of other equipment in the train shall be included in the damped unbalanced analysis (that is, a train lateral analysis shall be performed).

Note: This analysis should be considered for machinery trains with coupling spacers greater than 1 meter (36 inches), rigid couplings, or both.

2.8.2.4 As a minimum, the damped unbalanced response analysis shall include the following:

a. A plot and identification of the mode shape at each resonant speed (critically damped or not) from zero to trip, as well as the next mode occurring above the trip speed.

b. Frequency, phase, and response amplitude data (Bode plots) at the vibration probe locations through the range of each critical speed, using the arrangement of unbalance shown in Figures 2A and 2B for the particular mode. This unbalance shall be sufficient to raise the displacement of the rotor at the probe locations to the vibration limit defined by Equation 1:

$$L_v = 25.4\sqrt{\frac{12,000}{N}} \qquad (1)$$

In U.S. Customary units,

$$L_v = \sqrt{\frac{12,000}{N}}$$

Where:

L_v = vibration limit (amplitude of unfiltered vibration), in micrometers (mils) peak to peak.
N = operating speed nearest the critical of concern, in revolutions per minute.

This unbalance shall be no less than two times the unbalance defined by Equation 2:

$$U = 6350W/N \qquad (2)$$

In U.S. Customary units,

$$U = 4W/N$$

Where:

U = input unbalance from the rotor dynamic response analysis, in gram-millimeters (ounce-inches).
W = journal static weight load, in kilograms (pounds); or for bending modes where the maximum deflection occurs at the shaft ends, the overhung weight load (that is, the weight outboard of the bearing), in kilograms (pounds).
N = operating speed nearest the critical of concern, in revolutions per minute.

The unbalance weight or weights shall be placed at the locations that have been analytically determined to affect the particular mode most adversely. For translatory modes, the unbalance shall be based on both journal static weights and shall be applied at the locations of maximum displacement. For conical modes, each unbalance shall be based on the journal weight and shall be applied at the location of maximum displacement of the mode nearest the journal used for the unbalance calculation, 180 degrees out of phase. Figures 2A and 2B show the typical mode shapes

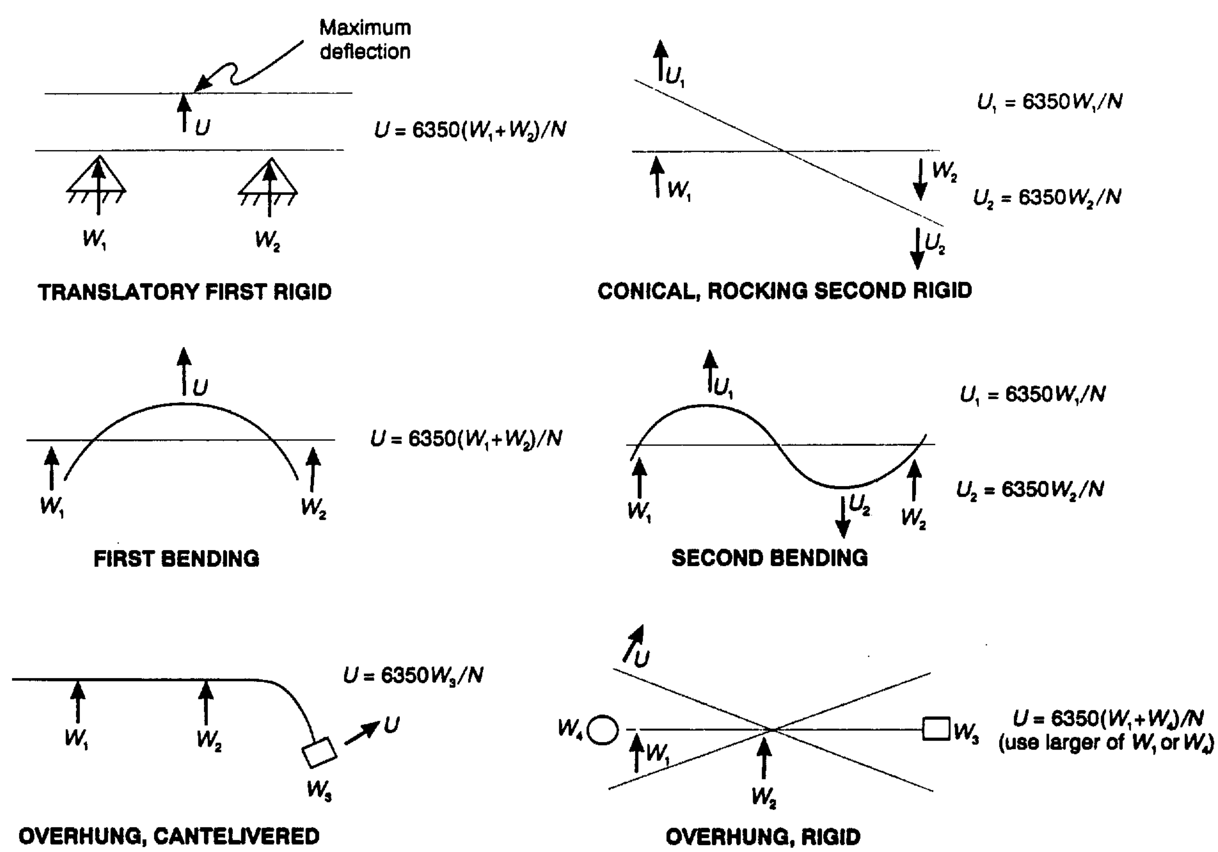


Figure 2A—Typical Mode Shapes (SI Units)

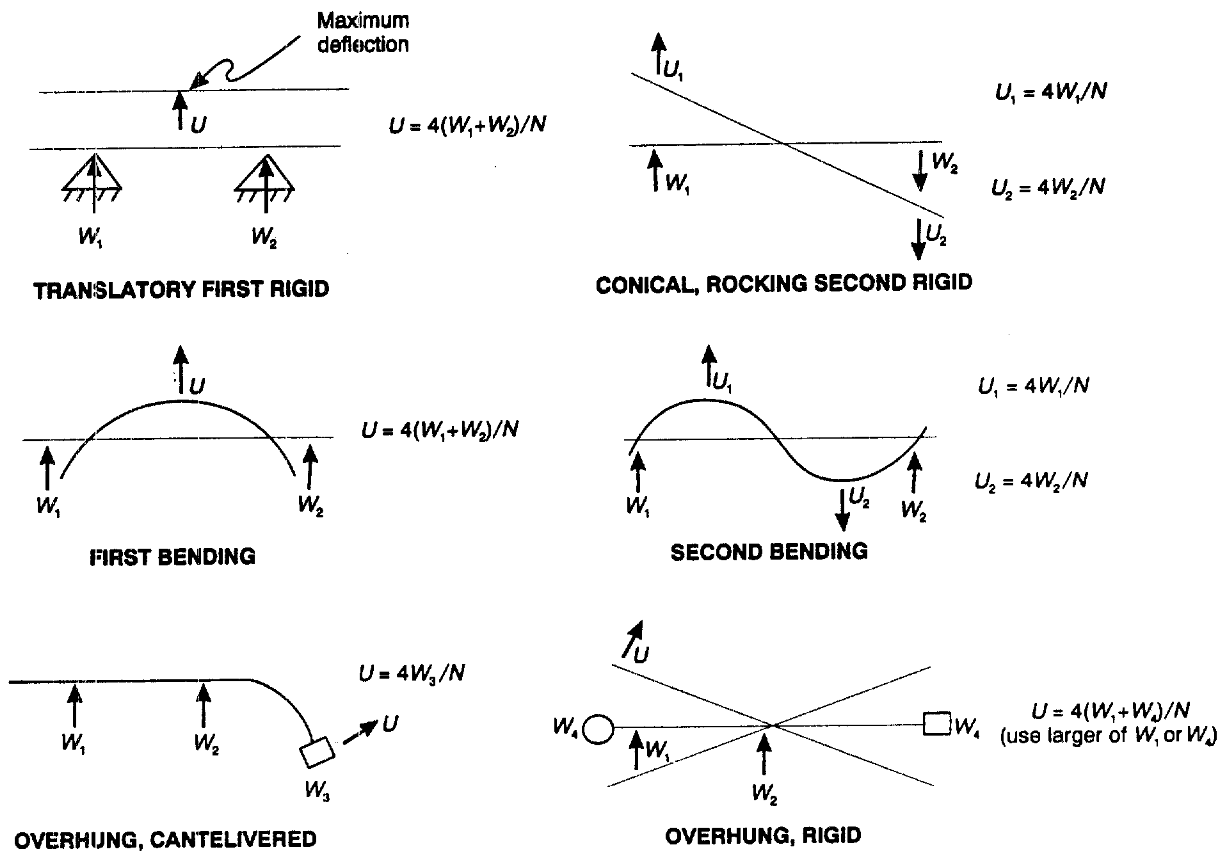


Figure 2B—Typical Mode Shapes (U.S. Customary Units)

and indicates the location and definition of U for each of the shapes.

c. Modal diagrams for each response in 2.8.2.4, Item b, shall indicate the phase and major-axis amplitude at each coupling engagement plane, the centerlines of the bearings, the locations of the vibration probes, and each seal area throughout the machine. The minimum design diametral running clearance of the seals shall also be indicated.

d. To establish the validity of the analytical model, a verification test of the rotor unbalance is required at the completion of the mechanical running test. Therefore, additional plots based on the actual unbalance to be used during this test shall be provided. For machines that meet the requirements of 2.8.2.4, Item b, and 2.8.2.5, additional Bode plots, as specified in 2.8.2.4, Item b, shall be provided. The location of the test unbalance shall be determined by the vendor. The amount of unbalance shall be sufficient to raise the vibration levels, as measured at the vibration probes, to those specified in 2.8.2.4, Item b. In all cases, the unbalance plots shall include the effects of any test-stand conditions (including the effects of test seals) that may be used during the verification test of the rotor unbalance (see 2.8.3).

e. Unless otherwise specified, a stiffness map of the undamped rotor response from which the damped unbalanced response analysis specified in 2.8.2.4, Item c, was derived shall be provided. This plot shall show frequency versus support system stiffness, with the calculated support system stiffness curves superimposed.

f. For machines whose bearing support system stiffness values are less than or equal to 3.5 times the bearing stiffness values, the calculated frequency-dependent support stiffness and damping values (impedances) or the values derived from modal testing. The results of the damped unbalanced response analysis shall include Bode plots that compare absolute shaft motion with shaft motion relative to the bearing housing.

2.8.2.5 The damped unbalanced response analysis shall indicate that the machine in the unbalanced condition described in 2.8.2.4, Item b, will meet the following acceptance criteria (see Figure 1):

a. If the amplification factor is less than 2.5, the response is considered critically damped and no separation margin is required.

b. If the amplification factor is 2.5 to 3.55, a separation margin of 15 percent above the maximum continuous speed and 5 percent below the minimum operating speed is required.

c. If the amplification factor is greater than 3.55 and the critical response peak is below the minimum operating speed, the required separation margin (a percentage of minimum speed) is defined by Equation 3:

$$SM = 100 - \left(84 + \frac{6}{AF - 3}\right) \qquad (3)$$

Where:

SM = Separation margin.
AF = Amplification factor.

d. If the amplification factor is greater than 3.55 and the critical response peak is above the trip speed, the required separation margin (a percentage of maximum continuous speed) is defined by Equation 4:

$$SM = \left(126 - \frac{6}{AF - 3}\right) - 100 \qquad (4)$$

Where:

SM = Separation margin.
AF = Amplification factor.

2.8.2.6 The calculated unbalanced peak-to-peak rotor amplitudes (see 2.8.2.4, Item b) at any speed from zero to trip shall not exceed 75 percent of the minimum design diametral running clearances throughout the machine (with the exception of floating-ring seal locations).

2.8.2.7 If after the purchaser and the vendor have agreed that all practical design efforts have been exhausted, the analysis indicates that the separation margins still cannot be met or that a critical response peak falls within the operating speed range, acceptable amplitudes shall be mutually agreed upon by the purchaser and the vendor, subject to the requirements of 2.8.2.6.

2.8.3 SHOP VERIFICATION OF UNBALANCED RESPONSE ANALYSIS

2.8.3.1 A demonstration of rotor response at future unbalanced conditions is necessary because a well-balanced rotor may not be representative of future operating conditions (see 2.8.2.4, Item d). This test shall be performed as part of the mechanical running test (see 4.3.3) and the results shall be used to verify the analytical model. Unless otherwise specified, the verification test of the rotor unbalance shall be performed only on the first rotor (normally the spare rotor, if two rotors are purchased). The actual response of the rotor on the test stand to the same unbalance weight as was used to develop the Bode plots specified in 2.8.2.4 shall be the criterion for determining the validity of the damped unbalanced response analysis. To accomplish this, the following procedure shall be followed:

a. During the mechanical running test (see 4.3.3), the amplitudes and phase angle of the indicated vibration at the speed nearest the critical or criticals of concern shall be determined.

b. A trial weight, not more than one-half the amount calculated in 2.8.2.4, Item b, shall be added to the rotor at the location specified in 2.8.2.4, Item d; 90 degrees away from the phase of the indicated vibration at the speed or speeds closest to the critical or criticals of concern.

c. The machine shall then be brought up to the operating speed nearest the critical of concern, and the indicated vibration amplitudes and phase shall be measured. The results of this test and the corresponding indicated vibration data from 2.8.3.1, Item a, shall be vectorially added to determine the magnitude and phase location of the final test weight required to produce the required test vibration amplitudes.

d. The final test weight described in 2.8.3.1, Item c, shall be added to the rotor and the machine shall be brought up to the operating speed nearest the critical of concern. When more than one critical of concern exists, additional test runs shall be performed for each, using the highest speed for the initial test run.

Note: The dynamic response of the machine on the test stand will be a function of the agreed-upon test conditions and, unless the test-stand results are obtained at the conditions of pressure, temperature, speed, and load expected in the field, they may not be the same as the results expected in field.

2.8.3.2 The parameters to be measured during the test shall be speed and shaft synchronous (1×) vibration amplitudes with corresponding phase. The vibration amplitudes and phase from each pair of x–y vibration probes shall be vectorially summed at each response peak to determine the maximum amplitude of vibration. The major-axis amplitude of each response peak shall not exceed the limits specified in 2.8.2.6. (More than one application of the unbalance weight and test run may be required to satisfy these criteria.)

The gain of the recording instruments used shall be predetermined and preset before the test so that the highest response peak is within 60–100 percent of the recorder's full scale on the test-unit coast-down (deceleration; see 2.8.3.4). The major-axis amplitudes at the operating speed nearest the critical or criticals of concern shall not exceed the values predicted in accordance with 2.8.2.4, Item d, before coast-down through the critical of concern.

2.8.3.2.1 Vectorial addition of slow-roll (300–600 revolutions per minute) electrical and mechanical runout is required to determine the actual vibration amplitudes and phase during the verification tests. Vectorial addition of the bearing-housing motion is required for machines that have flexible rotor supports (see 2.8.2.4, Item f).

Note 1: The phase on each vibration signal, x or y, is the angular measure, in degrees, of the phase difference (lag) between a phase reference signal (from a phase transducer sensing a once-per-revolution mark on the rotor, as described in API Standard 670) and the next positive peak, in time, of the synchronous (1×) vibration signal. (A phase change will occur through a critical or if a change in a rotor's balance condition occurs because of shifting or looseness in the assembly.)

Note 2: The major-axis amplitude is properly determined from a lissajous (orbit) display on an oscilloscope or equivalent instrument. When the phase angle between the x and y signals is not 90 degrees, the major-axis amplitude can be approximated by $(x^2 + y^2)^{1/2}$. When the phase angle between the x and y signals is 90 degrees, the major-axis amplitude value is the greater of the two vibration signals.

2.8.3.2.2 The results of the verification test shall be compared with those from the original analytical model. The vendor shall correct the model if it fails to meet any of the following criteria:

a. The actual critical speeds shall not deviate from the predicted speeds by more than ±5 percent.
b. The predicted amplification factors shall not deviate from the actual test-stand values by more than ±20 percent.
c. The actual response peak amplitudes, including those that are critically damped, shall be within ±50 percent of the predicted amplitudes.

2.8.3.3 Additional testing is required if, from the test data described or from the damped, corrected unbalanced response analysis (see 2.8.3.2.2), it appears that either of the following conditions exists:

a. Any critical response will fail to meet the separation margin requirements (see 2.8.2.5) or will fall within the operating speed range.
b. The requirements of 2.8.2.6 have not been met.

2.8.3.4 Rotors requiring additional testing per 2.8.3.3 shall receive additional testing as follows: Unbalance weights shall be placed as described in 2.8.2.4, Item b; this may require disassembly of the machine. Unbalance magnitudes shall be achieved by adjusting the indicated unbalance that exists in the rotor from the initial run to raise the displacement of the rotor at the probe locations to the vibration limit defined by Equation 1 (see 2.8.2.4, Item b) at the maximum continuous speed. However, the unbalance used shall be no less than twice the unbalance limit specified in 2.8.5.2. The measurements from this test, taken in accordance with 2.8.3.2, shall meet the following criteria:

a. At no speed outside the operating speed range, including the separation margins, shall the shaft deflections exceed 90 percent of the minimum design running clearances.
b. At no speed within the operating speed range, including the separation margins, shall the shaft deflections exceed 55 percent of the minimum design running clearances or 150 percent of the allowable vibration limit at the probes (see 2.8.2.4, Item b).

The internal deflection limits specified in this section, Items a and b, shall be based on the calculated displacement ratios between the probe locations and the areas of concern identified in 2.8.2.4, Item c. Actual internal displacements for these tests shall be calculated by multiplying these ratios by the peak readings from the probes. Acceptance will be based on these calculated displacements or on inspection of the seals if the machine is opened. Damage to any portion of the machine as a result of this testing shall constitute failure of the test. Minor internal seal rubs that do not cause clearance change outside the vendor's new-part tolerance do not constitute damage.

2.8.4 TORSIONAL ANALYSIS

2.8.4.1 Excitations of torsional resonances may come from many sources, which should be considered in the analysis. These sources may include but are not limited to the following:

a. Gear problems such as unbalance and pitch line runout.
b. Start-up conditions such as speed detents (under inertial impedances) and other torsional oscillations.
c. Torsional transients such as start-ups of synchronous electric motors.
d. Torsional excitation resulting from drivers such as electric motors.
e. Hydraulic governors and electronic feedback and control-loop resonances from variable-frequency motors.
f. Torsional transients from synchronous generators caused by phase-to-phase or phase-to-ground faults.

For a logic diagram showing torsional analysis requirements, see Figure C-2.

2.8.4.2 Unless otherwise specified, the vendor having train responsibility shall perform a torsional vibration analysis of the complete coupled train and shall be responsible for directing the modifications necessary to meet the requirements of 2.8.4.3 through 2.8.4.5.

2.8.4.3 The undamped torsional natural frequencies of the complete train shall be at least 10 percent above or 10 percent below any possible excitation frequency within the specified operating speed range (from minimum to maximum continuous speed).

2.8.4.4 Torsional criticals at two or more times running speeds shall preferably be avoided or, in systems in which corresponding excitation frequencies occur, shall be shown to have no adverse effect. In addition to multiples of running speeds, torsional excitations that are not a function of operating speeds or that are nonsynchronous in nature shall be considered in the torsional analysis when applicable and shall be shown to have no adverse effect. Identification of these frequencies shall be the mutual responsibility of the purchaser and the vendor.

2.8.4.5 When torsional resonances are calculated to fall within the margin specified in 2.8.4.3 (and the purchaser and the vendor have agreed that all efforts to remove the critical from within the limiting frequency range have been exhausted), a stress analysis shall be performed to demonstrate that the resonances have no adverse effect on the complete train. The acceptance criteria for this analysis shall be mutually agreed upon by the purchaser and the vendor.

2.8.5 VIBRATION AND BALANCING

2.8.5.1 Major parts of the rotating element, such as the shaft, balancing drum, and disks, shall be dynamically balanced. When a bare shaft with a single keyway is dynamically balanced, the keyway shall be filled with a fully crowned half-key. The initial balance correction to the bare shaft shall be recorded. A shaft with keyways 180 degrees apart but not in the same transverse plane shall also be filled as described above.

2.8.5.2 The rotating element shall be multiplane dynamically balanced during assembly. This shall be accomplished after the addition of no more than two major components. Balancing correction shall be applied only to the elements added. Minor correction of other components may be required during the final trim balancing of the completely assembled element. On rotors with single keyways, the keyway shall be filled with a fully crowned half-key. The weight of all half-keys used during final balancing of the assembled element shall be recorded on the residual unbalance work sheet (see Appendix D). The maximum allowable residual unbalance per plane (journal) shall be calculated using Equation 5:

$$U_{max} = 6350W/N \qquad (5)$$

In U.S. Customary units,

$$U_{max} = 4W/N$$

Where:

U_{max} = residual unbalance, in gram-millimeters (ounce-inches).
W = journal static weight load, in kilograms (pounds).
N = maximum continuous speed, in revolutions per minute.

When spare rotors are supplied, they shall be dynamically balanced to the same tolerances as the main rotor.

2.8.5.3 After the final balancing of each assembled rotating element has been completed, a residual unbalance check shall be performed and recorded as described in Appendix D.

2.8.5.4 High-speed balancing (balancing in a high-speed balancing machine at the operating speed) shall be done only with purchaser's specific approval. The acceptance criteria for this balancing shall be mutually agreed upon by the purchaser and the vendor.

2.8.5.5 During the shop test of the machine, assembled with the balanced rotor, operating at its maximum continuous speed or at any other speed within the specified operating speed range, the peak-to-peak amplitude of unfiltered vibration in any plane, measured on the shaft adjacent and relative to each radial bearing, shall not exceed the value calculated from Equation 6 or 25 micrometers (1.0 mil), whichever is less:

$$A = 25.4\sqrt{\frac{12,000}{N}} \qquad (6)$$

In U.S. Customary units,

$$A = \sqrt{\frac{12,000}{N}}$$

Where:

A = amplitude of unfiltered vibration, in micrometers (mils) peak to peak.
N = maximum continuous speed, in revolutions per minute.

At any speed greater than the maximum continuous speed, up to and including the trip speed of the driver, the vibration shall not exceed 150 percent of the maximum value recorded at the maximum continuous speed.

Note: These limits are not to be confused with the limits specified in 2.8.3 for shop verification of unbalanced response.

2.8.5.6 Electrical and mechanical runout shall be determined and recorded by rolling the rotor in V-blocks at the journal centerline while measuring runout with a noncontacting vibration probe and a dial indicator at the centerline of the probe location and one probe-tip diameter to either side.

2.8.5.7 Accurate records of electrical and mechanical runout, for the full 360 degrees at each probe location, shall be included in the mechanical test report.

2.8.5.8 If the vendor can demonstrate that electrical or mechanical runout is present, a maximum of 25 percent of the test level calculated from Equation 6 or 6.0 micrometers (0.25 mil), whichever is greater, may be vectorially subtracted from the vibration signal measured during the factory test.

2.9 Bearings and Bearing Housings

2.9.1 RADIAL BEARINGS

2.9.1.1 Hydrodynamic radial bearings shall be required and shall be split for ease of assembly, precision bored, and sleeved or padded, with steel-backed, babbitted replaceable liners, pads, or shells. These bearings shall be equipped with antirotation pins and shall be positively secured in the axial direction. The bearing design shall suppress hydrodynamic instabilities and provide sufficient damping over the entire range of allowable bearing clearances to limit rotor vibration to the maximum specified amplitudes (see 2.8.5.5) while the equipment is operating loaded or unloaded at specified operating speeds, including operation at any critical frequency. The liners, pads, or shells shall be in horizontally split housings and shall be replaceable without the removal of the top half of the casing of an axially split machine or the head of a radially split unit and without the removal of the coupling hub.

2.9.1.2 Radial bearing design shall be such that load transfer to the bearing housing by the bearing will not cause damage to critical bearing housing surfaces which are not considered normal wearing surfaces subject to repair or replacement.

2.9.2 THRUST BEARINGS AND COLLARS

2.9.2.1 Thrust bearings shall be hydrodynamic and steel-backed, with babbitted multiple segments, designed for equal thrust capacity in both directions, and arranged for continuous pressurized lubrication to each side. Tilting pads shall be used on both sides and shall incorporate a self-leveling feature ensuring that each pad carries an equal share of the thrust load with minor variations in pad thickness. The manufacturer shall note on the data sheets when the thrust bearing design is combined with the radial bearing.

2.9.2.2 Thrust bearings shall be sized for continuous operation under the most adverse specified operating conditions. Calculation of the thrust load shall include, but shall not be limited to, the following factors:

a. Fouling and variation in seal clearances up to twice the design internal clearances.
b. Step thrust from all diameter changes
c. Stage reaction and stage differential pressure.
d. Variations in inlet, extraction, induction, and exhaust pressure.
e. External loads from the driven equipment as described in 2.9.2.3 through 2.9.2.5.

2.9.2.3 For gear couplings, the external thrust force shall be calculated from Equation 7:

$$F = \frac{(0.25)(9,550)P_r}{(N_r D)} \qquad (7)$$

In U.S. Customary units,

$$F = \frac{(0.25)(63,000)P_r}{(N_r D)}$$

Where:

F = external thrust force, in kiloNewtons (pounds).
P_r = rated power, in kilowatts (horsepower).
N_r = rated speed, in revolutions per minute.
D = shaft diameter at the coupling, in millimeters (inches).

Note: Shaft diameter is an approximation of the coupling pitch radius.

2.9.2.4 Thrust forces for flexible-element couplings shall be calculated on the basis of the maximum allowable deflection permitted by the coupling manufacturer.

2.9.2.5 If two or more rotor thrust forces are to be carried by one thrust bearing (such as in a gear box), the resultant of the forces shall be used provided the directions of the forces make them numerically additive; otherwise, the largest of the forces shall be used.

2.9.2.6 Thrust bearings shall be selected at no more than 50 percent of the bearing manufacturer's ultimate load rating. The ultimate load rating is the load that will produce the minimum acceptable oil-film thickness without inducing failure during continuous service or the load that will not exceed the creep-initiation or yield strength of the babbitt at the maximum temperature location on the pad, whichever load is less. In sizing thrust bearings, consideration shall be given to, but shall not be limited to, the following for each specific application:

a. The shaft speed.
b. The temperature of the bearing babbitt.
c. The deflection of the bearing pad.
d. The minimum oil-film thickness.
e. The feed rate, viscosity, and supply temperature of the oil.
f. The design configuration of the bearing.
g. The babbitt alloy.
h. The shoe material.
i. The turbulence of the oil film.

The basis for the bearing manufacturer's sizing of thrust bearings shall be reviewed and approved by the purchaser.

2.9.2.7 Thrust bearings shall be arranged to allow axial positioning of each rotor relative to the casing and setting of the bearings' clearance or preload.

2.9.2.8 Unless otherwise specified, integral thrust collars shall be furnished. They shall be provided with at least 3 millimeters ($^1/_8$ inch) of additional stock on total thickness to enable refinishing if the collar is damaged. When replaceable collars are furnished, they shall be shrunk on and positively locked to the shaft to prevent fretting.

2.9.2.9 Both faces of thrust collars shall have surface finishes in the range of 0.4–0.8 micrometers (16–32 microinches) R_a. The axial total indicator runout of either face shall not exceed 13 micrometers (0.0005 inch).

2.9.3 BEARING HOUSINGS

2.9.3.1 Bearing housings for pressure-lubricated hydrodynamic bearings shall be arranged to minimize foaming. The drain system shall be adequate to maintain the oil and foam level below shaft end seals. The rise in oil temperature through the bearing and housings shall not exceed 28°C (50°F) under the most adverse specified operating conditions. The bearing outlet oil temperature shall not exceed 82°C (180°F). When the inlet oil temperature exceeds 49°C (120°F), special consideration shall be given to bearing design, oil flow, and allowable temperature rise. Oil outlets from flooded thrust bearings shall be tangential and in the upper half of the control ring or, if control rings are not used, in the thrust-bearing cartridge.

2.9.3.2 Bearing housings shall be equipped with replaceable labyrinth-end seals and deflectors where the shaft passes through the housing; lip-end seals shall not be used. The seals and deflectors shall be made of nonsparking materials. The design of the seals and deflectors shall effectively retain oil in the housing and prevent entry of foreign material into the housing.

2.9.3.3 Cantilevered shaft support structures bolted to steel cases shall also be steel.

2.9.3.4 Cast iron bearing housings or bearing housing supports are unacceptable.

2.9.3.5 Provision shall be made for mounting two radial-vibration probes in each bearing housing, two axial-position probes at the thrust end of each machine, and a one-event-per-revolution probe in each machine. The probe installation shall be as specified in API Standard 670 (see 3.4.8).

● **2.9.3.6** When specified, provisions for mounting accelerometers on the bearing housings shall be made in accordance with API Standard 670 (see 3.4.8).

2.9.3.7 Machines equipped with sleeved journal bearings shall be designed for field installation of tilting-pad radial bearings without remachining of the bearing bracket.

2.9.4 GROUNDING

Unless otherwise specified, condensing turbines shall be provided with at least two grounding brushes on the shaft. Brushes shall be located in an area not flooded by oil for convenient replacement and shall not interfere with the proper function of any noncontacting vibration probes. The brushes shall be a standard size and grade suitable for the service. The vendor shall include drawings with the proposal showing the number and location of the brushes.

Note: Both brushes should be on the same end of the shaft to prevent circulating shaft electrical currents.

2.10 Lubrication and Control-Oil System

2.10.1 Unless otherwise specified, bearings and bearing housing shall be arranged for hydrocarbon oil lubrication.

● **2.10.2** When specified, a pressurized oil system shall be furnished to supply oil at a suitable pressure or pressures, as applicable, to the following:

a. The bearings of the driver and of the driven equipment (including any gear).
b. The continuously lubricated couplings.
c. The control-oil system.
d. The trip system.

2.10.3 If the pressurized oil system is furnished by others, the turbine vendor shall:

a. Furnish the level of steady and transient oil-flow and pressure required, the degree of filtration required, and the maximum heat load imposed.
b. Furnish piping to a single feed connection for each pressure level. One drain connection shall be provided for all oil to be returned to the reservoir.

2.10.4 Pressurized oil systems shall conform to the requirements of API Standard 614.

● **2.10.5** Where oil is supplied from a common system to two or more machines (such as a compressor, a gear, and a turbine), the oil's characteristics will be specified on the data sheets by the purchaser on the basis of mutual agreement with all vendors supplying equipment served by the common oil system.

Note: The usual lubricant employed in a common oil system is a hydrocarbon oil that corresponds to ISO Grade 32, as specified in ISO 3448.

2.10.6 Any points that require grease lubrication shall have suitable extension lines to permit access during operation.

2.11 Materials

2.11.1 General

2.11.1.1 Materials of construction shall be the manufacturer's standard for the specified operating conditions, except as required by the data sheets or this standard.

2.11.1.2 Materials shall be identified in the proposal with their applicable ASTM, AISI,[12] ASME, or SAE[13] numbers, including the material grade. When no such designation is available, the vendor's material specification, giving physical properties, chemical composition, and test requirements, shall be included in the proposal.

2.11.1.3 The vendor shall specify the ASTM optional tests and inspection procedures necessary to ensure that materials are satisfactory for service. Such tests and inspections shall be listed in the proposal. The purchaser may consider

[12]American Iron and Steel Institute, 1000 16th Street, N.W., Washington, D.C. 20036.
[13]Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, Pennsylvania 15096.

specifying additional tests and inspections, especially for materials used in critical components.

2.11.1.4 External parts that are subject to rotary or sliding motions (such as control linkage joints and adjusting mechanisms) shall be of corrosion-resistant materials suitable for the site environment.

2.11.1.5 Minor parts that are not identified (such as nuts, springs, washers, gaskets, and keys) shall have corrosion resistance at least equal to that of specified parts in the same environment.

● **2.11.1.6** The purchaser will specify any corrosive agents present in the steam and in the environment, including constituents that may cause stress corrosion cracking.

Note: The vendor shall recognize that some steam systems include contaminants such as sodium hydroxide, chlorides, sulfates, phosphates, copper, and lead, and shall consider these when selecting materials.

2.11.1.7 If parts exposed to conditions that promote intergranular corrosion are to be fabricated, hard faced, overlaid, or repaired by welding, they shall be made of low-carbon or stabilized grades of austenitic stainless steel.

Note: Overlays or hard surfaces that contain more than 0.10 percent carbon can sensitize both low-carbon and stabilized grades of austenitic stainless steel unless a buffer layer that is not sensitive to intergranular corrosion is applied.

2.11.1.8 Where mating parts such as studs and nuts of austenitic stainless steel per ASTM A 269 or materials with similar galling tendencies are used, they shall be lubricated with an antiseizure compound of the proper temperature specification.

Note: Torque loading values will differ considerably with and without an antiseizure compound.

● **2.11.1.9** Materials with a yield strength of more than 620 MPa (90,000 pounds per square inch) or a hardness of more than Rockwell C 22 shall not be used for components exposed to wet H_2S service, including trace quantities. Components that are fabricated by welding shall be stress relieved, if required, so that both the welds and the heat-affected zones meet the yield strength and hardness requirements. The purchaser will specify the presence of such agents in the media.

2.11.1.10 Unless otherwise specified, the vendor shall list in the proposal all steam path components (valves, seats, blades, shrouds, closing pieces and pins, damping wires, wheels, bolting, and so forth) with a hardness of more than Rockwell C 22. The vendor shall also indicate the hardness range of each component.

2.11.1.11 Materials, casting factors, and the quality of any welding shall be equal to those required by Section VIII, Division 1, of the ASME Code. The manufacturer's data report forms, as specified in the code, are not required.

2.11.1.12 Pressure-containing parts shall be of steel for specified steam conditions exceeding 1,700 kPa (250 pounds per square inch gauge) or 230°C (450°F). Non-condensing exhaust casings shall be of steel if the maximum exhaust pressure exceeds 520 kPa (75 pounds per square inch gauge) or no-load exhaust temperature exceeds 230°C (450°F). Alloy steels shall be used for maximum steam temperatures exceeding 410°C (775°F).

2.11.1.13 Material for turbine parts shall be forged steel for wheels and shaft and 11–13 percent chromium steel, titanium, or nickel-copper alloy (similar to ASTM B 127) for nozzles, closing pieces, rotating and stationary blading, and shrouding and steam strainers, unless otherwise approved.

Note: For high inlet temperature or high speed applications, rotor materials high in chrome (Cr) content are used due to the higher strength of these alloys. For rotors with over 2½% Cr, consideration should be given to alternate materials for the thrust collar and journal surfaces to prevent the wire wooling effect that these alloys can have on babbitted bearings.

2.11.1.14 The use of ASTM A 515 steel is prohibited. Low-carbon steels can be notch sensitive and susceptible to brittle fracture at ambient or low temperatures. Therefore, only fully killed, normalized steels made to fine-grain practice are acceptable.

