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NATIONAL IRANIAN OIL REFINING & DISTRIBUTION COMPANY  
NATIONAL IRANIAN OIL ENGINEERING  
& CONSTRUCTION COMPANY

# NIOEC SP

## NIOEC SPECIFICATION FOR SPECIAL PURPOSE STEAM TURBINES

FIRST EDITION

JULY, 2005

THIS SPECIFICATION IS THE PROPERTY OF NATIONAL IRANIAN OIL ENGINEERING & CONSTRUCTION COMPANY. IT IS CONFIDENTIAL AND ALL RIGHTS RESERVED TO THE OWNER. NEITHER WHOLE NOR ANY PART OF THIS DOCUMENT MAY BE DISCLOSED TO ANY THIRD PARTY, REPRODUCED, STORED IN ANY RETRIEVAL SYSTEM OR TRANSMITTED IN ANY FORM OR BY ANY MEANS WITHOUT THE PRIOR WRITTEN CONSENT OF THE NATIONAL IRANIAN OIL ENGINEERING & CONSTRUCTION COMPANY.

**IN THE NAME OF GOD****FOREWORD**

By their very nature, technical Specifications are continuously subject to modifications and revisions. To strengthen their merit and usefulness, continuous improvements, addendum, deletion of disparate information and consequently provision of updated revisions are to be made in order to ascertain that such Specifications meet the current requirements, inclusive of Iranian Petroleum Standards (IPS) and the recognized and acceptable national and international Standards, as well as the optimal codes and practices based on the accumulated in-house know-how and plant knowledge and experiences.

However, in reality, due to several reasons, not to mention the complexity of the matter, the ultimate goal of continuous direct embedment of the required changes on the relevant Specifications may be far reaching. Therefore, in the interim periods between the officially issued revisions, the required changes will appear in other documents related to the engineering and design work of the ongoing projects.

In response to the initiative of the Design and Engineering Directorate, and considering that the task of the execution of several important and mega projects for the realization of the new oil refineries, pipelines and oil terminals as well as improvements of the existing facilities, has been assigned to NIOEC, it was decided to update the NIOEC Specifications and to issue new official revisions.

The Design and Engineering Directorate was itself entrusted to carry out this important task, and as such by forming several special technical committees, working in close co-operation and cohesion and sharing their expertise and knowledge, the updated and revised NIOEC Specifications were successfully prepared and complied.

These Specifications are intended to be used for Oil Refineries, Distribution Depots, Oil Terminals, Pipelines and Pump Stations within NIOEC's projects, and have been proven to be of high value for such purposes. It must however be appreciated that these Specifications represent the minimum requirements and should in no way be interpreted as a restriction on the use of better procedures, engineering and design practices or materials.

We encourage and highly appreciate the users and other clear sighted and experts to send their comments on the Specifications to the Design and Engineering Director of NIOEC for evaluation and approval.

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## NOTES:

- 1) THIS SHEET IS A RECORD OF ALL REVISIONS TO THIS SPECIFICATION.
- 2) WHEN APPROVED EACH REVISION SHALL BE CONSIDERED AS A PART OF THE ORIGINAL DOCUMENT.
- 3) NUMBER OF PAGES EXCLUDES THIS SHEET AND THE COVER SHEET.

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| 1    | SEPTEMBER,<br>2016 | M.R.DEILAMI | GH.R.ANVARI  | M.R.FARZAM | A.R.ARMAN<br>MOGHADAM |
| 0    | JULY, 2005         | FROUTAN/B.A | A.SADEGHILAR | M.R.FARZAM | M.A.A.SAJEDI          |
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## INTRODUCTION

To satisfy the requirements of this NIOEC Specification, API 612, 7<sup>th</sup> Edition with the modifications as specified herein after shall be strictly followed.

The following annotations, as specified hereunder, have been used at the bottom right hand side of each clause or paragraph to indicate the type of change made to the equivalent clause or paragraph of API.

**Substitution:** The clause in API shall be deleted and replaced by the new clause in this Standard.

**Addition:** The new clause with the new number shall be added to the relevant section of API.

**Modification:** Part of the clause or paragraph in API shall be modified and/or the new description.

## 1. SCOPE

- 1.1. This Specification covers the general requirements for special purpose steam turbines which shall conform to the American petroleum institute standard 612 7<sup>th</sup> edition.
- 1.2. This Specification supplements Specification sheets for each individual turbine on which the operating conditions and special requirements are listed in detail. Whenever the data included on the individual Specification sheet conflicts with the provisions of this general Specification, the former shall govern.
- 1.3. Compliance with the provision of this Specification dose not relieve the manufacturer/ contractor of the responsibility of furnishing turbines of proper design, mechanically suited to meet operating guarantees at the specified service conditions.
- 1.4. Deviations from this specification will only be permitted on obtaining written approval from NIOEC.
- 1.5. Resolution on cases not explicitly stipulated in this Specification, or on cases where conflicts may arise among the requirements of the referenced IPS and the international standards, shall be made through written consent and approval of NIOEC

## 2. REFERENCES

The following standards, codes, and specifications, to the extent specified hereinafter, shall constitute a part of this NIOEC Specification. Latest edition of the undated referenced documents and the cited edition of the dated references shall apply. The applicability of changes made to the dated references, after the cited date shall be mutually agreed upon between NIOEC and the Vendor /Contractor.

### API (AMERICAN PETROLEUM INSTITUTE)

|         |                                                                                 |
|---------|---------------------------------------------------------------------------------|
| API 612 | "Special purpose steam turbines."-7 <sup>th</sup> edition - 2014                |
| API 671 | "Special-Purpose Couplings for Petroleum, Chemical, and Gas Industry Services"  |
| API 613 | "Special Purpose Gear Units for Petroleum, Chemical and Gas Industry Services". |

**ASME (AMERICAN SOCIETY OF MECHANICAL ENGINEERS)**

**NEMA (NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION)**

**NIOEC-SP (NIOEC SPECIFICATION)**

|                |                                                                                                          |
|----------------|----------------------------------------------------------------------------------------------------------|
| NIOEC-SP-00-01 | "NIOEC Specification for Civil Design Criteria"                                                          |
| NIOEC-SP-00-10 | "NIOEC Specification for Unit"                                                                           |
| NIOEC-SP-00-11 | "NIOEC Specification for Site Conditions"                                                                |
| NIOEC-SP-00-50 | "NIOEC Specification for Design Criteria for Process and Mechanics"                                      |
| NIOEC-SP-40-03 | "NIOEC Specification for Spare Parts Requirements"                                                       |
| NIOEC-SP-40-04 | "NIOEC Specification for Lubricating, Sealing and Controlling Oil"                                       |
| NIOEC-SP-46-00 | "NIOEC Specification for Pumps, Drivers and Auxiliary Equipment"                                         |
| NIOEC-SP-46-01 | "NIOEC Specification for Centrifugal Pumps for General Refinery Services"                                |
| NIOEC-SP-46-07 | "NIOEC Specification for Lubrication, Shaft Sealing, Control Oil System for Special Purpose Application" |
| NIOEC-SP-47-10 | "NIOEC Specification for Noise Control and Vibration"                                                    |
| NIOEC-SP-60-02 | "NIOEC Specification for Induction Motors"                                                               |
| NIOEC-SP-90-52 | "NIOEC Specification for Packing and Packages"                                                           |

**NIOEC-SIP (NIOEC Shop Inspection Procedures)**

|                 |                                                           |
|-----------------|-----------------------------------------------------------|
| NIOEC-SIP-46-01 | "Shop Inspection Procedures for Steam Turbine Generators" |
|-----------------|-----------------------------------------------------------|

**3. UNITS**

International system of units (SI) shall be used in accordance with NIOEC-SP-00-10, unless otherwise specified.

**4. MODIFICATION TO API 612**

The paragraph numbering follows API Standard 612 7th edition August 2014 and each paragraph denotes an addition, modification, substitution or employer's choice. Those optional sections not covered in the text are included in the Specification data sheets.

**1. SCOPE (Mod.)**

This standard specifies requirements and gives recommendations for the design, materials, fabrication, inspection, testing and preparation for shipment and Guarantee and Warranty for steam turbines in special-purpose services for use by NIOEC in Refineries.

## 4.2 DIMENSIONS (Sub.)

NIOEC Specification for Units (NIOEC-SP-00-10) shall be used. Component parts may be fabricated to other dimensional standards when this does not conflict with the intent of the design features included in the referenced NIOEC Specifications. However, all external connections (either flanges or tapped openings) intended for the attachment of external piping and any external piping material of whatever kind furnished by the vendor incidental to the equipment shall without exception conform to the dimensional requirements of the NIOEC Specification for Units NIOEC-SP-00-10.

## 5. STATUTORY REQUIREMENTS (Mod.)

Add this term at the end of Paragraph:

“A vendor may offer an alternate of manufacturer’s design. All deviations in the manufacturer’s standard design from the requirements specified herein shall be described fully in the proposal. The Employer will determine if the alternate is acceptable or not. However, a turbine which completely meets these Specifications shall be selected.”

### 6.1.5 (Mod.)

Add this term at the end of Paragraph:

On multistage condensing type turbines care should be exercised in the design to eliminate the possibility of interstage silicate deposit build-up on turbine blading and to minimize erosion on the last stages of turbine blading.

### 6.1.8 (Mod.)

Add this term at the end of Paragraph:

- b) The manufacturer shall specify the limits of variation from rated steam conditions which the turbine can work.

If this point is not specified on the data sheet by the purchaser, the vendor of the driven equipment shall provide this data to the turbine vendor.

### 6.1.8 (Add.)

- i) Turbines will be washed at normal speed and reduced load. The turbine vendor shall confirm suitability of its turbine for the following procedure in its proposal, and recommend any special precautions required to protect the equipment:

#### **Method of Washing:**

Washing of a steam turbine down to about 8°C of superheat, holding the temperature at this near saturation value for a definite period of time and then gradually restoring the temperature to its initial value.

#### **Facility Requirements:**

Desuperheating shall be by the injection of high pressure, high purity water such as condensate or polished demineralized water. The desuperheated steam shall pass through a steam temperature during washing shall be automatically controlled such that the temperature shall not vary by more than 1°C per minute.