2.11.1.15 For the selection of materials other than austenitic stainless steel for service below −29°C (−20°F), the vendor shall require a Charpy V-notch impact test of the base metal and of the weld joint.

Note: To avoid brittle failure during operation, maintenance, transportation, erection, and testing, good design practices shall be followed in the selection of fabrication methods, welding procedures, and materials for vendor-furnished carbon steel piping and appurtenances that may be subject to temperatures below the ductile-brittle transition point. The published design-allowable stresses for many materials in the ASME Code and ANSI standards are based on minimum tensile properties. They do not differentiate between rimmed, semikilled, fully killed, hot-rolled, and normalized material, nor do they take into account whether materials were produced under fine- or coarse-grain practices. The vendor shall exercise caution in the selection of materials intended for service between −29°C (−20°F) and 38°C (100°F).

2.11.2 CASTINGS

2.11.2.1 Castings shall be sound and free from porosity, hot tears, shrink holes, blow holes, cracks, scale, blisters, and similar injurious defects. Surfaces of castings shall be cleaned by sandblasting, shotblasting, chemical cleaning, or any other standard method. Mold-parting fins and remains of gates and risers shall be chipped, filed, or ground flush.

2.11.2.2 The use of chaplets in pressure castings shall be held to a minimum. The chaplets shall be clean and corrosion free (plating permitted) and of a composition compatible with the casting.

2.11.2.3 Ferrous castings shall not be repaired by welding, peening, plugging, burning-in, or impregnating, except as specified in 2.11.2.3.1 and 2.11.2.3.2.

2.11.2.3.1 Weldable grades of steel castings may be repaired by welding, using a qualified welding procedure based on the requirements of Section VIII, Division 1, and Section IX of the ASME Code.

2.11.2.3.2 Cast grey iron or nodular iron may be repaired by plugging within the limits specified in ASTM A 278, A 395, or A 536. The holes drilled for plugs shall be carefully examined, using liquid penetrant, to ensure that all defective material has been removed. All repairs that are not covered by ASTM specifications shall be subject to the purchaser's approval.

2.11.2.4 Fully enclosed cored voids, including voids closed by plugging, are prohibited.

2.11.2.5 Nodular iron castings shall be produced in accordance with ASTM A 395. The production of the castings shall also conform to the conditions specified in 2.11.2.5.1 through 2.11.2.5.5.

2.11.2.5.1 A minimum of one set (three samples) of Charpy V-notch impact specimens at one-third the thickness of the test block shall be made from the material adjacent to the tensile specimen on each keel or Y-block. These specimens shall have a minimum impact value of 14 joules (10 foot-pounds) at room temperature.

2.11.2.5.2 The keel or Y-block cast at the end of the pour shall be at least as thick as the thickest section of the main casting.

2.11.2.5.3 Integrally cast test bosses, preferably at least 25 millimeters (1 inch) in height and diameter, shall be provided at critical areas of the casting for subsequent removal for the purposes of hardness testing and microscopic examination. Critical areas are typically heavy sections, section changes, flanges and other high-stress points as agreed upon by the purchaser and the vendor. Classification of graphite nodules shall be in accordance with ASTM A 247.

2.11.2.5.4 An as-cast sample from each ladle shall be chemically analyzed.

2.11.2.5.5 Brinell hardness readings shall be made on the actual casting at feasible locations on section changes and flanges. Sufficient surface material shall be removed before hardness readings are made to eliminate any skin effect. Readings shall also be made at the extremities of the casting at locations that represent the sections poured first and last. These shall be made in addition to Brinell readings on the keel or Y-blocks.

2.11.3 WELDING

2.11.3.1 Welding of piping and pressure-containing parts, as well as any dissimilar-metal welds and weld repairs, shall be performed and inspected by operators and procedures qualified in accordance with Section VIII, Division 1 and Section IX of the ASME Code.

2.11.3.2 The vendor shall be responsible for the review of all repairs and repair welds to ensure that they are properly heat treated and nondestructively examined for soundness and compliance with the applicable qualified procedures (see 2.11.1.11). Repair welds shall be nondestructively tested by the same method used to detect the original flaw. As a minimum, the inspection shall be by the magnetic particle method, in accordance with 4.2.2.4.

2.11.3.3 Unless otherwise specified, all welding other than that covered by Section VIII, Division 1, of the ASME Code and ASME B31.3, such as welding on baseplates, nonpressure ducting, lagging, and control panels, shall be performed in accordance with AWS D1.1.

2.11.3.4 Pressure-containing casings made of wrought materials or combinations of wrought and cast materials shall conform to the conditions specified in 2.11.3.4.1. through 2.11.3.4.4.

2.11.3.4.1 Plate edges shall be inspected by magnetic particle or liquid penetrant examination as required by Section VIII, Division 1, UG-93(d)(3), of the ASME Code.

2.11.3.4.2 Accessible surfaces of welds shall be inspected by magnetic particle or liquid penetrant examination after back chipping or gouging and again after post-weld heat treatment.

2.11.3.4.3 Pressure-containing welds, including welds of the case to horizontal- and vertical-joint flanges, shall be full-penetration welds.

2.11.3.4.4 Fabricated casings (regardless of thickness) shall be post-weld heat treated.

2.11.3.5 Connections welded to pressure casings shall be installed as specified in 2.11.3.5.1 through 2.11.3.5.5.

● **2.11.3.5.1** In addition to the requirements of 2.11.3.1, the purchaser may specify that 100-percent radiography, magnetic particle inspection, or liquid penetrant inspection of welds is required.

2.11.3.5.2 Auxiliary piping welded to chromium-molybdenum alloy steel or 12-percent chrome steel components shall be of the same material, except that chromium-molybdenum alloy steel pipe may be substituted for 12-percent chrome steel pipe.

2.11.3.5.3 When heat treatment is required, piping welds shall be made before the component is heat treated.

2.11.3.5.4 Unless otherwise specified, proposed connection designs shall be submitted to the purchaser for approval before fabrication. The drawings shall show weld designs, size, materials, and pre- and post-weld heat treatments.

2.11.3.5.5 All welds shall be heat treated in accordance with the methods described in Section VIII, Division 1, UW-40, of the ASME Code.

2.12 Nameplates and Rotation Arrows

2.12.1 A nameplate shall be securely attached at a readily visible location on the equipment and on any other major piece of auxiliary equipment.

2.12.2 Rotation arrows shall be cast in or attached to each major item of rotating equipment at a readily visible location. Nameplates and rotation arrows (if attached) shall be of AISI Standard Type 300 stainless steel or of nickel-copper alloy (monel or its equivalent). Attachment pins shall be of the same material. Welding is not permitted. A rotation arrow shall be located on the thrust bearing housing.

2.12.3 Data shall be clearly stamped on the nameplate and shall include but not be limited to the following:

a. Purchaser's equipment item number (may be on a separate nameplate if there is insufficient space on the rating nameplate).
b. Vendor's name.
c. Serial number.
d. Size and type.
e. Rated power and speed.
f. First critical speed.
g. Second critical speed (may be omitted for stiff-shaft turbines).
h. Maximum continuous speed.
i. Trip speed (see 1.4.36).
j. Normal and maximum inlet steam temperature and pressure.
k. Normal and maximum exhaust steam pressure.

Note: Any critical speeds determined from running tests shall be stamped on the nameplate followed by the word "Test." Critical speeds predicted by calculation up to and includng the critical speed above trip speed and not identifiable by test shall be stamped on the nameplate followed by the abbreviation "Calc."

● **2.12.4** The purchaser will specify whether SI or U.S. Customary units are to be shown on the nameplate.

SECTION 3—ACCESSORIES

3.1 Couplings and Guards

3.1.1 Flexible couplings and guards between drivers and driven equipment shall be supplied by the manufacturer of the driven equipment, unless otherwise specified on the data sheets. When the turbine vendor supplies tandem drivers, the vendor shall furnish flexible coupling(s) and guard(s) between the units.

3.1.2 Couplings and guards shall conform to API Standard 671. The make, type, and mounting arrangement of the couplings shall be agreed upon by the purchaser and the vendors of the driver and driven equipment.

Note: Couplings and coupling spacers are often used to relocate torsional resonances to more favorable locations (system tuning) by changing the coupling stiffness. All parties involved should provide torsional data as soon as possible to the party responsible for the torsional analysis. The selection of couplings cannot be made until the torsional analysis, when required, is complete.

3.1.3 Information on shafts, keyway dimensions (if any), and shaft end movements due to end play and thermal effects shall be furnished to the vendor supplying the coupling.

3.1.4 Balanced idling adapters and solo plates or a half weight simulator in accordance with 4.3.3.1.6 shall be furnished by the purchaser of the coupling to the driver manufacturer along with the half-coupling. Upon completion of all testing, the idling adapters and solo plates shall be furnished to the owner as part of the special tools.

3.1.5 Unless otherwise specified on the data sheets, the turbine half of the coupling or couplings shall be mounted by the turbine manufacturer unless the rotor is furnished with an integral-flanged shaft end.

3.2 Mounting Plates

3.2.1 GENERAL

● **3.2.1.1** The equipment shall be furnished with soleplates or a baseplate, as specified on the data sheets.

3.2.1.2 In 3.2.1.2.1 through 3.2.1.2.13, the term *mounting plate* refers to both baseplates and soleplates.

3.2.1.2.1 Turbine mounting pads shall be machined flat within 0.05 millimeter (0.002 inch). Multiple mounting pads on baseplates shall also be machined coplanar within 0.05 millimeter (0.002 inch).

Note: Field installation should duplicate these machine tolerances in order to avoid distortion of turbine casing and supports.

3.2.1.2.2 Mounting plates shall be equipped with vertical jackscrews. Baseplate vertical leveling screws shall be located at each foundation anchor bolt hole location.

3.2.1.2.3 When the equipment supported weighs more than 450 kilograms (1000 pounds), the mounting plates shall be furnished with horizontal jackscrews the same size as or larger than the vertical jackscrews. The lugs holding these jackscrews shall be attached to the mounting plates so that they do not interfere with the installation or removal of the equipment jackscrews or shims.

3.2.1.2.4 Machinery supports shall be designed to limit a change of alignment caused by the worst combination of pressure, torque, and allowable piping stress to 50 micrometers (0.002 inch) at the coupling flange. (See 2.5 for allowable piping forces.)

3.2.1.2.5 When centerline supports are provided, they shall be designed and manufactured to permit the machine to be moved by using horizontal jackscrews.

3.2.1.2.6 The vendor shall coat all mounting surfaces with a rust preventive immediately after machining.

3.2.1.2.7 Unless otherwise specified on the data sheet, the vendor shall commercially sandblast, in accordance with SSPC SP 6, all grouting surfaces on the mounting plates and shall precoat these surfaces with a catalyzed epoxy primer. The epoxy primer shall be compatible with epoxy grout. The vendor shall submit to the purchaser instructions for field preparation of the epoxy primer.

Note: The grout manufacturer should be consulted for specifications to ensure satisfactory bonding of the grout, including field preparation of the mounting plate, proper application of epoxy primers, and time restrictions between application of the primer and grouting of the equipment.

3.2.1.2.8 Mounting plates shall not be drilled for equipment to be mounted by others. Mounting plates intended for installation on concrete shall be supplied with leveling screws. Mounting plate surfaces that are to be grouted shall have 50-millimeter-radiused (2-inch-radiused) outside corners (in the plan view). See Figures 3A, 3B, 3C, and 3D.

3.2.1.2.9 Mounting plates shall extend at least 25 millimeters (1 inch) beyond the outer three sides of equipment feet.

3.2.1.2.10 Anchor bolts will be furnished by the purchaser.

3.2.1.2.11 Fasteners for attaching the components to the mounting plates and jackscrews for leveling the pedestal soleplates shall be supplied by the vendor.

3.2.1.2.12 The equipment feet shall be drilled with pilot holes that are accessible for use in final doweling.

3.2.1.2.13 The vendor of the mounting plates shall furnish austenitic stainless steel per ASTM A 269 shim packs a minimum of 3 millimeters ($^1/_8$ inch) thick and a maximum of 13 millimeters ($^1/_2$ inch) thick between the equipment feet and the mounting plates. All shim packs shall straddle hold-down bolts and vertical jackscrews and shall be at least 6 millimeters ($^1/_4$ inch) larger on all sides than the footprint of the equipment.

● **3.2.1.2.14** When leveling plates are specified, they shall be steel plates at least 19 millimeters ($^3/_4$ inch) thick. They shall be circular in shape in the plan view.

3.2.2 BASEPLATES

3.2.2.1 When a baseplate is furnished, the data sheets will indicate the major equipment to be mounted on it. A baseplate shall be a single fabricated steel unit, unless the purchaser and the vendor mutually agree that it may be fabricated in multiple sections. Multiple-section baseplates shall have machined and doweled mating surfaces to ensure accurate field reassembly.

Note: A baseplate with nominal length of more than 12 meters (40 feet) or a nominal width of more than 3.5 meters (12 feet) may have to be fabricated in multiple sections because of shipping restrictions.

● **3.2.2.2** The baseplate shall be provided with leveling pads or targets. When specified, they shall be provided with protective covers. The leveling pads or targets shall be accessible for field leveling after installation, with the equipment mounted and the baseplate on the foundation.

● **3.2.2.3** When specified, the baseplate shall be suitable for column mounting (that is, of sufficient rigidity to be supported at specified points) without continuous grouting under structural members. The baseplate design shall be mutually agreed upon by the purchaser and the vendor.

3.2.2.4 The baseplate shall be provided with lifting lugs for at least a four-point lift. Lifting the baseplate complete with all equipment mounted shall not permanently distort or otherwise damage the baseplate or the machinery mounted on it.

● **3.2.2.5** The bottom of the baseplate between structural members shall be open. When the baseplate is installed on a concrete foundation, accessibility shall be provided for grouting under all load-carrying structural members. The mounting pads on the bottom of the baseplate shall be in one plane to permit use of a single-level foundation. When specified, subplates shall be provided by the vendor.

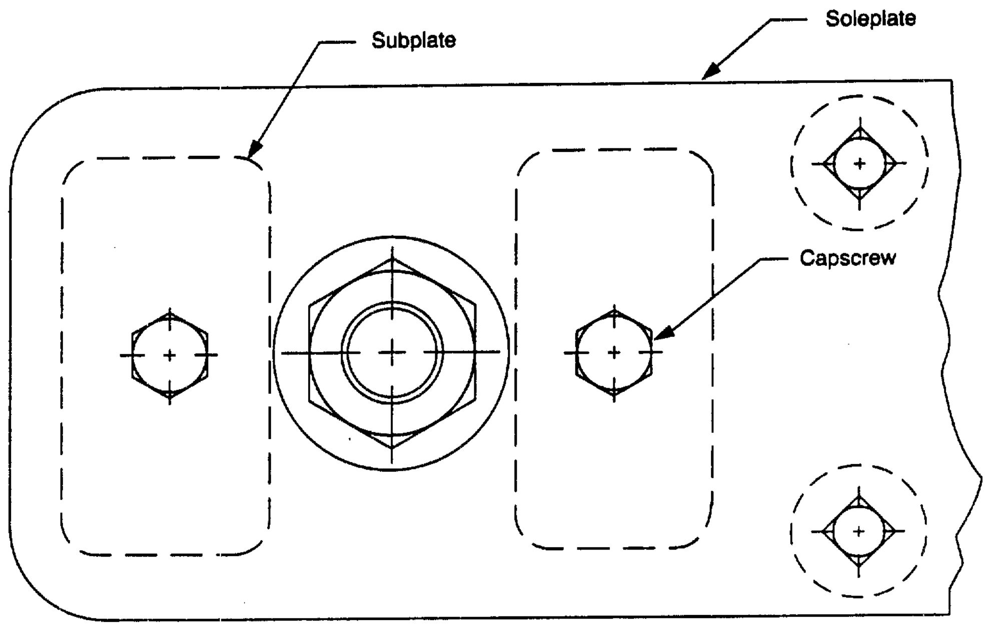
3.2.2.6 Unless otherwise specified, nonskid decking covering all walk and work areas shall be provided on top of the baseplate.

3.2.2.7 The baseplate mounting pads shall be machined after the baseplate is fabricated.

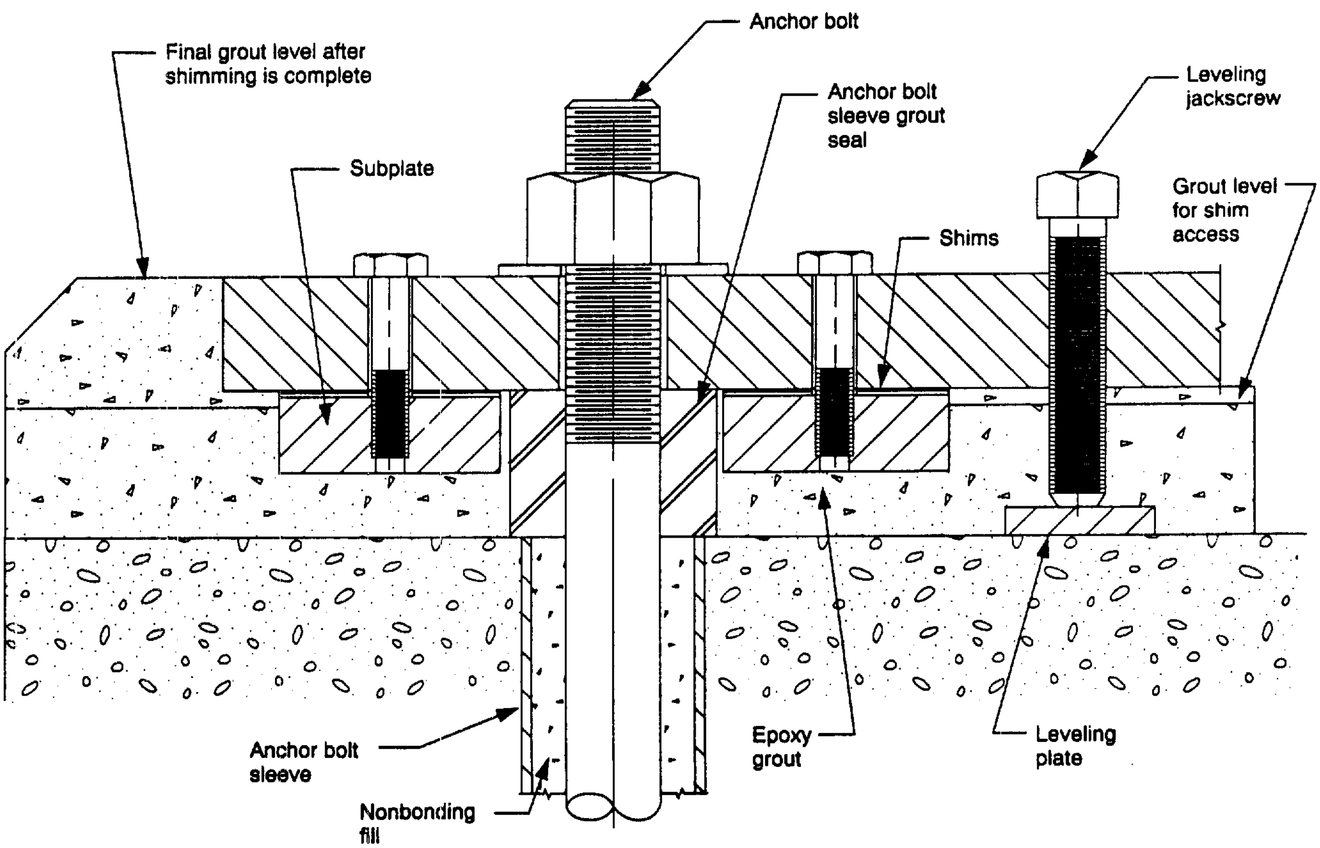
3.2.3 SOLEPLATES AND SUBPLATES

3.2.3.1 When soleplates are furnished, they shall meet the requirements of 3.2.3.1.1 through 3.2.3.1.3 in addition to those of 3.2.2.

3.2.3.1.1 Soleplates shall be larger than the individual mounting pad area for each mating pad.



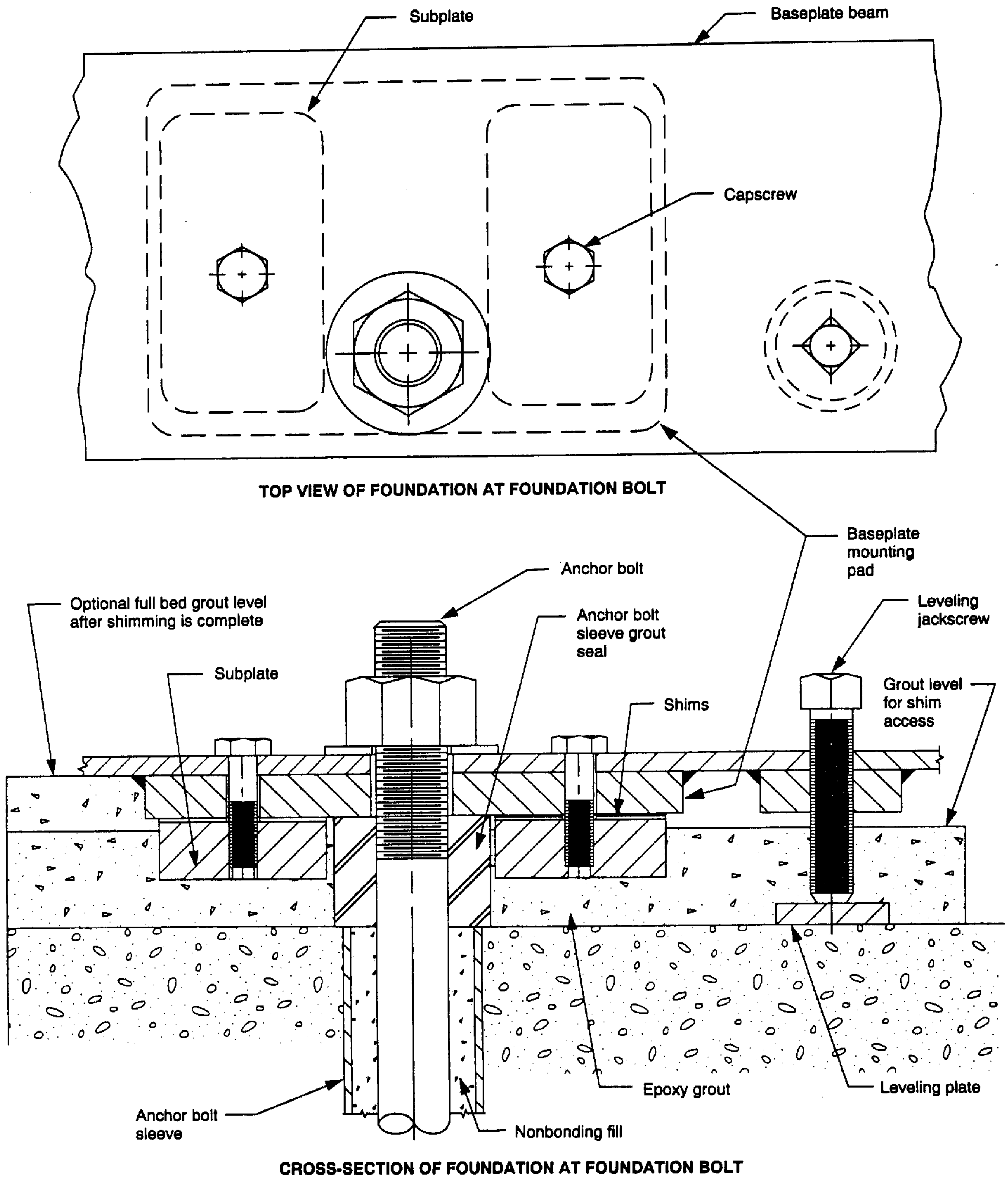
TOP VIEW OF FOUNDATION AT FOUNDATION BOLT



CROSS-SECTION OF FOUNDATION AT FOUNDATION BOLT

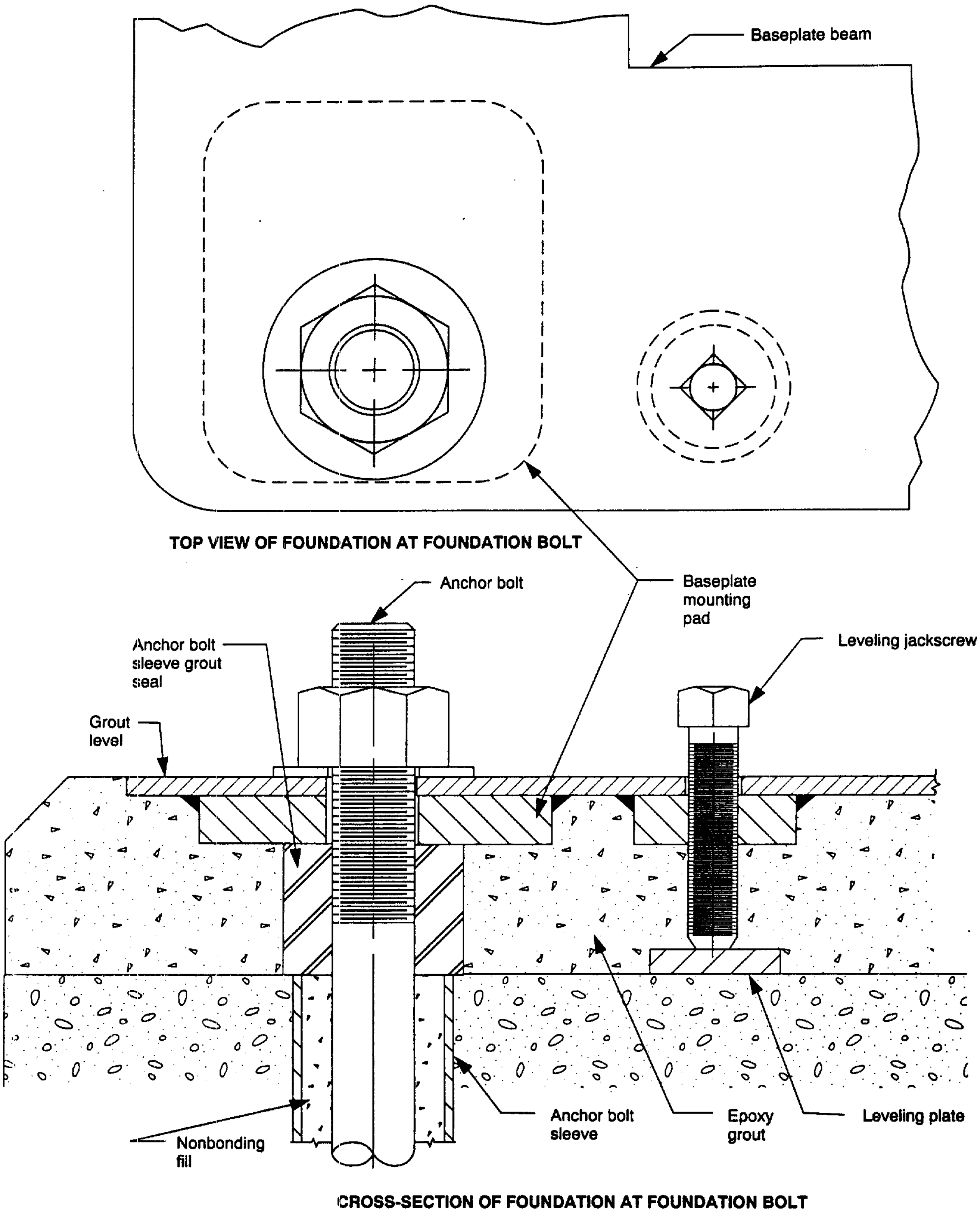
Note: Epoxy grout not to contact anchor bolt. Leveling jackscrew to be prevented from adhering to epoxy grout by applying wax, grease, or other protectant.

Figure 3A—Typical Mounting Plate Arrangement



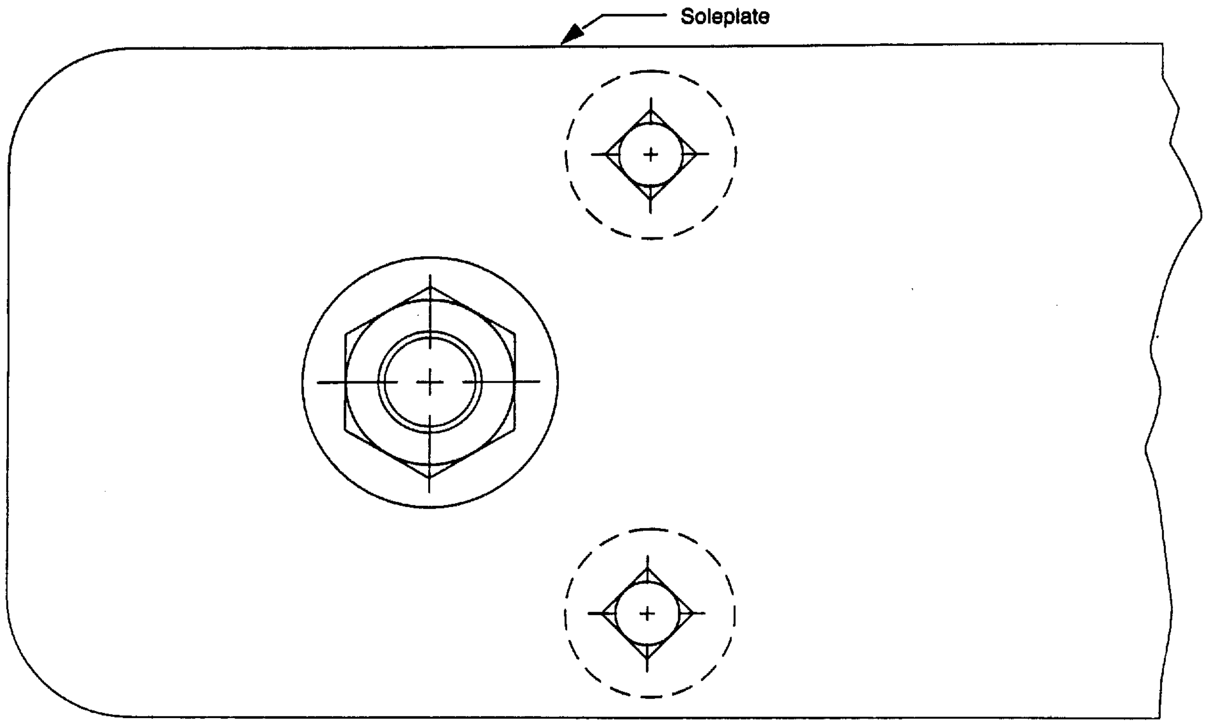
Note: Epoxy grout not to contact anchor bolt. Leveling jackscrew to be prevented from adhering to epoxy grout by applying wax, grease, or other protectant.

Figure 3B—Typical Mounting Plate Arrangement

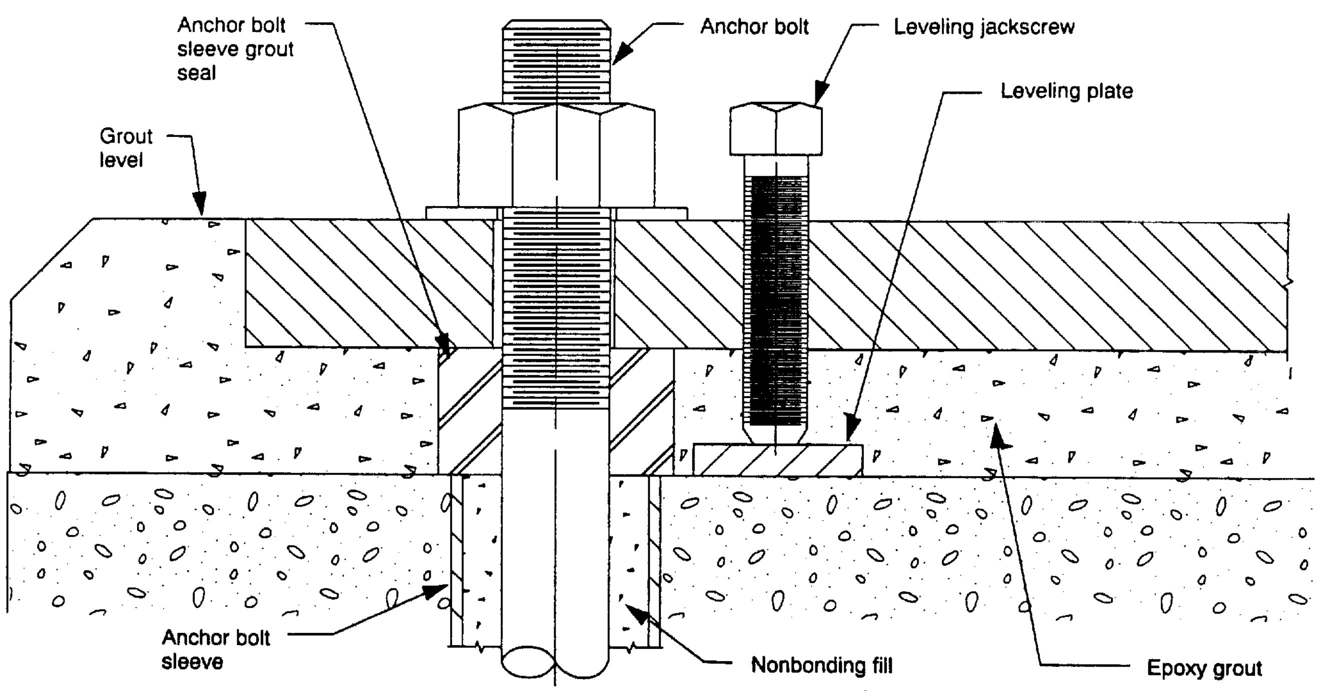


Note: Epoxy grout not to contact anchor bolt. Leveling jackscrew to be prevented from adhering to epoxy grout by applying wax, grease, or other protectant.

Figure 3C—Typical Mounting Plate Arrangement



TOP VIEW OF FOUNDATION AT FOUNDATION BOLT



CROSS-SECTION OF FOUNDATION AT FOUNDATION BOLT

Note: Epoxy grout not to contact anchor bolt. Leveling jackscrew to be prevented from adhering to epoxy grout by applying wax, grease, or other protectant.

Figure 3D—Typical Mounting Plate Arrangement

3.2.3.1.2 Adequate working clearance shall be provided at the bolting locations to allow the use of socket or box wrenches and to allow the equipment to be moved using the horizontal and vertical jackscrews.

3.2.3.1.3 Soleplates shall be steel plates that are thick enough to transmit the expected loads from the equipment feet to the foundation, but in no case shall the plates be less than 40 millimeters ($1^1/_2$ inches) thick.