**6.1.10 (Sub.)**

The turbine and accessories shall perform on the test stand and when installed on the permanent foundation, within the specified acceptance criteria.

The combined performance of the turbine and its driven equipment after installation shall be the responsibility of the vendor, who has been nominated as being responsible for the complete unit.

**6.1.12 (Sub.)**

The arrangement of turbine and driven equipment installation, including auxiliaries and platforms shall be developed jointly by purchaser and vendor to provide adequate clearance area and safe access for operation and maintenance and to be submitted for Employer's approval. In the case of outdoor installation, the turbines condenser shall not be located beneath the turbine.

**6.1.17 (Mod.)**

Add this term at the end of Paragraph:

Noise level shall normally be limited to the requirements of NIOEC-SP-47-10 and NIOEC-SP-46-00 whichever lower, however if under different operating conditions exhaust steam flow is anticipated to have higher noise levels; supply of proper silencer shall be the responsibility of the steam turbine supplier.

**6.1.19 (Mod.)**

Add this term at the end of Paragraph:

The turbine and all its auxiliary equipment shall be suitable for outdoor installation exposed to dusty and refinery atmosphere. Refer to unit data sheets for ambient conditions and area classifications.

Minimum ambient dry bulb temperature is based on local condition.

**6.1.22 (Add.)**

Non condensing capabilities of the condensing steam turbines shall also be specified by the steam turbine supplier in the proposal.

**6.1.23 (Add.)**

The steam strainer shall be a separate. Y-type strainer with Monel screen and openings of approximately 1/8 in., and in addition, strainer basket with 1/16 inch openings shall be supplied for temporary use during start-up.

**7.1.10 (Mod.)**

Turbine shall be designed so that jig fixtures are not required for removal and replacement of upper half of turbine case. Removable extended dowels guiding the top half will be acceptable.

**7.1.12 (Mod.)**

Add this term at the end of Paragraph:

On condensing turbines with top exhaust, connections and drain system shall be provided to drain condensate continuously from the exhaust casing.

**7.2.2 (Mod.)**

Welded joints of pressure casings shall be completely radiographed and shall have full penetration.

**7.2.14 (Add.)**

For non-welded casing materials, threaded openings not required to be connected to piping shall be plugged with solid, round-head steel plugs in accordance with ASME B16.11, unless otherwise specified. Plugs that may later require removal shall be corrosion-resistant material. Plastic plugs are not permitted. Plugs (if used) shall have a shank at least 1½ inch in length to permit the use of pipe wrench.

**7.2.7 (Mod.)**

Where “commercially smooth finish” is specified for raised face flanges on data sheets, the gasket surface of the flanges shall have maximum machined roughness which will not exceed 250 root mean square micro inches with 0.002 inch maximum peak to valley measurement. It shall be understood that all other raised flanges shall have stock finish as follows:

- 1- For nominal size 12 inch and smaller a continuous spiral groove generated by a 1/16 inch round nosed tool at a feed of 1/32 inch per revolution.
- 2- For nominal flanges size above 12 inch a continuous spiral groove generated by a 1/8 inch radius round nosed tool at a feed of 3/64” each revolution.

**7.2.8 (Mod.)**

Add this term at the end of Paragraph:

Mating flange (if there is any) shall meet these requirements:

Flanges shall be welding neck type with bolt hole spacing and bolt circle diameter exactly matching the machine flanges.

Each flange shall be furnished with at least 3 dowel pins each machined with a close fit tolerance to the diameter of the bolt holes bore.

The turbine shall be shipped with flanges bolted in place and with dowel pins installed. Each flange (turbine and pipe), dowel pin and bolt replacement for the dowel pin shall be positively identified. For connections to surface condenser, expansion bellows shall be provided as a separate flanged spool connection for condensing steam turbines.

**7.2.16 (Add.)**

Vendor shall provide readily accessible flanged casing connection(s) for injection of dry gas purge during extended outage. If connection for other purpose exist which can also be used for this purpose, vendor shall indicate it in proposal and on general arrangement drawing(s).

**7.3.1 (Sub.)**

All control stage nozzle rings and all bladed inlet nozzle blocks, shall be replaceable; welded-in design is not acceptable.

**8.1.4 (Mod.)**

Facilities for field balancing are required.

**8.3.9 (Add.)**

Replaceable blade inlet nozzle blocks are preferred. Welded in design shall be considered. Stationary bladeing shall be mounted in replaceable diaphragms.

**9.1.3 (Mod.)**

Add this term at the end of Paragraph:

The turbine vendor shall furnish the driven equipment manufacturer all necessary information for calculation of torsional and lateral vibration analysis.

**9.2.11 (Mod.)**

Add this term at the end of Paragraph:

The first critical speed shall not be within 20 percent of any operating speed.

**9.4.1.4 (Mod.)**

Add this term at the end of Paragraph:

The first critical speed shall not be within 20 percent of any operating speed.

**9.6.2 (Mod.)**

Add this term at the end of Paragraph:

Excitation of turbine blade resonant vibration response for in-phase tangential, out-of-phase tangential, axial, torsional and any other high response modes of each blade row by multiples of running speed, nozzle passing frequency and twice nozzle passing frequency shall be verified as outside the specified operating speed range. If this is not feasible, stress levels developed for any specified mode of driven equipment operation shall be low enough to insure indefinite life if resonant vibration response is within the operating range.

Blades shall be designed to withstand operation at resonant frequencies during normal warm-up, but the Vendor shall advise the Purchaser of speeds below the operating range corresponding to such blade resonance.

**9.7.8 (Mod.)**

Add this term at the end of Paragraph:

Rotor balance during shop test and permanent installation shall be such that during operation at maximum continuous speed or any other specified operating speed, the peak-to-peak amplitude of vibration in any plane measured on the shaft adjacent to the bearing housing at each end of the shaft shall not exceed the following (including shaft runout):

| <u>Speed (rpm)</u> | <u>Vibration (mm)</u> |
|--------------------|-----------------------|
| Up to 10,000       | 0.025                 |
| 10,001 & above     | 0.0190                |

Vibration readings taken on bearing housings are not acceptable.

Turbine and driven equipment (such as compressor) shall be balanced as a unit.

**9.7.11 (Add.)**

Vibration shall be measured directly on a polished area of the shaft adjacent to each bearing. The shaft runout shall not exceed 0.0005 inch at the point of vibration measurement.

**10.1.1 & 11.1.4 (Mod.)**

Add the following term at the end of Paragraph:

Renewable liners or shells (if there is any) shall be Babbitt lined and steel backed. Copper backed bearings shall not be used.

**10.3.5 (Mod.)**

Add this term at the end of Paragraph:

Thrust bearing temperature sensing element shall be located in the metal of the bearing shoes, and in the oil discharge from the thrust bearing.

**10.3.7 (Mod.)**

Add the following term at the end of Paragraph:

The thrust collar shall be designed such that heating is not required for its removal.

**10.4.1 (Mod.)**

Add the following term at the end of Paragraph:

All bearing housings shall be furnished with either vendor's standard breather or a DN 25 minimum vent connection fitted with a steel pipe plug.

**10.6.1 (Mod.)**

Add this term at the end of Paragraph:

Turbines shall have labyrinth shaft seals. Carbon rings are not acceptable.

**10.6.3 (Mod.)**

Add this term at the end of Paragraph:

An automatic pressure regulating system shall be provided for sealing steam pressure.

**10.6.4 (Mod.)**

Add this term at the end of Paragraph:

Gland condensers shall be provided on all turbines.

**11.1.14 (Mod.)**

Add this term at the end of Paragraph:

Carbon steels shall have an impact strength at the lowest temperature sufficient to qualify under the minimum Charpy-V notch impact energy requirements of the ASME Code, Section VIII, Division 1, UG-84.

**11.1.16 (Add.)**

For operating temperatures below -29°C and for other low ambient temperatures, steels shall have, at the lowest specified temperature, an impact strength sufficient to qualify under the minimum Charpy V-notch impact energy requirements of section 8, Division 1, UG-84, of the ASME code. For materials and thicknesses not covered by code the vendor shall indicate in the proposal the recommended inspection and testing level.

**11.2.4 (Mod.)**

Add the following term at the end of Paragraph:

Improperly fused chaplets in iron castings may not be replaced with plugs.

**11.3.3 (Mod.)**

Add the following term at the end of Paragraph:

Welded joints of pressure casings shall be completely radiographed and shall have full penetration.

**11.3.4.6 (Add.)**

Steel cases shall receive a stress relief heat treatment after fabrication is completed, before final machining.

All welds in auxiliary piping, including seal welds and pipe to case welds, shall be heat treated, hardness tested in accordance with ASME B 31.3 and examined by magnetic particle or dry penetrant. Vendor may propose radiography for special cases in the proposal.

**12.2.3 (Mod.)**

Add the following term at the end of Paragraph:

For electric power generation service, the governor shall conform to NEMA SM 21 Class D. and may be manufacturer's standard governor.

Unless otherwise specified, the speed governor for mechanical drive application shall conform to NEMA SM-23, Class D, with an adjustable speed range of 30 percent below maximum continuous speed. Speed adjustment shall be provided at the governor by a hand speed changer.

**12.3.1.6 (Mod.)**

Add the following term at the end of Paragraph:

Hydraulic actuated trip and throttle valve shall be furnished. Provide tripping device (oil dump valve) to be actuated by all shut-down devices specified in this Specification.

**12.3.1.11 (Add.)**

The shutdown system shall prevent opening of the trip valve(s) if the governor-controlled valve(s) are not fully closed. Two or more hand-operated nozzle control valves shall be provided on all turbines having single governor valve.

**12.3.4.1 (Mod.)**

Add the following term at the end of Paragraph:

The trip & throttle valves shall include a 110 volt D.C. solenoid trip mechanism.

On extraction or extraction-admission turbines, the vendor shall supply an additional protective device on all possible steam supply lines. Make, Model, and location of the device(s) shall be mutually agreed upon by purchaser and vendor.

Unless otherwise specified, actuation of a trip device shall cause the steam inlet valves to close in addition to closing the trip and throttle valve. Facilities needed to permit one operator to restart the turbine shall be provided. Vendor shall describe the provisions in the proposal.