● **3.2.3.2** When specified, subplates shall be furnished. They shall be steel, a minimum of 25 millimeters (1 inch) thick, and have a mating surface finish matching the soleplates (see 3.2.1.2.1).

3.2.3.3 Corners shall be rounded to a minimum 50-millimeter (2-inch) radius in the plan view (see Figure 3A).

3.3 Gear Units

Gear units shall conform to the requirements of API Standard 613.

3.4 Controls and Instrumentation

3.4.1 GENERAL

3.4.1.1 Unless otherwise specified, instrumentation and installation shall conform to the requirements of API Standard 614.

3.4.1.2 Unless otherwise specified, controls and instrumentation shall be suitable for outdoor installation and shall meet or exceed the requirements of NEMA 4, as detailed in NEMA Publication 250.

3.4.2 OVERSPEED SHUTDOWN SYSTEM

3.4.2.1 An overspeed shutdown system (see Figures 4 and 5), independent of the governing system, shall be provided. The system shall prevent the turbine rotor speed from exceeding 127% of the rated speed on an instantaneous, complete loss of coupled inertia load while operating at the rated conditions. This system consists of the following:

a. Electronic overspeed circuit (speed sensors and logic device).
b. Electro-hydraulic solenoid valves.
c. Hydraulic/mechanical emergency trip valve/combined trip and throttle valve.

The turbine manufacturer shall have unit responsibility for the overspeed shutdown system.

3.4.2.2 Electronic Overspeed Circuit

3.4.2.2.1 At least two separate electrical overspeed circuits consisting of speed sensors and logic devices shall be provided. The minimum criteria shall include the following:

a. An overspeed condition sensed by either circuit shall initiate a shutdown.
b. Failure of a speed sensor or logic device in either circuit shall initiate an alarm only (deenergized).
c. Failure of both circuits shall initiate a shutdown.
d. Items a, b, and c require manual reset.
e. All settings incorporated in the overspeed circuits shall be field changeable and shall be protected through controlled access.
f. Each overspeed circuit shall accept inputs from a frequency generator for verifying the trip speed setting. A controlled access lockout shall be provided for on-line testing.
g. Each overspeed circuit shall provide an output for speed readout with indicator.
h. The overspeed system speed sensors shall not be shared with any other system.
i. Peak hold feature with controlled access reset shall be provided to indicate the maximum speed obtained during a trip condition.

● **3.4.2.2.2** When specified, an overspeed shutdown system based on two-out-of-three voting logic shall be furnished.

3.4.2.2.3 Unless otherwise specified, magnetic pickups shall be supplied for speed sensing.

3.4.2.2.4 A multitoothed surface for speed sensing shall be provided integral with, or positively attached, or locked, to the turbine shaft. This surface may be shared by the speed governor, overspeed shutdown system, and tachometer.

Note: The number of teeth on a toothed wheel will vary depending on the speed of the turbine and the diameter of the wheel. Special attention should be made during initial startup of the unit at the factory mechanical running test, and again during commissioning, to check the number of teeth on the wheel, to assure that the governor, overspeed shutdown system and tachometers are calibrated for the correct number of teeth for the input from the toothed wheel.

3.4.2.3 Electro-Hydraulic Solenoid Valves

3.4.2.3.1 The turbine shall be provided with two separate electro-hydraulic solenoid-operated valves located in the trip system. Unless otherwise specified, the solenoid valves shall be energized to trip.

3.4.2.3.2 The solenoid valves and any required interposing relays shall be capable of on-line testing without defeating trip protection.

Note 1: Solenoids can draw significantly high currents. Interposing relays may be used when the current requirements of the solenoids exceed the current rating of the relay in the overspeed shutdown system.

Note 2: The electronic overspeed shutdown system should be powered by an uninterruptable power source.

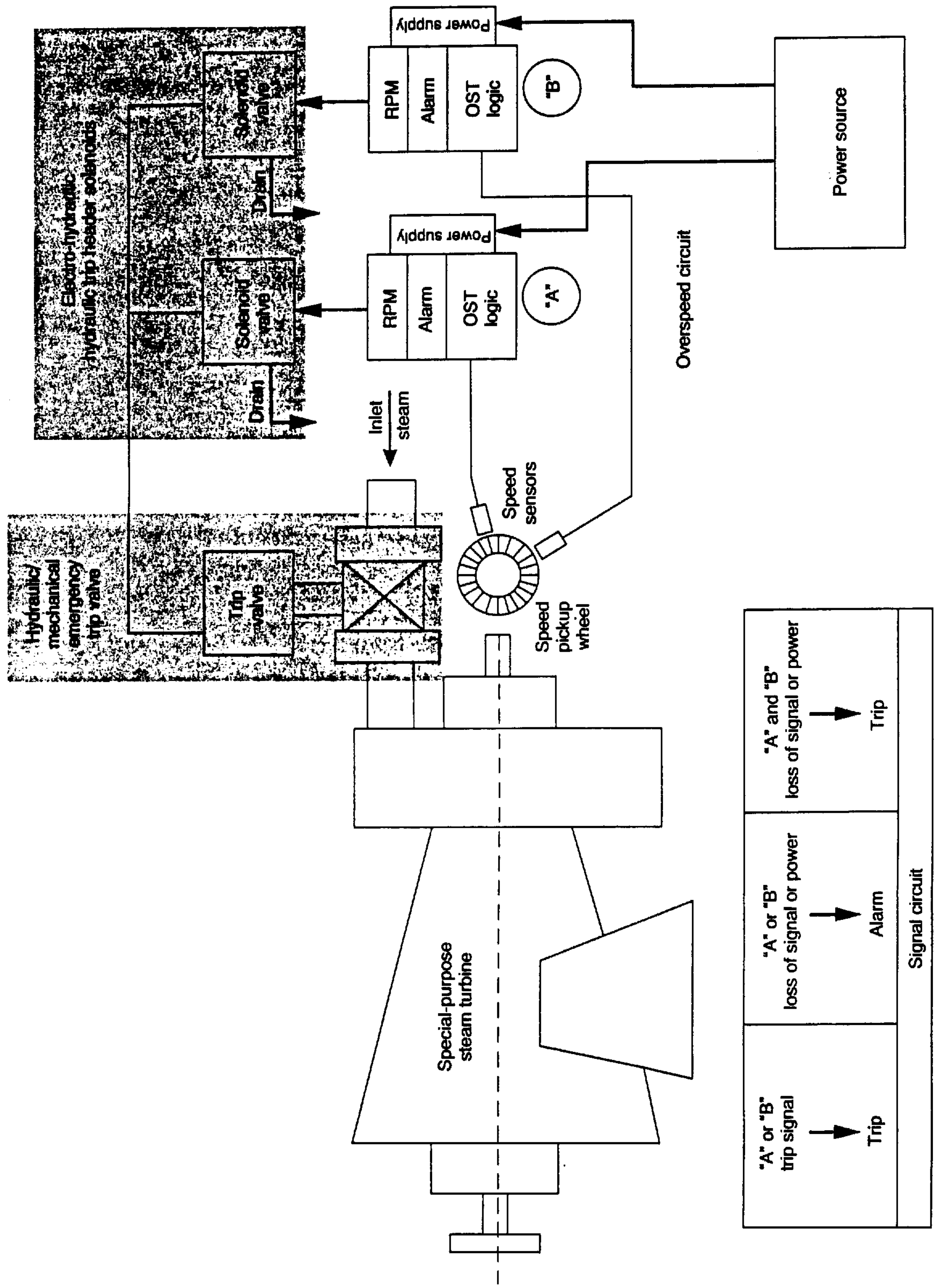
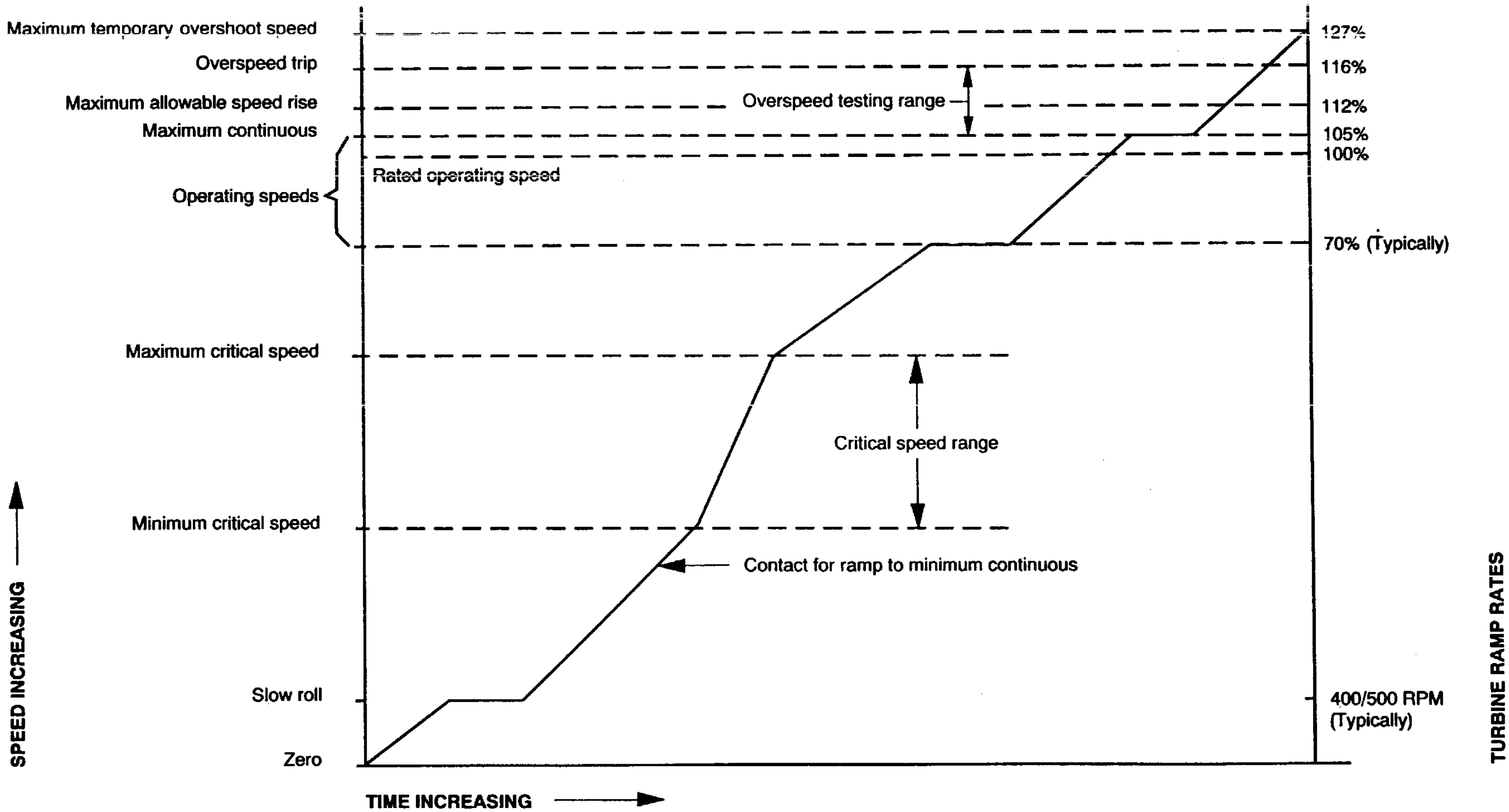


Figure 4—Overspeed Shutdown System



Note: Maximum allowable speed rise shall be in accordance with the requirements of NEMA SM 23, Class D.

Figure 5—Overspeed Trip Requirements

3.4.2.4 Trip Valve/Combined Trip and Throttle Valve

● **3.4.2.4.1** A separate independent trip valve or combined trip and throttle valve, as specified by the purchaser, shall be provided for each steam inlet.

Note: Trip valve(s) operate in the shut (tripped) or fully open position *only*. In addition to the functions provided by trip valve(s), combined trip and throttle valve(s) provide intermediate valve positioning.

3.4.2.4.2 The criteria for the design of trip valve(s)/ combined trip and throttle valve(s) shall include but not be limited to the following:

a. Stem and seating surfaces of corrosion-resistant material.
b. Prevention of steam contaminate deposits on the valve stem which inhibit closure.
c. A back-seated valve stem to minimize leakage.
d. Spring loading and steam flow to assist closure.
e. Above and below seat drain connections, as required by the body style and mounting position, and valve stem leak-off connections.
f. Reset capability with maximum inlet steam pressure on the line.
g. Hydraulic connection to trip system.
h. Partial stroking capability which does not interrupt operation of the turbine.
i. Replacement of wearing parts with the valve in place.
j. A corrosion-resistant steam strainer.

3.4.2.4.3 The trip valve/combined trip and throttle valve steam strainer shall be designed to prevent in-service failure. The strainer shall be removable without dismantling any of the inlet steam piping. The effective free area of the strainer shall be at least twice the cross-sectional area of the valve inlet connection. The steam strainer shall be capable of withstanding a pressure differential at least equal to 25 percent of the inlet pressure.

3.4.2.4.4 The trip valve/combined trip and throttle valve shall not depend on steam flow assist to meet the required closure time. The closure time of the valve shall be verified during the mechanical running test.

3.4.2.5 Other Protective Devices

3.4.2.5.1 Solenoids and relays normally operating in a de-energized state, shall have a detection system to alarm on failure of the coil (resistance and open circuit).

3.4.2.5.2 A manual trip shall be provided local to the turbine front standard to allow an operator to trip the unit. This device shall dump the hydraulic header which would close the trip or trip and throttle valve(s), governor-controlled valve(s), and any nonreturn valve(s).

3.4.2.5.3 On induction or extraction/induction turbines, the turbine manufacturer shall supply a trip valve on each induction steam supply line. The valve shall be constructed in accordance with 3.4.2.4.1 through 3.4.2.4.4. On extraction turbines, the manufacturer shall supply a nonreturn valve equipped with a spring-loaded hydraulic or pneumatic-actuated cylinder to assist in closing the valve on each extraction line. The hydraulic or pneumatic cylinder on these valves shall be actuated by the trip system. The manufacturer, model, quantity, and location of the device(s) shall be mutually agreed upon by the purchaser and the turbine manufacturer.

Note 1: Nonreturn valves are normally mounted directly to steam turbine extraction connections or as close as possible to the turbine to avoid trapping large volumes of steam, which can keep the turbine operating when extraction valves do not fully close.

Note 2: Location of nonreturn valves in piping below the turbine requires that low-point drain provisions be furnished to eliminate water from the extraction line before startup and to eliminate the accumulation of water during operation with no extraction flow.

Note 3: Location of nonreturn valves in piping below oil console level may result in drainage problems. Alternative actuator methods may be required.

● **3.4.2.5.4** When specified, a turbine with an exhaust pressure less than atmospheric pressure shall be provided with an exhaust vacuum breaker actuated by the trip system. Details of such a system shall be mutually agreed upon by the purchaser and the turbine manufacturer.

Note: Even when the emergency trip valve is closed, a turbine exhausting to subatmospheric pressure may leak enough steam to prevent the turbine and driven equipment from coming to a complete stop. A vacuum breaker will admit air to the exhaust casing, increase exhaust pressure, and reduce coast-down time. For turbines exhausting to a common condensing system, air admission may not be feasible and a more positive-emergency trip valve(s) may be required.

● **3.4.2.5.5** When specified, the turbine shall be provided with an independent mechanical overspeed trip.

3.4.3 GOVERNING SYSTEM

3.4.3.1 The governing system is the primary system necessary to match the turbine speed to the application. The governing system (see Figures 6 and 7) includes the speed governor, control mechanism, and governor-controlled valve(s). The turbine manufacturer shall have unit responsibility for the entire governing system. For generator drive applications, the requirements shall be as mutually agreed upon by the purchaser and the turbine manufacturer as noted on the data sheet.

Note: The speed governor should be powered by an uninterruptable power source.

3.4.3.2 Unless otherwise specified, a dedicated digital microprocessor-based speed governor unit shall be furnished. The unit shall be capable of meeting or exceeding the specifications of NEMA SM 23, Table 3-1, Class "D", with no service exclusions.

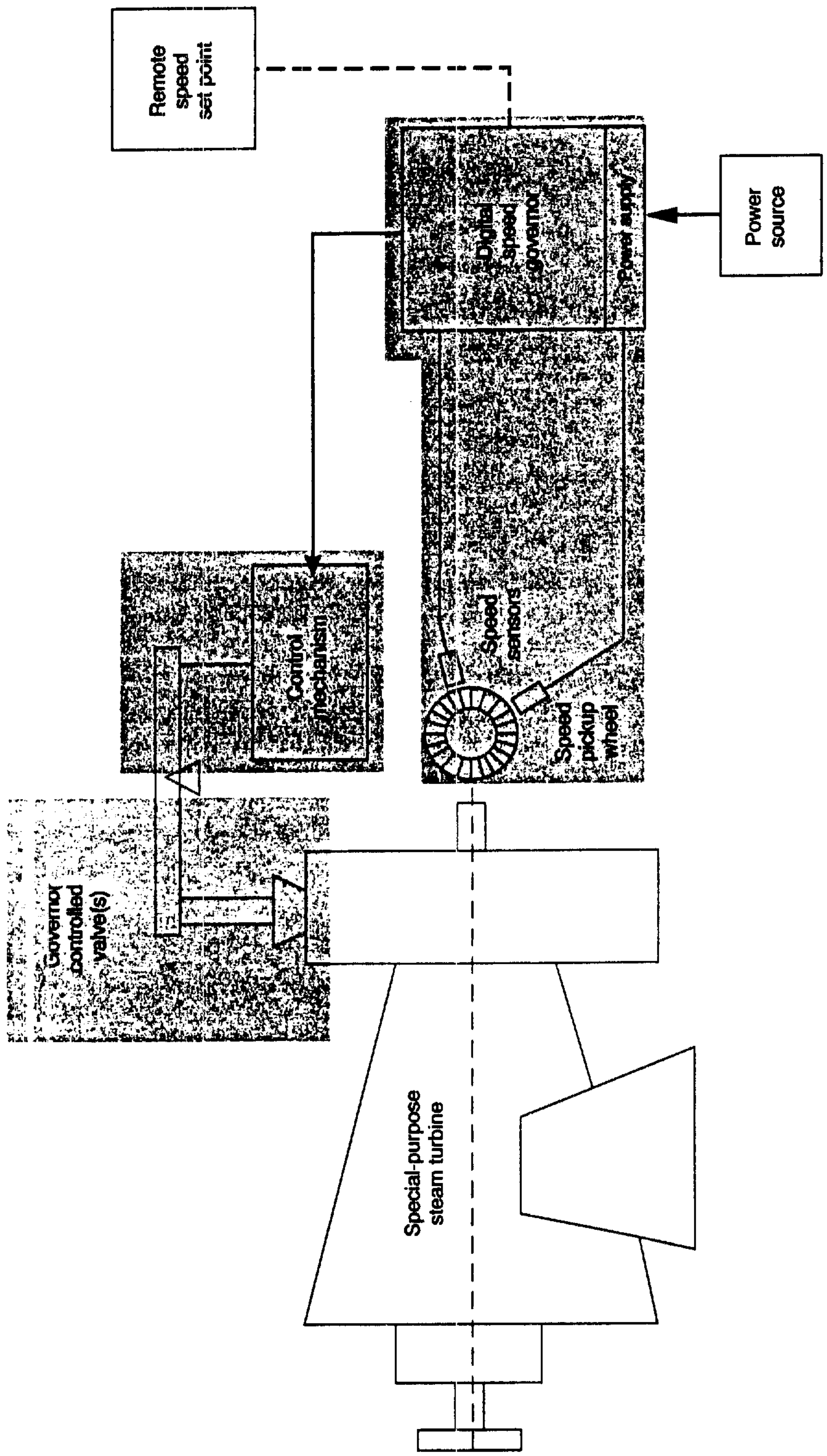
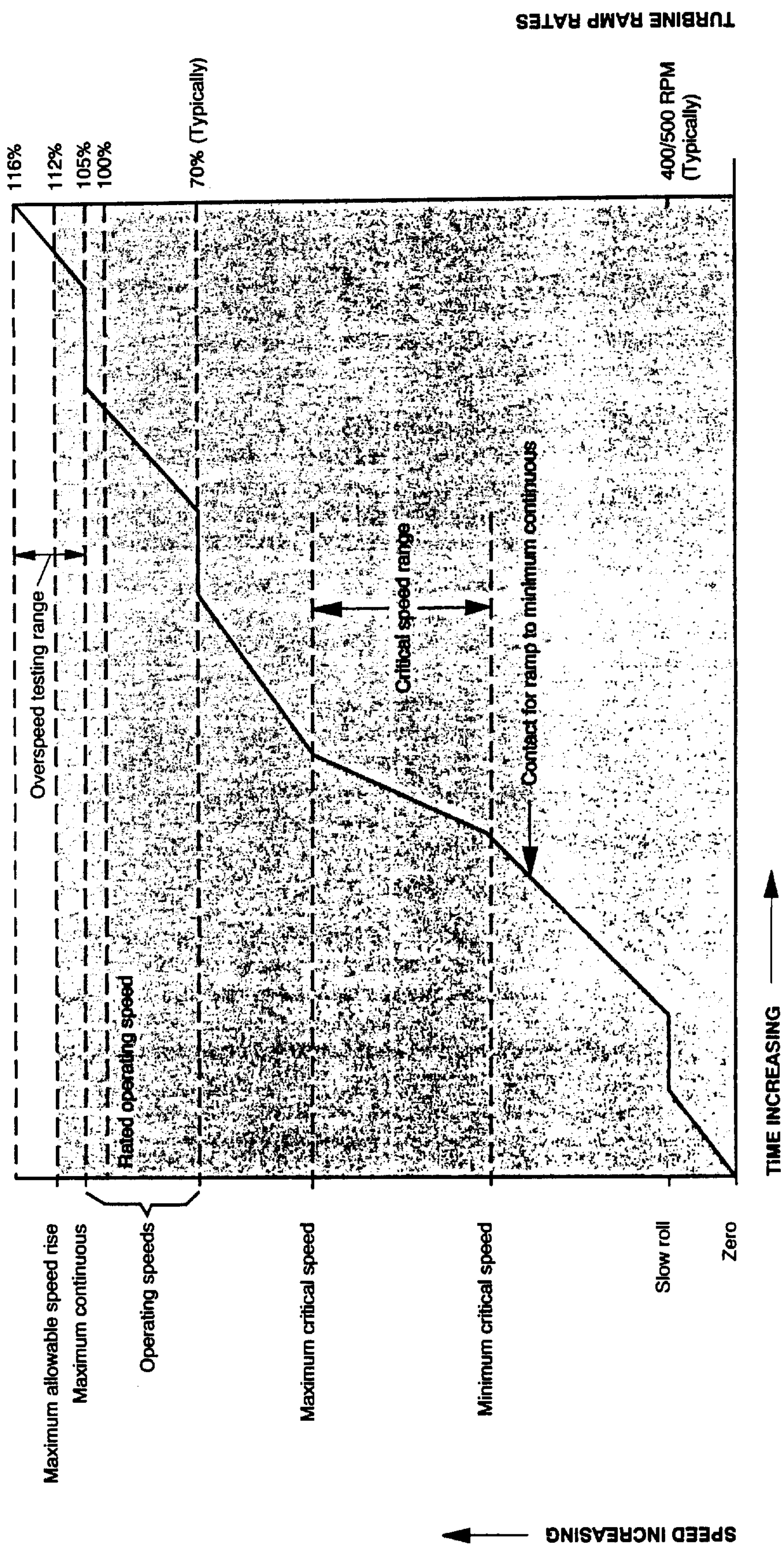


Figure 6—Governing System



Note: Maximum allowable speed rise shall be in accordance with the requirements of NEMA SM 23, Class D.

Figure 7—Governing System Requirements

3.4.3.3 The speed governing system shall include two speed sensors dedicated for speed control. The speed governor shall discriminate the signals from the speed-sensing elements by high signal selection. The failure of either speed-sensing element shall initiate an alarm only. The failure of both elements shall initiate a trip.

3.4.3.4 A multitoothed surface for speed sensing shall be provided integral with, or positively attached, or locked, to the turbine shaft. This surface may be shared by the speed governor, overspeed shutdown system, and tachometer. The speed sensors are not to be shared with the overspeed shutdown system.

3.4.3.5 The criteria for the speed governor shall include but not be limited to the following:

a. An assignable speed range corresponding to the normal range of operation (typically 70–105 percent of rated operating speed).
b. Speed setpoint adjustment.
c. Remote process or speed setpoint.
d. Digital speed indication.
e. Individual outputs to each control mechanism actuator.
f. Adjustable speed ramp rate.
g. Slow roll control.
h. Critical speed band avoidance.
i. Manually activated override for testing the external overspeed trip system.
j. Settings which are field changeable and protected through controlled access.

3.4.3.6 The speed of the turbine shall vary linearly with the setpoint signal. An increase in setpoint signal will increase turbine speed.

3.4.3.7 The governing system shall provide for both slow roll (typically 400–500 revolutions per minute) and startup using the governor-controlled valves as opposed to the turbine trip valve.

3.4.3.8 The failure of the speed governor shall initiate a trip.

3.4.3.9 Activation of any trip device shall cause the governor-controlled valve(s) and the trip valve(s)/combined trip and throttle valve(s) to close and initiate a signal to non-return valve(s).

3.4.3.10 The trip system shall prevent opening of the trip valve(s) if the governor-controlled valve(s) are not fully closed.

● **3.4.3.11** Additional modes of control such as single automatic extraction/induction shall be as specified on the data sheet.

● **3.4.3.12** Options for multiple microprocessors or other component redundancies shall be as specified on the data sheet.

● **3.4.3.13** Speed governor options such as mechanical/hydraulic or analog/electronic shall be specified on the data sheet.

3.4.4 INSTRUMENT AND CONTROL PANELS

● **3.4.4.1** When specified, a panel shall be provided and shall include all panel-mounted instruments for the driven equipment and the driver. Such panels shall be designed and fabricated in accordance with the purchaser's description. The purchaser will specify whether the panel is to be freestanding, located on the base of the unit, or in another location. The instruments on the panel shall be clearly visible to the operator from the driver control point. A lamp test push button shall be provided. The instruments to be mounted on the panel will be specified on the data sheets by the purchaser.

3.4.4.2 Panels shall be completely assembled, requiring only connection to the purchaser's external piping and wiring circuits. When more than one wiring point is required on a unit for control or instrumentation, the wiring to each switch or instrument shall be provided from a single terminal box with terminal posts mounted on the unit (or its base, if any). Wiring shall be installed in metal conduits or enclosures. All leads and posts on terminal strips, switches, and instruments shall be tagged for identification.

3.4.4.3 All terminal boards in junction boxes and control panels shall have at least 20 percent spare terminal points.

● **3.4.4.4** Air purging may be used to prevent moisture problems and to reduce the hazardous area classification within panels on instrument housings. When specified, the vendor shall supply panels and instrument housing in accordance with NFPA 496 and any specific purchaser requirements.

3.4.5 INSTRUMENTATION

3.4.5.1 Tachometers

Unless otherwise specified, two electronic digital-speed indicators shall be furnished. The minimum tachometer range shall be from 0–125 percent of the maximum continuous speed. Gate time updating shall be no more than 1.5 seconds. One indicator shall be locally mounted and one shall be supplied to the purchaser for remote mounting.

3.4.5.2 Temperature Gauges

3.4.5.2.1 Dial temperature gauges shall be heavy duty and corrosion resistant. They shall be at least 125 millimeters (5 inches) in diameter and bimetallic or gas filled. Black printing on a white background is standard for gauges.

3.4.5.2.2 Liquid-filled temperature gauges are not permitted.

3.4.5.2.3 The sensing elements of temperature gauges shall be in the flowing fluid. This is particularly important for lines that may run partially full.

3.4.5.3 Thermowells

Temperature gauges that are in contact with flammable or toxic fluids or that are located in pressurized or flooded lines shall be furnished with $^3/_4$-inch National Pipe Thread (NPT) AISI Standard Type 300 stainless steel separable solid-bar thermowells.

3.4.5.4 Thermocouples and Resistance Temperature Detectors

Where practical, the design and location of thermocouples and resistance temperature detectors, except bearing temperature sensors (see 3.4.8.3), shall permit replacement while the unit is operating. The lead wires of thermocouples and resistance temperature detectors shall be installed as continuous leads between the thermowell or detector and the terminal box. Conduit runs from thermocouple heads to a pull box or boxes located on the baseplate shall be provided.

3.4.5.5 Pressure Gauges

Pressure gauges (not including built-in instrument air gauges) shall be furnished with AISI Standard Type 316 stainless steel bourdon tubes and stainless steel movements, 110-millimeter ($4^1/_2$-inch) dials [150-millimeter (6-inch) dials for the range over 5500 kPa (800 pounds per square inch)], and $^1/_2$-inch NPT male alloy steel connections. Black printing on a white background is standard for gauges. Liquid-filled gauges shall be furnished in locations subject to vibration. Gauge ranges shall preferably be selected so that the normal operating pressure is at the middle of the gauge's range. In no case, however, shall the maximum reading on the dial be less than the applicable relief valve setting plus 10 percent. Each pressure gauge shall be provided with a device such as a disk insert or blowout back designed to relieve excess case pressure.

3.4.5.6 Solenoid Valves

Solenoid valves shall not be used in continuously energized service, but shall have a continuous service rating with Class F insulation.

3.4.5.7 Relief Valves

The vendor shall furnish the relief valves that are to be installed on equipment or in piping that the vendor is supplying. Other relief valves will be furnished by the purchaser. Relief valves for all operating equipment shall meet the limiting relief valve requirements defined in API Recommended Practice 520, Parts I and II, and in API Standard 526. The vendor shall provide flow rate, set pressure, and temperature for purchaser's use in relief valve sizing and selection. The vendor's quotation shall list all relief valves and shall clearly indicate those to be furnished by the vendor. Relief valve settings, including accumulation, shall take into consideration all possible types of equipment failure and the protection of piping systems.

3.4.5.7.1 Unless otherwise specified, relief valves shall have steel bodies.

● **3.4.5.7.2** When specified, thermal relief valves shall be provided for components that may be blocked in by isolation valves.

3.4.6 ALARMS AND SHUTDOWNS

3.4.6.1 Alarm and Trip Switches

3.4.6.1.1 Each alarm switch and each shutdown switch shall be furnished in a separate housing located to facilitate inspection and maintenance. Hermetically sealed, single-pole, double-throw switches with a minimum capacity of 5 amperes at 120 volts AC and $^1/_2$ ampere at 120 volts DC shall be used. Mercury switches shall not be used.

3.4.6.1.2 Unless otherwise specified, electric switches that open (deenergize) to alarm and close (energize) to trip shall be furnished by the vendor.

3.4.6.1.3 Alarm- and trip-switch settings shall not be adjustable from outside the housing. Alarm and trip switches shall be arranged to permit testing of the control circuit, including, when possible, the actuating element, without interfering with normal operation of the equipment. The vendor shall provide a clearly visible light on the panel to indicate when trip circuits are in a test bypass mode. Unless otherwise specified, shutdown systems shall be provided with switches or another suitable means to permit testing without shutting down the unit.

3.4.6.1.4 Pressure-sensing elements shall be of AISI Standard Type 300 stainless steel. Low-pressure alarms, which are activated by falling pressure, shall be equipped with a valved bleed or vent connection to allow controlled depressurizing so that the operator can note the alarm set pressure on the associated pressure gauge. High-pressure alarms, which are activated by rising pressure, shall be equipped with valved test connections so that a portable test pump can be used to raise the pressure.

3.4.6.1.5 The vendor shall furnish with the proposal a complete description of the alarm and shutdown facilities to be provided.

3.4.6.2 Removal of Instruments and Controls

All instruments and controls other than shutdown sensing devices shall be installed with sufficient valving to permit their removal while the system is in operation.

3.4.6.3 Housings for Arcing Switches

Particular attention is called to the requirements of 2.1.13 concerning the characteristics of housings for arcing switches outlined in the applicable codes.

• 3.4.6.4 Annunciator

When specified, a first-out annunciator in accordance with ISA S18.1 shall be furnished by the vendor. The annunciator shall contain approximately 25 percent spare points and when specified, shall be arranged for purging. Connections shall be provided for actuation of a remote signal when any function alarms or trips. The sequence of operation shall be as specified in 3.4.6.4.1 through 3.4.6.4.3.

3.4.6.4.1 Alarm indication shall consist of the flashing of a light and the sounding of an audible device.

3.4.6.4.2 The alarm condition shall be acknowledged by operating an alarm-silencing button common to all alarm functions.

3.4.6.4.3 When the alarm is acknowledged, the audible device shall be silenced, but the light shall remain steadily lit as long as the alarm condition exists. The annunciator shall be capable of indicating a new alarm (with a flashing light and sounding horn) if another function reaches an alarm condition, even if the previous alarm condition has been acknowledged but still exists.

3.4.6.5 Provisions shall be made for a local manual mechanical shutdown which will close the trip or combined trip and throttle valve(s), control valve(s), and any nonreturn valve(s).

3.4.7 ELECTRICAL SYSTEMS

• **3.4.7.1** The characteristics of electrical power supplies for motors, heaters, and instrumentation will be specified by the purchaser. A pilot light shall be provided on the incoming side of each supply circuit to indicate that the circuit is energized. The pilot lights shall be installed on the control panels.

3.4.7.2 Electrical equipment located on the unit or on any separate panel shall be suitable for the hazard classification specified. Electrical starting and supervisory controls may be either AC or DC.

3.4.7.3 Power and control wiring within the confines of the baseplate shall be resistant to oil, heat, moisture, and abrasion. Stranded conductors shall be used within the confines of the baseplate and in other areas subject to vibration. Measurement and remote-control panel wiring may be solid conductor. Where elastomer insulation is used, a Neoprene (or equivalent) or high-temperature thermoplastic sheath shall be provided for insulation protection. Wiring shall be suitable for the environmental temperatures specified.

3.4.7.4 To facilitate maintenance, liberal clearances shall be provided for all energized parts (such as terminal blocks and relays) on equipment. The clearances required for 600-volt service shall also be provided for lower voltages. To guard against accidental contact, enclosures shall be provided for all energized parts.

3.4.7.5 Electrical materials including insulation shall be corrosion-resistant and nonhygroscopic to the greatest extent possible. When specified for tropical location, materials shall be given the treatments specified in 3.4.7.5.1 and 3.4.7.5.2.

3.4.7.5.1 Parts (such as coils and windings) shall be protected from fungus attack.

3.4.7.5.2 Unpainted surfaces shall be protected from corrosion by plating or other suitable coating.

3.4.7.6 Control, instrumentation, and power wiring (including thermocouple leads) within the limits of the baseplate shall be installed in the rigid metallic conduits and boxes, properly bracketed to minimize vibration and isolated or shielded to prevent interference between voltage levels. Conduits may terminate (and in the case of temperature element heads, shall terminate) with a flexible metallic conduit long enough to permit access to the unit for maintenance without removal of the conduit. If thermocouple heads will be exposed to temperatures above 60°C (140°F), a 20 millimeter ($^3/_4$ inch) bronze hose with four-wall interlocking construction and joints with packed-on (heat-proof) couplings shall be used.