**12.3.4.4 (Mod.)**

f) Trip and throttle valves shall be capable of being partially stroked (either manually or hydraulically) to exercise the valve without interrupting the operation of the turbine.

**12.4.1 (Sub.)**

An, alarm/shutdown system shall be provided in accordance with NIOEC-SP-46-07.

**12.4.3 (Mod.)**

As a minimum requirement, following alarm/shutdown switches, control devices, and annunciator display units shall be furnished additionally to those specified in API paragraph 12.4.3, for the following services:

|                                                                                             | Function |          |      |
|---------------------------------------------------------------------------------------------|----------|----------|------|
|                                                                                             | Alarm    | Shutdown | Trip |
| 1- High and low level alarm for condenser.                                                  | X        |          |      |
| 2- Turbine trouble light (First out alarm).                                                 | X        |          |      |
| 3- Inlet steam temperature alarm and trip.                                                  | X        |          | X    |
| 4- Turbine back pressure alarm.                                                             | X        |          |      |
| 5- Steam low pressure alarm.                                                                | X        |          |      |
| 6- Gauges for oil temperature for each bearing of turbine (With high temp. alarm and trip). | X        |          | X    |
| 7- Standby lube oil pump operating                                                          | X        |          |      |
| 8- Low lube oil pressure                                                                    | X        | X        | X    |
| 9- Over speed trip operation                                                                |          | X        |      |
| 10- High oil filter differential pressure                                                   | X        |          |      |
| 11- Low oil reservoir level                                                                 | X        |          |      |
| 12- Excessive vibration in turbine                                                          | X        | XX       | X    |
| 13- Excessive axial rotor displacement of turbine and driven equipment                      | X        | XX       |      |
| 14- High thrust bearing shoe temperature                                                    | X        |          |      |
| 15- Other protection of turbine auxiliaries                                                 | XX       | XX       |      |
| 16- Other process or driven equipment function                                              | XX       | XX       |      |
| XX- As specified on data sheet or recommended by Vendor.                                    |          |          |      |

**12.5 Instrument and Control Panels (Mod.)**

Add the following term at the end of Paragraph:

All instruments furnished under Items 12.5, 12.6, 12.7, 12.8 shall meet the requirements specified on data sheet and to be provided from the NIOEC approved Vendors.

Individual instrument with separate connection shall be provided for all shut-down and alarm devices.

**12.5.1 (Sub.)**

Instrument and control panel shall conform to requirements of NIOEC-SP-46-07.

A free stand instrument panel shall be provided and shall include all panel-mounted instruments for the turbine and driven units.

Following are the minimum requirement of panel-mounted instruments for turbine:

- 1- Steam inlet pressure gauge.
- 2- Exhaust steam pressure gauge.
- 3- Steam chest pressure gauge.
- 4- First stage pressure gauge on multistage turbines.
- 5- Extraction pressure gauge.
- 6- Pressure gauge for first stage after extraction section.
- 7- Steam seal pressure gauge.
- 8- Lube oil pressure gauge.
- 9- Indicator for an electronic tachometer.
- 10- Gages for driven equipment.
- 11- Alarms and indicator light.
- 12- Other instrument specified on data sheet and recommended by Vendors.
- 13- Control (governor) oil pressure gage.
- 14- Bearing temperature indicator.
- 15- Vibration and axial position readout equipment.
- 16- Inlet and exhaust steam temperature gage.
- 17- Each bearing oil temperature gage.
- 18- Bearings oil pressure gage.
- 19- Temperature recorder for thrust bearing shoes.

#### 12.5.4 (Add.)

All instruments and controls, including alarm and shutdown sensing devices, shall be installed with sufficient valving for isolation to permit testing and removal while the system is in operation.

#### 12.6.1.1 (Mod.)

Add the following term at the end of Paragraph:

Speed-indicator readout shall be to nearest 10 revolutions per minute.

#### 12.7 Vibration Monitors (Add.)

Turbines shall be provided with a non-contacting vibration monitoring system as specified in para. 10.4.5

#### 12.8 Axial Position Monitors (Add.)

An accurate and reliable axial displacement safety and monitoring system shall be provided to take care of the following functions:

- Continuous local indication of rotor position.
- Alarm at a predetermined excessive axial rotor displacement.
- Shut-down of the driver in case of unsafe condition if specified on data sheet or recommended by Vendor.

#### 14.1.1 (Mod.)

API std. 614 to substitute by NIOEC-SP-46-07.

**14.1.6 (Add.)**

Piping in size 1½ inch and smaller shall preferably be used for socket welding fittings except at equipment and/or valves.

**14.1.7 (Add.)**

Where needed for start-up and operation, drains with valves and plugs shall be provided at low points in the piping systems and vent connections with valves and plugs shall be provided at all high points of the piping systems.

Vents and drains, including casing drains, shall be piped to the edge of base plates or subassemblies, unless mutually agreed otherwise.

Drains shall be 1½ inch flanged minimum. All drain lines shall be designed to flow at not more than half full basis maximum flow conditions.

Horizontal runs shall slope continuously 40 mm per meter minimum toward the reservoir.

**14.2 Oil Piping (Mod.)**

API std. 614 to substitute by NIOEC-SP-46-07.

**14.2.1 (Add.)**

Following fabrication, stainless steel lube oil and control oil lines shall be flushed clean with solvent prior to shipment.

All lube oil and control oil supply piping, fittings and drain lines shall be 304 stainless steel with the exception of valves which should have 12% chrom trim.

**14.2.2 (Add.)**

By-passing of oil system for the bearing during shop and field prestart up oil flushing operation shall be provided without disassembling of bearing housing.

**15.1.2 (Sub.)**

Coupling shall be forged steel and continuously lubricated type.

Couplings and guards shall conform to API Standard 671.

**15.10 Gear Units (Add.)**

Gear units shall conform to API-613 unless otherwise specified on data sheet.

**15.2.1.1 (Mod.)**

Add the following term at the end of Paragraph:

The turbine and driven equipment shall be mounted on a common base plate, unless otherwise specified on data sheet. Baseplate shall be furnished by the supplier of driven equipment.

**15.2.1.2.7 (Sub.)**

Anchor bolts will be furnished by the manufacturer unless otherwise specified.

**15.2.2.15 (Sub.)**

Use of sub-soleplates shall be mutually agreed to between purchaser and vendor. If required, sub-sole plates (leveling plates) shall be provided by the vendor.

**15.3.2 (Mod.)**

Add the following term at the end of Paragraph:

Provisions shall be made to relief full flow of steam at any stage or section of the casing which is not designed to withstand its previous stage steam pressure including the first steam chest. Use of sentinel warning valve does not suffice.

**15.4 Lubrication and control-oil System**

NIOEC-SP-40-04 as well as NIOEC-SP-46-07 shall be followed.

**15.4.2 (Mod.)**

Add the following term at the end of Paragraph:

The lubrication system shall be in complete conformance to NIOEC-SP-46-07 Lubrication, Shaft Sealing, and Control Oil System for Special Purpose Applications.

**15.4.2.1 (Add.)**

All lube and control oil headers shall be regulated by automatic control valves. Hand control valves or orifices are not acceptable for controlling header pressures. Pump relief valves shall not be used for continuous pressure regulation.

The trim and stem material of all control valves and pressure regulators shall be stainless steel.

**15.5.4.2 (Add.)**

Oil level indicator shall be external type with isolating valves.

**15.4.4 (Mod.)**

Add the following term at the end of Paragraph:

Unless otherwise specified, the driven equipment and turbine shall have a common lube oil system. The turbine vendor and the driven equipment vendor shall mutually decide and agree on oil characteristics.

**15.6.1 (Mod.)**

Add the following term at the end of Paragraph:

Vendor shall factory insulate the turbine, with a readily removable painted metal jacket which is to cover the steam chest down to the exhaust end.

**15.6.4 (Sub.)**

Insulation materials shall be furnished by the turbine vendor.

**15.8.1 (Sub.)**

A turning gear shall be furnished by the vendor if the turbine requires rotation of the shaft to avoid shaft thermal distortion (during turbine start-up or immediately following a shut down). Turing gear drive type shall be specified on the data sheet.

**15.9 (Mod.)**

Add the following term at the end of Paragraph:

Turbines shall be supplied with any special tools necessary to dismantle and assemble the unit. Cradles, bolt tensioners, etc., required for maintenance in the field shall be described in proposal.

**15.10 Condensers (Add.)****15.10.1 (Add.)**

Water-Cooled condensers shall be designed to be split into two independent halves on the water side, to allow for cleaning of the separate halves without interruption to operation of the turbine at loading which will be specified in the data sheet.

**15.10.2 (Add.)**

For steam-driven air ejectors, the ejector nozzle shall be of 13% Cr-type stainless steel and protected against clogging by 32 mesh basket-type steam strainers.

The ejector equipment shall be complete with all interconnecting piping, including valves, traps, etc., and with connections for pressure gages required for proper operation. Ejector equipment shall be fully spared.

**15.10.3 (Add.)**

Two condensate extraction pumps shall be installed, one for normal operation and one for stand-by duty. Unless otherwise specified, the main pumps shall be steam-turbine driven and the stand-by pump shall be electric-motor-driven.

Each pump shall be capable of handling the maximum flow of condensate plus 20%, and shall be provided with a minimum flow protection.

Pumps shall be centrifugal-type and shall comply with NIOEC-SP-46-01.

**15.10.4 (Add.)**

A water-sealed atmospheric relief valve shall be provided, and sized for full steam flow at 2 kPa (ga) back pressure. The condenser shall be capable of withstanding this pressure for prolonged periods.

**15.10.5 (Add.)**

The manufacturer shall provide a connection for a pressure switch to activate an alarm under high-pressure conditions.

**15.10.6 (Add.)**

The main condenser condensate sump or hot well shall be sized to provide a three-minute hold-up at maximum flow rate, and shall be provided with suitable level glasses and connections for level controller, condensate outlet, drains and high/low-level alarms.

**15.11 Washing Facilities (Add.)**

In case of requirement for blade washing and drying facilities, vendor shall specify the system and its equipment in the proposal.

**15.12 Sentinel Warning Valve (Add.)****15.12.1 (Add.)**

In addition to relief valves, turbines shall be provided with sentinel warning valves see also, 7.1.3 and 15.3.

**16.1 General (Sub.)**

All tests and inspections shall be performed in accordance with the relevant NIOEC inspection and test procedures including NIOEC-SIP-46-01 Shop Inspection Procedures for Steam Turbine Generators.

**16.1.4 (Mod.)**

Add the following term at the end of Paragraph:

All turbines shall be inspected during fabrication and assembly by Purchaser's and Employer's inspectors. When spare rotors are furnished, they are to be installed in casing and given a mechanical running test.

**16.2.1.3 (Mod.)**

Add the following term at the end of Paragraph:

Shaft and wheel forgings shall be ultrasonically inspected. Vendor shall identify blading inspection method(s) in proposal.

**16.2.2.1.4 (Add.)**

All surfaces of the steel casting including machined faces shall be magnetic particle examined.

**16.2.2.1.5 (Add.)**

When the thickness of pressure containing parts to be welded exceeds the thickness limits of table UCS-56 of ASME code Sec. VIII div. I, welds shall be 100% radiographed.

**16.3.1.1 (Mod.)**

Add the following term at the end of Paragraph:

The minimum witness tests required by Purchaser's and Employer's inspectors shall be as followings:

- a) Hydraulic test.
- b) No load running test.  
(Auxiliary equipment should be used during running test).
- c) Continuous operation for one hour at thermal equilibrium at maximum continuous speed, noting vibration and axial displacement, and monitoring equipment running test.
- d) During mechanical test run shaft lateral vibration frequency analysis is required.
- e) Following the running test, all turbines shall be opened for internal inspection.
- f) Noise level measurement according to NIOEC-SP-47-10.

**16.3.2.2.4 (Sub.)**

Use of any type of gaskets in axial split joint, including string or tape, is not permitted during hydrostatic testing.

**16.3.3.1 (Mod.)**

- i) Rotor balance during shop test and permanent installation shall be such that during operation at maximum continuous speed or any other specified operating speed, the peak-to-peak amplitude of vibration in any plane measured on the shaft adjacent to the bearing housing at each end of the shaft shall not exceed the following (including shaft runout):

| <u>Speed (rpm)</u> | <u>Vibration (mm)</u> |
|--------------------|-----------------------|
| Up to 10,000       | 0.025                 |
| 10,001 & above     | 0.0190                |

Vibration readings taken on bearing housings are not acceptable.

Turbine and driven equipment (such as compressor) shall be balanced as a unit.

Vibration shall be measured directly on a polished area of the shaft adjacent to each bearing. The shaft runout shall not exceed 0.0005 inch at the point of vibration measurement.

**16.3.3.2 (Mod.)**

- g) Reading shall be logged, as a minimum, every 20 minutes during the 4 hours run at maximum continuous speed.

**16.3.3.3 (Mod.)**

Modify Sub-Parts “a” and “c” as follow:

- a) Add the following term at the end of Paragraph:

- 1- A record of the following data for every 15 minutes during shop acceptance test:

Lube oil temperature and pressure, vibration, shaft vibration R.P.M. and all other relevant data normally recorded.

- 2- Vibration frequency and amplitude data for minimum specified and maximum continuous speeds adjacent to each bearing.

- 3- Speed plot with identified critical speeds for flexible shaft turbines.

Above mentioned information shall be furnished to purchaser's and Employer's inspectors.

- c) The measurement shall be recorded on deceleration (coast down).

**16.3.4.11 Governor System Response Test under Load (Mod.)**

Add the following term at the end of Paragraph:

Turbines shall be tested for response to control signal.

**16.3.5 Rotor over Speed Test (Add.)**

Each rotor shall be subjected to an over speed test of at least 115% of maximum continuous speed for a minimum duration of 3 minutes. After the over speed test, the rotor shall be checked for cracks and defects by magnetic particle inspection, and shall then be rebalanced.

**16.4.1 (Mod.)**

Add the following term at the end of Paragraph:

The turbine vendor shall prepare the equipment for export shipment. Each turbine shall be properly identified with an item number. No material shall be shipped separately. Miscellaneous parts shall be tagged or marked with securely affixed corrosion-resistant metal tags indicating the item and serial numbers for which it is intended. All such parts shall be suitably boxed and shipped with the unit.

Suitable bracing and supports shall be provided to prevent damage during shipment.

**16.4.1 (Mod.)**

In addition to API requirements, Shipping instructions shall comply with NIOEC-SP-90-52, Specification for Packing and Packages.

**17.2.3 e) & 17.3.4.1 (Mod.)**

Add the following term at the end of Paragraph:

NIOEC-SP-40-03 “Specifications for Spare Parts Requirements” shall be followed.

**17.3.1.1 (Mod.)**

Add the following term at the end of Paragraph:

Cross sectional drawings and information shall be provided showing all details of construction and design such as casing, casing joint, loading, rotor dynamics, number of stages, nozzles, control and shut-off valves and selection of materials.

In addition to the requirements specified in the conditions of contract the following final design information shall be submitted to Purchaser for review by Employer within 12 weeks of placing the order.

1. Dimensioned cross-sectional drawings that show all details of construction such as, rotor, bearings, shaft sealing valves, etc.
2. All rotor radial and axial internal clearances.
3. Calculated thrust loads and unit load for thrust and radial bearings.
4. Internal thrust analysis with tabulation of individual thrust contributors.
5. Input and results of rotor dynamic study including bearing and support stiff nesses and dampening as a function of speed.
6. Performance curves.
7. Dimensioned general arrangement drawing including driven equipment.
8. Complete mechanical data sheet with drawing for all equipment, auxiliaries and instruments, such as oil coolers, piping, oil reservoirs, valves, oil pumps and auxiliary turbines.
9. Campbell diagram for all blades and goodman diagram where the Campbell diagram indicate they are required.
10. Drawings showing lube and control oil system including all instrument and protective devices.
11. All instrument types and manufacturers.
12. Complete electrical list indicating type and manufacturers of equipment, such as relays etc...
13. All electrical drawings for control and protection of compressors and drivers.

**17.3.2 Drawings and technical data (Mod.)**

Add the following term at the end of Paragraph:

The vendor in any case shall supply the following data where relevant for each turbine:

- 1- Full load water rate 1b/hp/hr.
- 2- Max. steam flow through nozzles 1b/hr.
- 3- Inlet and exhaust nozzle sizes.

- 4- Cooling water required.
- 5- Lube oil pump capacity.
- 6- Lube oil reservoir capacity.
- 7- Shipping weight.

**17.3.5.1 (Mod.)**

Add the following term at the end of Paragraph:

The manufacturer shall recommend safe operating vibration amplitudes, along with alarm and shutdown criteria, and include them in the operating manual.

**18. GUARANTEE AND WARRANTY (Add.)****18.1 Mechanical (Add.)**

Unless exception is recorded by the vendor in his proposal, it shall be understood that the vendor agrees to the following guarantees and warranties:

During a period of 12 months after the date of commissioning, the vendor shall, with all possible speed and without cost to the purchaser, replace or repair the goods or any part thereof found to be defective due to faulty material, workmanship or to any act or omission of the vendor. In particular, the vendor shall reimburse any transportation and other charges incurred by the purchaser in effecting such replacement or repair at the point of use.

**18.2 Performance (Add.)**

The turbine and all auxiliaries shall be guaranteed for satisfactory performance at all operating conditions specified on the data sheet, and the operating range between those points. The thermodynamic performance guarantee point shall be the normal operating point or other point indicated "guarantee" on the data sheets. The steam rate at the guarantee point shall not exceed the value stated in the Proposal.

# Petroleum, Petrochemical, and Natural Gas Industries—Steam Turbines—Special-purpose Applications

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# Introduction

Users of this standard should be aware that further or differing requirements may be needed for individual applications. This standard is not intended to inhibit a vendor from offering, or the purchaser from accepting, alternative equipment or engineering solutions for the individual application. This may be particularly appropriate where there is innovative or developing technology. Where an alternative is offered, the vendor should identify any variations from this standard and provide details.

This standard requires the purchaser to specify certain details and features.

A bullet (●) at the beginning of a section or subsection indicates that either a decision is required or further information is to be provided by the purchaser. This information or decision should be indicated on the datasheets; otherwise it should be stated in the quotation request (inquiry) or in the order.

In this standard, where practical, U.S. Customary units have been included in brackets for information.

# Petroleum, Petrochemical, and Natural Gas Industries—Steam Turbines—Special-purpose Applications

## 1 Scope

This standard specifies the minimum requirements for steam turbines for special-purpose applications for use in the petroleum, petrochemical, and natural gas industries. These requirements include basic design, materials, fabrication, inspection testing, and preparation for shipment. It also covers the related lube oil systems, instrumentation, control systems, and auxiliary equipment. It is not applicable to general-purpose steam turbines, which are covered in API 611.

## 2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

API Standard 520, Part I, *Sizing, Selection, and Installation of Pressure-relieving Systems in Refineries, Part I—Sizing and Selection*

API Recommended Practice 520, Part II, *Sizing, Selection, and Installation of Pressure-relieving Systems in Refineries, Part II—Installation*

API Standard 526, *Flanged Steel Pressure-relief Valves*

API Standard 614, *Lubrication, Shaft-sealing and Oil-control Systems and Auxiliaries*

API Standard 670, *Machine Protection Systems*

API Standard 671, *Special Purpose Couplings for Petroleum, Chemical and Gas Industry Services*

API Recommended Practice 686, *Recommended Practices for Machinery Installation and Installation Design*

ASME *Boiler and Pressure Vessel Code (BPVC)*<sup>1</sup>, Section V: *Nondestructive Examination*

ASME *Boiler and Pressure Vessel Code (BPVC)*, Section VIII: *Pressure Vessels*

ASME *Boiler and Pressure Vessel Code (BPVC)*, Section IX: *Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators*

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

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

ASME B16.5, *Pipe Flanges and Flanged Fittings, NPS 1/2 through NPS 24 Metric/Inch Standard*

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

ASME B16.47, *Large Diameter Steel Flanges NPS 26 through NPS 60 Metric/Inch Standard*

ASME B17.1, *Keys and Keyseats*

ASME B31.3, *Process Piping*

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<sup>1</sup> ASME International, 2 Park Avenue, New York, New York 10016-5990, [www.asme.org](http://www.asme.org).