3.4.7.7 For Division 2 locations, flexible metallic conduits shall have a liquid-tight thermosetting or thermoplastic outer jacket and approved fittings. For Division 1 locations, an NFPA-approved connector shall be provided.

3.4.8 VIBRATION, POSITION, AND BEARING-TEMPERATURE DETECTORS

3.4.8.1 Unless otherwise specified, vibration and axial-position transducers shall be supplied, installed, and calibrated in accordance with API Standard 670.

3.4.8.2 Unless otherwise specified, vibration and axial-position monitors shall be supplied and calibrated in accordance with API Standard 670.

3.4.8.3 Unless otherwise specified, bearing-temperature sensors shall be furnished and installed in accordance with API Standard 670.

● **3.4.8.4** When specified, a bearing-temperature monitor shall be supplied and calibrated in accordance with API Standard 670.

3.5 Gland Vacuum System

3.5.1 Unless otherwise specified, a gland vacuum system shall be furnished by the vendor (see Appendix B). It shall include a gland condenser and steam ejector sized in accordance with 2.7.6. The condenser shall have a steel shell, admiralty tubes with a nominal wall thickness of 18 Birmingham wire gauge (BWG) [1.24 millimeters (0.049 inch)] and a diameter of at least 15.2 millimeters ($^5/_8$ inch), and fixed tube sheets with water on the tube side. U-tubes are not acceptable. The water side (tube side) shall conform to the requirements of 2.1.11. The shell side shall be designed for both full vacuum and 520 kPa (75 pounds per square inch gauge). The steam ejector shall have a steel body and a replaceable stainless steel steam nozzle.

● **3.5.2** When specified, a vacuum pump shall be provided in place of a steam ejector.

3.6 Piping and Appurtenances

3.6.1 GENERAL

3.6.1.1 Auxiliary piping systems provided by the vendor shall conform to the requirements of API Standard 614.

3.6.1.2 Auxiliary systems are defined as piping systems that are in the following services:

a. Instrument and control air.
b. Lubricating oil.
c. Control oil.
d. Sealing steam.
e. Cooling water.
f. Drains and vents.
g. Steam injection.

Note: Casing connections are discussed in 2.4.

3.6.1.3 Piping systems shall include piping, isolating valves, control valves, relief valves, pressure reducers, orifices, thermometers and thermowells, pressure gauges, sight flow indicators, and all related vents and drains.

3.6.1.4 The vendor shall furnish all piping systems, including mounted appurtenances, located within the confines of the main unit's base area, any oil console base area, or any auxiliary base area. The piping shall terminate with flanged connections at the edge of the base. The purchaser will furnish only interconnecting piping between equipment groupings and off-base facilities.

3.6.1.5 The design of piping systems shall achieve the following:

a. Proper support and protection to prevent damage from vibration or from shipment, operation, and maintenance.
b. Proper flexibility and normal accessibility for operation, maintenance, and thorough cleaning.
c. Installation in a neat and orderly arrangement adapted to the contour of the machine without obstructing access openings.
d. Elimination of air pockets by the use of valved vents or nonaccumulating piping arrangements.
e. Complete drainage through low points without disassembly of piping.

3.6.1.6 Piping shall preferably be fabricated by bending and welding to minimize the use of flanges and fittings. Welded flanges are permitted only at equipment connections, at the edge of any base, and for ease of maintenance. The use of flanges at other points is permitted only with the purchaser's specific approval. Other than tees and reducers, welded fittings are permitted only to facilitate pipe layout in congested areas. Threaded connections shall be held to minimum. Pipe bushings shall not be used.

3.6.1.7 Unless otherwise specified, pipe threads shall be taper threads in accordance with ANSI B1.20.1. Alternately, pipe threads in accordance with ISO 228, Part 1, are acceptable when required for compliance with local standards. Flanges shall be in accordance with ANSI B16.5. Slip-on flanges are permitted only with the purchaser's specific approval. When slip-on flanges are approved, the flanges shall be seal welded inside and out. For socket-welded construction, a 1.5-millimeter ($^1/_{16}$-inch) gap shall be left between the pipe end and the bottom of the socket.

3.6.1.8 Threaded joints for oil service and steam pressures above 520 kPa (75 pounds per square inch gauge) shall be seal welded; however, seal welding is not permitted on cast iron equipment, on instruments, or where disassembly is required for maintenance. Seal-welded joints shall be made in accordance with ASME B31.3.

3.6.1.9 Connections, piping, valves, and fittings that are NPS $1^1/_4$, $2^1/_2$, $3^1/_2$, 5, 7, or 9 shall not be used.

3.6.1.10 Piping systems containing steam at pressures above 520 kPa (75 pounds per square inch gauge) or oil shall be of seamless carbon steel or seamless stainless steel in accordance with API Standard 614, Table 1B.

3.6.1.11 Where space does not permit the use of NPS $^1/_2$-, $^3/_4$-, or 1-pipe, seamless tubing may be furnished in accordance with API Standard 614, Table 1A, 1B or 1C.

3.6.1.12 The minimum size of any connection shall be NPS $^3/_4$.

3.6.1.13 Valves shall have bolted bonnets and glands. For primary ASME service pressure ratings above 62 bar gauge (900 pounds per square inch gauge), block valves may be of welded-bonnet or no-bonnet construction with a bolted gland; these valves shall be suitable for repacking under pressure.

3.6.1.14 Instrument valves servicing such protected areas as panels and gauge boards may be $^1/_2$ inch American Standard Taper Pipe Thread instrument valves if a block valve is provided upstream of the instrument valve in the sensing line and the instrument valve is protected against accidental disassembly.

3.6.1.15 Piping systems furnished by the vendor shall be fabricated and properly supported. Unless otherwise mutually agreed upon by the purchaser and the vendor, all piping will be installed by the vendor prior to shipment. Bolt holes for flanged connections shall straddle lines parallel to the main horizontal or vertical centerline of the equipment.

3.6.1.16 Welding shall be performed in accordance with 2.11.3.

3.6.1.17 The gasket requirements specified in 2.4.9 for casing connections shall also apply to all steam piping connections.

3.6.2 OIL PIPING

3.6.2.1 Oil drains shall be sized to run no more than half full when flowing at a velocity of 0.3 meter per second (1 foot per second) and shall be arranged to ensure good drainage (recognizing the possibility of foaming conditions). Horizontal runs shall slope continuously, at least 42 millimeters per meter ($^1/_2$ inch per foot), toward the reservoir. If possible, laterals (not more than one in any transverse plane) should enter drain headers at 45-degree angles in the direction of the flow.

3.6.2.2 Backup rings and sleeved joints shall not be used. Pressure piping downstream of oil filters shall be free from internal obstructions that could accumulate dirt. Socket-welded fittings shall not be used in pressure piping downstream of oil filters.

3.6.2.3 Unless otherwise specified, oil-supply piping and tubing, including fittings (excluding slip-on flanges), shall be stainless steel, except that lube-oil stub-out piping from bolted-on steel bearing housings may be carbon steel. When used, stub-out piping shall terminate with a flange. The stub-out length shall be minimized but shall not exceed 0.3 meter (12 inches). Oil piping shall be in accordance with API Standard 614, Table 1C.

3.6.3 INSTRUMENT PIPING

3.6.3.1 The vendor shall supply all necessary piping, valves, and fittings for instruments and instrument panels (see 3.4.4.2).

3.6.3.2 Connections on equipment and piping for pressure instruments and test points shall conform to 3.6.1.4. Beyond the initial $^3/_4$-inch isolating valve, $^1/_2$-inch piping, valves, and fittings may be used. Where convenient, a common connection may be used for remotely mounted instruments that measure the same pressure. Separate secondary $^1/_2$-inch isolating valves are required for each instrument on a common connection. Where a pressure gauge is to be used for testing pressure alarm or shutdown switches, common connections are required for the pressure gauge and switches.

3.6.3.3 Instrument and control-air tubing shall be austenitic stainless steel per ASTM A 269. Tubing thickness shall meet the requirements of API Standard 614, Table 1A.

3.7 Insulation and Jacketing

● **3.7.1** When specified or required by the vendor, turbines shall be insulated and jacketed. The insulation and jacketing shall extend over portions of the turbine casing that may reach a normal operating temperature of 74°C (165°F) or higher.

Note: When insulation is not supplied, the vendor should furnish surface temperature of the casing and any special requirements. This applies to the turbine casing and does not include any auxiliary steam piping or bolted-on trip or trip and throttle valves). A jacket is a metal lagging or cover over the unit. A blanket is a removable, reusable fit insulation skin which is wired to the turbine casing.

3.7.2 The insulation shall maintain a surface temperature of not more than 74°C (165°F) under normal operating conditions. Jackets and insulation shall be designed to minimize possible damage during removal and replacement.

3.8 Special Tools

3.8.1 When special tools and fixtures are required to disassemble, assemble, or maintain the turbine unit, they shall be included in the quotation and furnished as part of the initial supply of the machine. For multiunit installations, the requirements for quantities of special tools and fixtures shall be mutually agreed upon by the purchaser and the vendor. These or similar special tools shall be used during shop assembly and post-test disassembly of the equipment.

3.8.2 When special tools are provided, they shall be packaged in a separate, rugged metal box or boxes and shall be marked "special tools for (tag/item number)." Each tool shall be stamped or tagged to indicate its intended use.

3.9 Turning Gear

● **3.9.1** A turning gear shall be provided when specified by the purchaser or required by the vendor.

Note: The need for a turning gear is typically determined by the bearing span and the rotor's vulnerability to temporary bow during shutdown.

3.9.2 The turning device shall be designed to conform to the requirements of 3.9.2.1 through 3.9.2.3.

3.9.2.1 Engagement must be possible only after lube-oil pressure has been established.

3.9.2.2 Disengagement must be automatic when the rotor accelerates during start-up.

3.9.2.3 Engagement on shutdown before the rotor has come to a stop shall be positively prevented if this could damage the turning device or the steam turbine.

● **3.9.3** The type of turning device shall be specified. It may be driven by a steam turbine, electrical motor, hydraulic motor, or pneumatic motor. Provision shall be made to permit manual operation of the turning gear.

3.9.4 The turning-gear rotational speed shall be mutually agreed upon by the purchaser and the vendor. Consideration shall be given to duration of use, minimum speed required for the turbine and driven equipment, and the type of lube-oil supply.

● **3.9.5** When specified, a turning gear operating station with associated control features as detailed by the purchaser shall be provided.

SECTION 4—INSPECTION, TESTING, AND PREPARATION FOR SHIPMENT

4.1 General

4.1.1 After advance notification of the vendor by the purchaser, the purchaser's representative shall have entry to all vendor and subvendor plants where manufacturing, testing, or inspection of the equipment is in progress.

4.1.2 The vendor shall notify subvendors of the purchaser's inspection and testing requirements.

4.1.3 The vendor shall provide sufficient advance notice to the purchaser before conducting any inspection or test that the purchaser has specified to be witnessed or observed.

● **4.1.4** The purchaser will specify the extent of his participation in the inspection and testing and the amount of advance notification he requires.

4.1.4.1 When shop inspection and testing have been specified by the purchaser, the purchaser and the vendor shall meet to coordinate manufacturing hold points and inspectors' visits.

4.1.4.2 *Witnessed* means that a hold shall be applied to the production schedule and that the inspection or test shall be carried out with the purchaser or his representative in attendance. For mechanical running or performance tests, this requires written notification of a successful preliminary test.

4.1.4.3 *Observed* means that the purchaser shall be notified of the timing of the inspection or test; however, the inspection or test shall be performed as scheduled, and if the purchaser or his representative is not present, the vendor shall proceed to the next step. (The purchaser should expect to be in the factory longer than for a witnessed test.)

4.1.5 Equipment for the specified inspection and tests shall be provided by the vendor.

● **4.1.6** When specified, the purchaser's representative, the vendor's representative, or both shall indicate compliance in accordance with the inspector's checklist (Appendix F) by initialing, dating, and submitting the completed checklist to the purchaser before shipment.

4.1.7 The purchaser's representative shall have access to the vendor's quality-control program for review.

4.2 Inspection

4.2.1 GENERAL

4.2.1.1 The vendor shall keep the following data available for at least 20 years for examination by the purchaser or his representative upon request:

a. Necessary certification of materials, such as mill test reports.
b. Purchase specifications for all items on bills of materials.
c. Test data to verify that the requirements of the specification have been met.
d. Results of quality-control tests and inspections.
e. Final-assembly maintenance and running clearances.

4.2.1.2 Pressure-containing parts shall not be painted until the specified inspection of the parts is completed.

● **4.2.1.3** In addition to the requirements of 2.11.3.1, the purchaser may specify the following:

a. Parts that shall be subjected to surface and subsurface examination.
b. The type of examination required, such as magnetic particle, liquid penetrant, radiographic, or ultrasonic examination.

4.2.2 MATERIAL INSPECTION

● 4.2.2.1 General

When radiographic, ultrasonic, magnetic particle, or liquid penetrant inspection of welds or materials is required or specified, the criteria in 4.2.2.2 through 4.2.2.5 shall apply unless other criteria are specified by the purchaser. Cast iron may be inspected in accordance with 4.2.2.4 and 4.2.2.5. Welds, cast steel, and wrought material may be inspected in accordance with 4.2.2.2 through 4.2.2.5.

4.2.2.2 Radiographic Inspection

4.2.2.2.1 Radiographic inspection shall be in accordance with ASTM E 94 and ASTM E 142.

4.2.2.2.2 The acceptance standard used for welded fabrications shall be Section VIII, Division 1, UW-51 and UW-52, of the ASME Code. The acceptance standard used for castings shall be Section VIII, Division 1, Appendix 7, of the ASME Code. With the purchaser's approval, ultrasonics may be used in place of radiographics.

Note: Radiographics would normally be considered for steam conditions exceeding 86 bar gauge (1250 pounds per square inch gauge) or 480°C (900°F).

4.2.2.3 Ultrasonic Inspection

4.2.2.3.1 Ultrasonic inspection shall be in accordance with Section V, Articles 5 and 23, of the ASME Code.

4.2.2.3.2 The acceptance standard used for welded fabrications shall be Section VIII, Division 1, Appendix 12, of the ASME Code. The acceptance standard used for castings shall be Section VIII, Division 1, Appendix 7, of the ASME Code.

4.2.2.3.3 Forgings used for turbine shafts, disks, and rotors with integrally forged disks shall be inspected by ultrasonic methods as specified in ASTM A 418.

4.2.2.3.4 Unless otherwise specified, a heat stability check shall be performed in accordance with ASTM A 472.

4.2.2.4 Magnetic Particle Inspection

4.2.2.4.1 Both wet and dry methods of magnetic particle inspection shall be in accordance with ASTM E 709.

4.2.2.4.2 The acceptance standard used for welded fabrications shall be Section VIII, Division 1, Appendixes 6 and 25, of the ASME Code. The acceptability of defects in castings shall be based on a comparison with the photographs in ASTM E 125. For each type of defect, the degree of severity shall not exceed the limits specified in Table 3.

4.2.2.5 Liquid Penetrant Inspection

4.2.2.5.1 Liquid penetrant inspection shall be in accordance with Section V, Article 6, of the ASME Code.

Table 3—Maximum Severity of Defects in Castings

Type	Defect	Maximum Severity Level
I	Linear discontinuities	1
II	Shrinkage	2
III	Inclusions	2
IV	Chills and chaplets	1
V	Porosity	1
VI	Welds	1

4.2.2.5.2 The acceptance standard used for welded fabrications shall be Section VIII, Division 1, Appendixes 8 and 24, of the ASME Code. The acceptance standard used for castings shall be Section VIII, Division 1, Appendix 7, of the ASME Code.

4.2.2.6 Fully identified records of all heat treatment and radiography, whether performed in the normal course of manufacture or as part of a repair procedure, shall be kept available for 5 years for review by the purchaser.

Note: Regardless of the limits specified in 4.2.2, the vendor shall be responsible for reviewing the design limits of the equipment if more stringent requirements are necessary. Defects that exceed the limits imposed in 4.2.2 shall be removed to meet the quality standards cited, as determined by the inspection method specified.

4.2.3 MECHANICAL INSPECTION

4.2.3.1 During assembly of the turbine and before testing, each component (including cast-in passages of these components) and all piping and appurtenances shall be cleaned chemically or by another appropriate method to remove foreign materials, corrosion products, and mill scale.

4.2.3.2 Any portion of the oil system furnished with the turbine shall meet the cleanliness requirements of API Standard 614.

● **4.2.3.3** When specified, the purchaser may inspect for cleanliness the equipment and all piping and appurtenances furnished by or through the vendor before installation of nozzle blocks and steam-chest covers, final assembly of piping, or closure of openings.

● **4.2.3.4** When specified, the hardness of parts, welds, and heat-affected zones shall be verified as being within the allowable values by testing of the parts, welds, or zones. The method, extent, documentation, and witnessing of the testing shall be mutually agreed upon by the purchaser and the vendor.

4.3 Testing

4.3.1 GENERAL

4.3.1.1 Equipment shall be tested in accordance with 4.3.2 and 4.3.3. Other tests that may be specified by the purchaser are described in 4.3.4.

4.3.1.2 At least 6 weeks before the first scheduled test, the vendor shall submit to the purchaser, for his review and comment, detailed procedures for all running tests, including acceptance criteria for all monitored parameters.

4.3.1.3 The vendor shall notify the purchaser not less than 5 working days before the date the equipment will be ready for testing. This requires written notification of a successful preliminary test. If the testing is rescheduled, the vendor shall notify the purchaser not less than 5 working days before the new test date.

4.3.2 HYDROSTATIC TEST

4.3.2.1 Pressure-containing parts (including auxiliaries) shall be tested hydrostatically with liquid at a minimum of 1.5 times the maximum allowable working pressure but not less than 1.4 bar gauge (20 pounds per square inch gauge). The test liquid shall be at a higher temperature than the nil-ductility transition temperature of the material being tested.

4.3.2.2 If the part tested is to operate at a temperature at which the strength of a material is below the strength of that material at room temperature, the hydrostatic test pressure shall be multiplied by a factor obtained by dividing the allowable working stress for the material at room temperature by that at operating temperature. The casing stress values used shall conform to those given in ASME B31.3 for piping or in Section II, of the ASME Code for vessels. The pressure thus obtained shall then be the minimum pressure at which the hydrostatic test shall be performed. The data sheets shall list actual hydrostatic test pressures.

4.3.2.3 Where applicable, tests shall be in accordance with the ASME Code. If a discrepancy exists between the code test pressure and the test pressure in this standard, the higher pressure shall govern.

4.3.2.4 The chloride content of liquids used to hydrotest austenitic stainless steel materials shall not exceed 50 parts per million. To prevent deposition of chlorides as a result of evaporative drying, all residual liquid shall be removed from tested parts at the conclusion of the test.

4.3.2.5 Tests shall be maintained for a sufficient period of time to permit complete examination of parts under pressure. The casing integrity hydrostatic test shall be considered satisfactory when neither leaks nor seepage through the casing is observed for a minimum of 30 minutes. Large, heavy castings may require a longer testing period to be agreed upon by the purchaser and the vendor. Seepage past internal test closures required for testing of segmented cases and operation of a test pump to maintain pressure are acceptable.

Note: The purpose of the hydrostatic test is to prove pressure casing integrity and not to prove joint sealing.

4.3.2.6 Use of a sealant compound or gasket on the casing joints is acceptable during the casing integrity hydrotest.

4.3.2.7 A hydrostatic test for casing joint integrity shall be performed. The hydrostatic test pressure shall be 1.5 times the maximum allowable working pressure in that pressure zone. Temperature corrections as specified in 4.3.2.2 are not required for this test. This test should be performed after the casing hydrostatic integrity test which may be done at higher pressures. Gaskets shall not be used at the casing joint for this test. Suitable joint compound may be used (see 2.2.5). The test shall be considered satisfactory when neither leaks nor seepage through the casing joint is observed for a minimum of 30 minutes. The casing joint integrity test may be done during the casing integrity hydrostatic test only if no casing joint gasket is used.

4.3.3 MECHANICAL RUNNING TEST

4.3.3.1 The requirements of 4.3.3.1.1 through 4.3.3.1.10 shall be met before the mechanical running test is performed.

4.3.3.1.1 The contract shaft seals and bearings shall be used in the machine for the mechanical running test. Bearing housing seals shall be checked and any leaks shall be corrected.

4.3.3.1.2 All oil pressures, viscosities, and temperatures shall be within the range of operating values recommended in the vendor's operating instructions for the specific unit being tested. For pressure lubrication systems, oil flow rates for each bearing housing shall be measured.

4.3.3.1.3 Test-stand oil filtration shall be 10 micrometers (10 microns) nominal or better. Oil system components downstream of the filters shall meet the cleanliness requirements of API Standard 614 before any test is started.

4.3.3.1.4 All joints and connections shall be checked for tightness, and any leaks shall be corrected.

4.3.3.1.5 All warning, protective, and control devices used during the test shall be checked, and adjustments shall be made as required.

4.3.3.1.6 The mechanical running test shall be performed with coupling-hub idling adapter(s)/half weight simulator in place. The resulting moments must be within ±10 percent of the moment of the contract coupling hub plus one-half that of the coupling spacer. When all testing is completed, the idling adapters shall be furnished to the purchaser as part of the special tools.

4.3.3.1.7 All purchased vibration probes, cables, oscillator-demodulators, and accelerometers shall be in use during the test. If vibration probes are not furnished by the equipment vendor or if the purchased probes are not compatible with shop readout facilities, then shop probes and readouts that meet the accuracy requirements of API Standard 670 shall be used.

4.3.3.1.8 Shop test facilities shall include instrumentation with the capability of continuously monitoring and plotting revolutions per minute, peak-to-peak displacement and phase angle (x–y–y'). Presentation of vibration displacement and phase marker shall also be by oscilloscope.

4.3.3.1.9 The vibration characteristics determined by the use of instrumentation specified in 4.3.3.1.7 and 4.3.3.1.8 shall serve as the basis for acceptance or rejection of the machine (see 2.8.5.5).

4.3.3.1.10 When seismic test values are specified, vibration data (minimum and maximum values) shall be recorded and located (clock angle) in a radial plan transverse to each bearing centerline (if possible), using shop instrumentation during the test.

4.3.3.2 Unless otherwise specified, the control systems shall be demonstrated and the mechanical running test of the steam turbine shall be conducted as specified in 4.3.3.2.1 through 4.3.3.2.7.

Note: Test steam conditions shall be as close to design as practical. Due to no-load operation for extended periods of time during the test, the inlet steam conditions may need to be reduced to prevent overheating of the unit and exceeding design clearances.

4.3.3.2.1 The equipment shall be operated at speed increments of approximately 10 percent from zero to the maximum continuous speed and run at maximum continuous speed until bearings, lube-oil temperatures, and shaft vibrations have stabilized.

4.3.3.2.2 The speed shall be increased to approximately 1 percent below the trip speed and the turbine shall be run for a minimum of 15 minutes.

4.3.3.2.3 Overspeed trip devices shall be checked and adjusted until values within 1 percent of the nominal trip setting are attained. Mechanical overspeed devices, when supplied, shall attain three consecutive nontrending trip values that meet this criterion.

4.3.3.2.4 The speed governor and any other speed-regulating devices shall be tested for smooth performance over the operating speed ranges. No-load stability and response to the control signal shall be checked.

4.3.3.2.5 The data recorded for governors shall include but not be limited to the sensitivity and linearity of relationship between speed and control signal, and for adjustable governors, response speed range.

4.3.3.2.6 The turbine shall be run continuously at the maximum continuous speed for at least 4 hours.

Note: Caution should be exercised when operating at or near critical speeds.

4.3.3.2.7 During the 4-hour test, lube-oil inlet pressures and temperatures shall be varied through the range specified in the steam turbine operating manual.

4.3.3.3 During the mechanical running test, the requirements specified in 4.3.3.3.1 through 4.3.3.3.7 shall be met.

4.3.3.3.1 During the mechanical running test, the mechanical operation of all equipment being tested, including all casing joints and connections, and the operation of the test instrumentation shall be satisfactory. The measured unfiltered vibration shall not exceed the limits of 2.8.5.5 and shall be recorded throughout the operating speed range.

4.3.3.3.2 While the equipment is operating at maximum continuous speed and at other speeds that may have been specified in the test agenda, sweeps shall be made for vibration amplitudes at frequencies other than synchronous. As a minimum, these sweeps shall cover a frequency range from 0.25–8 times the maximum continuous speed but not more than 1500 hertz (90,000 cycles per minute). If the amplitude of any discrete, nonsynchronous vibration exceeds 20 percent of the allowable vibration as defined in 2.8.5.5, the purchaser and the vendor shall mutually agree on requirements for any additional testing and on the equipment's suitability for shipment.

4.3.3.3.3 The mechanical running test shall verify that lateral critical speeds conform to the requirements of 2.8.2 and 2.8.3. The first lateral critical speeds shall be determined during the mechanical running test and stamped on the nameplate followed by the word *test*.

4.3.3.3.4 Shop verification of the unbalanced response analysis shall be performed in accordance with 2.8.3.

4.3.3.3.5 Tape recordings shall be made of all real-time vibration data.

● **4.3.3.3.6** When specified, the tape recordings of real-time vibration data shall be given to the purchaser.

● **4.3.3.3.7** Plots showing synchronous vibration amplitude and phase angle versus speed for deceleration shall be made before and after the 4-hour run. Plots shall be made of both the filtered (one per revolution) and unfiltered vibration levels. When specified, these data shall also be furnished in polar form. The speed range covered by these plots shall be from the specified trip speed to 400 revolutions per minute.

4.3.3.4 Unless otherwise specified, the requirements of 4.3.3.4.1 through 4.3.3.4.3 shall be met after the mechanical running test is completed.

4.3.3.4.1 Hydrodynamic bearings shall be removed, inspected, and reassembled after the mechanical running test is completed.

4.3.3.4.2 If replacement or modification of bearings or seals or dismantling of the case to replace or modify other parts is required to correct mechanical or performance deficiencies, the initial test will not be acceptable, and the final shop tests shall be run after these replacements or corrections are made.

4.3.3.4.3 When spare rotors are ordered to permit concurrent manufacture, each spare rotor shall also be given a mechanical running test in accordance with the requirements of this standard.

• 4.3.4 OPTIONAL TESTS AND INSPECTIONS

The purchaser will specify in the inquiry or in the order whether any of the shop tests specified in 4.3.4.1 through 4.3.4.8 shall be performed.

• 4.3.4.1 Performance Test

The machine shall be tested in accordance with ASME PTC 6. If this is not practicable, the vendor's proposal shall define the conditions under which the vendor proposes to conduct the test. Methodology and acceptance criteria shall be mutually agreed upon by the purchaser and the vendor.

• 4.3.4.2 Complete-Unit Test

Such components as compressors, gears, drivers, and auxiliaries that make up a complete unit shall be tested together during the mechanical running test. A separate auxiliary test may be performed with the purchaser's approval. When specified, torsional vibration measurements shall be made to verify the vendor's analysis. The complete-unit test shall be performed in place of or in addition to separate tests of individual components specified by the purchaser.

• 4.3.4.3 Auxiliary-Equipment Test

Auxiliary equipment such as oil systems and control systems shall be tested in the vendor's shop. Details of auxiliary-equipment tests shall be developed jointly by the purchaser and the vendor.

• 4.3.4.4 Post-Test Internal Inspection of Casing

The steam turbine shall be dismantled, inspected, and reassembled after satisfactory completion of the mechanical running test.

Note: The merits of post-test internal inspection of casing should be evaluated against the benefits of shipping a unit with proven mechanical assembly and casing joint integrity.

• 4.3.4.5 Emergency-Overspeed-Trip-Systems Test

The response time of the emergency overspeed trip system shall be recorded to confirm compliance with the requirements of 3.4.2.1.

• 4.3.4.6 Spare-Parts Test

Spare parts such as couplings, gears, diaphragms, bearings, and seals shall be tested as specified by the purchaser.

• 4.3.4.7 Inspection of Hub/Shaft Fit for Hydraulically Mounted Couplings

After the running tests, the shrink fit of hydraulically mounted couplings shall be inspected by comparing hub/shaft match marks to ensure that the coupling hub has not moved on the shaft during the tests.

• 4.3.4.8 Additional Tests

Additional optional tests as specified by the purchaser or alternative acceptance tests presented by the vendor or both shall be developed jointly and shall be mutually agreed upon by the purchaser and the vendor.

4.4 Preparation for Shipment

• **4.4.1** Equipment shall be suitably prepared for the type of shipment specified, including blocking of the rotor when necessary. Blocked rotors shall be identified by means of corrosion-resistant tags attached with stainless steel wire. The preparation shall make the equipment suitable for 6 months of outdoor storage from the time of shipment, with no disassembly required before operation, except for inspection of bearings and seals. If storage for a longer period is contemplated, the purchaser will consult with the vendor regarding the recommended procedures to be followed.

4.4.2 The vendor shall provide the purchaser with the instructions necessary to preserve the integrity of the storage preparation after the equipment arrives at the job site and before startup.

4.4.3 The equipment shall be prepared for shipment after all testing and inspection has been completed and the equipment have been released by the purchaser. The preparation shall include that specified in 4.4.3.1 through 4.4.3.11.

4.4.3.1 Exterior surfaces, except for machined surfaces, shall be given at least one coat of the manufacturer's standard paint. The paint shall not contain lead or chromates.

4.4.3.2 Exterior machined surfaces shall be coated with a suitable rust preventive.

4.4.3.3 The interior of the equipment shall be clean; free from scale, welding spatter, and foreign objects; and sprayed or flushed with a suitable rust preventive that can be removed with solvent.

4.4.3.4 Internal steel areas of bearing housings and carbon steel oil systems' auxiliary equipment such as reservoirs, vessels, and piping shall be coated with a suitable oil-soluble rust preventive.

4.4.3.5 Flanged openings shall be provided with metal closures at least 5 millimeters ($^3/_{16}$ inch) thick, with elastomer gaskets and at least four full-diameter bolts. For studded openings, all nuts needed for the intended service shall be used to secure closures.

4.4.3.6 Threaded openings shall be provided with steel caps or round-head steel plugs in accordance with ANSI B16.11. The caps or plugs shall be of material equal to or better than that of the pressure casing. In no case shall nonmetallic (such as plastic) caps or plugs be used.

4.4.3.7 Turbines supplied without self-supporting baseplates shall be bolted to a shipping skid formed of heavy timbers suitable for sling-lift or forklift truck handling. Larger turbines shall have supports as required by the type of transportation and handling.

4.4.3.8 Lifting points and the center of gravity shall be clearly identified on the equipment package. The vendor shall provide the recommended lifting arrangement.

4.4.3.9 The equipment shall be identified with item and serial numbers. Material shipped separately shall be identified with securely affixed, corrosion-resistant metal tags indicating the item and serial number of the equipment for which it is intended. In addition, crated equipment shall be shipped with duplicate packing lists, one inside and one on the outside of the shipping container. Turbines with carbon seal rings shall have the seal rings removed by the vendor and shipped in a separate container. If applicable, a red tag securely affixed to the turbine shall read as follows:

CARBON SEALS MUST BE INSERTED BEFORE THIS TURBINE IS STARTED.

4.4.3.10 When a spare rotor is purchased, the rotor shall be prepared for unheated indoor storage for a period of at least 3 years. The rotor shall be treated with a rust preventive and shall be housed in a vapor-barrier envelope with a slow-release vapor-phase-inhibitor. The rotor shall be crated for domestic or export shipment, as specified. Lead sheeting, at least 3 millimeters ($^1/_8$ inch) thick, or a purchaser-approved equivalent shall be used between the rotor and the cradle at the support areas. The rotor shall not be supported at journals.

4.4.3.11 Exposed shafts and shaft couplings shall be wrapped with waterproof, moldable waxed cloth or vapor-phase-inhibitor paper. The seams shall be sealed with oil-proof adhesive tape.

4.4.4 Auxiliary piping connections furnished on the purchased equipment shall be impression stamped or permanently tagged to agree with the vendor's connection table or general arrangement drawing. Service and connection designations shall be indicated.

4.4.5 Bearing assemblies shall be fully protected from the entry of moisture and dirt. If vapor-phase-inhibitor crystals in bags are installed in large cavities to absorb moisture, the bags must be attached in an accessible area for easy removal. Where applicable, bags shall be installed in wire cages attached to flanged covers, and bag locations shall be indicated by corrosion-resistant tags attached with stainless steel wire.

4.4.6 One copy of the manufacturer's installation instructions shall be packed and shipped with the turbine.

SECTION 5—VENDOR'S DATA

5.1 General

5.1.1 The information to be furnished by the vendor is specified in 5.2 and 5.3. The vendor shall complete and forward the Vendor Drawing and Data Requirements form (see Appendix E) to the address or addresses noted on the inquiry or order. This form shall detail the schedule for transmission of drawings, curves, and data as agreed to at the time of the order, as well as the number and type of copies required by the purchaser.

5.1.2 The data shall be identified on transmittal (cover) letters and in title blocks or title pages with the following information:

a. The purchaser/user's corporate name.
b. The job/project number.
c. The equipment item number and service name.
d. The inquiry or purchase order number.
e. Any other identification specified in the inquiry or purchase order.
f. The vendor's identifying proposal number, shop order number, serial number, or other reference required to identify return correspondence completely.

5.1.3 A coordination meeting shall be held, preferably at the vendor's plant, within 4-6 weeks after the purchase commitment. Unless otherwise specified, the vendor will prepare and distribute an agenda prior to this meeting, which shall include but not be limited to review of the following items:

a. The purchase order, scope of supply, unit responsibility, and subvendor items.
b. The data sheets.
c. Applicable specifications and previously agreed-upon exceptions.
d. Schedules for transmittal of data, production, and testing.
e. The quality assurance program and procedures.
f. Inspection, expediting, and testing.
g. Schematics and bills of material for auxiliary systems.
h. The physical orientation of the equipment, piping, and auxiliary systems.
i. Coupling selections.
j. Thrust-bearing sizing and estimated loadings.
k. The rotor dynamics analysis.
l. Other technical items.

5.2 Proposals

● 5.2.1 GENERAL

The vendor shall forward the original proposal and the specified number of copies to the addressee specified in the inquiry documents. As a minimum, the proposal shall include the data specified in 5.2.2 through 5.2.4, as well as a specific statement that the system and all its components are in strict accordance with this standard. If the system and components are not in strict accordance, the vendor shall include a list that details and explains each deviation. The vendor shall provide details to enable the purchaser to evaluate any proposed alternative designs. All correspondence shall be clearly identified in accordance with 5.1.2.

5.2.2 DRAWINGS

5.2.2.1 The drawings indicated on the Vendor Drawing and Data Requirements form (see Appendix E) shall be included in the proposal. As a minimum, the following data shall be furnished:

a. A general preliminary arrangement or outline drawing for each major skid or system, showing overall dimensions, maintenance clearance dimensions, overall weights, erection weights, and maximum maintenance weights (indicated for each piece). The vendor shall also provide diagrams showing the location of inlet, induction, extraction, and exhaust openings, a description of the governing system, and schematics of the lube- and control-oil systems and the gland sealing system when furnished by the turbine vendor. The direction of rotation shall also be indicated.
b. Typical cross-sectional drawings and literature to fully describe details of the following:
1. Governor systems.
2. Inlet, induction, and extraction valves.
3. Blade and shroud attachments design.
4. Shaft sealing.
5. Bearings.
6. Internal construction.
7. Nonreturn valves.
8. Trip or combined trip and throttle valve(s).
9. Grounding brush for condensing turbines.
10. Governor control valve(s).

c. Schematics of all auxiliary systems, including the steam, lube-oil, control, and electrical systems. Preliminary bills of material shall be included.
d. Sketches that show methods of lifting the assembled machine or machines and major components. (This information may be included on the drawings specified in 5.2.2.1, Item a.)

5.2.2.2 If typical drawings, schematics, and bills of material are used, they shall be marked up to show the correct weight and dimension data and to reflect the actual equipment and scope proposed.

5.2.3 TECHNICAL DATA

The following data shall be included in the proposal:

a. The purchaser's data sheets, with complete vendor's information entered thereon and literature to fully describe details of the offering.
b. The purchaser's noise data sheet.
c. The Vendor Drawing and Data Requirements form (see Appendix E), indicating the schedule according to which the vendor agrees to transmit all the data specified as part of the contract.
d. A schedule for shipment of the equipment, in weeks after receipt of the order.
e. A list of major wearing components, showing interchangeability with the purchaser's other units
f. A list of recommended start-up spares, including any items that the vendor's experience indicates are likely to be required.
g. A list of the special tools furnished for maintenance. The vendor shall identify any metric items included in the offering.
h. A statement of any special protection required for startup, operation, and periods of idleness under the site conditions specified on the data sheets. The list shall show the protection to be furnished by the purchaser, as well as that included in the vendor's scope of supply.
i. A complete tabulation of utility requirements, such as those for steam, water, electricity, air, gas, and lube oil, including the quantity of lube oil required and the supply pressure, the heat load to be removed by the oil, and the nameplate power rating and operating power requirements of auxiliary drivers. (Approximate data shall be defined and clearly identified as such.)
j. A description of the tests and inspection procedures for materials, as required by 2.11.1.3.
k. A description of any special requirements specified in the purchaser's inquiry and as outlined in 2.10.2, 2.11.1.2, 3.4.5.7, and 3.4.6.1.5.
l. A list of similar machines installed and operating under conditions analogous to those specified in the proposal.
m. Any startup, shutdown, or operating restrictions required to protect the integrity of the equipment.
n. Approximate potential maximum power output of the unit under normal steam conditions and at normal speed that could be obtained by field modification. The required field modifications shall be described in general (for example, valve, nozzle, diaphragm, or blade changes with no changes to the rotor or casing).
o. A list of all relief valves as required by 3.4.5.7, including size and set pressure. Relief valves furnished by the vendor shall also be specified, with valve manufacturer and model data provided.

5.2.4 CURVES

The vendor shall provide complete performance curves to encompass the map of operations, with any limitations indicated thereon. The curves shall include those indicated by the purchaser on the Vendor Drawing and Data Requirements form (see Appendix E).

● 5.2.5 OPTIONS

When specified, the vendor shall furnish a list of the procedures for any special or optional tests that have been specified by the purchaser or proposed by the vendor.

5.3 Contract Data

5.3.1 GENERAL

5.3.1.1 The contract data to be furnished by the vendor is specified in Appendix E. Each drawing, bill of material, and data sheet shall have a title block in its lower right-hand corner that shows the date of certification, a reference to all identification data specified in 5.1.2, the revision number and date, and the title.

5.3.1.2 The purchaser will promptly review the vendor's data when he receives them; however, this review shall not constitute permission to deviate from any requirements in the order unless specifically agreed upon in writing. After the data have been reviewed, the vendor shall furnish certified copies in the quantity specified.

5.3.1.3 A complete list of vendor data shall be included with the first issue of the major drawings. This list shall contain titles, drawing numbers, and a schedule for transmission of all the data the vendor will furnish (see Appendix E).

5.3.2 DRAWINGS

The drawings furnished shall contain sufficient information so that with the drawings and the manuals specified in 5.3.6, the purchaser can properly install, operate, and maintain the ordered equipment. Drawings shall be clearly legible, shall be identified in accordance with 5.3.1.1, and shall be in accordance with the ANSI Y14.2M. As a minimum, the drawings shall include the details listed in Appendix E.

5.3.3 TECHNICAL DATA

The data shall be submitted in accordance with Appendix E and identified in accordance with 5.3.1.1. Any comments on the drawings or revisions of specifications that necessitate a change in the data shall be noted by the vendor. These notations will result in the purchaser's issue of completed, corrected data sheets as part of the order specifications.

5.3.4 PROGRESS REPORTS

The vendor shall submit progress reports to the purchaser at the intervals specified on the Vendor Drawing and Data Requirements form (see Appendix E). The reports shall include engineering, purchasing, and manufacturing schedules for all major components. Planned and actual dates and the percentage completed shall be indicated for each milestone in the schedule.

5.3.5 RECOMMENDED SPARE PARTS

The vendor shall submit a complete list of spare parts, including those shown in the original proposal. The list shall include spare parts for all equipment and accessories supplied, with cross-sectional or assembly drawings for identification, part numbers, and delivery times. Part numbers shall identify each part for purposes of interchangeability. Standard purchased items shall be identified by the original manufacturer's numbers. The vendor shall forward the list to the purchaser promptly after receipt of the reviewed drawings and in time to permit order and delivery of the parts before field startup. The transmittal letter shall be identified with the data specified in 5.1.2.

5.3.6 INSTALLATION, OPERATION, MAINTENANCE, AND TECHNICAL DATA MANUALS

5.3.6.1 General

The vendor shall provide sufficient written instructions, including a cross-referenced list of all drawings, to enable the purchaser to correctly install, operate, and maintain all of the equipment ordered. This information shall be compiled in a manual (or manuals) with a cover sheet containing all identifying data specified in 5.1.2, an index sheet containing section titles, and a complete list of referenced and enclosed drawings by title and drawing number. The manual shall be prepared for the specified installation; a typical manual is not acceptable.

5.3.6.2 Installation Manual

All special information required for proper installation design that is not on the drawings shall be compiled in a manual that is separate from the operating and maintenance instructions. This manual shall be forwarded at a time that is mutually agreed upon in the order, but not later than the final issue of drawings. The manual shall contain information such as special alignment or grouting procedures, utility specifications (including quantities), and all installation design data, including the drawings and data specified in 5.2.2 and 5.2.3. The manual shall also include sketches that show the location of the center of gravity and rigging provisions to permit the removal of the top half of the casings, rotors, and any subassemblies that weigh more than 136 kilograms (300 pounds).

5.3.6.3 Operating and Maintenance Manual

The manual containing operating and maintenance data shall be forwarded no more than 2 weeks after all of the specified tests have been successfully completed. This manual shall include a section that provides special instructions for operation at specified extreme environmental conditions (such as temperature). As a minimum, the manual shall also include all the data listed in Appendix E.

• 5.3.6.4 Technical Data Manual

When specified, the vendor shall provide the purchaser with a technical data manual within 30 days of completion of shop testing. (See Appendix E for detail requirements.)

APPENDIX A—TYPICAL DATA SHEETS

SPECIAL PURPOSE STEAM TURBINE DATA SHEET SI UNITS

JOB NO. ____________ ITEM NO. ____________
PURCH. ORDER NO. ____________ DATE ____________
INQUIRY NO. ____________ BY ____________
REVISION ____________ DATE ____________

APPLICABLE TO: ○ PROPOSAL ○ PURCHASE ☐ AS-BUILT
FOR ____________ UNIT ____________
SITE ____________ SERIAL NO. ____________
SERVICE ____________ NO. REQUIRED ____________
MANUFACTURER ____________ MODEL ____________ DRIVEN EQUIP. ITEM NO. ____________
DRIVEN EQUIPMENT TYPE: ○ COMPRESSOR ○ GENERATOR ○ OTHER ____________
NOTE: INFORMATION TO BE COMPLETED BY: ○ PURCHASER ☐ MANUFACTURER ○ ☐ PURCHASER OR MANUFACTURER

PERFORMANCE

OPERATING POINTS	SHAFT		INLET			INDUCT./EXTRACT.			EXHAUST		
○ ☐ AS APPL.	POWER	SPEED	FLOW	PRESS (BARG)	TEMP	FLOW	PRESS (BARG)	TEMP	PRESS	TEMP	ENTHAPLY
	kW	RPM	kg/HR	(kPa)	°C TT	kg/HR	(kPa)	°C TT	BARG/mmHgA	°C TT	kJ/kg
RATED(1.4.27)											
NORMAL(1.4.22)											
MINIMUM(1.4.11)											
OTHER											

☐ STEAM RATE, kg/kW-HR (1.4.34) NORMAL ______ RATED ______ INDUCTION ○ CONTROLLED ○ UNCONTROLLED
☐ INDUCTION FLOW, kg/HR MINIMUM ______ MAXIMUM ______
☐ EXTRACTION FLOW, kg/HR MINIMUM ______ MAXIMUM ______ EXTRACTION ○ CONTROLLED ○ UNCONTROLLED

STEAM CONDITIONS

○ INLET
NORMAL ______ (BARG)(kPa) ______ °C TT
MAXIMUM ______ (BARG)(kPa) ______ °C TT
MINIMUM ______ (BARG)(kPa) ______ °C TT

○ EXTRACTION
NORMAL ______ (BARG)(kPa) ______ °C TT
MAXIMUM ______ (BARG)(kPa) ______ °C TT
MINIMUM ______ (BARG)(kPa) ______ °C TT

○ EXHAUST
NORMAL ______ (BARG/mmHgA) ______ °C TT
MAXIMUM ______ (BARG/mmHgA) ______ °C TT
MINIMUM ______ (BARG/mmHgA) ______ °C TT

○ INDUCTION
NORMAL ______ (BARG)(kPa) ______ °C TT
MAXIMUM ______ (BARG)(kPa) ______ °C TT
MINIMUM ______ (BARG)(kPa) ______ °C TT

SITE AND UTILITY DATA

LOCATION:
○ INDOOR ○ HEATED ○ UNDER ROOF ○ OUTDOOR
○ UNHEATED ○ PARTIAL SIDES ○ GRADE ○ MEZZANNE
○ ____________
○ WINTERIZATION REQD. ○ TROPICALIZATION REQD.
○ LOW TEMPERATURE ○ CORROSIVE AGENTS
○ ELECT. AREA CLASSIFICATION: CL ____ GP ____ DIV ____

SITE DATA:
○ ELEVATION ______ m ○ BAR ______ kPaABS/mmHgA
○ WINTER TEMP. ______ °C SUMMER TEMP. ______ °C
○ REL. HUMIDITY ______ % DESIGN WET BULB ______ °C
○ UNUSUAL CONDITIONS: ○ DUST ○ FUMES
OTHER ____________

UTILITY CONDITIONS:

○ AUXILIARY STEAM:	MAX	NORM	MIN
INIT. PRESSURE(BARG/kPa)			
INITIAL TEMP(°C TT)			
EXH PRESS(BARG/kPa/mmHgA)			

INST. AIR(BARG/kPa): NORM ______ MIN ______ MAX ______
INST. AIR DEW POINT: ______ °C

○ ELECTRIC:	DRIVERS	HEATING	INST./ CONTROL	ALARM/ SHUTDOWN
VOLTS				
PHASE				
HERTZ				
KW AVAIL				

○ COOLING WATER:
TEMP. INLET: ______ °C MAX RETURN ______ °C
PRESS. NORM.: ______ (BARG/kPa) DESIGN: ______ (BARG/kPa)
MAX RETURN PRESS.: ______ (BARG/kPa)
MAX. ALLOWABLE PRESS. DROP: ______ (BAR/kPa)
WATER SOURCE: ____________
VELOCITY, m/s: MIN ______ MAX ______
FOULING FACTOR: ______ W/(m²C)

○ UTILITY CONSUMPTION:
COOLING WATER: ______ m³/HR INST. AIR ______ m³/HR
AUX. STM: NORMAL ______ kg/HR MAXIMUM ______ kg/HR
AUX. DRIVERS: ELEC. ______ kW STEAM ______ kW
HEATER(S): ______ kW OTHER: ____________

REMARKS: ____________

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SPECIAL PURPOSE STEAM TURBINE
DATA SHEET
SI UNITS

JOB NO. ______________ ITEM NO. ______________
REVISION ______________ DATE ______________
BY ______________

APPLICABLE SPECIFICATIONS:

API 612, SPECIAL PURPOSE STEAM TURBINES
○ OTHER: ______________
____
○ VENDOR HAVING UNIT RESPONSIBILITY:
____
○ GOVERNING SPECIFICATION, IF DIFFERENT:
____

NOISE SPECIFICATIONS:

○ APPLICABLE TO MACHINE:
SEE SPECIFICATION: ______________
○ APPLICABLE TO NEIGHBORHOOD:
SEE SPECIFICATION: ______________
ACOUSTICAL TREATMENT ○ Yes ○ No

CONSTRUCTION FEATURES

TURBINE TYPE ○ BACKPRESSURE ○ CONDENSING ○ OTHER

☐ SPEEDS:
MAX CONT. ______ RPM TRIP ______ RPM
MAX ALLOW. ______ RPM

☐ LATERAL CRITICAL SPEEDS(DAMPED)
FIRST CRITICAL ______ RPM ______ MODE
SECOND CRITICAL ______ RPM ______ MODE
THIRD CRITICAL ______ RPM ______ MODE
FOURTH CRITICAL ______ RPM ______ MODE

☐ VIBRATION ______ μM (PEAK TO PEAK)

☐ TORSIONAL CRITICAL SPEEDS:
FIRST CRITICAL ______ RPM
SECOND CRITICAL ______ RPM
THIRD CRITICAL ______ RPM
FOURTH CRITICAL ______ RPM
○ TRAIN LATERAL ANALYSIS REQUIRED
○ UNDAMPED STIFFNESS MAP REQUIRED
○ TRAIN TORSIONAL ANALYSIS REQUIRED

☐ CASINGS, NOZZLES& DIAPHRAGMS

☐ MAWP(1.4.13)(2.2.3)
INLET SECT. ______ (BARG)(kPa) EXH. SECT. ______ (BARG)(kPa)
INDUCTION/EXTRACT. SECTION ______ (BARG)(kPa)
OTHER ______ (BARG)(kPa)

☐ MAX OPERATING TEMPERATURE(1.4.12)(1.4.18)(2.2.2)
INLET SECTION ______ °C EXH. SECTION ______ °C
INDUCTION/EXTRACTION SECTION ______ °C
OTHER ______ °C

☐ HYDROSTATIC TEST PRESSURE(4.3.2.1)(4.3.2.2)
HP CASING ______ (BARG) (kPa) MID CASING ______ (BARG) (kPa)
EXHAUST CASING ______ (BARG) (kPa) OTHER ______ (BARG) (kPa)
○ WELDED NOZZLE RING(2.3.1) NOZZLE RING ______ % ADM.
DIAPH.BLADE ATTACH.: ☐ INTEGRALLY CAST ☐ WELDED
☐ OTHER ______________
DIAPHRAGM AXIAL LOCATION: ☐ INDIVIDUALLY ☐ STACKED

CASING CONNECTIONS

CONNECTION	○ DESIGN APPROVAL REQD(2.11.3.5.4)	☐ SIZE	☐ FACING	○ POSITION	☐○ FLANGED OR STUDDED (2.4.1)	○ MATING FLG. & GASKET BY VENDOR (2.4.6.4)	☐ MAX STEAM FLOW kg/HR	☐ MIN STEAM FLOW kg/HR
INLET								
EXHAUST								
EXTRACTION								
INDUCTION								

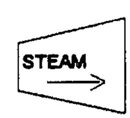
PIPE CONNECTIONS ○ TAPERED ○ STRAIGHT

☐ ALLOWABLE FORCES & MOMENTS

	INLET		EXHAUST		EXTRAC/INDUCT	
	FORCE	MOMENT	FORCE	MOMENT	FORCE	MOMENT
	N	N-m	N	N-m	N	N-m
PARALLEL TO SHAFT						
VERTICAL						
HORZ. 90°						

ROTATION:(VIEWED FROM INLET END)

○ CW ○ CCW VIEW →



SPECIAL PURPOSE STEAM TURBINE DATA SHEET SI UNITS

JOB NO. ______ ITEM NO. ______
REVISION ______ DATE ______
BY ______

MATERIALS- CASINGS & APPURTENANCES:

- ☐ HIGH PRESSURE CASING ______
- ☐ MID PRESSURE CASING ______
- ☐ EXHAUST CASING ______
- ☐ STEAM CHEST ______
- ☐ NOZZLE RING ______
- ○ STEAM CONTAMINANTS(2.11.1.6) ______
- ○ STEAM PATH COMPONENTS< RC22(2.11.1.9)
- ○ SPECIAL LOW TEMP MATERIAL REQUIREMENTS(2.11.1.15)
- ☐ DIAPHRAGM/BLADE CARRIERS ______
- ☐ DIAPHRAGM NOZZLES ______
- ☐ OTHER ______

ROTATING ELEMENTS(2.6)

SHAFT TYPE:
☐ INTEGRAL WHEELS ☐ BUILT-UP ☐ COMBINATION
☐ DOUBLE EXTENDED
☐ NO. STAGES ______ BEARING SPAN ______ mm.
☐ SHAFT MATERIAL ______
☐ SHAFT MATERIAL UNDER SEALS(2.6.2.4) ☐ INTEGRAL
APPLIED BY: ☐ PLATING ☐ SLEEVE ☐ SPRAY
SPRAY APPLICATION METHOD: ______
BLADES(BUCKETS): ☐ MAX TIP SPEED ______ m/s
☐ FINAL STG. BLADE LENGTH ______ mm MAX. ______ mm

☐ SHAFT ENDS: DIA, @ COUPLING ______ mm.
○ STRAIGHT ○ TAPER ______ mm PER m
○ KEYED ○ SINGLE ○ DOUBLE
○ HYDRAULIC FIT ○ INTEGRAL FLANGE
○ FIELD BALANCING RINGS REQUIRED(2.6.1.5)
☐ NO. ______ ☐ LOCATION ______
REMARKS: ______

	STAGE	STAGE	STAGE	STAGE	STAGE	STAGE	STAGE
☐ WHEEL MATERIAL							
☐ BLADE MATERIAL							
☐ BLADE ROOT TYPE							
☐ CLOSURE PIECE TYPE							
☐ TIE WIRE MATERIAL							
☐ SHROUD MATERIAL							
☐ SHROUD ATTACH.							
☐ PITCH DIAMETER							
☐ BLADE HEIGHT							
☐ BLADE TYPE							
☐ ______							
☐ ______							

SHAFT SEALS(2.7)

	INLET	EXHAUST
☐ SURFACE SPEED(2.7.2)	m/s	m/s
☐ MAX SEAL PRESS(1.4.20)	(BARG) (kPa)	(BARG) (kPa)
☐ STEAM LEAKAGE	kg/HR	kg/HR
☐ AIR LEAKAGE	Sm³/HR	Sm³/HR
☐ SHAFT DIA @ SEAL	mm.	mm.
☐ NO. RINGS PER SEAL		
☐ DIFF. PRESS PER SEAL	BAR	BAR
☐ STAT. LABY. TYPE		
☐ ROT. LABY. TYPE		
☐ MATERIAL		

END SEALS:
TYPE: ○ LABYRINTH(2.7.1) ○ OTHER
MATERIAL ______

INTERSTAGE SEALS:
TYPE: ○ LABYRINTH ○ OTHER
MATERIAL: ______

REMARKS ______

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JOB NO. ____________ ITEM NO. ____________
REVISION ____________ DATE ____________
BY ____________

BEARINGS AND BEARING HOUSINGS(2.9)

RADIAL(2.9.1)

	INLET	EXHAUST
☐ TYPE		
☐ MANUFACTURER		
☐ LENGTH	mm	mm
☐ SHAFT DIA	mm	mm
☐ UNIT LOAD(ACT/ALLOW)	N	N
☐ BASE MATERIAL		
☐ BABBIT THICKNESS	mm	mm
☐ NO. PADS		
☐ LOAD: B'TWN/ON PAD		
☐ PIVOT: CTR/OFFSET, %		
☐ ____________		
☐ ____________		

THRUST(2.9.2)

	ACTIVE	INACTIVE
☐ TYPE		
☐ MANUFACTURER		
☐ UNIT LOADING(MAX)	BAR	BAR
☐ UNIT LOAD(ULT.)	BAR	BAR
☐ NO. PADS		
☐ AREA	mm^2	mm^2
☐ PIVOT: CTR/OFFSET, %		
☐ PAD BASE MATL.		

LUBRICATION: ◯ FLOODED ◯ DIRECTED

THRUST COLLAR: ◯ INTEGRAL ◯ REPLACEABLE

BEARING TEMPERATURE DEVICES:

◯ THERMISTORS
◯ TYPE ______ POS TEMP COEFF ______ NEG TEMP COEFF
◯ TEMP SWITCH & INDICATOR BY: ______ PURCH ______ MFR
◯ THERMOCOUPLES
◯ SELECTOR SWITCH & INDICATOR BY: ______ PURCH ______ MFR
◯ RESISTANCE TEMP DETECTORS
◯ RESISTANCE MATL ______ ☐ ______ OHMS
◯ SELECTOR SWITCH & INDICATOR BY: ______ PURCH ______ MFR
◯ LOCATION-JOURNAL BRG
NO. ______ EA. PAD ______ EVERY OTHER PAD ______ PER BRG
OTHER ____________
◯ LOCATION-THRUST BRG
NO. ______ EA. PAD ______ EVERY OTHER PAD ______ PER BRG
OTHER ____________
NO.(INACT) ______ EA. PAD ______ EVERY OTHER PAD ______ PER BRG
OTHER ____________
◯ MONITOR SUPPLIED BY: ____________
◯ LOCATION ____________ ENCLOSURE ____________
◯ MFR. ____________ ☐ MODEL ____________
☐ SCALE RGE ______ ALARM ☐ SET @ ______ °C
◯ SHTDWN ☐ SET @ ______ °C ◯ DELAY ______ SEC

VIBRATION DETECTORS:

◯ TYPE ____________ ☐ MODEL ____________
◯ MANUFACTURER ____________
◯ NO AT EACH SHAFT BRG ______ TOTAL NO ______
◯ OSCILLATOR-DETECTORS SUPPLIED BY ____________
◯ MFR ____________ ☐ MODEL ____________
MONITOR SUPPLIED BY ____________
◯ LOCATION ____________ ENCLOSURE ____________
◯ MFR ____________ ☐ MODEL ____________
☐ SCALE RGE ______ ALARM ☐ SET @ ______ MILS
◯ SHTDWN: ☐ SET @ ______ MILS ◯ DELAY ______ SEC

AXIAL POSITION DETECTORS:

◯ TYPE ____________ ☐ MODEL ____________
◯ MFR ____________ ◯ NO. REQD ____________
◯ OSCILLATOR-DEMOD. SUPPLIED BY ____________
◯ MFR ____________ ☐ MODEL ____________
MONITOR SUPPLIED BY ____________
◯ LOCATION ____________ ENCLOSURE ____________
◯ MFR ____________ ☐ MODEL ____________
☐ SCALE RGE ______ ALARM ☐ SET @ ______ MILS
◯ SHTDWN ☐ SET @ ______ MILS ◯ DELAY ______ SEC
◯ LOAD CELLS, NO. OF PADS ____________

LUBRICATION AND CONTROL OIL SYSTEM(2.10)

REFERENCE SPECIFICATIONS: ____________
FURNISHED BY ◯ TURBINE MFR ☐ OTHERS
◯ SEPARATE FOR TURBINE ONLY
◯ ☐ COMMON W/ DRV. EQUIPMENT & INCL(2.10.2)(2.10.5)
____

TURBINE MFR TO SUPPLY:
◯ CONTROL OIL OR ACCUMULATOR
◯ STAINLESS STEEL OIL SUPPLY HEADING PIPING
◯ OIL DRAIN HEADER PIPING
◯ STAINLESS STEEL ◯ CARBON STEEL
◯ SIGHT FLOW INDICATORS

OIL REQUIREMENTS:	CTRL OIL	LUBE OIL
☐ NORMAL FLOW, m^3/HR		
☐ TRANSIENT FLOW, m^3/HR		
☐ PRESSURE,(BARG)(kPa)		
☐ TEMPERATURE, °C		
☐ TOT. HEAT REJ., MJ/HR		
☐ OIL TYPE, HC/SYN		
☐ VISCOSITY, SSU@37.8 °C		
☐ FILTRATION, MICRONS		
☐ ____________		
☐ ____________		

SPECIAL PURPOSE STEAM TURBINE DATA SHEET SI UNITS

JOB NO. ____________ ITEM NO. ____________
REVISION ____________ DATE ____________
BY ____________

ACCESSORIES

COUPLINGS AND GUARDS(3.1.2)

NOTE: SEE ROTATING ELEMENTS-SHAFT ENDS

○ SEE ATTACHED API-671 DATA SHEET

COUPLING FURNISHED BY ____________

MANUFACTURER ____________ TYPE ____________ MODEL ____________

COUPLING GUARD FURNISED BY ____________

TYPE ○ FULLY ENCLOSED ○ SEMI OPEN ○ OTHER ____________

COUPLING DETAILS

☐ MAX. O.D ____________ mm

☐ HUB WEIGHT ____________ kg

☐ SPACER LENGTH ____________ mm

☐ SPACER WEIGHT ____________ kg

○ VENDOR MOUNT HALF COUPLING

○ IDLING ADAPTER/SOLO MOMENT SIMULATOR REQD(3.1.4)

LUBRICATION REQUIREMENTS

○ GREASE ○ CONT. OIL LUBE ○ NONE

QUANTITY PER HUB ____________ kg OR m³/HR

MOUNTING PLATES(3.2)

BASEPLATES FURNISHED BY: ____________

○ UNDER TURBINE ONLY ○ OTHER(3.2.2.1)

○ OPEN ○ NON-SKID DECKING(3.2.2.6)

○ DRIP RIM ○ LEVELING PADS(3.2.2.2)

○ COLUMN MOUNTING(3.2.2.3) ○ SUB PLATES REQD(3.2.2.5)

○ LEVELING(CHOCK) BLOCKS REQD

FURNISHED BY: ____________

SOLEPLATES FURNISHED BY: ____________

THICKNESS ____________ mm

○ SUB PLATES REQUIRED(3.2.3.2)

○ HOLD-DOWN BOLTS FURNISHED BY ____________

○ EPOXY PRIMER VENDOR(3.2.1.2.7) ____________

○ ANCHOR BOLTS FURNISHED BY ____________

GEAR UNIT

FURNISHED BY: ____________ ○ REFERENCE API 613 ○ OTHER ____________

SEE DATA SHEETS ____________

CONTROLS AND INSTRUMENTATION(3.4)

INSTRUMENTS AND CONTROL PANELS SHALL BE IN ACCORDANCE WITH THE FOLLOWING ATTACHED DATA SHEETS(3.4.4.1):

○ API-614 APPENDIX B, PAGES ____________
○ API 670 APPENDIX D, PAGES ____________
○ PURCHASER'S DATA SHEETS ____________
○ ANNUC. PER ISA S 18-1 OPTION ____________

PROTECTIVE DEVICES

PROTECTIVE DEVICES(3.4.2)	EXHAUST RELIEF VALVE (2.2.3)(2.2.4)(3.4.5.7)	EXTRACT./INDUCT. RELIEF VALVE (2.2.3)(2.2.4)(3.4.5.7)	VACUUM BREAKER (3.4.2.5.4)	NON-RETURN VALVE (3.4.2.5.2)	
MOUNTING LOCATION				X	
SET RELIEF PRESS. (BARG)(kPa)			X		
CAPACITY, kg/HR STEAM			X		
VALVE MANUFACTURER					
VALVE TYPE					
VALVE SIZE/RATING					
FLANGE FACING					
FURNISHED BY					
QUANTITY					

REMARKS:

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SPECIAL PURPOSE STEAM TURBINE
DATA SHEET
SI UNITS

JOB NO. ____________ ITEM NO. ____________
REVISION ____________ DATE ____________
BY ____________

○ **TRIP** ○ **TRIP & THROTTLE VALVE(3.4.2.4)**

LOCATION: ○ MAIN INLET ○ INDUCTION
PROVIDED BY: ○ VENDOR ○ PURCHASER
☐ MANUFACTURER ________ MODEL ________
☐ SIZE ____ RATING ____ FACING ____
☐ SIZE ____ RATING ____ FACING ____
☐ SIZE ____ RATING ____ FACING ____
CONSTRUCTION FEATURES:
RESET: ○ MANUAL ○ HYDRAULIC
TRIP: ○ LOCAL(MANUAL) ○ REMOTE
EXERCISER: ○ LOCAL(MANUAL) ○ REMOTE
○ FULLY OIL OPERATED

INLET	INDUCT.