ASTM A194 <sup>2</sup>, *Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both*

ASTM A247, *Standard Test Method for Evaluating the Microstructure of Graphite in Iron Castings*

ASTM A278, *Standard Specification for Grey Iron Castings for Pressure-Containing Parts for Temperatures Up to 650 °F (350 °C)*

ASTM A307, *Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength*

ASTM A395, *Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures*

ASTM A418, *Standard Practice for Ultrasonic Examination of Turbine and Generator Steel Rotor Forgings*

ASTM A472, *Standard Specification for Heat Stability of Steam Turbine Shafts and Rotor Forgings*

ASTM A536, *Standard Specification for Ductile Iron Castings*

AWS D1.1 <sup>3</sup>, *Structural Welding Code—Steel*

EN 287 <sup>4</sup>, *Qualification test of welders—Fusion welding—Part 1: Steels*

IEC 60045-1 <sup>5</sup>, *Steam turbines—Part 1: Specifications*

IEC 60072, *Dimensions and output series for rotating electrical machines* (all parts)

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

IEC 61508, *Functional safety of electrical/electronic/programmable electronic safety-related systems* (all parts)

IEC 61511, *Functional safety—Safety instrumented systems for the process industry sector* (all parts)

ISO 261 <sup>6</sup>, *ISO General Purpose Metric Screw Threads—General Plan*

ISO 262, *ISO general-purpose metric screw threads—Selected sizes for screws, bolts and nuts*

ISO 724, *ISO general-purpose metric screw threads—Basic dimensions*

ISO 965 (all parts), *ISO general-purpose metric screw threads—Tolerances*

ISO 1940-1, *Mechanical vibration—Balance quality requirements for rotors in a constant (rigid) state—Part 1: Specification and verification of balance tolerances*

ISO 3744, *Acoustics—Determination of sound power levels and sound energy levels of noise sources using sound pressure—Engineering methods for an essentially free field over a reflecting plane*

ISO 7005-1, *Pipe flanges—Part 1: Steel flanges for industrial and general service piping systems*

ISO 7005-2, *Metallic flanges—Part 2: Cast iron flanges*

<sup>2</sup> ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, [www.astm.org](http://www.astm.org).

<sup>3</sup> American Welding Society, 8669 NW 36 Street, #130, Miami, Florida 33166-6672, [www.aws.org](http://www.aws.org).

<sup>4</sup> European Committee for Standardization, Avenue Marnix 17, B-1000 Brussels, Belgium, [www.cen.eu](http://www.cen.eu).

<sup>5</sup> International Electrotechnical Commission, 3 rue de Varembe, P.O. Box 131, CH-1211 Geneva 20, Switzerland, [www.iec.ch](http://www.iec.ch).

<sup>6</sup> International Organization for Standardization, 1, ch. de la Voie-Creuse, Case postale 56, CH-1211 Geneva 20, Switzerland, [www.iso.org](http://www.iso.org).

ISO 8068, *Lubricants, industrial oils and related products (class L)—Family T (Turbines)—Specification for lubricating oils for turbines*

ISO 8501-1, *Preparation of steel substrates before application of paints and related products—Visual assessment of surface cleanliness—Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings*

ISO 8821, *Mechanical vibration—Balancing—Shaft and fitment key convention*

ISO 15607 *Specification and qualification of welding procedures for metallic materials—General rules*

ISO 15649, *Petroleum and natural gas industries—Piping*

MSS SP-44<sup>7</sup>, *Steel Pipeline Flanges*

NEMA SM 24<sup>8</sup>, *Land-Based Steam Turbine Generator Sets 0 to 33,000 kW*

NFPA 70<sup>9</sup>, *National Electrical Code*

NFPA 497, *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*

SSPC-SP6<sup>10</sup>/NACE No. 3<sup>11</sup>, *Commercial Blast Cleaning*

### 3 Terms and Definitions

For the purposes of this document, the following terms and definitions apply. (See Annex B for a guide to steam turbine nomenclature.)

#### 3.1

##### **alarm point**

Preset value of a measured parameter at which an alarm is actuated to warn of a condition that requires corrective action.

#### 3.2

##### **anchor bolts**

Bolts used to attach the mounting plate to the support structure or foundation.

#### 3.3

##### **axially split**

Split with the principal joint parallel to the shaft centerline.

#### 3.4

##### **baseplate**

Fabricated steel structure designed to support the complete steam turbine and/or the driven equipment and other ancillaries that may be mounted upon it.

<sup>7</sup> Manufacturers Standardization Society of the Valve and Fittings Industry, Inc., 127 Park Street, NE, Vienna, Virginia 22180-4602, [www.mss-hq.com](http://www.mss-hq.com).

<sup>8</sup> National Electrical Manufacturers Association, 1300 North 17th Street, Suite 1752, Rosslyn, Virginia 22209, [www.nema.org](http://www.nema.org).

<sup>9</sup> National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02169-7471, [www.nfpa.org](http://www.nfpa.org).

<sup>10</sup> The Society for Protective Coatings, 40 24th Street, 6th Floor, Pittsburgh, Pennsylvania 15222, [www.spc.org](http://www.spc.org).

<sup>11</sup> NACE International (formerly the National Association of Corrosion Engineers), 1440 South Creek Drive, Houston, Texas 77084-4906, [www.nace.org](http://www.nace.org).

**3.5****control mechanism**

All of the equipment between the speed governor and the governor-controlled valve(s) (such as linkages, pilot valves, power servos, and so forth).

**3.6****critical speed**

Shaft rotational speed at which the rotor-bearing-support system is in a state of resonance.

**3.7****design**

Manufacturer's calculated parameter.

NOTE This is a term used by the equipment manufacturer to describe various parameters such as design power, design pressure, design temperature, or design speed. It is not intended for the purchaser to use this term.

**3.8****duplex**

The provision of two microprocessors instead of one in situations where a fail-over function is required.

NOTE Availability is typically in the 98 % range.

**3.9****enclosure**

Compartment designed to provide noise protection and/or weather protection.

NOTE The compartment can include walls, doors, and a roof.

**3.10****fail safe system**

System that causes the equipment to revert to a permanently safe condition (shutdown and/or depressurized) in the event of a component failure or failure of the energy supply to the system.

**3.11****field changeable**

Design feature that permits alteration of a function after the equipment has been installed.

NOTE The alteration can 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.

**3.12****gauge board**

Bracket or plate used to support and display gauges, switches, and other instruments.

NOTE A gauge board is open and not enclosed. A panel is typically fully enclosed.

**3.13****general-purpose turbine**

Horizontal or vertical turbines used to drive equipment that is usually spared.

**NOTE** General-purpose steam turbines are intended for applications where the inlet gauge pressure does not exceed 4800 kPa (700 psi) and the inlet temperature does not exceed 400 °C (750 °F), and where the speed does not exceed 6000 r/min.

### 3.14

#### **governor-controlled valve**

Device that controls the flow of steam into or out of the turbine in response to the speed governor.

### 3.15

#### **hold-down bolts**

#### **mounting bolts**

Bolts that hold the equipment to the mounting plate or plates.

### 3.16

#### **hydrodynamic bearings**

Bearings that use the principles of hydrodynamic lubrication.

**NOTE** The bearing surfaces are oriented so that relative motion forms an oil wedge, or wedges, to support the load without shaft-to-bearing contact.

### 3.17

#### **informative**

Information only.

**NOTE** An informative reference or annex provides advisory or explanatory information. It is intended to assist the understanding or use of the document.

### 3.18

#### **internal friction damping**

Damping effect that causes a phase difference between the stress and strain in any material under cyclic loading.

**NOTE** This phase difference produces the characteristic hysteric loop on a stress-strain diagram and is thus a destabilizing damping force.

### 3.19

#### **local**

(Device) mounted on or near the equipment or console.

### 3.20

#### **manufacturer**

Organization responsible for the design and manufacture of equipment.

**NOTE** The manufacturer is often a different entity than the vendor.

### 3.21

#### **maximum allowable speed**

Highest speed at which the manufacturer's design permits continuous operation.

**NOTE** The maximum allowable speed is usually set by rotation element stress values.

### 3.22

#### **maximum allowable temperature**

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 any specified operating conditions.

**3.23****maximum allowable working pressure**

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 maximum allowable temperature.

**3.24****maximum continuous speed**

Highest speed at which the turbine, as built and tested, is capable of continuous operation, at any of the specified steam conditions.

**3.25****maximum exhaust casing pressure**

Highest exhaust steam pressure that the purchaser requires the casing to contain, with steam supplied at maximum inlet conditions.

NOTE The turbine casing is subjected to the maximum temperature and pressure under these conditions.

**3.26****maximum exhaust pressure**

Highest exhaust steam pressure at which the turbine is required to operate continuously.

**3.27****maximum inlet pressure and temperature**

Highest inlet steam pressure and temperature conditions, at the inlet to the trip and throttle valve, at which the turbine is required to operate continuously.

**3.28****maximum sealing pressure**

Highest pressure the seals are required to seal during any specified static or operating conditions and during start-up and shutdown.

**3.29****minimum allowable speed**

Lowest speed at which the manufacturer's design permits continuous operation.

**3.30****minimum exhaust pressure**

Lowest exhaust steam pressure at which the turbine is required to operate continuously.

**3.31****minimum inlet pressure and temperature**

Lowest inlet steam pressure and temperature conditions at which the turbine is required to operate continuously.

**3.32****mounting plate**

An intermediate plate or structure that is designed to simplify mounting and attachment of equipment to the foundation or to another steel structure. This is either a baseplate(s) or soleplates.

**3.33****nominal pipe size****NPS**

Dimensionless value approximately equal to the diameter in inches.

**3.34****normal operating point**

Point at which usual operation is expected and optimum efficiency is desired.

NOTE This point is usually the point at which the vendor certifies that performance is within the tolerances stated in this standard.