☐ STRAINER: OPENING SIZE ________ (mm./MESH)
MATERIAL ________
○ TEMPORARY START-UP STRAINER ________ (MESH)
MATERIAL ________
☐ STEM MATL ________ HARDNESS ________ RC
☐ SEAT MATL ________ HARDNESS ________ RC
☐ PACKING MATL ________ LEAKOFF ________ kg/HR
☐ SPRING SUPPORT OF VALVE REQUIRED
○ BY VENDOR ○ BY PURCHASER

CONTROL VALVES:

LOCATION	MAIN INLET	INDUCTION	INDUCTION EXTRACTION	INDUCTION EXTRACTION	NOTES
TRIP POSITION(OPEN/CLOSED)					
NUMBER OF VALVES					
PROVIDED BY					
MANUFACTURER					
CONNECTION SIZE					
RATING					
FACING(RF,RTJ,OTHER)					
ACTION(CAM,BAR,OTHER)					
STEM MATERIAL					
STEM MATERIAL HARDNESS, RC					
SEAT MATERIAL					
SEAT MATERIAL HARDNESS, RC					
PACKING MATERIAL					
PACKING LEAKOFF, kg/HR					

TURNING GEAR(3.9)

○ TURNING GEAR REQUIRED(3.9.1)
○ FURNISHED BY ________
○ TYPE ________ SPEED ________ RPM
○ ENGAGEMENT: ○ AUTO ○ MANUAL
○ MFR ________ MODEL ________
○ MOUNTED BY ________
○ DRIVER: REF. SPEC: ________
TYPE: ○ ELEC ○ OTHER
○ OPERATOR STATION(3.9.5) ○ LOCAL ○ REMOTE

MISCELLANEOUS

○ START-UP ASSISTANCE(2.1.7) ________ DAYS
○ VENDOR'S REVIEW & COMMENTS ON PURCHASER'S PIPING & FOUNDATION DRAWINGS(2.1.7)
○ VENDOR WITNESS INITIAL ALIGNMENT(2.1.7)
○ "Y" TYPE STAINER
○ WATER WASHING CONNECTIONS
○ STATIC CONDUCTING BRUSHES
○ TARGETS(3.2.2.2) ○ LEVELING PADS
○ ________

INSULATION & JACKETING(3.7)

○ BLANKET ○ OTHER ________
○ JACKETING
○ CARBON STEEL ○ STAINLESS STEEL
○ EXTENT ________

SPECIAL TOOLS(3.8)

○ COUPLING RING AND PLUG GAUGE
○ HYDRAULIC COUPLING MOUNTING/REMOVAL KIT
○ OTHER ________

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SPECIAL PURPOSE STEAM TURBINE DATA SHEET SI UNITS

JOB NO. ______ ITEM NO. ______
REVISION ______ DATE ______
BY ______

GOVERNOR(3.4.3)

TYPE ○ MECHANICAL ○ ELECTRONIC
○ SIMPLEX
○ MULTIPROCESSOR

○ NEMA CLASSIFICATION ______
○ MFR ______ MODEL ______
○ SUPPLIED BY ______

STEAM TURBINE TYPE

○ SINGLE VALVE SINGLE STAGE
○ MULTIVALVE MULTISTAGE
○ DOUBLE AUTO EXTRACTION
○ DOUBLE AUTO EXTRACTION/INDUCTION

○ SINGLE VALVE MULTISTAGE
○ SINGLE AUTO EXTRACTION
○ SINGLE AUTO EXTRACTION/INDUCTION
○ OTHER ______

DRIVEN EQUIPMENT TYPE

○ CENTRIFUGAL COMPRESSOR
○ SYNCHRONOUS GENERATOR
○ FAN

○ CENTRIFUGAL PUMP
○ INDUCTION GENERATOR
○ OTHER ______

SERVICE REQUIREMENTS

MECHANICAL DRIVE

○ SPEED CONTROL BY ______

PROCESS PRESSURE

EXTRACTION	○ PRESSURE	○ FLOW
INDUCTION	○ PRESSURE	○ FLOW
TURBINE INLET	○ PRESSURE	○ FLOW
TURBINE EXHAUST	○ PRESSURE	○ FLOW

GENERATOR DRIVE

○ DROOP CONTROL
○ FREQ. CONTROL
○ LOAD CONTROL
○ KW CONTROL
○ KW IMPORT/EXPORT CONTROL
○ LOAD SHEDDING
○ AUTO SYNCHRONIZATION
○ AUTO VOLTAGE REGULATION
○ TURBINE INLET PRESSURE LIMITING
○ INLET PRESSURE LIMITER

MINIMUM INPUT/OUTPUT REQUIREMENTS

DISCRETE INPUTS

○ START OR RESET
○ NORMAL STOP
○ EMERGENCY TRIP
○ RAISE TRIP
○ LOWER SPEED
○ ENABLE/DISABLE REMOTE SPEED SETPOINT
○ RAMP TO MINIMUM CONTINUOUS
○ OVERSPEED TEST ENABLE
○ ENABLE PRESSURE CONTROL
○ ENABLE ALARM CLEAR/ACKNOWLEDGE
○ REMOTE ALARM CLEAR/ACKNOWLEDGE
○ ENABLE AUTO SYNCH.
○ CASCADE RAISE/LOWER
○ OTHER ______

ANALOG INPUTS(4-20mA)

○ REMOTE SET POINT
○ PROCESS PRESSURE
○ EXTRACTION ○ PRESSURE ○ FLOW
○ KW IND. LOAD ○ PRESSURE ○ FLOW
○ KW IMPORT/EXPORT
○ OTHER ______
______

DISCRETE OUTPUTS

○ COMMON SHUTDOWN
○ COMMON ALARM
○ OVERSPEED TRIP ______ RPM
○ REMOTE SPEED SETPOINT ENABLED
○ PRESSURE CONTROL ENABLED
○ FLOW CONTROL ENABLED
○ EXTRACTION CONTROL ENABLED
○ INDUCTION CONTROL ENABLED
○ SPEED PICKUP ALARM
○ OTHER ______
______
______

ANALOG ACCESSORY OUTPUTS(4-20 mA)

○ SPEED
○ SPEED SETPOINT
○ REMOTE SPEED SETPOINT
○ EXTRACTION PRESSURE
○ EXTRACTION PRESSURE SETPOINT
○ ACTUATOR POSITION
○ PROCESS PRESSURE
○ kW
○ kW IMPORT/EXPORT

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SPECIAL PURPOSE STEAM TURBINE DATA SHEET SI UNITS

JOB NO. ____ ITEM NO. ____
REVISION ____ DATE ____
BY ____

GOVERNOR INSTALLATION REQUIREMENTS

LOCATION: ○ LOCAL(AT TURBINE) ○ REMOTE(CONTROL ROOM) ○ OTHER ____

MOUNTING: ○ FLUSH MOUNT IN PANEL ○ SURFACE MOUNT ○ VERTICAL RACK

ENCLOSURE: ○ GENERAL PURPOSE ○ NEMA 4 ○ NEMA 4X ○ NEMA PURGE TYPE ○ EXPLOSION PROOF

POWER SOURCE	SINGLE	DUAL
120 VAC	○	○
220 VAC	○	○
125 VDC	○	○
24 VDC	○	○

LOCAL GOVERNOR CONTROL PANEL ○ REQUIRED ○ NOT REQUIRED

LOCATION: ○ LOCAL(AT TURBINE) ○ REMOTE CONTROL ROOM ○ OTHER ____

ENCLOSURE: ○ GENERAL PURPOSE ○ NEMA 4 ○ NEMA 4X ○ EXPLOSION PROOF

OUTPUTS FROM PANEL TO GOVERNOR:
- ○ START
- ○ TRIP
- ○ RAISE
- ○ LOWER
- ○ OVERSPEED TEST
- ○ RAMP TO MINIMUM CONTINUOUS
- ○ REMOTE SETPOINT ENABLE/DISABLE
- ○ RESET
- ○ OTHER ____

INPUTS TO PANEL FROM GOVERNOR:
- ○ COMMON ALARM TRIP
- ○ TRIP LAMP
- ○ REMOTE SETPOINT ENABLED LAMP
- ○ SPEED SETPOINT METER
- ○ OTHER ____

MISCELLANEOUS GOVERNOR DETAILS

GOVERNOR ACTION ON LOSS OF REMOTE SIGNAL: ○ LOCKS ON LAST VALUE ○ GOES TO MINIMUM CONTINUOUS ○ GOES TO MAXIMUM CONTINUOUS

EXTERNAL INTERFACE DEVICE TYPE: ○ PRINTER ○ CRT

FORMAT: ○ GRAPHIC DISPLAY ○ TABULAR DATA ○ TRENDING(REAL TIME) ○ HISTORICAL ARCHIVING

○ DISTRIBUTIVE CONTROL SYSTEM MANUFACTURER ____ ○ MODEL ____

DATA TRANSMISSION: ○ SERIAL DATA LINK ○ DISCRETE I/O ○ NETWORK TYPE ____

○ PROTOCOL ____

○ BAUD RATE: ○ 300 ○ 4800 ○ 1200 ○ 9600 ○ 2400 ○ 19200

MAGNETIC SPEED PICKUP

MANUFACTURER ____ MODEL ____ INSTALLATION: ○ DUAL ○ TRIPLE ○ INSTALLED SPARE

GOVERNOR SPEED PICKUP(S)(3.4.3.3): ○ NO. REQD ____ ○ DIRECT ○ 60 TOOTH WHEEL ○ OTHER ____

TURBINE MOUNTED ACCESSORIES

ACTUATOR: ○ SUPPLIED BY ____ ○ MANUFACTURER ____ ○ MODEL ____

ACTUATOR TYPE: ○ HYDRAULIC ○ PNEUMATIC ○ SINGLE COIL ○ MULTI COIL ○ OTHER ____

TACHOMETER: ○ MANUFACTURER ____ ○ MODEL ____ ○ NO. REQD ____ ○ LOCATION(S) ____

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SPECIAL PURPOSE STEAM TURBINE DATA SHEET SI UNITS

JOB NO. ____________ ITEM NO. ____________
REVISION ____________ DATE ____________
BY ____________

OVERSPEED TRIP(3.4.2)

○ FURNISHED BY ____________
○ MFR ____________ ○ MODEL ____________
☐ ELECTRONIC, SET POINT ____________ RPM
○ OVERSPEED SHUTDOWN REQUIREMENTS
○ 1 OUT OF 2 ○ 2 OUT OF 3 VOTING LOGIC
○ OTHER ____________
○ MECHANICAL OVERSPEED SET POINT ____________
☐ TYPE ____________

○ NO. SPEED PICKUPS ______ ☐ TYPE ______ TOOTHWHEEL
○ OTHER ____________
○ SPEED PICKUPS FURNISHED BY ____________
○ SOLENOIDS SHALL: ○ DE-ENERGIZE TO TRIP
○ ENERGIZE TO TRIP
○ CONTACTS SHALL BE: ○ NORMALLY OPEN
○ NORMALLY CLOSED

GLAND SEALING AND VACUUM SYSTEM(3.5)

SYSTEM PER: ○ APPENDIX B-1 ○ APPENDIX B-2
○ OTHER ____________
○ AVAIL. HEADER PRESS ______ (BARG) (kPa) TEMP ______ °C
○ AVAIL. SEAL STEAM SUPPLY PRESS ______ (BARG) (kPa)
○ AVAIL. SEAL STEAM SUPPLY TEMP. ______ °C
☐ SEALING STM. PRESS ______ (BARG) (kPa) ☐ FLOW ______ kg/HR.
☐ SEALING STM. RELIEF VALVE SET PRESS ______ (BARG) (kPa)
FURNISHED BY ____________
☐ FLOW ADJUSTING VALVES, TYPE ____________
FURNISHED BY ____________

○ VACUUM SYSTEM FURNISHED BY ____________
○ SHIP LOOSE ○ SKID MOUNTED
○ OTHER ____________
○ GLAND CONDENSER, SEE SPEC. ____________
○ STEAM EJECTOR ☐ STM. PRESS ______ (BARG) (kPa)
☐ STM. FLOW ______ kg/HR.
○ VACUUM PUMP(3.5.2), SEE SPEC. ____________
○ CONDENSATE RECEIVER
○ LOOP SEAL HEIGHT ______ m

INSPECTION AND TESTING(4.2)(4.3)

GENERAL

○ SHOP INSPECTION(4.1.4)
EXTENT: ____________

INSPECTION AND MATERIAL TESTING

○ FINAL ASSEMBLY RECORDS REQUIRED(4.2.11.e)

SPECIAL MAT'L INSP. & TESTING REQUIREMENTS

COMPONENT	MAG PART	DYE PEN	R.T.	U.T.	OBSVD	WIT
TRIP & T&T VALVE					○	○
STM CHEST					○	○
CASING					○	○
PIPING					○	○
ROTOR					○	○
					○	○

	OBSVD	WIT
○ HEAT STABILITY(4.2.2.3.4)	○	○
○ CLEANLINESS(4.2.3.2)	○	○
○ HARDNESS(4.2.3.4)	○	○
○ HYDROSTATIC TESTS(4.3.2)	○	○
○ BLADE SHAKER(STATIC)	○	○
ROTOR BALANCE ○ STANDARD(2.8.5)	○	○
○ HIGH SPEED(2.8.5.4)	○	○
○ FINAL SURFACE INSPECTION(4.4.3)	○	○
○ CRATING INSPECTION	○	○
○ SPARE ROTOR FIT	○	○
○ CASING JOINT LEAK TEST(4.3.2.7)	○	○
○ ____________	○	○
○ ____________	○	○
○ ____________	○	○

MECHANICAL RUNNING TEST(4.3.3)

	OBSVD	WIT
○ CONTRACT ROTOR	○	○
○ SPARE ROTOR	○	○
○ TEST W/JOB COUPLING	○	○
○ TEST TAPE RECORD. REQ'D	○	○
○ TEST TAPE GIVEN TO PURCH.	○	○
○ TEST W/JOB L.O. CONSOLE	○	○
○ ____________	○	○

OPTIONAL TESTS AND INSPECTIONS(4.3.4)

	OBSVD	WIT
○ PERFORMANCE(4.3.4.1)	○	○
○ COMPLETE UNIT(4.3.4.2)	○	○
○ TORSIONAL MEASMT'S(4.3.4.2)	○	○
AUX. EQUIPMENT(4.3.4.3)		
○ TRIP/T&T VALVE	○	○
○ GLAND SEAL. SYSTEM	○	○
○ GLAND VACUUM SYSTEM	○	○
○ RELIEF VALVES	○	○
○ ____________	○	○
○ CASING INTERNAL INSP(4.3.4.4)	○	○
○ COUPLING TO SHAFT FIT(API 671)	○	○
○ TURNING GEAR	○	○
ADDITIONAL TEST OR INSPECTIONS		
○ ____________	○	○
○ ____________	○	○
○ ____________	○	○
○ ____________	○	○
○ ____________	○	○

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SPECIAL PURPOSE STEAM TURBINE DATA SHEET SI UNITS

JOB NO. ______________ ITEM NO. ______________
REVISION ______________ DATE ______________
BY ______________

MISCELLANEOUS

PAINTING

◯ MANUFACTURER'S STANDARD
◯ OTHER ______________
◯ ______________

SHIPMENT(4.4.1)(4.4.3.10)

◯ DOMESTIC ◯ EXPORT
◯ EXP BOXING REQUIRED ◯ OUTDOOR STORAGE OVER 6 MONTHS
◯ WATERPROOF BOXING REQUIRED
◯ SPARE ROTOR ASSEMBLY PACKAGED FOR:
◯ HORIZONTAL STORAGE ◯ VERTICAL STORAGE

WEIGHTS:

☐ TURBINE ______ kg
☐ ROTOR ______ kg
☐ TURBINE UPPER HALF CASING ______ kg
☐ MAX. FOR MAINT.(IDENTIFY) ______ kg
☐ TRIP/T & T VALVE ______ kg
☐ MISC. ______ kg
☐ TOTAL SHIPPING WEIGHT ______ kg

SPACE REQUIREMENTS:

☐ COMPLETE UNIT:	L ______ mm	W ______ mm	H ______ mm
☐ CONTROL PANEL:	L ______ mm	W ______ mm	H ______ mm
☐ OTHER:	L ______ mm	W ______ mm	H ______ mm
☐ OTHER:	L ______ mm	W ______ mm	H ______ mm

VENDOR DWG & DATA REQUIREMENTS(5)

◯ APPENDIX(5.3.3.1)
◯ OTHER
◯ PROGRESS REPORTS REQ'D(5.3.4)
FREQUENCY ______________

REMARKS AND ADDITIONAL REQUIREMENTS ______________

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SPECIAL PURPOSE STEAM TURBINE DATA SHEET CUSTOMARY UNITS

JOB NO. ____________ ITEM NO. ____________
PURCH. ORDER NO. ____________ DATE ____________
INQUIRY NO. ____________ BY ____________
REVISION ____________ DATE ____________

APPLICABLE TO: ○ PROPOSAL ○ PURCHASE ☐ AS-BUILT
FOR ____________ UNIT ____________
SITE ____________ SERIAL NO. ____________
SERVICE ____________ NO. REQUIRED ____________
MANUFACTURER ____________ MODEL ____________ DRIVEN EQUIP. ITEM NO. ____________
DRIVEN EQUIPMENT TYPE: ○ COMPRESSOR ○ GENERATOR ○ OTHER ____________
NOTE: INFORMATION TO BE COMPLETED BY: ○ PURCHASER ☐ MANUFACTURER ○ ☐ PURCHASER OR MANUFACTURER

PERFORMANCE

OPERATING POINTS	SHAFT		INLET			INDUCT./EXTRACT.			EXHAUST		
○ ☐ AS APPL.	POWER	SPEED	FLOW	PRESS	TEMP	FLOW	PRESS	TEMP	PRESS	TEMP	ENTHAPLY
	HP	RPM	LBS/HR	PSIG	°FTT	LBS/HR	PSIG	°FTT	PSIG/IN HGA	°FTT	BTU/LB.
RATED(1.4.27)											
NORMAL(1.4.22)											
MINIMUM(1.4.11)											
MINIMUM(1.4.11)											

☐ STEAM RATE, LBS/HP-HR(1.4.34) NORMAL ______ RATED ______ INDUCTION ○ CONTROLLED ○ UNCONTROLLED
☐ INDUCTION FLOW, LBS/HR: MINIMUM ______ MAXIMUM ______ EXTRACTION ○ CONTROLLED ○ UNCONTROLLED
☐ EXTRACTION FLOW, LBS/HR MINIMUM ______ MAXIMUM ______

STEAM CONDITIONS

○ **INLET**
NORMAL ______ PSIG ______ °FTT
MAXIMUM ______ PSIG ______ °FTT
MINIMUM ______ PSIG ______ °FTT

○ **EXTRACTION**
NORMAL ______ PSIG/IN HG A ______ °FTT
MAXIMUM ______ PSIG/IN HG A ______ °FTT
MINIMUM ______ PSIG/IN HG A ______ °FTT

○ **EXHAUST**
NORMAL ______ PSIG/IN HG A ______ °FTT
MAXIMUM ______ PSIG/IN HG A ______ °FTT
MINIMUM ______ PSIG/IN HG A ______ °FTT

○ **INDUCTION**
NORMAL ______ PSIG/IN HG A ______ °FTT
MAXIMUM ______ PSIG/IN HG A ______ °FTT
MINIMUM ______ PSIG/IN HG A ______ °FTT

SITE AND UTILITY DATA

LOCATION:
○ INDOOR ○ HEATED ○ UNDER ROOF ○ OUTDOOR
○ UNHEATED ○ PARTIAL SIDES ○ GRADE ○ MEZZANNE
○ ____________
○ WINTERIZATION REQD. ○ TROPICALIZATION REQD.
○ LOW TEMPERATURE ○ CORROSIVE AGENTS
○ ELECT. AREA CLASSIFICATION: CL ____ GP ____ DIV ____

SITE DATA:
○ ELEVATION ______ FT. ○ BAR ______ PSIA/HgA
○ WINTER TEMP. ______ °F SUMMER TEMP. ______ °F
○ REL. HUMIDITY ______ % DESIGN WET BULB ______ °F
○ UNUSUAL CONDITIONS: ○ DUST ○ FUMES
OTHER ____________

UTILITY CONDITIONS:

○ AUXILIARY STEAM:	MAX	NORM	MIN
INIT. PRESSURE(PSIG)			
INITIAL TEMP(°FTT)			
EXH PRESS(PSIG/IN HGA)			

INSTRUMENT AIR(PSIG): NORM ______ MIN ______ MAX ______
INSTRUMENT AIR DEW POINT: ______ °F

○ **ELECTRIC:**

	DRIVERS	HEATING	INST./ CONTROL	ALARM/ SHUTDOWN
VOLTS				
PHASE				
HERTZ				
KW AVAIL				

○ **COOLING WATER:**
TEMP. INLET: ______ °F MAX RETURN ______ °F
PRESS. NORM.: ______ PSIG DESIGN: ______ PSIG
MAX RETURN PRESS.: ______ PSIG
MAX. ALLOWABLE PRESS. DROP: ______ PSI
WATER SOURCE: ____________
VELOCITY, FPS: MIN ______ MAX ______
FOULING FACTOR: ______ HR-FT²/BTU

○ **UTILITY CONSUMPTION:**
COOLING WATER: ______ GPM INST. AIR ______ ACFM
AUX. STM: NORMAL ______ LBS/HR MAXIMUM ______ LBS/HR
AUX. DRIVERS: ELEC. ______ HP STEAM ______ HP
HEATER(S): ______ KW OTHER: ______

REMARKS: ____________

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SPECIAL PURPOSE STEAM TURBINE DATA SHEET CUSTOMARY UNITS

JOB NO. ____________ ITEM NO. ____________

REVISION ____________ DATE ____________

BY ____________

APPLICABLE SPECIFICATIONS:

API 612, SPECIAL PURPOSE STEAM TURBINES

○ OTHER: ____________

○ VENDOR HAVING UNIT RESPONSIBILITY: ____________

○ GOVERNING SPECIFICATION, IF DIFFERENT: ____________

NOISE SPECIFICATIONS:

○ APPLICABLE TO MACHINE:
SEE SPECIFICATION: ____________

○ APPLICABLE TO NEIGHBORHOOD:
SEE SPECIFICATION: ____________

ACOUSTICAL TREATMENT ○ Yes ○ No

CONSTRUCTION FEATURES

TURBINE TYPE ○ BACKPRESSURE ○ CONDENSING ○ OTHER

☐ SPEEDS:
MAX CONT. ______ RPM TRIP ______ RPM
MAX ALLOW. ______ RPM

☐ LATERAL CRITICAL SPEEDS(DAMPED)
FIRST CRITICAL ______ RPM ______ MODE
SECOND CRITICAL ______ RPM ______ MODE
THIRD CRITICAL ______ RPM ______ MODE
FOURTH CRITICAL ______ RPM ______ MODE

☐ VIBRATION ______ MILS (PEAK TO PEAK)

☐ TORSIONAL CRITICAL SPEEDS:
FIRST CRITICAL ______ RPM
SECOND CRITICAL ______ RPM
THIRD CRITICAL ______ RPM
FOURTH CRITICAL ______ RPM

○ TRAIN LATERAL ANALYSIS REQUIRED
○ UNDAMPED STIFFNESS MAP REQUIRED
○ TRAIN TORSIONAL ANALYSIS REQUIRED

☐ CASINGS, NOZZLES& DIAPHRAGMS

☐ MAWP(1.4.13)(2.2.3)
INLET SECTION ______ PSIG EXH. SECTION ______ PSIG
INDUCTION/EXTRACT. SECTION ______ PSIG
OTHER ______ PSIG

☐ MAX OPERATING TEMPERATURE(1.4.12)(1.4.18)(2.2.2)
INLET SECTION ______ °F EXH. SECTION ______ °F
INDUCTION/EXTRACTION SECTION ______ °F
OTHER ______ °F

☐ HYDROSTATIC TEST PRESSURE(4.3.2.1)(4.3.2.2)
HP CASING ______ PSIG MID CASING ______ PSIG
EXHAUST CASING ______ PSIG OTHER ______ PSIG

○ WELDED NOZZLE RING(2.3.1) NOZZLE RING ______ % ADM.

DIAPH.BLADE ATTACH.: ☐ INTEGRALLY CAST ☐ WELDED
☐ OTHER ______

DIAPHRAGM AXIAL LOCATION: ☐ INDIVIDUALLY ☐ STACKED

CASING CONNECTIONS

CONNECTION	○ DESIGN APPROVAL REQD(2.11.3.5.4)	☐ SIZE	☐ FACING	○ POSITION	☐○ FLANGED OR STUDDED (2.4.1)	○ MATING FLG. & GASKET BY VENDOR (2.4.6.4)	☐ MAX STEAM FLOW LBS/HR	☐ MIN STEAM FLOW LBS/HR
INLET								
EXHAUST								
EXTRACTION								
INDUCTION								

PIPE CONNECTIONS ○ TAPERED ○ STRAIGHT

☐ ALLOWABLE FORCES & MOMENTS

	INLET		EXHAUST		EXTRAC/INDUCT	
	FORCE	MOMENT	FORCE	MOMENT	FORCE	MOMENT
	LB	FT-LB	LB	FT-LB	LB	FT-LB
PARALLEL TO SHAFT						
VERTICAL						
HORZ. 90°						

ROTATION:(VIEWED FROM INLET END)

○ CW ○ CCW VIEW →

STEAM →

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SPECIAL PURPOSE STEAM TURBINE DATA SHEET CUSTOMARY UNITS

JOB NO. ____________ ITEM NO. ____________
REVISION ____________ DATE ____________
BY ____________

MATERIALS- CASINGS & APPURTENANCES:

- ☐ HIGH PRESSURE CASING ____________
- ☐ MID PRESSURE CASING ____________
- ☐ EXHAUST CASING ____________
- ☐ STEAM CHEST ____________
- ☐ NOZZLE RING ____________
- ○ STEAM CONTAMINANTS(2.11.1.6) ____________
- ○ STEAM PATH COMPONENTS< RC22(2.11.1.9)
- ○ SPECIAL LOW TEMP MATERIAL REQUIREMENTS(2.11.1.15)
- ☐ DIAPHRAGM/BLADE CARRIERS ____________
- ☐ DIAPHRAGM NOZZLES ____________
- ☐ OTHER ____________

ROTATING ELEMENTS(2.6)

SHAFT TYPE:

☐ INTEGRAL WHEELS ☐ BUILT-UP ☐ COMBINATION

☐ DOUBLE EXTENDED

☐ NO. STAGES ________ BEARING SPAN ________ IN.

☐ SHAFT MATERIAL ____________

☐ SHAFT MATERIAL UNDER SEALS(2.6.2.4) ☐ INTEGRAL

APPLIED BY: ☐ PLATING ☐ SLEEVE ☐ SPRAY

SPRAY APPLICATION METHOD: ____________

BLADES(BUCKETS): ☐ MAX TIP SPEED ________ FPM

☐ FINAL STG. BLADE LENGTH ________ IN. MAX. ________ IN.

☐ SHAFT ENDS: DIA, @ COUPLING ________ IN.

○ STRAIGHT ○ TAPER ________ INCH PER FOOT

○ KEYED ○ SINGLE ○ DOUBLE

○ HYDRAULIC FIT ○ INTEGRAL FLANGE

○ FIELD BALANCING RINGS REQUIRED(2.6.1.5)

☐ NO. ________ ☐ LOCATION ________

REMARKS: ____________

	STAGE	STAGE	STAGE	STAGE	STAGE	STAGE	STAGE
☐ WHEEL MATERIAL							
☐ BLADE MATERIAL							
☐ BLADE ROOT TYPE							
☐ CLOSURE PIECE TYPE							
☐ TIE WIRE MATERIAL							
☐ SHROUD MATERIAL							
☐ SHROUD ATTACH.							
☐ PITCH DIAMETER							
☐ BLADE HEIGHT							
☐ BLADE TYPE							
☐ ________							
☐ ________							

SHAFT SEALS(2.7)

	INLET	EXHAUST
☐ SURFACE SPEED(2.7.2)		
☐ MAX SEAL PRESS(1.4.20)		
☐ STEAM LEAKAGE		
☐ AIR LEAKAGE		
☐ SHAFT DIA @ SEAL		
☐ NO. RINGS PER SEAL		
☐ DIFF. PRESS PER SEAL		
☐ STAT. LABY. TYPE		
☐ ROT. LABY. TYPE		
☐ MATERIAL		

END SEALS:

TYPE: ○ LABYRINTH(2.7.1) ○ OTHER

MATERIAL ____________

INTERSTAGE SEALS:

TYPE: ○ LABYRINTH ○ OTHER

MATERIAL: ____________

REMARKS ____________

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SPECIAL PURPOSE STEAM TURBINE DATA SHEET CUSTOMARY UNITS

JOB NO. ____________ ITEM NO. ____________
REVISION ____________ DATE ____________
BY ____________

BEARINGS AND BEARING HOUSINGS(2.9)

RADIAL(2.9.1)	INLET	EXHAUST
☐ TYPE		
☐ MANUFACTURER		
☐ LENGTH(IN)		
☐ SHAFT DIA(IN)		
☐ UNIT LOAD(ACT/ALLOW)		
☐ BASE MATERIAL		
☐ BABBIT THICKNESS(IN)		
☐ NO. PADS		
☐ LOAD: B'TWN/ON PAD		
☐ PIVOT: CTR/OFFSET, %		
☐ ____________		
☐ ____________		

THRUST(2.9.2)	ACTIVE	INACTIVE
☐ TYPE		
☐ MANUFACTURER		
☐ UNIT LOADING(MAX PSI)		
☐ UNIT LOAD(ULT)(PSI)		
☐ NO. PADS		
☐ AREA(IN²)		
☐ PIVOT: CTR/OFFSET, %		
☐ PAD BASE MATL.		

LUBRICATION: ○ FLOODED ○ DIRECTED
THRUST COLLAR: ○ INTEGRAL ○ REPLACEABLE

BEARING TEMPERATURE DEVICES:

○ THERMISTORS
○ TYPE ______ POS TEMP COEFF ______ NEG TEMP COEFF
○ TEMP SWITCH & INDICATOR BY: ______ PURCH ______ MFR
○ THERMOCOUPLES
○ SELECTOR SWITCH & INDICATOR BY: ______ PURCH ______ MFR
○ RESISTANCE TEMP DETECTORS
○ RESISTANCE MATL ______ ☐ ______ OHMS
○ SELECTOR SWITCH & INDICATOR BY: ______ PURCH ______ MFR
○ LOCATION-JOURNAL BRG
NO. ______ EA. PAD ______ EVERY OTHER PAD ______ PER BRG
OTHER ____________
○ LOCATION-THRUST BRG
NO. ______ EA. PAD ______ EVERY OTHER PAD ______ PER BRG
OTHER ____________
NO.(INACT) ______ EA. PAD ______ EVERY OTHER PAD ______ PER BRG
OTHER ____________
○ MONITOR SUPPLIED BY: ____________
○ LOCATION ______ ENCLOSURE ______
○ MFR. ______ ☐ MODEL ______
☐ SCALE RGE ______ ALARM ☐ SET @ ______ °F
○ SHTDWN ☐ SET @ ______ °F ○ DELAY ______ SEC

VIBRATION DETECTORS:

○ TYPE ______ ☐ MODEL ______
○ MANUFACTURER ____________
○ NO AT EACH SHAFT BRG ______ TOTAL NO ______
○ OSCILLATOR-DETECTORS SUPPLIED BY ______
○ MFR ______ ☐ MODEL ______
MONITOR SUPPLIED BY ______
○ LOCATION ______ ENCLOSURE ______
○ MFR ______ ☐ MODEL ______
☐ SCALE RGE ______ ALARM ☐ SET @ ______ MILS
○ SHTDWN: ☐ SET @ ______ MILS ○ DELAY ______ SEC

AXIAL POSITION DETECTORS:

○ TYPE ______ ☐ MODEL ______
○ MFR ______ ○ NO. REQD ______
○ OSCILLATOR-DEMOD. SUPPLIED BY ______
○ MFR ______ ☐ MODEL ______
MONITOR SUPPLIED BY ______
○ LOCATION ______ ENCLOSURE ______
○ MFR ______ ☐ MODEL ______
☐ SCALE RGE ______ ALARM ☐ SET @ ______ MILS
○ SHTDWN ☐ SET @ ______ MILS ○ DELAY ______ SEC
○ LOAD CELLS, NO. OF PADS ______

LUBRICATION AND CONTROL OIL SYSTEM(2.10)

REFERENCE SPECIFICATIONS: ____________
FURNISHED BY ○ TURBINE MFR ☐ OTHERS
○ SEPARATE FOR TURBINE ONLY
○ ☐ COMMON W/ DRV. EQUIPMENT & INCL(2.10.2)(2.10.5)
____
TURBINE MFR TO SUPPLY:
○ CONTROL OIL OR ACCUMULATOR
○ STAINLESS STEEL OIL SUPPLY HEADING PIPING
○ OIL DRAIN HEADER PIPING
○ STAINLESS STEEL ○ CARBON STEEL
○ SIGHT FLOW INDICATORS

OIL REQUIREMENTS:	CTRL OIL	LUBE OIL
☐ NOMINAL FLOW, GPM		
☐ TRANSIENT FLOW, GPM		
☐ PRESSURE, PSIG		
☐ TEMPERATURE, °F		
☐ TOT. HEAT REJ, BTU/HR.		
☐ OIL TYPE, HC/SYN		
☐ VISCOSITY, SSU@ 100°F		
☐ FILTRATION, MICRONS		
☐ ____________		
☐ ____________		

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SPECIAL PURPOSE STEAM TURBINE
DATA SHEET
CUSTOMARY UNITS

JOB NO. ______ ITEM NO. ______
REVISION ______ DATE ______
BY ______

ACCESSORIES

COUPLINGS AND GUARDS(3.1.2)

NOTE: SEE ROTATING ELEMENTS-SHAFT ENDS
○ SEE ATTACHED API-671 DATA SHEET
COUPLING FURNISHED BY ______
MANUFACTURER ______ TYPE ______ MODEL ______
COUPLING GUARD FURNISED BY ______
TYPE ○ FULLY ENCLOSED ○ SEMI OPEN ○ OTHER ______

COUPLING DETAILS
☐ MAX. O.D ______
☐ HUB WEIGHT ______
☐ SPACER LENGTH ______
☐ SPACER WEIGHT ______

○ VENDOR MOUNT HALF COUPLING
○ IDLING ADAPTER/SOLO MOMENT SIMULATOR REQD(3.1.4)
LUBRICATION REQUIREMENTS
○ GREASE ○ CONT. OIL LUBE ○ NONE
QUANTITY PER HUB ______ LBS. OR GPM

MOUNTING PLATES(3.2)

BASEPLATES FURNISHED BY: ______
○ UNDER TURBINE ONLY ○ OTHER(3.2.2.1)
○ OPEN ○ NON-SKID DECKING(3.2.2.6)
○ DRIP RIM ○ LEVELING PADS(3.2.2.2)
○ COLUMN MOUNTING(3.2.2.3) ○ SUB PLATES REQD(3.2.2.5)
○ LEVELING(CHOCK) BLOCKS REQD
FURNISHED BY: ______

SOLEPLATES FURNISHED BY: ______
THICKNESS ______ IN.
○ SUB PLATES REQUIRED(3.2.3.2)
○ HOLD-DOWN BOLTS FURNISHED BY ______
○ EPOXY PRIMER VENDOR(3.2.1.2.7) ______
○ ANCHOR BOLTS FURNISHED BY ______

GEAR UNIT

FURNISHED BY: ______ ○ REFERENCE API 613 ○ OTHER ______
SEE DATA SHEETS ______

CONTROLS AND INSTRUMENTATION(3.4)

INSTRUMENTS AND CONTROL PANELS SHALL BE IN ACCORDANCE WITH THE FOLLOWING ATTACHED DATA SHEETS(3.4.4.1):

○ API-614 APPENDIX B, PAGES ______
○ API 670 APPENDIX D, PAGES ______
○ PURCHASER'S DATA SHEETS ______
○ ANNUC. PER ISA S 18-1 OPTION ______

PROTECTIVE DEVICES

PROTECTIVE DEVICES(3.4.2)	EXHAUST RELIEF VALVE (2.2.3)(2.2.4)(3.4.5.7)	EXTRACT./INDUCT. RELIEF VALVE (2.2.3)(2.2.4)(3.4.5.7)	VACUUM BREAKER (3.4.2.5.4)	NON-RETURN VALVE (3.4.2.5.2)	
MOUNTING LOCATION					
SET RELIEF PRESS. PSIG					
CAPACITY, LBS/HR STEAM					
VALVE MANUFACTURER					
VALVE TYPE					
VALVE SIZE/RATING					
FLANGE FACING					
FURNISHED BY					
QUANTITY					

REMARKS:

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SPECIAL PURPOSE STEAM TURBINE DATA SHEET CUSTOMARY UNITS

JOB NO. ____________ ITEM NO. ____________
REVISION ____________ DATE ____________
BY ____________

○ TRIP ○ TRIP & THROTTLE VALVE(3.4.2.4)

LOCATION: ○ MAIN INLET ○ INDUCTION
PROVIDED BY: ○ VENDOR ○ PURCHASER
☐ MANUFACTURER ____________ MODEL ____________
☐ SIZE ______ RATING ______ FACING ______
☐ SIZE ______ RATING ______ FACING ______
☐ SIZE ______ RATING ______ FACING ______

CONSTRUCTION FEATURES:	INLET	INDUCT.
RESET: ○ MANUAL ○ HYDRAULIC		
TRIP: ○ LOCAL(MANUAL) ○ REMOTE		
EXERCISER: ○ LOCAL(MANUAL) ○ REMOTE		
○ FULLY OIL OPERATED		

☐ STRAINER: OPENING SIZE ________ (IN./MESH)
MATERIAL ____________
○ TEMPORARY START-UP STRAINER ________ (MESH)
MATERIAL ____________
☐ STEM MATL ____________ HARDNESS ________ RC
☐ SEAT MATL ____________ HARDNESS ________ RC
☐ PACKING MATL ____________ LEAKOFF ________ LB/HR
☐ SPRING SUPPORT OF VALVE REQUIRED
○ BY VENDOR ○ BY PURCHASER

CONTROL VALVES:

LOCATION	MAIN INLET	INDUCTION	INDUCTION EXTRACTION	INDUCTION EXTRACTION	NOTES
TRIP POSITION(OPEN/CLOSED)					
NUMBER OF VALVES					
PROVIDED BY					
MANUFACTURER					
CONNECTION SIZE					
RATING					
FACING(RF,RTJ,OTHER)					
ACTION(CAM,BAR,OTHER)					
STEM MATERIAL					
STEM MATERIAL HARDNESS, RC					
SEAT MATERIAL					
SEAT MATERIAL HARDNESS, RC					
PACKING MATERIAL					
PACKING LEAKOFF, LBS/HR					

TURNING GEAR(3.9)

○ TURNING GEAR REQUIRED(3.9.1)
○ FURNISHED BY ____________
○ TYPE ____________ SPEED ________ RPM
○ ENGAGEMENT: ○ AUTO ○ MANUAL
○ MFR ____________ MODEL ____________
○ MOUNTED BY ____________
○ DRIVER: REF. SPEC: ____________
TYPE: ○ ELEC ○ OTHER
○ OPERATOR STATION(3.9.5) ○ LOCAL ○ REMOTE

MISCELLANEOUS

○ START-UP ASSISTANCE (2,1,7) ________ DAYS
○ VENDOR'S REVIEW & COMMENTS ON PURCHASER'S PIPING & FOUNDATION DRAWINGS(2.1.7)
○ VENDOR WITNESS INITIAL ALIGNMENT(2.1.7)
○ "Y" TYPE STAINER
○ WATER WASHING CONNECTIONS
○ STATIC CONDUCTING BRUSHES
○ TARGETS(3.2.2.2) ○ LEVELING PADS
○ ____________

INSULATION & JACKETING(3.7)

○ BLANKET ○ OTHER ____________
○ JACKETING
○ CARBON STEEL ○ STAINLESS STEEL
○ EXTENT ____________

SPECIAL TOOLS(3.8)

○ COUPLING RING AND PLUG GAUGE
○ HYDRAULIC COUPLING MOUNTING/REMOVAL KIT
○ OTHER ____________

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SPECIAL PURPOSE STEAM TURBINE
DATA SHEET
CUSTOMARY UNITS

JOB NO. ____________ ITEM NO. ____________
REVISION ____________ DATE ____________
BY ____________

GOVERNOR(3.4.3)

TYPE ○MECHANICAL ○ELECTRONIC
○SIMPLEX
○MULTIPROCESSOR

○NEMA CLASSIFICATION ____________
○MFR ____________ MODEL ____________
○SUPPLIED BY ____________

STEAM TURBINE TYPE

○SINGLE VALVE SINGLE STAGE
○MULTIVALVE MULTISTAGE
○DOUBLE AUTO EXTRACTION
○DOUBLE AUTO EXTRACTION/INDUCTION

○SINGLE VALVE MULTISTAGE
○SINGLE AUTO EXTRACTION
○SINGLE AUTO EXTRACTION/INDUCTION
○OTHER ____________

DRIVEN EQUIPMENT TYPE

○CENTRIFUGAL COMPRESSOR
○SYNCHRONOUS GENERATOR
○FAN

○CENTRIFUGAL PUMP
○INDUCTION GENERATOR
○OTHER ____________

SERVICE REQUIREMENTS

MECHANICAL DRIVE

○SPEED CONTROL BY ____________

PROCESS PRESSURE

EXTRACTION	○PRESSURE	○FLOW
INDUCTION	○PRESSURE	○FLOW
TURBINE INLET	○PRESSURE	○FLOW
TURBINE EXHAUST	○PRESSURE	○FLOW

GENERATOR DRIVE

○DROOP CONTROL
○FREQ. CONTROL
○LOAD CONTROL
○KW CONTROL
○KW IMPORT/EXPORT CONTROL
○LOAD SHEDDING
○AUTO SYNCHRONIZATION
○AUTO VOLTAGE REGULATION
○TURBINE INLET PRESSURE LIMITING
○INLET PRESSURE LIMITER

MINIMUM INPUT/OUTPUT REQUIREMENTS

DISCRETE INPUTS

○START OR RESET
○NORMAL STOP
○EMERGENCY TRIP
○RAISE TRIP
○LOWER SPEED
○ENABLE/DISABLE REMOTE SPEED SETPOINT
○RAMP TO MINIMUM CONTINUOUS
○OVERSPEED TEST ENABLE
○ENABLE PRESSURE CONTROL
○ENABLE ALARM CLEAR/ACKNOWLEDGE
○REMOTE ALARM CLEAR/ACKNOWLEDGE
○ENABLE AUTO SYNCH.
○CASCADE RAISE/LOWER
○OTHER ____________

ANALOG INPUTS(4-20mA)

○REMOTE SET POINT
○PROCESS PRESSURE
○EXTRACTION ○PRESSURE ○FLOW
○KW IND. LOAD ○PRESSURE ○FLOW
○KW IMPORT/EXPORT
○OTHER ____________
____

DISCRETE OUTPUTS

○COMMON SHUTDOWN
○COMMON ALARM
○OVERSPEED TRIP ____________ RPM
○REMOTE SPEED SETPOINT ENABLED
○PRESSURE CONTROL ENABLED
○FLOW CONTROL ENABLED
○EXTRACTION CONTROL ENABLED
○INDUCTION CONTROL ENABLED
○SPEED PICKUP ALARM
○OTHER ____________
____
____

ANALOG ACCESSORY OUTPUTS(4-20 mA)

○SPEED
○SPEED SETPOINT
○REMOTE SPEED SETPOINT
○EXTRACTION PRESSURE
○EXTRACTION PRESSURE SETPOINT
○ACTUATOR POSITION
○PROCESS PRESSURE
○KW
○KW IMPORT/EXPORT

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SPECIAL PURPOSE STEAM TURBINE DATA SHEET CUSTOMARY UNITS

JOB NO. ______ ITEM NO. ______
REVISION ______ DATE ______
BY ______

GOVERNOR INSTALLATION REQUIREMENTS

LOCATION: ○ LOCAL(AT TURBINE) ○ REMOTE(CONTROL ROOM) ○ OTHER ______

MOUNTING: ○ FLUSH MOUNT IN PANEL ○ SURFACE MOUNT ○ VERTICAL RACK

ENCLOSURE: ○ GENERAL PURPOSE ○ NEMA 4 ○ NEMA 4X ○ NEMA PURGE TYPE ○ EXPLOSION PROOF

POWER SOURCE	SINGLE	DUAL
120 VAC	○	○
220 VAC	○	○
125 VDC	○	○
24 VDC	○	○

LOCAL GOVERNOR CONTROL PANEL ○ REQUIRED ○ NOT REQUIRED

LOCATION: ○ LOCAL(AT TURBINE) ○ REMOTE CONTROL ROOM ○ OTHER ______

ENCLOSURE: ○ GENERAL PURPOSE ○ NEMA 4 ○ NEMA 4X ○ EXPLOSION PROOF

OUTPUTS FROM PANEL TO GOVERNOR

- ○ START
- ○ TRIP
- ○ RAISE
- ○ LOWER
- ○ OVERSPEED TEST
- ○ RAMP TO MINIMUM CONTINUOUS
- ○ REMOTE SETPOINT ENABLE/DISABLE
- ○ RESET
- ○ OTHER ______

INPUTS TO PANEL FROM GOVERNOR

- ○ COMMON ALARM TRIP
- ○ TRIP LAMP
- ○ REMOTE SETPOINT ENABLED LAMP
- ○ SPEED SETPOINT METER
- ○ OTHER ______

MISCELLANEOUS GOVERNOR DETAILS

GOVERNOR ACTION ON LOSS OF REMOTE SIGNAL: ○ LOCKS ON LAST VALUE ○ GOES TO MINIMUM CONTINUOUS ○ GOES TO MAXIMUM CONTINUOUS

EXTERNAL INTERFACE DEVICE TYPE: ○ PRINTER ○ CRT

FORMAT: ○ GRAPHIC DISPLAY ○ TABULAR DATA ○ TRENDING(REAL TIME) ○ HISTORICAL ARCHIVING

○ DISTRIBUTIVE CONTROL SYSTEM MANUFACTURER ______ ○ MODEL ______

DATA TRANSMISSION: ○ SERIAL DATA LINK ○ DISCRETE I/O ○ NETWORK TYPE ______

○ PROTOCOL ______

○ BAUD RATE ○ 300 ○ 4800 ○ 1200 ○ 9600 ○ 2400 ○ 19200

MAGNETIC SPEED PICKUP

MANUFACTURER ______ MODEL ______ INSTALLATION: ○ DUAL ○ TRIPLE ○ INSTALLED SPARE

GOVERNOR SPEED PICKUP(S)(3.4.3.3): ○ NO. REQD ______ ○ DIRECT ○ 60 TOOTH WHEEL

○ OTHER ______

TURBINE MOUNTED ACCESSORIES

ACTUATOR: ○ SUPPLIED BY ______ ○ MANUFACTURER ______ ○ MODEL ______

ACTUATOR TYPE ○ HYDRAULIC ○ PNEUMATIC ○ SINGLE COIL ○ MULTI COIL ○ OTHER ______

TACHOMETER ○ MANUFACTURER ______ ○ MODEL ______ ○ NO. REQD ______

○ LOCATION(S) ______

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SPECIAL PURPOSE STEAM TURBINE DATA SHEET CUSTOMARY UNITS

JOB NO. ____________ ITEM NO. ____________
REVISION ____________ DATE ____________
BY ____________

OVERSPEED TRIP(3.4.2)

( ) FURNISHED BY ____________
( ) MFR ____________ ( ) MODEL ____________
[ ] ELECTRONIC, SET POINT ____________ RPM
( ) OVERSPEED SHUTDOWN REQUIREMENTS
( ) 1 OUT OF 2 ( ) 2 OUT OF 3 VOTING LOGIC
( ) OTHER ____________
( ) MECHANICAL OVERSPEED SET POINT ____________
[ ] TYPE ____________

( ) NO. SPEED PICKUPS ______ [ ] TYPE ______ TOOTHWHEEL
( ) OTHER ____________
( ) SPEED PICKUPS FURNISHED BY ____________
( ) SOLENOIDS SHALL: ( ) DE-ENERGIZE TO TRIP ( ) ENERGIZE TO TRIP
( ) CONTACTS SHALL BE: ( ) NORMALLY OPEN ( ) NORMALLY CLOSED

GLAND SEALING AND VACUUM SYSTEM(3.5)

SYSTEM PER: ( ) APPENDIX B-1 ( ) APPENDIX B-2
( ) OTHER ____________
( ) AVAIL. HEADER PRESS ______ PSIG TEMP ______ °F
( ) AVAIL. SEAL STEAM SUPPLY PRESS ______ PSIG
( ) AVAIL. SEAL STEAM SUPPLY TEMP. ______ °F
[ ] SEALING STM. PRESS ______ PSIG [ ] FLOW ______ LBS/HR.
[ ] SEALING STM. RELIEF VALVE SET PRESS ______ PSIG
FURNISHED BY ____________
[ ] FLOW ADJUSTING VALVES, TYPE ____________
FURNISHED BY ____________

( ) VACUUM SYSTEM FURNISHED BY ____________
( ) SHIP LOOSE ( ) SKID MOUNTED
( ) OTHER ____________
( ) GLAND CONDENSER, SEE SPEC. ____________
( ) STEAM EJECTOR [ ] STM. PRESS. ______ PSIG
[ ] STM. FLOW ______ LBS/HR.
( ) VACUUM PUMP(3.5.2), SEE SPEC. ____________
( ) CONDENSATE RECEIVER
( ) LOOP SEAL HEIGHT ______ FT.

INSPECTION AND TESTING(4.2)(4.3)

GENERAL

( ) SHOP INSPECTION(4.1.4)
EXTENT: ____________

INSPECTION AND MATERIAL TESTING

( ) FINAL ASSEMBLY RECORDS REQUIRED(4.2.1.1.e)
SPECIAL MAT'L INSP. & TESTING REQUIREMENTS

COMPONENT	MAG PART	DYE PEN	R.T.	U.T.	OBSVD	WIT
TRIP & T&T VALVE					( )	( )
STM CHEST					( )	( )
CASING					( )	( )
PIPING					( )	( )
ROTOR					( )	( )
					( )	( )

	OBSVD	WIT
( ) HEAT STABILITY(4.2.2.3.4)	( )	( )
( ) CLEANLINESS(4.2.3.2)	( )	( )
( ) HARDNESS(4.2.3.4)	( )	( )
( ) HYDROSTATIC TESTS(4.3.2)	( )	( )
( ) BLADE SHAKER(STATIC)	( )	( )
ROTOR BALANCE ( ) STANDARD(2.8.5)	( )	( )
( ) HIGH SPEED(2.8.5.4)	( )	( )
( ) FINAL SURFACE INSPECTION(4.4.3)	( )	( )
( ) CRATING INSPECTION	( )	( )
( ) SPARE ROTOR FIT	( )	( )
( ) CASING JOINT LEAK TEST(4.3.2.7)	( )	( )
( ) ____________	( )	( )
( ) ____________	( )	( )
( ) ____________	( )	( )

MECHANICAL RUNNING TEST(4.3.3)

	OBSVD	WIT
( ) CONTRACT ROTOR	( )	( )
( ) SPARE ROTOR	( )	( )
( ) TEST W/JOB COUPLING	( )	( )
( ) TEST TAPE RECORD. REQ'D	( )	( )
( ) TEST TAPE GIVEN TO PURCH.	( )	( )
( ) TEST W/JOB L.O. CONSOLE	( )	( )
( )	( )	( )

OPTIONAL TESTS AND INSPECTIONS(4.3.4)

	OBSVD	WIT
( ) PERFORMANCE(4.3.4.1)	( )	( )
( ) COMPLETE UNIT(4.3.4.2)	( )	( )
( ) TORSIONAL MEASMT'S(4.3.4.2)	( )	( )
AUX. EQUIPMENT(4.3.4.3)		
( ) TRIP/T&T VALVE	( )	( )
( ) GLAND SEAL. SYSTEM	( )	( )
( ) GLAND VACUUM SYSTEM	( )	( )
( ) RELIEF VALVES	( )	( )
( ) ____________	( )	( )
( ) CASING INTERNAL INSP(4.3.4.4)	( )	( )
( ) COUPLING TO SHAFT FIT(API 671)	( )	( )
( ) TURNING GEAR	( )	( )
ADDITIONAL TEST OR INSPECTIONS		
( ) ____________	( )	( )
( ) ____________	( )	( )
( ) ____________	( )	( )
( ) ____________	( )	( )
( ) ____________	( )	( )

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SPECIAL PURPOSE STEAM TURBINE DATA SHEET CUSTOMARY UNITS

JOB NO. ______________ ITEM NO. ______________

REVISION ______________ DATE ______________

BY ______________

MISCELLANEOUS

PAINTING

○ MANUFACTURER'S STANDARD
○ OTHER ______________
○ ______________

SHIPMENT(4.4.1)(4.4.3.10)

○ DOMESTIC ○ EXPORT
○ EXP BOXING REQUIRED ○ OUTDOOR STORAGE OVER 6 MONTHS
○ WATERPROOF BOXING REQUIRED
○ SPARE ROTOR ASSEMBLY PACKAGED FOR:
○ HORIZONTAL STORAGE ○ VERTICAL STORAGE

WEIGHTS:

☐ TURBINE ______ LB.
☐ ROTOR ______ LB.
☐ TURBINE UPPER HALF CASING ______ LB.
☐ MAX. FOR MAINT.(IDENTIFY) ______ LB.
☐ TRIP/T & T. VALVE ______ LB.
☐ MISC. ______ LB.
☐ TOTAL SHIPPING WEIGHT ______ LB.

SPACE REQUIREMENTS:

☐ COMPLETE UNIT: L ______ IN. W ______ IN. H ______ IN.
☐ CONTROL PANEL: L ______ IN. W ______ IN. H ______ IN.
☐ OTHER: L ______ IN. W ______ IN. H ______ IN.
☐ OTHER: L ______ IN. W ______ IN. H ______ IN.

VENDOR DWG & DATA REQUIREMENTS(5)

○ APPENDIX E(5.3.3.1)
○ OTHER
○ PROGRESS REPORTS REQ'D(5.3.4)
FREQUENCY ______________

REMARKS AND ADDITIONAL REQUIREMENTS ______________

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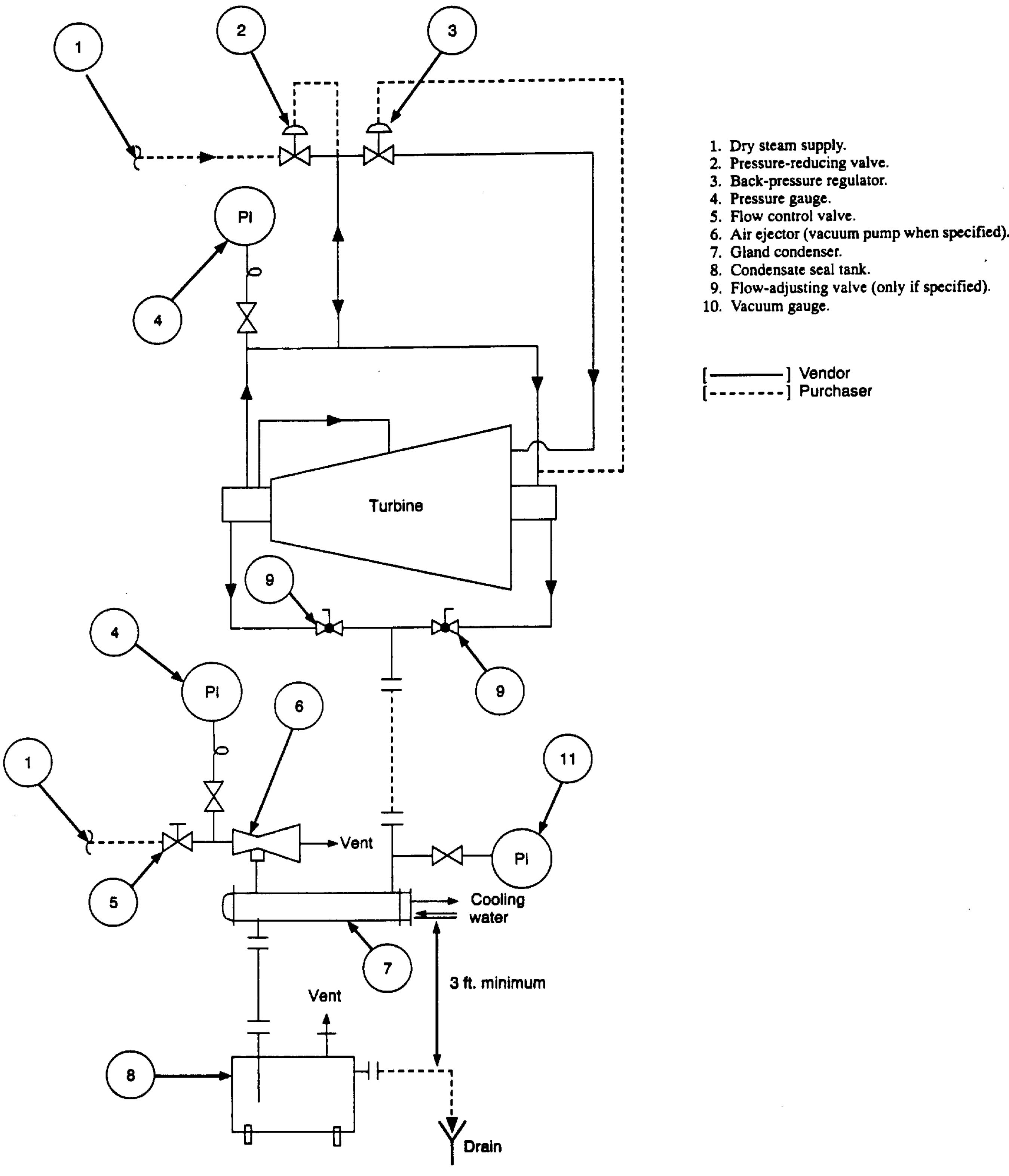
APPENDIX B—GLAND SEALING AND LEAK-OFF SYSTEM



Note: Broken lines indicate the purchaser's piping.

Figure B-1—Typical Gland Sealing and Leak-Off System for Condensing Turbines

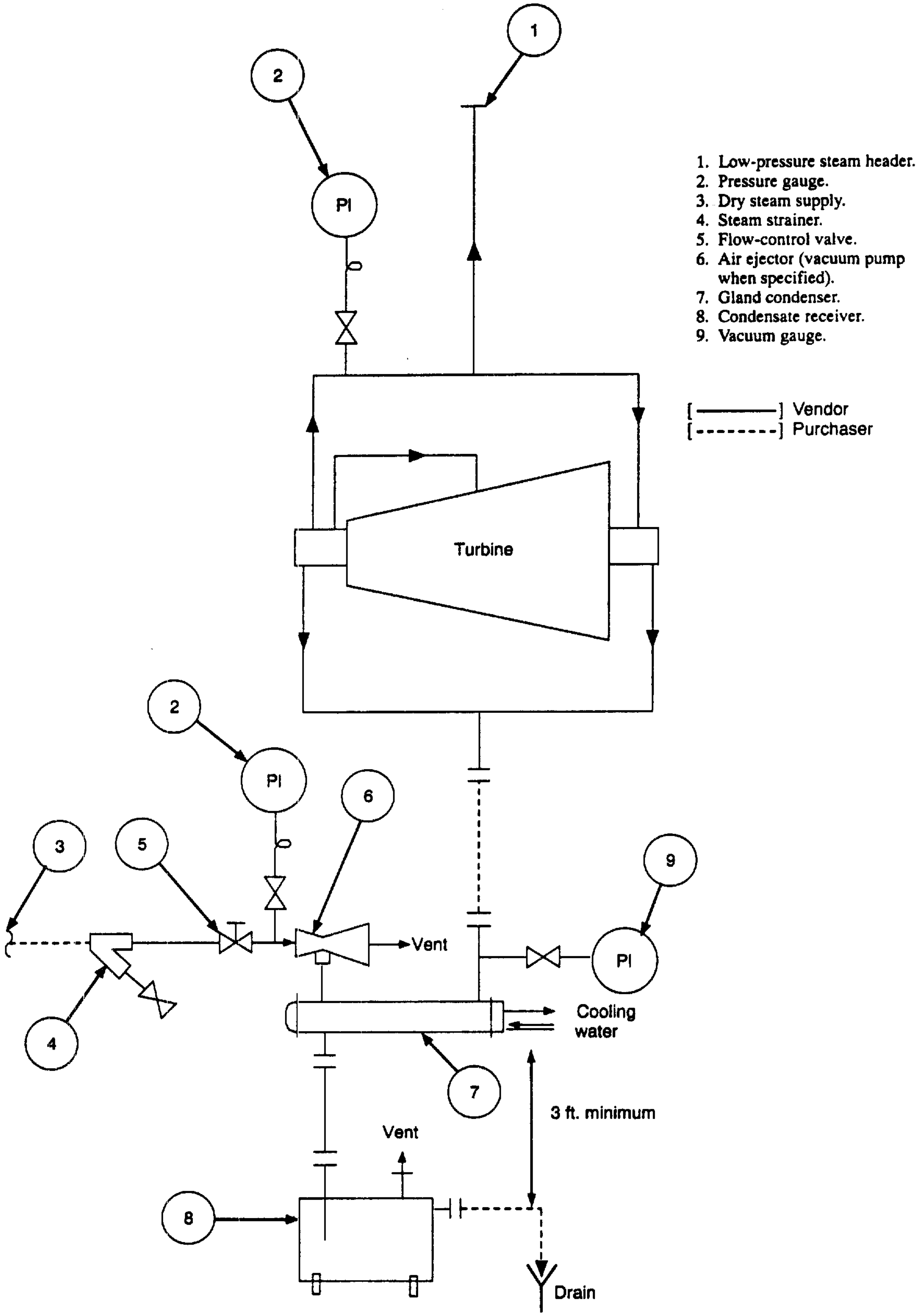
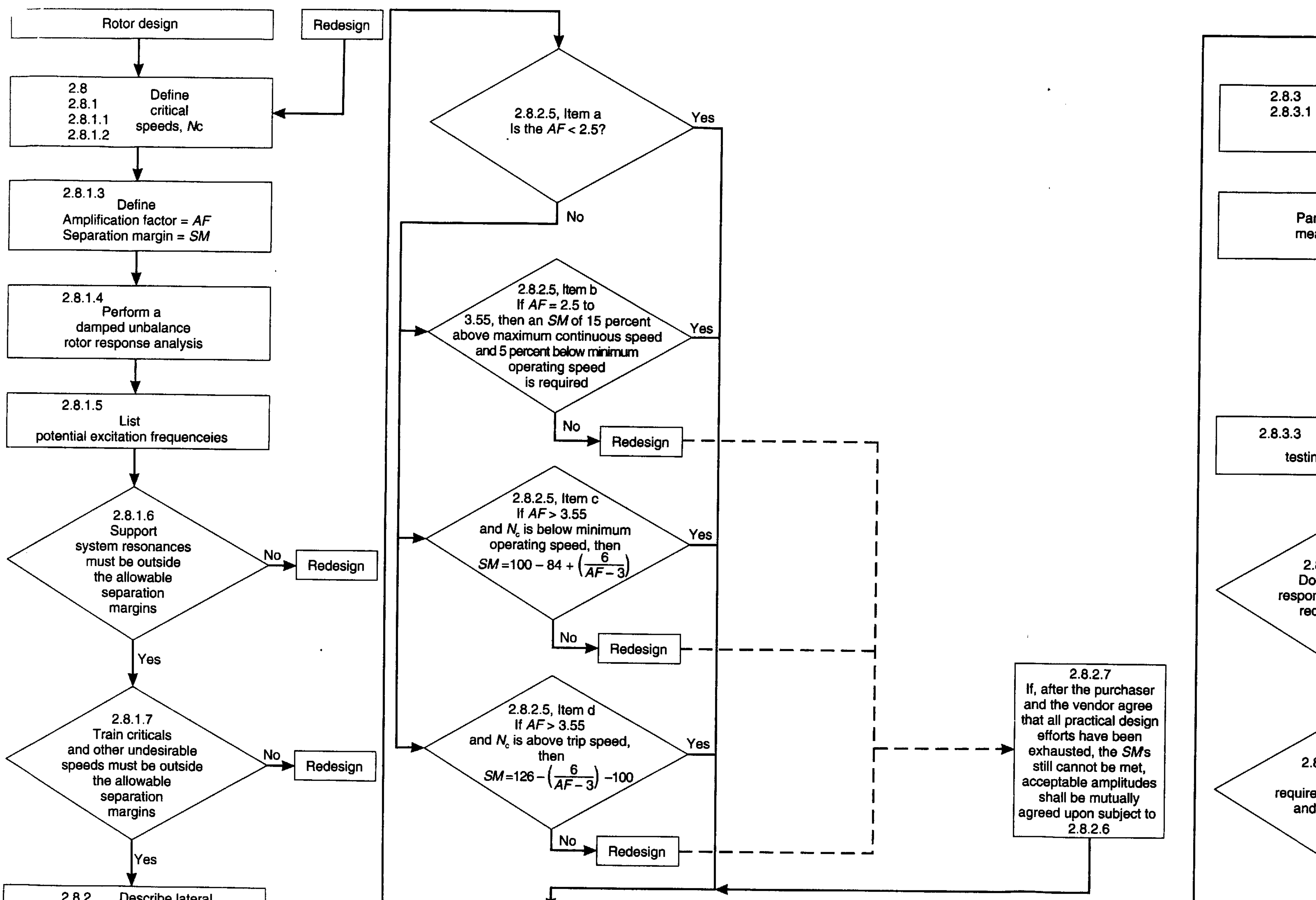


Figure B-2—Typical Gland Leak-Off System for Back-Pressure Turbines

APPENDIX C—ROTOR DYNAMICS LOGIC DIAGRAMS


Rotor design
Redesign
2.8
2.8.1
2.8.1.1
2.8.1.2
Define critical speeds, Nc
2.8.1.3
Define
Amplification factor = AF
Separation margin = SM
2.8.1.4
Perform a damped unbalance rotor response analysis
2.8.1.5
List potential excitation frequenceies
2.8.1.6
Support system resonances must be outside the allowable separation margins
No
Redesign
Yes
2.8.1.7
Train criticals and other undesirable speeds must be outside the allowable separation margins
No
Redesign
Yes
2.8.2 Describe lateral
2.8.2.5, Item a
Is the AF < 2.5?
Yes
No
2.8.2.5, Item b
If AF = 2.5 to 3.55, then an SM of 15 percent above maximum continuous speed and 5 percent below minimum operating speed is required
Yes
No
Redesign
2.8.2.5, Item c
If AF > 3.55 and Nc is below minimum operating speed, then SM = 100 – 84 + (6/(AF – 3))
Yes
No
Redesign
2.8.2.5, Item d
If AF > 3.55 and Nc is above trip speed, then SM = 126 – (6/(AF – 3)) –100
Yes
No
Redesign
2.8.2.7
If, after the purchaser and the vendor agree that all practical design efforts have been exhausted, the SMs still cannot be met, acceptable amplitudes shall be mutually agreed upon subject to 2.8.2.6
2.8.3
2.8.3.1
2.8.3.3

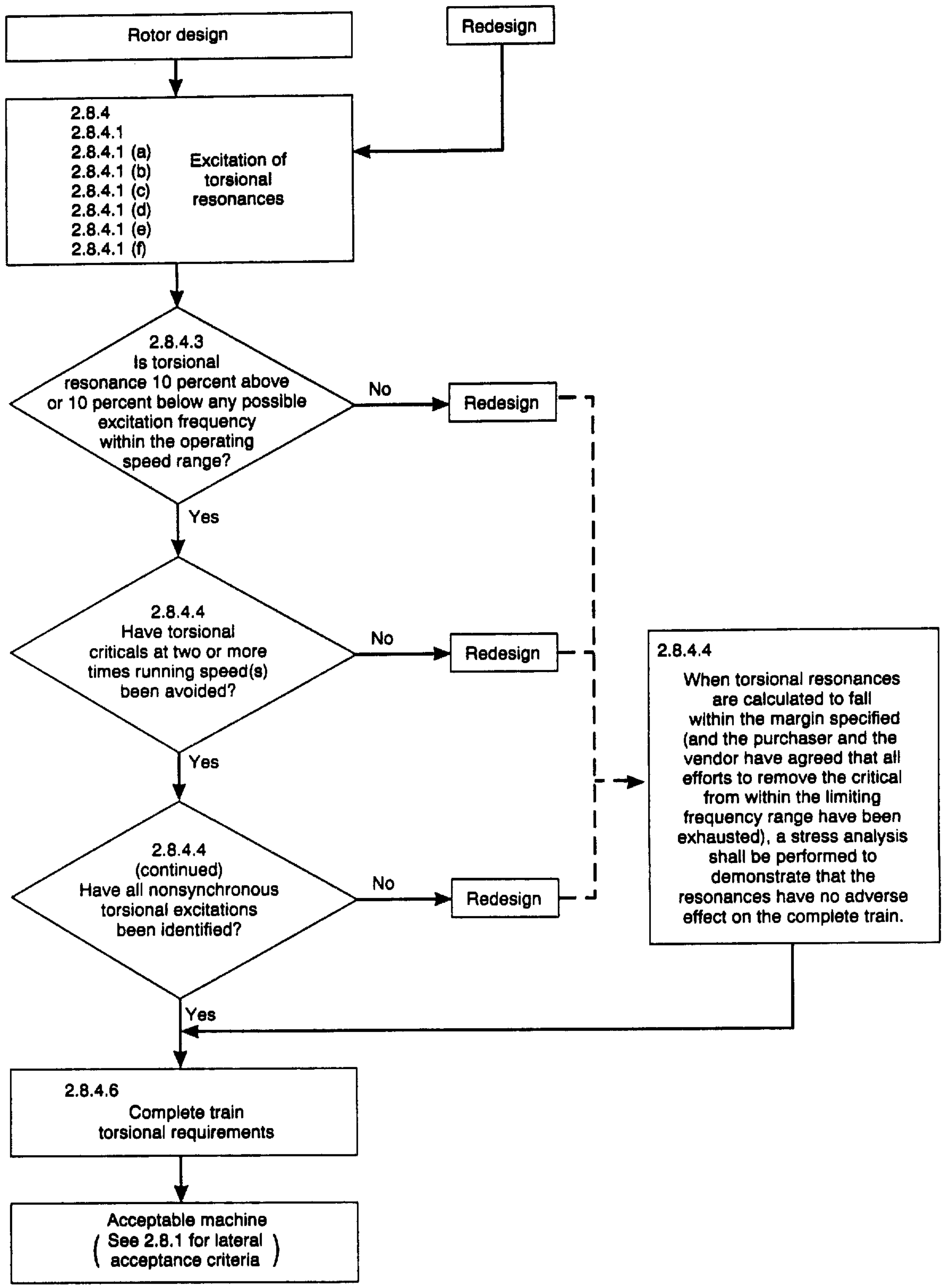


Figure C-2—Rotor Dynamics Logic Diagram (Torsional Analysis)

APPENDIX D—PROCEDURE FOR DETERMINATION OF RESIDUAL UNBALANCE

D.1 Scope

This appendix describes the procedure to be used to determine residual unbalance in machine rotors. Although some balancing machines may be set up to read out the exact amount of unbalance, the calibration can be in error. The only sure method of determining residual unbalance is to test the rotor with a known amount of unbalance.

D.2 Definition

Residual unbalance refers to the amount of unbalance remaining in a rotor after balancing. Unless otherwise specified, residual unbalance shall be expressed in g•mm or oz-in.

D.3 Maximum Allowable Residual Unbalance

D.3.1 The maximum allowable residual unbalance per plane shall be calculated using Equation 5 in 2.8.5.2 of this standard.

D.3.2 If the actual static weight load on each journal is not known, assume that the total rotor weight is equally supported by the bearings. For example, a two bearing rotor weighing 3000 kg (6600 lbs) would be assumed to impose a static weight load of 1500 kg (3300 lbs) on each journal.

D.4 Residual Unbalance Check

D.4.1 GENERAL

D.4.1.1 When the balancing machine readings indicate that the rotor has been balanced to within the specified tolerance, a residual unbalance check shall be performed before the rotor is removed from the balancing machine.

● **D.4.1.2** To check the residual unbalance, a known trial weight is attached to the rotor sequentially in six (or twelve, if specified by the purchaser) equally spaced radial positions, each at the same radius. The check is run in each correction plane, and the readings in each plane are plotted on a graph using the procedure specified in D.4.2.

D.4.2 PROCEDURE

D.4.2.1 Select a trial weight and radius that will be equivalent to between one and two times the maximum allowable residual unbalance [that is, if U_{max} is 1440 g•mm (2 oz-in.), the trial weight should cause 1440–2880 g•mm (2–4 oz-in.) of unbalance].

D.4.2.2 Starting at the last known heavy spot in each correction plane, mark off the specified number of radial positions (six or twelve) in equal (60 or 30 degree) increments around the rotor. Add the trial weight to the last known heavy spot in one plane. If the rotor has been balanced very precisely and the final heavy spot cannot be determined, add the trial weight to any one of the marked radial positions.

D.4.2.3 To verify that an appropriate trial weight has been selected, operate the balancing machine and note the units of unbalance indicated on the meter. If the meter pegs, a smaller trial weight should be used. If little or no meter reading results, a larger trial weight should be used. Little or no meter reading generally indicates that the rotor was not balanced correctly, the balancing machine is not sensitive enough, or a balancing machine fault exists (i.e., a faulty pickup). Whatever the error, it must be corrected before proceeding with the residual check.

D.4.2.4 Locate the weight at each of the equally spaced positions in turn, and record the amount of unbalance indicated on the meter for each position. Repeat the initial position as a check. All verification shall be performed using only one sensitivity range on the balance machine.

D.4.2.5 Plot the readings on the residual unbalance work sheet and calculate the amount of residual unbalance (see Figure D-1). The maximum meter reading occurs when the trial weight is added at the rotor's heavy spot; the minimum reading occurs when the trial weight is opposite the heavy spot. Thus, the plotted readings should form an approximate circle (see Figure D-2). An average of the maximum and minimum meter readings represents the effect of the trial weight. The distance of the circle's center from the origin of the polar plot represents the residual unbalance in that plane.