**3.35****normal power**

Turbine power at the normal operating point.

**3.36****normative**

Required.

NOTE A normative reference or annex enumerates a requirement or mandate of the specification.

**3.37****observed (inspection or test)**

Inspection or test where the purchaser is notified of the timing of the inspection or test and the inspection or test is performed as scheduled even if the purchaser or his/her representative is not present.

**3.38****owner**

Final recipient of the equipment.

NOTE The owner can delegate procurement of the equipment to an agent.

**3.39****panel**

Enclosure used to mount, display and protect gauges, switches, and other instruments.

**3.40****potential maximum power**

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

**3.41****pressure casing**

Composite of all stationary pressure-containing parts of the unit, including all nozzles and other attached parts.

**3.42****purchaser**

Agency that issues the order and specification to the vendor.

NOTE The purchaser can be the owner of the plant in which the equipment is to be installed or the owner's appointed agent.

**3.43****radially split**

Split with the principal joint perpendicular to the shaft centerline.

**3.44****rated power**

Greatest turbine power specified and its corresponding speed; it includes all the margin required by the specifications of the driven equipment.

**3.45****rated speed****100 % speed**

Highest rotational speed required to meet any of the specified operating conditions.

**3.46****relief valve set pressure**

Pressure at which a relief valve starts to lift.

**3.47****remote**

(Device) located away from the equipment or console, typically in a control room.

**3.48****separation margin**

Margin between a critical speed and the nearest required operating speed.

**3.49****shutdown set point**

Preset value of a measured parameter at which automatic or manual shutdown of the system or equipment is required.

**3.50****slow roll**

Speed recommended by the vendor (typically, 500 r/min to 800 r/min) for warm-up and initial check of equipment integrity prior to full operation.

**3.51****special-purpose turbines**

Horizontal turbines used to drive equipment that are usually not spared and are used in uninterrupted continuous operation in critical service.

NOTE This category is not limited by steam conditions, power or turbine speed.

**3.52****special tool**

Tool that is not a commercially available catalogue item.

**3.53****stability analysis**

Determination of the natural frequencies and the corresponding logarithmic decrement of the damped rotor and support system using a complex eigenvalue analysis.

**3.54****stage**

One set of stationary and rotating blade rows.

**3.55****synchronous tilt pad coefficient**

Coefficient derived from the complex frequency-dependent coefficients with the frequency equal to the rotational speed of the shaft.

**3.56****steam rate**

Quantity of steam required by the turbine per unit of power output measured at the output shaft of the turbine.

**3.57****triple modular redundancy****TMR**

The provision of three microprocessors instead of one in situations where continuing functioning has to be ensured. Availability is typically in the 99.9999 % range.

**3.58****trip speed**

Rotational speed at which the independent overspeed shutdown system operates to shut down a turbine.

NOTE Trip speed is usually expressed in revolutions per minute.

**3.59****unit responsibility**

Responsibility for coordinating the documentation, delivery, and technical aspects of the equipment and all auxiliary systems included in the scope of the order.

NOTE The technical aspects to be considered include, but are not limited to, such factors as the power requirements, speed, rotation, general arrangement, couplings, dynamics, noise, lubricant selection, instrumentation, piping, testing of components, conformance to specifications, and material test reports.

**3.60****vendor****supplier**

Agency that supplies the equipment in response to the order.

NOTE The vendor may be the manufacturer of the equipment or the manufacturer's agent and is normally responsible for service support.

**3.61****witnessed (inspection or test)**

Inspection or test that the purchaser attends.

NOTE A hold is applied to the production schedule and the inspection or test is carried out with the purchaser or purchaser's representative in attendance.

## **4 General**

### **4.1 Unit Responsibility**

The vendor who has unit responsibility shall ensure that all sub-vendors comply with the requirements of this standard.

### **4.2 Dimensions**

- Drawings and maintenance dimensions shall be in SI units or U.S. customary (USC) units. Use of a SI datasheet indicates that SI units shall be used. Use of a USC datasheet indicates that USC units shall be used. Typical datasheets in both systems of units are given in Annex A.



### 4.3 Unit Conversion

The factors in API *MPMS* Ch. 15, shall be used to convert between USC units and SI units.

### 4.4 Nomenclature

A guide to steam turbine nomenclature is presented in Annex B.

### 4.5 Conflicting Requirements

In the event of conflict between this standard and the enquiry, the enquiry shall govern. At the time of the order, the order shall govern.

## 5 Statutory Requirements

The purchaser and vendor shall mutually determine the measures to be taken to comply with any governmental codes, regulations, ordinances, or rules that are applicable to the equipment, its packaging, and preservatives used.

## 6 Basic Design

### 6.1 General

- **6.1.1** The purchaser shall specify the period of uninterrupted continuous operation, during which time the equipment should not require shutdown to perform maintenance or inspection.

NOTE It is recognized that achievement of this objective requires a joint effort of the purchaser, vendor, and user.

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

**6.1.3** The vendor who has unit responsibility shall ensure that all sub-vendors comply with the requirements of this standard.

- **6.1.4** The purchaser shall specify the equipment's normal operating point and any other required operating points, including the inlet and exhaust steam conditions and any extraction or induction steam quantities and pressures. The purchaser shall also specify the maximum and minimum values of the inlet, exhaust, and extraction/induction steam conditions.

**6.1.5** Unless otherwise specified, steam purity limits shall be in accordance with IEC 60045-1 and NEMA SM 24.

**6.1.6** Variations from maximum inlet steam pressure and maximum inlet steam temperature can be expected for short durations. Allowable swings and time durations over a 12 month period are defined in NEMA SM 24. The turbine shall be capable of withstanding these variations.

**6.1.7** For generator drive applications in which process steam to or from the turbine is associated with a critical service need or if the power required from the turbine generator is specified as critical service, this standard may invoke.

**6.1.8** Turbines shall be capable of the following:

- a) operation at normal power and speed with normal steam conditions, with the steam rate certified by the manufacturer at these conditions;

- b) delivering rated power at its corresponding speed with coincident minimum inlet and maximum exhaust conditions specified;

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, with a maximum continuous speed of at least 105 % of rated speed;
- d) continuous operation at rated power and speed with maximum inlet steam conditions and maximum or minimum exhaust steam conditions;
- e) continuous operation at the lowest speed at which maximum torque is required with minimum inlet and maximum exhaust conditions, with the purchaser specifying both the speed and torque values required;
- f) continuous operation at specified conditions for extraction and/or induction;
- g) operation with variations from rated steam conditions and steam purity levels recommended in IEC 60045-1 or NEMA SM 24;

NOTE Regardless of the design limit of any turbine component, the turbine should not be operated or rerated outside the nameplate limits without a thorough design review.

- h) operation uncoupled with maximum inlet steam conditions.

Governing instability and high acceleration rates can occur and may require action such as throttling of the inlet pressure. Care should also be taken when operating at no or light load (in any turbine section) and high speed or uncoupled, as typically applicable for generator sets, but occasionally also applicable to mechanical drive applications. This type of operation may require reducing the inlet temperature to keep exhaust and/or extraction temperature within acceptable limits for the turbine, piping, and (if applicable) condenser. One concern that should be evaluated is the risk of the rotor expansion above the normal case when the turbine is operated at high exhaust temperatures.

**6.1.9** Equipment shall be designed for operation at momentary speeds up to the trip speed without damage. The turbine trip speed shall be 110 % of maximum continuous speed, normally 116 % of rated speed. For generator drive, trip speed is 10 % above synchronous speed.

This requirement should not be construed to allow continuous operation above maximum continuous speed.

**6.1.10** The turbine and accessories shall perform on the test stand and when installed on the 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.

- **6.1.11** If specified, the vendor's representative shall witness:

- a) a check of the piping alignment performed by unfastening the major flanged connections of the equipment;
- b) the initial shaft alignment check;
- c) shaft alignment at operating temperature.

NOTE 1 Many factors can adversely affect site performance. These factors include such items as piping loads, alignment at operating conditions, supporting structure, handling during shipment, and handling and assembly at the site.

NOTE 2 Further information on machinery installation and installation design is given in API 686.

**6.1.12** 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.

**6.1.13** 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 to ensure accurate alignment on reassembly. This may be accomplished by the use of shouldering, cylindrical dowels, or keys.

**6.1.13.1** Any maintenance item with a mass more than 20 kg (44 lb) shall be provided with lifting lugs or similar dedicated fixed lifting point(s). Screw-in eyebolts are only acceptable for bearing housing covers and for internal components where other lifting arrangements are impractical. Holes for eyebolts shall be permanently marked with the correct bolt size to be used. If this marking is impractical, bolt size information shall be clearly indicated in the instruction manual.

**6.1.14** 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.

**6.1.15** 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.

**Table 1—Design Criteria and Specifications for Cooling Water Systems**

| Criteria                                                                                                                                                                                           | SI Units                  | USC Units                        |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|----------------------------------|
| Water velocity over heat exchanger surfaces                                                                                                                                                        | 1.5 m/s to 2.5 m/s        | 5 ft/s to 8 ft/s                 |
| Maximum allowable working pressure, gauge                                                                                                                                                          | 700 kPa                   | 100 psi (7 bar)                  |
| Test pressure (1.3 MAWP), gauge                                                                                                                                                                    | 1050 kPa                  | 150 psi (10.5 bar)               |
| Maximum pressure drop                                                                                                                                                                              | 100 kPa                   | 15 psi (1 bar)                   |
| Maximum inlet temperature                                                                                                                                                                          | 30 °C                     | 90 °F                            |
| Maximum outlet temperature                                                                                                                                                                         | 50 °C                     | 120 °F                           |
| Maximum temperature rise                                                                                                                                                                           | 20 K                      | 30 °F                            |
| Minimum temperature rise                                                                                                                                                                           | 10 K                      | 20 °F                            |
| Fouling factor on water side                                                                                                                                                                       | 0.35 m <sup>2</sup> ·K/kW | 0.002 hr·ft <sup>2</sup> ·°F/Btu |
| Shell corrosion allowance                                                                                                                                                                          | 3.0 mm                    | <sup>1</sup> / <sub>8</sub> in.  |
| NOTE The criterion for velocity over heat exchange surface is intended to minimize waterside fouling; the criterion for minimum temperature rise is intended to minimize the use of cooling water. |                           |                                  |

**6.1.16** The vendor shall notify the purchaser if the criteria for minimum temperature rise and velocity over heat exchange surfaces result in a conflicting design. If such a conflict exists, the purchaser shall approve the final selection.