D.4.2.6 Repeat the steps described in D.4.2.1 through D.4.2.5 for each balance plane. If the specified maximum allowable residual unbalance has been exceeded in any balance plane, the rotor shall be balanced more precisely and checked again. If a correction is made in any balance plane, the residual unbalance check shall be repeated in all planes.

D.4.2.7 For stack component balanced rotors, a residual unbalance check shall be performed after the addition and balancing of the first rotor component, and at the completion of balancing of the entire rotor, as a minimum.

Note: This ensures that time is not wasted and rotor components are not subjected to unnecessary material removal in attempting to balance a multiple component rotor with a faulty balancing machine.

Equipment (Rotor) No.: ______________

Purchase Order No.: ______________

Correction Plane (inlet, drive end, etc.—use sketch): ______________

Balancing Speed: ______________ rpm

N—Maximum Allowable Rotor Speed: ______________ rpm

W—Weight of Journal (closest to this correction plane): ______________ kg (lbs)

U_{max} = Maximum Allowable Residual Unbalance =
6350 *W/N* (4 *W/N*)
6350 × ______ kg/______ rpm; (4 × ______lbs/______rpm) ______________ g•mm (oz-in.)

Trial unbalance (2 × U_{max}) ______________ g•mm (oz-in.)

R—Radius (at which weight will be placed): ______________ mm (in.)

Trial Unbalance Weight = Trial Unbalance/*R*

______g•mm/______mm (______oz-in./______in.) ______________ g (oz)

Conversion Information: 1 ounce = 28.350 grams

Test Data

Position	Trial Weight Angular Location	Balancing Machine Amplitude Readout
1	*0°*	
2	*60°*	
3	*120°*	
4	*180°*	
5	*240°*	
6	*300°*	
Repeat 1	*0°*	

Rotor Sketch

Test Date—Graphic Analysis

Step 1: Plot data on the polar chart (Figure D-1 continued). Scale the chart so the largest and smallest amplitude will fit conveniently.

Step 2: With a compass, draw the best fit circle through the six points and mark the center of this circle.

Step 3: Measure the diameter of the circle in units of scale chosen in Step 1 and record. ______________ units

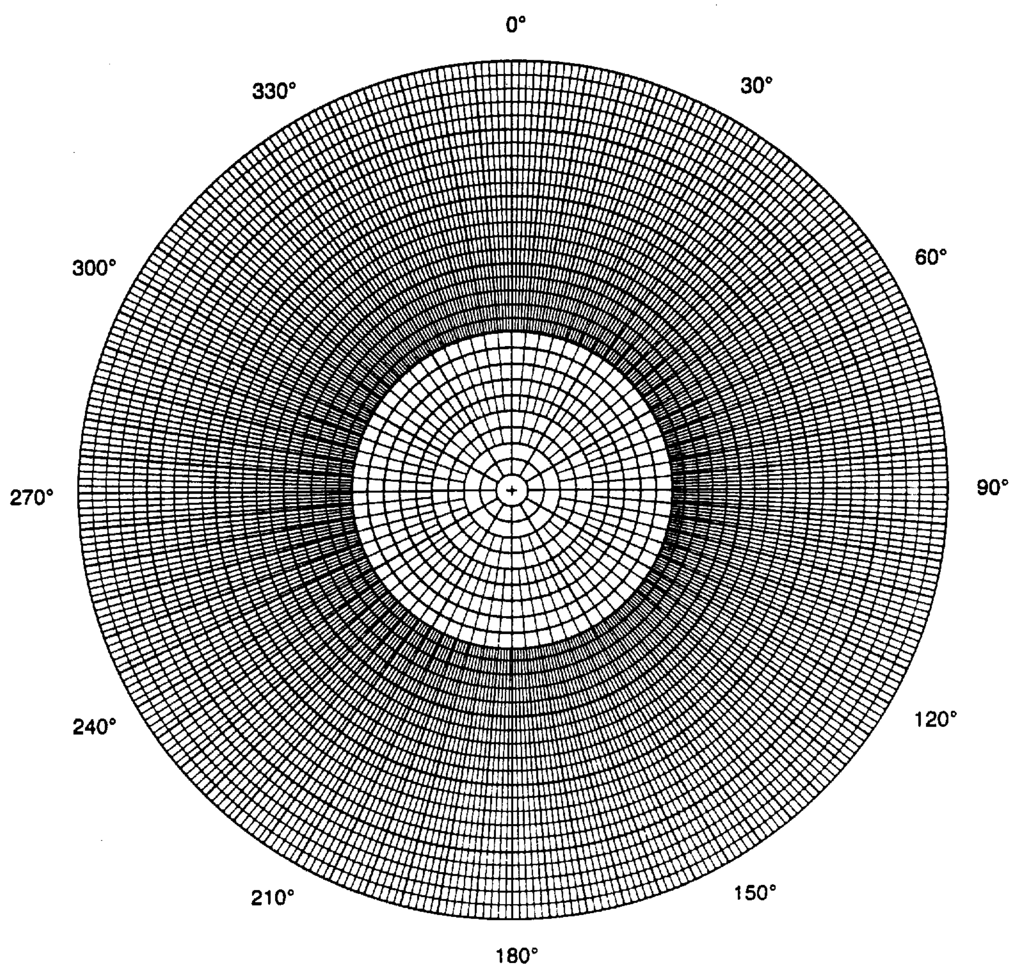
Step 4: Record the trial unbalance from above. ______________ g•mm (oz-in.)

Step 5: Double the trial unbalance in Step 4 (may use twice the actual residual unbalance). ______________ g•mm (oz-in.)

Step 6: Divide the answer in Step 5 by the answer in Step 3. ______________ Scale Factor

You now have a correlation between the units on the polar chart and the actual balance.

Figure D-1—Residual Unbalance Work Sheet



The circle you have drawn must contain the origin of the polar chart. If it doesn't, the residual unbalance of the rotor exceeds the applied test unbalance.

NOTE: Several possibilities for the drawn circle not including the origin of the polar chart are: operator error during balancing, a faulty balancing machine pickup or cable, or the balancing machine is not sensitive enough.

If the circle does contain the origin of the polar chart, the distance between origin of the chart and the center of your circle is the actual residual unbalance present on the rotor correction plane. Measure the distance in units of scale you choose in Step 1 and multiply this number by the scale factor determined in Step 6. Distance in units of scale between origin and center of the circle times scale factor equals actual residual unbalance.

Record actual residual unbalance ____________________(g•mm)(oz-in.)

Record allowable residual unbalance (from Figure D-1) ________(g•mm)(oz-in.)

Correction plane ____________ for Rotor No. __________ (has/has not) passed.

By ____________________________ Date ____________________________

Figure D-1—Residual Unbalance Work Sheet (Continued)

Equipment (Rotor) No.: *C–101*

Purchase Order No.: ______

Correction Plane (inlet, drive end, etc.–use sketch): *A*

Balancing Speed: *800* rpm

N—Maximum Allowable Rotor Speed: *10,000* rpm

W—Weight of Journal (closet to this correction plane): *908* ~~kg~~ (lbs)

U_{max} = Maximum Allowable Residual Unbalance =
6350 *W*/*N* (4 *W*/*N*)
~~6350 × ______ kg/______ rpm~~; 4 × *908* lbs/ *10,000* rpm — *0.36* ~~g-mm~~ (oz-in.)

Trial unbalance (2 × U_{max}) — *0.72* ~~g-mm~~ (oz-in.)

R—Radius (at which weight will be placed): *6.875* ~~mm~~ (in.)

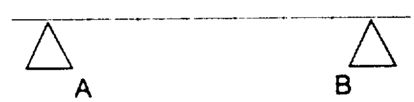
Trial Unbalance Weight = Trial Unbalance/*R*
~~______ g-mm/______ mm~~ *0.72* oz-in./ *6.875* in. — *0.10* ~~g~~ (oz)

Conversion Information: 1 ounce = 28.350 grams

Test Data

Position	Trial Weight Angular Location	Balancing Machine Amplitude Readout
1	*0°*	*14.0*
2	*60°*	*12.0*
3	*120°*	*14.0*
4	*180°*	*23.5*
5	*240°*	*23.0*
6	*300°*	*15.5*
Repeat 1	*0°*	*13.5*

Rotor Sketch



C-101

Test Date—Graphic Analysis

Step 1: Plot data on the polar chart (Figure D-2 continued). Scale the chart so the largest and smallest amplitude will fit conveniently.

Step 2: With a compass, draw the best fit circle through the six points and mark the center of this circle.

Step 3: Measure the diameter of the circle in units of scale chosen in Step 1 and record. — *35* units

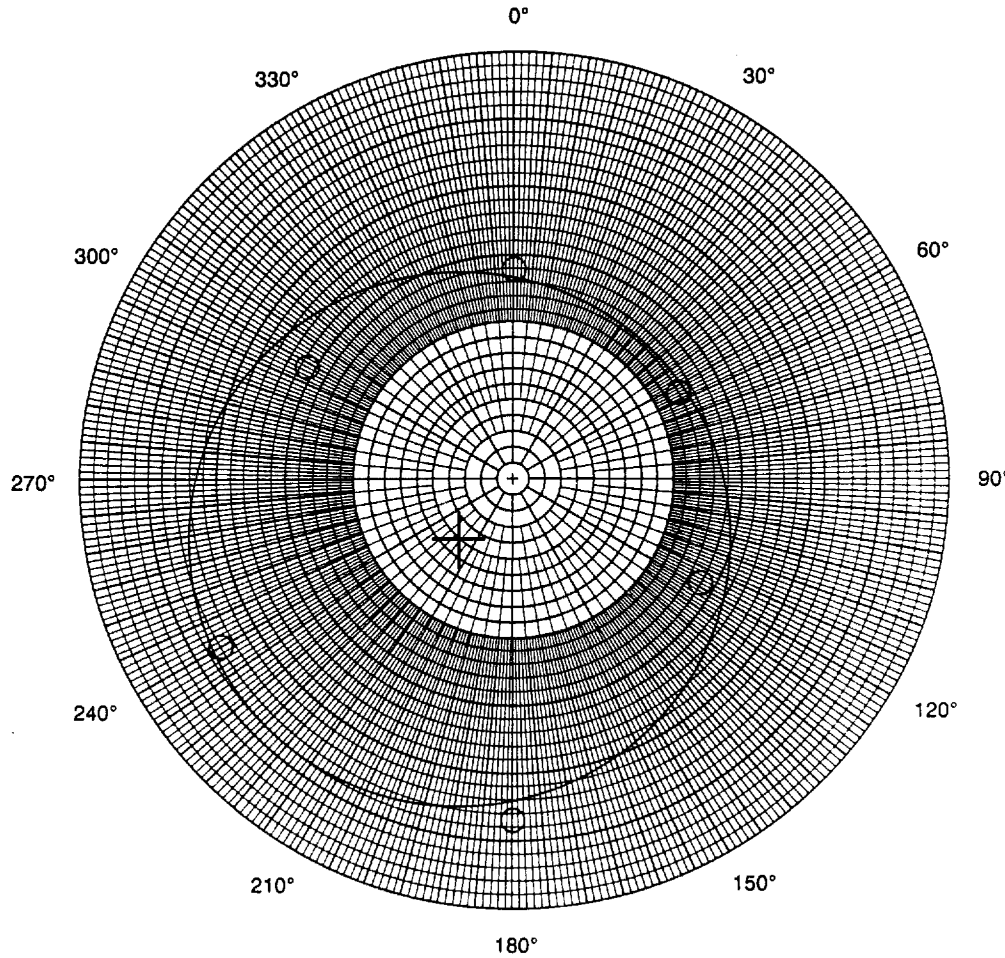
Step 4: Record the trial unbalance from above. — *0.72* ~~g-mm~~ (oz-in.)

Step 5: Double the trial unbalance in Step 4 (may use twice the actual residual unbalance). — *1.44* ~~g-mm~~ (oz-in.)

Step 6: Divide the answer in Step 5 by the answer in Step 3. — *0.041* Scale Factor

You now have a correlation between the units on the polar chart and the actual balance.

Figure D-2—Sample Calculations for Residual Unbalance



The circle you have drawn must contain the origin of the polar chart. If it doesn't, the residual unbalance of the rotor exceeds the applied test unbalance.

NOTE: Several possibilities for the drawn circle not including the origin of the polar chart are: operator error during balancing, a faulty balancing machine pickup or cable, or the balancing machine is not sensitive enough.

If the circle does contain the origin of the polar chart, the distance between origin of the chart and the center of your circle is the actual residual unbalance present on the rotor correction plane. Measure the distance in units of scale you choose in Step 1 and multiply this number by the scale factor determined in Step 6. Distance in units of scale between origin and center of the circle times scale factor equals actual residual unbalance.

Record actual residual unbalance *5 (0.041) = 0.21* (~~g-mm~~) (oz-in.)

Record allowable residual unbalance (from Figure B-3) *0.36* (~~g-mm~~) (oz-in.)

Correction plane *A* for Rotor No. *C-101* (has/~~has not~~) passed.

By *John Inspector* Date *11-31-94*

Figure D-2—Sample Calculations for Residual Unbalance (Continued)

APPENDIX E—SPECIAL PURPOSE STEAM TURBINE VENDOR DRAWING AND DATA REQUIREMENTS

SPECIAL PURPOSE STEAM TURBINE VENDOR DRAWING AND DATA REQUIREMENTS

JOB NO. ____________ ITEM NO. ____________

PURCHASE ORDER NO. ____________ DATE ____________

REQUISITION NO. ____________ DATE ____________

INQUIRY NO. ____________ DATE ____________

PAGE 1 OF 2 BY ____________

REVISION ____________

UNIT ____________

NO. REQUIRED ____________

FOR ____________

SITE ____________

SERVICE ____________

Proposal[a] Bidder shall furnish ______ copies of data for all items indicated by an X.

Review[b] Vendor shall furnish ______ copies and ______ transparencies of drawings and data indicated.

Final[c] Vendor shall furnish ______ copies and ______ transparencies of drawings and data indicated.
Vendor shall furnish ______ operating and maintenance manuals.

DISTRIBUTION RECORD

Final—Received from vendor
Final—Due from vendor[c]
Review—Returned to vendor
Review—Received from vendor
Review—Due from vendor[c]

Proposal	Review	Final	DESCRIPTION	Review—Due from vendor	Review—Received from vendor	Review—Returned to vendor	Final—Due from vendor	Final—Received from vendor
			1. Certified dimensional outline drawing and list of connections.					
			2. Cross-sectional drawings and bills of materials.					
			3. Rotor assembly drawings and bills of materials.					
			4. Thrust-bearing assembly drawing and bill of materials.					
			5. Journal-bearing assembly drawing and bill of materials.					
			6. Seal assembly drawing and bill of materials.					
			7. Coupling assembly drawing and bill of materials.					
			8. Gland sealing and leak-off schematic and bill of materials.					
			9. Gland sealing and leak-off arrangement drawing and list of connections.					
			10. Gland sealing and leak-off component drawings and data.					
			11. Lube-oil schematics and bills of materials.					
			12. Lube-oil system arrangement drawing and list of connections.					
			13. Lube-oil component drawings and data.					
			14. Electrical and instrumentation schematics and bills of materials.					
			15. Electrical and instrumentation arrangement drawings and lists of connections.					
			16. Control- and governor-system description and schematic.					
			17. Overspeed shutdown system description and schematic.					
			18. Curves showing steam flow versus horsepower (certified).					
			19. Curve showing steam flow versus first-stage pressure (certified).					
			20. Curves showing steam flow versus speed and efficiency (certified).					
			21. Curve showing steam flow versus valve lift.					
			22. Curves showing extraction/induction performance (certified).					
			23. Steam correction factors (certified).					
			24. Blading vibration analysis data.					
			25. Lateral critical analysis.					
			26. Torsional critical analysis.					
			27. Transient torsional analysis.					
			28. Anticipated thermal movements for major connections.					
			29. Coupling alignment diagram.					
			30. Weld procedures for fabrication and repair.					
			31. Hydrostatic test logs (certified).					
			32. Mechanical running test logs.					

[a]Proposal drawings and data do not have to be certified or as-built.
[b]Purchaser will indicate in this column the time frame for submission of materials using the nomenclature given at the end of this form.
[c]Bidder shall complete these two columns to reflect the actual distribution schedule and include this form with the proposal.

SPECIAL PURPOSE STEAM TURBINE VENDOR DRAWING AND DATA REQUIREMENTS

JOB NO. ______ ITEM NO. ______
PAGE 2 OF 2 BY ______
DATE ______ REVISION ______

Proposal[a] Bidder shall furnish ______ copies of data for all items indicated by an X.

Review[b] Vendor shall furnish ______ copies and ______ transparencies of drawings and data indicated.

Final[c] Vendor shall furnish ______ copies and ______ transparencies of drawings and data indicated.
Vendor shall furnish ______ operating and maintenance manuals.

DISTRIBUTION RECORD

Final—Received from vendor
Final—Due from vendor[c]
Review—Returned to vendor
Review—Received from vendor
Review—Due from vendor[c]

Proposal	Review	Final	DESCRIPTION—continued	Review—Due from vendor	Review—Received from vendor	Review—Returned to vendor	Final—Due from vendor	Final—Received from vendor
			33. Nondestructive test procedures.					
			34. Mill test reports (certified).					
			35. Rotor balancing logs.					
			36. Rotor combined mechanical and electrical runout.					
			37. As-built data sheets.					
			38. As-built dimensions and data.					
			39. Installation manual.					
			40. Operating and maintenance manuals.					
			41. List of spare parts.					
			42. Progress reports and delivery schedule.					
			43. Drawing list.					
			44. Shipping list.					
			45. List of special tools for maintenance.					
			46. Technical data manual.					
			47. Preservation, packaging and shipping procedures.					
			48. Rigging and lifting instructions.					
			49. Vibration-probe sensing area/shaft drawing.					

[a] Proposal drawings and data do not have to be certified or as-built.
[b] Purchaser will indicate in this column the time frame for submission of materials using the nomenclature given at the end of this form.
[c] Bidder shall complete these two columns to reflect the actual distribution schedule and include this form with the proposal.

Notes:

1. The vendor (______ shall) (______ shall not) proceed with manufacture upon receipt of the order. (Review of drawings is required in either case.)
2. Send all drawings and data to ______
3. All drawings and data must show project, appropriation, purchase order, and item numbers in addition to the plant location and unit. In addition to the copies specified above, one set of the drawings and instructions necessary for field installation must be forwarded with the shipment.
4. All of the information indicated on the distribution schedule shall be received before final payment is made.

Nomenclature:

S—number of weeks prior to shipment.
F—number of weeks after firm order.
D—number of weeks after receipt of approved drawings.

Vendor ______
Date ______ Vendor Reference ______
Signature ______
(Signature acknowledges receipt of all instructions)

DESCRIPTION

1. Certified dimensional outline drawing and list of connections, including the following:
   a. Size, rating, and location of all customer connections.
   b. Approximate overall handling weights.
   c. Overall dimensions, maintenance clearances, and dismantling clearances.
   d. Shaft centerline height, denoting nominal shim dimension.
   e. Dimensions of baseplates (if furnished), complete with diameter, number, and locations of bolt holes, thickness of metal through which bolts must pass, and recommended clearance; centers of gravity; and details for foundation design.
   f. Direction of rotation.

2. Cross-sectional drawings and bills of materials, including the following:
   a. Journal-bearing clearances and tolerances.
   b. Axial rotor float.
   c. Shaft end and internal labyrinth seal clearances and tolerances.
   d. Axial position of wheel(s), blades relative to inlet nozzles or vanes of diaphragms, and tolerances allowed.
   e. Radial clearances at blade tips.

3. Rotor assembly drawings and bills of materials, including the following:
   a. Axial position from active thrust-collar face to—
      1. Each wheel, inlet side.
      2. Each radial probe.
      3. Each journal-bearing centerline.
      4. Phase-angle notch.
      5. Coupling face or end of shaft.
   b. Thrust-collar assembly details, including—
      1. Collar-shaft, with tolerance.
      2. Concentricity (or axial runout) tolerance.
      3. Required torque for locknut.
      4. Surface finish requirements for collar faces.
      5. Preheat method and temperature requirements for shrunk-on collar installation.
   c. Dimensioned shaft ends for coupling mountings.

4. Thrust-bearing assembly drawing and bill of materials.

5. Journal-bearing assembly drawing and bill of materials.

6. Seal assembly drawing and bill of materials.

7. Coupling manufacturer's shaft-coupling assembly drawing and bill of materials, including the following:
   a. Hydraulic mounting procedure.
   b. Shaft end gap and tolerance.
   c. Coupling guards
   d. Thermal growth from a baseline of 59°F (15°C).
   e. Make, size and serial number.
   f. Axial natural frequency over allowable spacer stretch (disc couplings).
   g. Balance tolerances.
   h. Coupling "pull-up" mounting dimensions.

8. Gland sealing and leak-off schematic and bill of materials, including the following:
   a. Steady-state and transient steam and air flows and pressures and temperatures.
   b. Control-valve settings.
   c. Utility requirements, including electrical, water, steam, and air.
   d. Pipe and valve sizes.
   e. Instrumentation, safety devices, and control schemes.
   f. Bill of materials.

9. Gland sealing and leak-off arrangement drawing and list of connections, including size, rating, and location of all customer connections.

10. Gland sealing and leak-off component outline and sectional drawings and data, including the following:
    a. Gland-condenser fabrication drawing and bill of materials.
    b. Completed data sheets for condenser.
    c. Air or water ejector drawing and performance curves.
    d. Control valves and instrumentation.
    e. Vacuum pump schematic, performance curves, cross section, outline drawing, and utility requirements (if pump is furnished).

11. Lube-oil schematics and bills of materials, including the following:
    a. Steady-state and transient oil flows and pressures at each use point.
    b. Control, alarm, and trip settings (pressure and recommended temperatures).
    c. Supply temperature and heat loads at each use point at maximum load.
    d. Utility requirements, including electrical, water, and air.
    e. Pipe and valve sizes.
    f. Instrumentation, safety devices, and control schemes.
    g. Relief valve set-points.

12. Lube-oil system arrangement drawing and list of connections, including size, rating, and location of all customer connections.

13. Lube-oil component drawings and data, including the following:
    a. Pumps and drivers—
       1. Certified dimensional outline drawing.
       2. Cross-section and bill of materials.
       3. Mechanical seal drawing and bill of materials.
       4. Performance curves for centrifugal pumps.
       5. Instruction and operating manuals.
       6. Completed data sheets for pumps and for drivers.
    b. Coolers, filters, and reservoir—
       1. Fabrication drawings.
       2. Maximum, minimum, and normal liquid levels in reservoir.
       3. Completed data form for coolers.
    c. Instrumentation—
       1. Controllers.
       2. Switches.
       3. Control valves.
       4. Gauges.
    d. Priced spare parts list(s) and recommendations.

14. Electrical and instrumentation schematics and bills of materials, including the following:
    a. Vibration alarm and shutdown limits.
    b. Bearing-temperature alarm and shutdown limits.
    c. Axial shaft position alarm and shutdown limits.

15. Electrical and instrumentation arrangement drawings and lists of connections.
16. Control- and governor-system description and schematic, including the following:
    a. Valve-lift sequence on multivalves and final settings.
    b. Control-lever setting diagram.
    c. Control-system drawings.
    d. Control setting instructions.
    e. Control-oil schematic, bill of materials, and steady-state and transient flows and pressures at each use point.
    f. Governor cross-section and bill of materials.
17. Overspeed shutdown system description, including schematic and mechanical trip setting diagram.
18. Curves showing steam flow versus horsepower at normal and rated speeds with normal steam conditions.
19. Curve showing steam flow versus first-stage pressure for multistage machines or versus nozzle-bowl pressure for single-stage machines at normal and rated speed with normal steam.
20. Curves showing steam flow versus speed and efficiency at normal steam conditions.
21. Curve showing steam flow versus valve lift.
22. Curves showing extraction/induction performance.
23. Steam-rate correction factors for the curves listed in Items 18–22 with off-design steam, as follows:
    a. Inlet pressure to maximum and minimum values listed on the data sheets in increments agreed upon at the time of the order.
    b. Inlet temperature to maximum and minimum values listed on the data sheets in increments agreed upon at the time of the order.
    c. Speed from 80–105 percent in 5-percent increments.
    d. Exhaust pressure to maximum and minimum values listed on the data sheets in increments agreed upon at the time of the order.
24. Blading vibration analysis data, including the following:
    a. Tabulation of all potential excitation sources, such as vanes, blades, nozzles, and critical speeds.
    b. Campbell diagram for each stage.
    c. Goodman diagram for each stage.
25. Lateral critical analysis report, including, but not limited to, the following:
    a. Complete description of the method used.
    b. Graphic display of critical speeds versus operating speeds.
    c. Graphic display of bearing and support stiffness and its effect on critical speeds.
    d. Graphic display of rotor response to unbalance (including damping).
    e. Journal static loads.
    f. Stiffness and damping coefficients.
    g. Tilting-pad goemetry and configuration, including—
        1. Pad angle (arc) and number of pads.
        2. Pivot offset.
        3. Pad clearance (with journal radius, pad bore radius, and bearing-set bore radius).
        4. Preload.

26. Torsional critical analysis report, including, but not limited to, the following:
    a. Complete description of the method used.
    b. Graphic display of mass elastic system.
    c. Tabulation identifying the mass moment and torsional stiffness for each component identified in the mass elastic system.
    d. Graphic display of exciting forces versus speed and frequency.
    e. Graphic display of torsional critical speeds and deflections (mode-shape diagram).
    f. Effects of alternative coupling on analysis.
27. Transient torsional analysis for all units using synchronous starter/helper motors (mandatory) or driving synchronous generators (optional).
28. Anticipated thermal movements referenced to a defined point for major connections referenced to a defined point.
29. Coupling alignment diagram, including recommended coupling limits during operation. Note all shaft-end position changes and support growth from a reference ambient temperature of 59°F (15°C) or another temperature specified by the purchaser. Include the recommended alignment method and cold setting targets.
30. Welding procedures for fabrication and repair.
31. Hydrostatic test logs.
32. Mechanical running test logs, including, but not limited to, the following:
    a. Oil flows, pressures, and temperatures.
    b. Vibration, including an *x–y* plot of amplitude and phase angle versus revolutions per minute during startup and shutdown.
    c. Bearing metal temperatures.
    d. Observed critical speeds (for flexible rotors).
    e. When specified, tape recordings of real-time vibration data.
    f. Control data (see 4.3.3.2.5).
33. Nondestructive test procedures and acceptance criteria as itemized on the purchase order data sheets or the Vendor Drawing and Data Requirements form.
34. Mill test reports of items agreed upon in the precommitment or preinspection meetings.
35. Rotor balancing logs, including a residual unbalance report in accordance with Appendix D.
36. Rotor combined mechanical and electrical runout in accordance with 2.6.2.2.
37. As-built data sheets.
38. As-built dimensions (including nominal dimensions with design tolerances) and data for the following listed parts:
    a. Shaft or sleeve diameters at—
        1. Thrust collar (for separate collars).
        2. Each seal component.
        3. Each wheel (for stacked rotors) or bladed disk.
        4. Each interstage labyrinth.
        5. Each journal bearing.
    b. Each wheel or disk bore (for stacked rotors) and outside diameter.
    c. Each labyrinth or seal-ring bore.
    d. Thrust-collar bore (for separate collars).

e. Each journal-bearing inside diameter.
f. Thrust-collar axial runout.
g. Thrust-bearing, journal-bearing, and seal clearances.
h. Metallurgy and heat treatment for—
   1. Shaft.
   2. Wheels or bladed disks.
   3. Thrust collar.
   4. Blades, vanes, and nozzles.

39. Installation manual describing the following (see 5.3.6.2):
   a. Storage procedures.
   b. Foundation plan.
   c. Grouting details.
   d. Setting equipment, rigging procedures, component weights, and lifting diagrams.
   e. Coupling alignment diagram (as specified in Appendix E, Item 29).
   f. Piping recommendations, including allowable flange loads.
   g. Composite outline drawings for driver/driven-equipment train, including anchor-bolt locations.
   h. Dismantling clearances.

40. Operating and maintenance manuals describing the following (see 5.3.6.3):
   a. Startup
   b. Normal shutdown.
   c. Emergency shutdown.
   d. Operating limits or other operating restrictions and a list of undesirable speeds.
   e. Grease and lube-oil recommendations and specifications.
   f. Routine operational procedures, including recommended inspection schedules and procedures.
   g. Instructions for—
      1. Disassembly and reassembly of rotor in casing.
      2. Rotor unstacking and restacking procedures.
      3. Disassembly and reassembly of journal bearings (for tilting-pad bearings, the instructions shall include "go/no-go" dimensions with tolerances for three-step plug gauges).
      4. Disassembly and reassembly of thrust bearing.
      5. Disassembly and reassembly of seals (including maximum and minimum clearances).
      6. Disassembly and reassembly of thrust collar.
      g. Wheel reblading procedures.
      h. Bolting procedures and torque values.
   h. Performance data, including—
      1. Curves showing steam flow versus normal and rated power at rated speed, including extraction/induction curves when applicable.
      2. Curve showing steam flow versus first-stage pressure.
      3. Curves showing steam flow versus speed and efficiency.
      4. Curve showing steam flow versus valve lift.
      5. Curves showing extraction/induction.
      6. Steam condition correction factors (prefer monograph).
      7. Speed versus torque.
      8. Exhaust steam temperature versus power.
      9. First-stage pressure versus thrust.
   i. Vibration analysis data, as specified in Appendix E, Items 24–27.

j. As-built data, including—
   1. As-built data sheets.
   2. As-built dimensions or data, including assembly clearances.
   3. Hydrostatic test logs, as specified in Appendix E, Item 31.
   4. Mechanical running test logs, as specified in Appendix E, Item 32.
   5. Rotor balancing logs, as specified in Appendix E, Item 35.
   6. Rotor combined mechanical and electrical runout at each journal, as specified in Appendix E, Item 36.
   7. Physical and chemical mill test certificates, as specified in Appendix E, Item 34.
   8. Test logs of all specified optional tests.

k. Drawings and data, including—
   1. Certified dimensional outline drawing and list of connections.
   2. Cross-sectional drawing and bill of materials.
   3. Rotor assembly drawings and bills of materials.
   4. Thrust-bearing assembly drawing and bill of materials.
   5. Journal-bearing assembly drawings and bills of materials.
   6. Seal-component drawing and bill of materials.
   7. Lube-oil schematics and bills of materials.
   8. Lube-oil assembly drawing and list of connections.
   9. Lube-oil component drawings and data.
   10. Electrical and instrumentation schematics and bills of materials.
   11. Electrical and instrumentation assembly drawings and list of connections.
   12. Governor-, control-, and trip-system drawings and data.
   13. Trip/combined trip and throttle-valve construction drawings.

41. List of spare parts with stocking level recommendations, in accordance with 5.3.5.

42. Progress reports and delivery schedule, including vendor buyouts and milestones.

43. Drawing list, including latest revision numbers and dates.

44. Shipping list, including all major components that will ship separately.

45. List of special tools furnished for maintenance.

46. Technical data manual, including the following:
    a. As-built purchaser data sheets, as specified in Appendix E, Item 37.
    b. Certified performance curves, as specified in Appendix E, Items 18–23.
    c. Drawings, in accordance with 5.3.2.
    d. As-built assembly clearances.
    e. Spare parts list, in accordance with 5.3.5.
    f. Utility data, as specified in Appendix E, Item 17.
    g. Vibration data, as specified in Appendix E, Item 24.
    h. Reports, as specified in Appendix E, Items 25–27, 29, 33, and 35.

47. Preservation, packaging, and shipping procedures.

48. Recommended equipment rigging and lifting instruction (see 4.4.3.8).

49. Vibration-probe sensing area/shaft drawing which accurately locates sensing areas on the shaft axis which are not to be metallized, sleeved, or plated.

Note: Items 14, 15, 26(f) and 40(k.7–k.9) are required only for a turbine manufacturer's scope of supply.

APPENDIX F—INSPECTOR'S CHECKLIST

INSPECTOR'S CHECKLIST

Item	API Standard 612 Reference	Reviewed	Observed	Witnessed	Inspected By	Status
General						
Vendor data records	4.2.1.1					
Final assembly maintenance and clearances	4.2.1.1.e					
Surface and subsurface inspection	4.2.1.3					
Material Inspection						
Material inspection certification/testing	4.2.2.1					
Mechanical Inspection						
Stud markings	2.2.12.3					
Equipment feet (vertical and horizontal) jackscrews	3.2.1.2.2 2.2.14					
Foot/baseplate shims	3.2.1.2.12					
Nozzle flange dimensions	2.4.1					
Casing openings size/finish	2.4.6.6 2.4.3					
Rotor identification	2.6.1.4					
Shaft finishes	2.6.2.1					
Shaft electrical and mechanical runout	2.8.5.6 2.6.2.2					
Shaft gauss	2.6.2.6					
Coupling fit (API Standard 671)	2.6.2.5					
Rotor balance (balance machine residual)	2.8.5.2 2.8.5.3					
Rotation arrow/nameplate data/units	2.12					
Mounting surfaces coated	3.2.1.2.6					
Mounting surfaces epoxy primed	3.2.1.2.7					
Oil system cleanliness (API Standard 614)	2.2.12.4 4.2.3.2					
Equipment cleanliness	4.2.3.3					
Material hardness	4.2.3.4					
Mechanical Running Test						
Contract shaft seals and bearings	4.3.3.1.1					
Oil flows, pressure, and temperature as specified	4.3.3.1.2					

INSPECTOR'S CHECKLIST—continued

Item	API Standard 612 Reference	Reviewed	Observed	Witnessed	Inspected By	Status
No leaks observed	4.3.3.1.4					
Protective devices operational	4.3.3.1.5					
Control devices operational	4.3.3.1.5					
Contract instrumentation used	4.3.3.1.7					
Control system functional under specified speeds	4.3.3.2					
Four-hour test complete	4.3.3.2.6					
Lateral critical speeds as predicted	4.3.3.3.3					
Tape recordings complete	4.3.3.3.6					
Bearing inspection after test satisfactory	4.3.3.4.1					
Spare rotor fit and run	4.3.3.4.3					
Optional Tests						
Performance test	4.3.4.1					
Complete unit test	4.3.4.2					
Auxiliary-equipment test	4.3.4.3					
Post-test casing internal inspection	4.3.4.4					
Emergency-overspeed-trip-systems test	4.3.4.5					
Spare parts test	4.3.4.6					
Turning gear test	3.9					
Preparation for Shipment						
Preparation complete	4.4.1					
Paint	4.4.3.1					
Rust preventative (exterior and interior)	4.4.3.2 4.4.3.3					
Tags complete	4.4.3.9 4.4.5					
Installation instructions shipped	4.4.6					
Special tools complete	3.8					
Spare parts complete						
Studs installed						

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

Order No. C61204