- **6.1.17** 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 SPL specified. The vendor shall provide details of any special measures taken to achieve the stated levels. The vendor shall ensure these noise limits are specified to all sub-suppliers.

In order to determine compliance, the vendor shall provide both maximum sound pressure and sound power level data per octave band for each principal component supplied.

- **6.1.18** Motors, electrical components, and electrical installations shall be suitable for the area classification (class, group, and division or zone) specified by the purchaser and shall meet the requirements of the

applicable sections of IEC 60079 or NFPA 70, Articles 500, 501, 502, and 504, as well as any local codes specified (and, if requested by the vendor, furnished) by the purchaser.

- **6.1.19** The equipment, including all auxiliaries, shall be suitable for operation under the environmental conditions specified by the purchaser. These conditions shall include whether the installation is indoors (heated or unheated) or outdoors (with or without a roof), maximum and minimum temperatures, unusual humidity, and dusty or corrosive conditions.
- **6.1.20** The equipment, including all auxiliaries, shall be suitable for operation, using the utility conditions specified by the purchaser.

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

## **6.2 Nameplates and Rotation Arrows**

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

**6.2.2** Rotation arrows shall be cast in, or attached to, each major item of rotating equipment at a readily visible location. Welding is not permitted. A rotation arrow shall be located on the thrust-bearing housing.

**6.2.3** Nameplates and rotation arrows (if attached) shall be of austenitic stainless steel or of nickel-copper alloy. Attachment pins shall be of the same material.

**6.2.4** 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) year ship;
- d) serial number;
- e) size and type;
- f) rated power and speed;
- g) all lateral critical speeds less than trip speed;
- h) the next lateral critical speed greater than trip speed;
- i) maximum continuous speed;
- j) trip speed;
- k) normal and maximum inlet steam temperature and pressure;
- l) normal and maximum exhaust steam pressure;
- m) number of teeth in the multi-toothed surface provided for speed sensing.

**6.2.5** Any lateral critical speeds determined from mechanical running tests shall be stamped on the nameplate followed by the word "Test." Critical speeds, predicted by calculation, up to and including the first critical speed above trip speed, and not identifiable by test, shall be stamped on the nameplate followed by the abbreviation "Calc."

## 7 Casings

### 7.1 Pressure Casings

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

**7.1.2** Pressure casing material stress shall comply with 7.1.2.1, 7.1.2.2, or 7.1.2.3. The manufacturer shall state the source of the material properties, such as ASTM or ASME, as well as the casting factors applied, in their proposal. The NDE requirements for various casting quality factors shall be determined from the published material properties or be equivalent to those required by ASME *BPVC*, Section VIII, Division 1.

**7.1.2.1** Any material's tensile stress used in the design of the pressure casing shall not exceed 25 % of the minimum ultimate tensile strength for that material at the maximum specified operating temperature, multiplied by the appropriate casting quality factor.

**NOTE** To provide the initial load required to obtain a reliable bolted joint, the bolting may be tightened to produce a bolt tensile stress that exceeds 25 % of its ultimate tensile stress. Values in the range of 70 % of yield are common.

**7.1.2.2** Any material used for pressure casings shall not exceed its maximum allowable stress at the maximum specified operating temperature, and, for castings, multiplied by the appropriate quality factor. The material maximum allowable stress and casting quality factor shall be defined per ASME *BPVC*, Section VIII, Division 1, Part UG-27 and Part UG-24, respectively.

**7.1.2.3** Pressure-containing components may be designed with the aid of finite element analysis provided that the design limits comply with Section VIII, Division 2 of the ASME *BPVC* stress intensity as modified by Equation (1).

$$I_{MAS} = I_{CS} \left( \frac{P_{ch}}{150} \right) \quad (1)$$

where

$I_{MAS}$  is the maximum allowable stress intensity in kPa (psi);

$I_{CS}$  is the code stress intensity in kPa (psi);

$P_{ch}$  is the code hydrotest pressure in percent of MAWP.

**7.1.3** The relief valve set pressure(s) shall be set no higher than the casing maximum allowable working pressure. For condensing turbines, the exhaust casing shall be designed for both full vacuum and for a maximum allowable working gauge pressure of at least 70 kPa (10 psi).

A full-capacity safety relief valve shall be installed in the exhaust piping between each exhaust connection and exhaust block valve to prevent overpressure and possible rupture of the turbine casing. For condensing turbines where there is no exhaust block valve, the relief valve may be located on the condenser.

Unless otherwise specified, the purchaser shall provide the safety relief valve(s). These relief valves are to be installed in the purchaser's piping and may affect the piping design.

**7.1.4** The vendor shall define the maximum allowable working pressure of the turbine casing and of each part of turbine casings designed for more than one maximum allowable pressure level (split-pressure-level casings). The exhaust of condensing turbine shall be capable of short-term running at 150 °C (300 °F).

**NOTE** During operation with poor vacuum or no load testing, the exhaust temperature will rise. This value is to ensure the turbine can operate in either of these conditions.

**7.1.5** The turbine casing shall be axially split. Turbine casings may also be split radially between high-pressure and low-pressure sections. Where possible, vertical joints in the turbine casing shall be discontinuous at the horizontal split to avoid a four-cornered joint.

**7.1.6** The main joint of axially and radially split casings shall use a metal-to-metal joint that is tightly maintained by bolting. The joint shall be sealed with a compound that is compatible with the fluids to be handled. Gaskets (including string type) shall not be used.

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

If the clearances vary from the closed casing readings, they shall be confirmed to be within manufacturer's allowable clearance tolerance and guidelines.

**7.1.8** Casings and supports shall be designed to have sufficient strength and rigidity to limit any change in the relative position of the shaft ends caused by the worst combination of allowable pressure, torque, and piping forces and moments, to 50  $\mu\text{m}$  (0.002 in.), see 7.4.

**NOTE** This section does not apply to thermal growth.

**7.1.9** Supports, and the design of jackscrews and their attachments, shall be rigid enough to permit the machine to be moved by the use of its lateral and axial jackscrews without flexing and damage of the support plates and jackscrews.

**7.1.10** Jackscrews, guide rods, cylindrical casing-alignment dowels, and/or other appropriate devices shall be provided to facilitate disassembly and reassembly. Guide rods shall be of sufficient length and rigidity to prevent damage to the internals or casing studs by the casing during disassembly and reassembly. Lifting lugs shall be provided for lifting only the top half of the casing.

**7.1.11** When jackscrews are used as a means of parting contacting faces, one of the faces shall be relieved (counter bored or recessed) to prevent a leaking joint or an improper fit caused by marring of the face.

**7.1.12** The steam chest and casing shall be provided with connections to ensure complete drainage. Drain connections shall be DN 25 (NPS 1) minimum size.

**7.1.13** The use of threaded 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 any allowance for corrosion, shall be left around and below the bottom of drilled and threaded holes. The depth of the threaded 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 (770 °F).

**7.1.14** Studded connections shall be furnished with studs installed. The first 1.5 threads at both ends of each stud shall be removed.

**7.1.15** Bolting shall be furnished as follows.

- a) The details of threading shall conform to ISO 261, ISO 262, ISO 724, and ISO 965, or ASME B1.1.
- b) Studs or through bolts shall be supplied on the main joint of axially split casings and end covers of radially split casing joint(s).
- c) Studs or through bolts shall be used instead of cap screws on all other joints, except where hexagonal head cap screws are essential for assembly purposes and have been approved by the purchaser.
- d) The manufacturer's marking, in accordance with the appropriate standard (e.g. ASTM), shall be located on all fasteners 6 mm ( $\frac{1}{4}$  in.) and larger (excluding washers and headless set screws). For studs, the marking shall be located on the nut end of the exposed stud.

- e) Adequate clearance shall be provided at all bolting locations to permit the use of socket or box wrenches.
- f) If specified, the main casing joint studs and nuts shall be designed for the use of hydraulic bolt tensioning. The vendor shall provide procedures and any special tooling required.
- g) Internal socket-type, slotted-nut, or spanner-type bolting shall not be used on the exterior of the turbine case unless specifically approved by the purchaser.
- h) The vendor shall provide a bolt torque schedule for main horizontal joint, valve chest (if bolted to the casing), and exhaust, which shall detail the bolt torque requirements and tightening patterns. ASME flanges shall be torque in accordance with ASME B31.3.

**7.1.16** Mounting surfaces shall meet the following criteria.

- a) The surface finish shall be 6  $\mu\text{m}$  (250  $\mu\text{in.}$ ) arithmetic average roughness, Ra, or better.
- b) The mounting surfaces in one plane shall be machined such that no point on any surface deviates from the common plane by more than 50  $\mu\text{m}$  (0.002 in.).
- c) The different mounting planes shall be parallel to each other within 1 in 1000, in any direction.
- d) The upper surfaces shall be machined or spot faced to a diameter larger than the bolt head, nut, or washer, parallel to the mounting surface.
- e) Unless the manufacturer provides special tools, mounting surfaces shall be designed to accept standard tools.

**7.1.17** Hold-down bolt holes shall be drilled perpendicular to the mounting surface(s) and shall be 15 mm (0.6 in.) larger in diameter than the hold-down bolt. Holes shall be machined or spot faced to a diameter suitable for a fully eccentric washer next to the hole to allow for equipment alignment. Holes shall not be slotted.

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

**7.1.19** If casing expansion keys and slide surfaces are used, the vendor shall provide a suitable material combination that prevents sticking during transient and normal operating conditions. Vendor shall provide details regarding their design, location, and materials of construction.

## **7.2 Casing Connections**

- **7.2.1** The purchaser shall specify the orientation of the main inlet and outlet steam connections. All connections shall be suitable for the maximum allowable working pressure(s) of the casing. Flanged connections shall be integral with the casing or, for casings of weldable material, may be formed by a socket-welded or butt-welded pipe nipple or transition piece, and shall terminate with a weld-neck or socket-weld flange.

**7.2.2** 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 11.3.4). All welding of connections shall be completed before the casing is hydrostatically tested (see 16.3.2).

**7.2.3** Casing openings for piping connections shall be at least DN 20 (NPS  $3/4$ ) and shall be flanged or machined and studded. Flanged connections shall be installed as follows.

- a) Pipe nipples shall be provided with a weld-neck or socket-weld flange.
- b) The nipple and flange materials shall meet the requirements of 7.2.2.

**7.2.4** Pipe nipples welded to the casing should not be more than 150 mm (6 in.) long and shall be a minimum of Schedule 160 seamless for sizes DN 25 (NPS 1) and smaller and a minimum of Schedule 80 for DN 40 (NPS 1 1/2). Bracing or reinforcement is required when nipples longer than 150 mm (6 in.) are necessary.

**7.2.5** Sizes DN 32, DN 65, DN 90, DN 125, DN 175, and DN 225 (NPS 1 1/4, NPS 2 1/2, NPS 3 1/2, NPS 5, NPS 7, and NPS 9) shall not be used.

**7.2.6** Steel flanges shall conform to ISO 7005-1 Series 1 or ISO 7005-2 Series 1 [or ASME B16.1, ASME B16.5, ASME B16.42, or ASME B16.47 (Series B)], as specified. Flanges other than those covered in ISO 7005-2 shall conform to the dimensional requirements specified above.

ISO 7005-1 (steel flanges) PN 20, PN 50, PN 110, PN 150, PN 260, and PN 420 are designed to be interchangeable with ASME B16.5 and MSS SP-44 flanges. ISO 7005-1 flanges are not identical to ASME B16.5 and MSS SP-44 flanges but are deemed to comply with the dimensions specified in the ASME B16.5 and MSS SP-44. ISO PN 2.5 and PN 6 do not have a corresponding ASME class, and ASME Classes 75, 400, and 800 do not have corresponding ISO PN designations. These PN and class flange ratings should therefore not be used.

**7.2.6.1** 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.

**7.2.6.2** Flanges shall be full faced or spot faced on the back and shall be designed for through bolting.

- **7.2.6.3** If ISO 7005-1 has been specified, materials shall be in accordance with ISO 7005-1 as specified. The pressure temperature ratings shall correspond to the materials specified.

**7.2.6.4** For all steel flanges, imperfections in the flange facing finish shall not exceed those permitted by ASME B16.5 or ASME 16.47 as applicable.

**7.2.6.5** Flat face flanges with full raised face thickness are acceptable on casings of all materials. Flanges in all materials that are thicker or have a larger outside diameter than required by ISO or ANSI are acceptable. Nonstandard (oversized) flanges shall be completely dimensioned on the arrangement drawing.

**7.2.7** Machined and studded connections shall conform to the facing and drilling requirements of ISO 7005-1 or ISO 7005-2 (or ASME B16.1, ASME B16.5, ASME B16.42, or ASME B16.47).

**7.2.8** Machined and studded connections and flanges not in accordance with ISO 7005-1:1992 or ISO 7005-2:1988 (or ASME B16.1, ASME B16.5, ASME B16.42, or ASME B16.47) require purchaser's approval. Unless otherwise specified, the vendor shall supply mating flanges, studs, and nuts for these nonstandard connections.

**7.2.9** To minimize nozzle loading and facilitate installation of piping, machine flanges shall be parallel to the plane of the flange as shown on the general arrangement drawing to within 0.5°. Studs or bolt holes shall straddle centerlines parallel to the main axes of the equipment.

**7.2.10** All of the purchasers' connections shall be accessible for disassembly without requiring the steam turbine, any major part, or attached auxiliary piping to be moved.

- **7.2.11** If specified, appropriate casing connections with valves shall be provided for an inert gas blanket to be used as preservation during long periods of standstill.

**7.2.12** The exhaust casing on condensing turbine shall be designed with adequate inspection openings for blade inspection and maintenance access to the exhaust hood. Machined and studded or flanged connections shall be required for inspection openings.

- **7.2.13** If specified, permanent connections with valves shall be provided to provide wet and dry preservation of the steam turbine during stand still.

### 7.3 Internal Stationary Components

**7.3.1** All control stage nozzle rings shall be replaceable. Nozzle rings welded to the outer casing are acceptable only when approved in advance by the purchaser.

**7.3.2** All noncontrol stage stationary blading shall be mounted in replaceable diaphragms or blade carriers. Nozzles or blades welded to the diaphragm are preferred. Partial blading at the diaphragm split line shall be designed to prevent failure of the thin part of the blading during turbine operations.

**7.3.3** Any internal fasteners shall be positively retained to prevent them from entering the steam path.

**7.3.4** The design shall ensure that water cannot be trapped in the wet region of a condensing turbine. The design of water drain holes in the wet region of a condensing turbine shall avoid the holes becoming blocked by corrosion or debris. In the case of drain holes in the diaphragms of an impulse type turbine, this shall be achieved by lining the drain holes with corrosion-resistant material.

**7.3.5** All diaphragms, blade carriers, or other inner casings shall be designed with vertical leveling and positioning lugs or shims located near the horizontal split line. Radial ground crush pins shall not be used to set the alignment. On condensing sections of reaction machines the diaphragms may be bolted to the exhaust casing. The vendor shall indicate the required assembly vertical and horizontal clearances for each diaphragm or blade carrier

**7.3.6** Packing holders for shaft end seals shall be designed with vertical leveling lugs located near the split line for adjustment. If adjustable packing holders are not supplied, the vendor shall define how the clearances can be adjusted during future maintenance. Manufacturer shall provide information and data that defines how future changes can be made and the relationship between the changes and final packing clearances.

**7.3.7** Turbines operating on saturated steam shall have components in the steam path (e.g. nozzles, blading, diaphragms) made of erosion-resistant materials or appropriate coatings applied.

**7.3.8** Provisions shall be made to minimize water cutting of wet stages at the horizontal joint and the diaphragm steam face. Options to minimize the problem include stainless steel inlay or inserted rings.

**7.3.9** Shaft seals or packing and inter-stage diaphragm seals shall be bronze, nickel bronze, stainless steel, or other suitable materials agreed upon by the purchaser and the turbine manufacture. Gray cast iron and Ni-resist diaphragm seals are prohibited.

### 7.4 External Forces and Moments

**7.4.1** Turbines shall be designed to withstand external forces and moments at least equal to the values calculated in accordance with NEMA SM 24.

**7.4.2** The turbine supplier shall tabulate the allowable forces and moments for each casing connection.

### 7.5 Material Inspection of Pressure Casing

NOTE 1 Refer to 16.2.2 for inspection of non-pressure-containing parts.

NOTE 2 Refer to 3.41 for the definition of pressure casing.

**7.5.1** Regardless of the generalized limits presented in this section, it shall be the vendor's responsibility to review the design limits of all materials and welds in the event that more stringent requirements are specified. Defects that exceed the limits imposed in 7.5.9 shall be removed to meet the quality standards

cited, as determined by additional magnetic particle or liquid penetrant inspection as applicable before repair welding.

- **7.5.2** If radiographic, ultrasonic, magnetic particle, or liquid penetrant inspection of welds or materials is required by the ASME *BPVC* or specified, the procedures and acceptance criteria in Table 2 shall apply, except as required by 7.5.4. Alternative standards may be proposed by the vendor for approval by the purchaser.

**Table 2—Materials Inspection Standards for Pressure Casings**

| Type of Inspection               | Methods                                                  | Acceptance Criteria                                                                                              |                                                              |
|----------------------------------|----------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|
|                                  |                                                          | For Fabrications                                                                                                 | For Castings                                                 |
| Radiography                      | Section V, Articles 2 and 22 of the ASME <i>Code</i>     | Section VIII, Division 1, UW-51 (for 100 % radiography) and UW-52 (for spot radiography) of the ASME <i>Code</i> | Section VIII, Division 1, Appendix 7 of the ASME <i>Code</i> |
| Ultrasonic inspection            | Section V, Articles 4, 5, and 23 of the ASME <i>Code</i> | Section VIII, Division 1, UW-53 and Appendix 12 of the ASME <i>Code</i>                                          | Section VIII, Division 1, Appendix 7 of the ASME <i>Code</i> |
| Magnetic particle inspection     | Section V, Articles 7 and 25 of the ASME <i>Code</i>     | Section VIII, Division 1, Appendix 6 of the ASME <i>Code</i>                                                     | See acceptance criteria in Table 3                           |
| Liquid penetrant inspection      | Section V, Articles 6 and 24 of the ASME <i>Code</i>     | Section VIII, Division 1, Appendix 8 of the ASME <i>Code</i>                                                     | Section VIII, Division 1, Appendix 7 of the ASME <i>Code</i> |
| Visual inspection (all surfaces) | ASME <i>Code</i> , Section V, Article 9                  | In accordance with the material specification and the manufacturer's documented procedures                       | MSS SP-55                                                    |

**7.5.3** The purchaser shall be notified before making a major repair to a pressure-containing part. Major repairs, for the purpose of purchaser notification only, is any defect that equals or exceeds any of the three criteria defined below.

- 1) The depth of the cavity prepared for repair welding exceeds 50 % of the component wall thickness.
- 2) The length of the cavity prepared for repair welding is longer than 150 mm (6 in.) in any direction.
- 3) The total area of all repairs to the part under repair exceeds 10 % of the surface area of the part.

**7.5.4** All repairs to pressure-containing parts shall be made as required by the following documents.

- 1) The repair of plates, prior to fabrication, shall be performed in accordance with the ASTM standard to which the plate was purchased.
- 2) The repair of castings or forgings shall be performed prior to final machining in accordance with the ASTM standard to which the casting or forging was purchased.
- 3) The repair of a fabricated casing or the defect in either a weld or the base metal of a cast or fabricated casing, uncovered during preliminary or final machining, shall be performed in accordance with Table 2.

**7.5.5** Plate used in fabrications shall be 100 % ultrasonic inspected prior to starting fabrication in accordance with the ASTM standard to which the plate was purchased.