

**ENGINEERING STANDARD**

**FOR**

**GENERAL DESIGN REQUIREMENTS**

**OF**

**MACHINERIES**

**SECOND EDITION**

**March 2009**

## 1. SCOPE

This Engineering specification gives general design requirements, specifications and guidance for rotating machineries (i.e. compressors, pumps, fans, blowers, steam and gas turbines); for use in oil refineries, chemical plants, gas plants and where applicable, in exploration, production and new ventures.

**Note:** This is a revised version of the "Engineering Standard for General Design Requirements of Machineries", which is issued as edition (2). Edition (1) of the said standard is withdrawn.

The contractor shall determine by careful security which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, economic and legal aspects.

Compliance with the requirements of this specification and the Standards and codes referred to herein shall not relieve the contractor or manufacturer of their responsibility to follow safe engineering practice throughout.

## 2. REFERENCES

Throughout this Standard, the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

### API (AMERICAN PETROLEUM INSTITUTE)

- 610 "Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries "
- 611 "General Purpose steam Turbine for Petroleum, Chemical and Natural Gas Industry services".
- 612 "Special Purpose Steam Turbine for Petroleum ,Chemical and Natural Gas Industry services"
- 613 " Special Purpose Gear Units for Petroleum, Chemical and Gas Industry Services"
- 614 "Lubrication, Shaft Sealing and Control Oil System and Auxiliaries for Petroleum, Chemical and Natural Gas Industry services".
- 615 "Sound Control of Mechanical Equipment for Refinery Services"
- 616 "Gas Turbines for Petroleum, Chemical and Natural Gas Industry services"
- 617 "Axial and Centrifugal Compressors and Expander – Compressors for Petroleum, Chemical and Gas Industry services"
- 618 "Reciprocating Compressors for Petroleum, Chemical and Natural Gas Industry services"
- 619 "Rotary Type Positive Displacement Compressors for Petroleum, Chemical and Natural Gas Industry services"
- 671 "Special Purpose Couplings for Petroleum, Chemical and Natural Gas Industry services"
- 672 "Packaged, Integrally Geared Centrifugal Air Compressor for Petroleum, Chemical and Natural Gas Industry services"
- 673 " Centrifugal Fans for Petroleum, Chemical and Gas Industry Services"

- 674 "Positive Displacement Pumps-Reciprocating"
- 675 "Positive Displacement Pumps-Controlled Volume"
- 676 "Positive Displacement Pumps-Rotary"
- 677 " General Purpose Gear Units for Petroleum, Chemical and Gas Industry Services "
- 680 "Packaged Reciprocating Plant and Instrument Air Compressors for General Refinery Service"
- 682 "Pumps – Shaft Sealing System for Centrifugal and Rotary Pumps"

**ISO (International Organization for Standardization)**

- ISO 5199 "Technical specifications for centrifugal pumps - Class II"

**IPS (IRANIAN PETROLEUM STANDARDS)**

- M-PM-100 "Engineering Standard for General Design Requirements of Machineries"
- M-PM-105 "Centrifugal Pumps for Process Services"
- M-PM-115 "Centrifugal Pumps for General Services"
- M-PM-125 "Centrifugal Fire Water Pumps"
- M-PM-130 "Positive Displacement Pumps - Reciprocating"
- M-PM-140 "Positive Displacement Pumps - Rotary"
- M-PM-150 "Positive Displacement Pumps - Controlled Volume"
- M-PM-170 "Centrifugal Compressors for Process Services"
- M-PM-180 "Packaged Integrally Geared Centrifugal Compressor for Utility and Instrument Air Services"
- M-PM-190 "Axial Flow Centrifugal Compressors"
- M-PM-200 "Reciprocating Compressors for Process Services"
- M-PM-211 "Reciprocating Compressors for Utility and Instrument Air Services"
- M-PM-220 "Positive Displacement Compressors - Rotary"
- M-PM-230 "Special purpose Centrifugal Fans "
- M-PM-235 "General purpose Centrifugal Fans "
- M-PM-240 "General Purpose Steam Turbines"
- M-PM-250 "Special Purpose Steam Turbines"

<u>M-PM-260</u>	"Combustion Gas Turbines"
<u>M-PM-300</u>	"Special Purpose Gear Units"
<u>M-PM-310</u>	"Special Purpose Couplings"
<u>M-PM-320</u>	"Lubrication, Shaft Sealing and Control Oil Systems for Special Purpose Applications"
<u>M-PM-330</u>	"Mixers"
<u>E-SF-900</u>	"Noise and Vibration Control"
<u>E-EL-110</u>	"Hazardous Area"
<u>E-PR-420</u>	"Process Design of Heat Tracing and Winterizing"
<u>E-GN-100</u>	"Engineering Standard for Units"
<u>G-ME-220</u>	"Shell and Tube Heat Exchangers"
<u>G-SF-900</u>	"General Standard for Noise Control and Vibration"

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

Boiler and Pressure Vessel Code Sec. VIII, Div. I

**TEMA (TUBULAR EXCHANGER MANUFACTURER'S ASSOCIATION)**

Class C

**NFPA (NATIONAL FIRE PROTECTION ASSOCIATION)**

No. 20

**3. DEFINITIONS AND TERMINOLOGY****Vital duty**

Vital duty is a service in which failure of equipment causes an unsafe condition of the plant or installation resulting in jeopardy to life and/or major damage (fire, explosion etc.). For such services, equipment shall be adequately spared to ensure 100% availability of the service under all circumstances. Besides, independent power sources shall be selected to ensure 100% service availability. For instance, diesel engine or electric motor driven fire water pumps are categorized in vital duty services.

**Essential duty**

Essential duty is a service in which failure of equipment renders a plant or process unit inoperable or reduces performance to a level unacceptable to the Company. For such services, installed spare equipment is normally selected based upon economic considerations and proven equipment availability, where potential losses due to equipment outage greatly outweigh equipment CAPEX. Sparing philosophy shall be economically evaluated and is typically 2x100% or 3x50%. For instance, boiler feed water pumps are categorized in essential duty services.

**Non-essential Duty:**

Non-essential duty is a service which is not categorized as vital or essential duty. For such services, an economic evaluation is required to justify spared equipment. For instance, drinking water pumps

and sewage pumps are categorized as non-essential duty.

### **Critical service**

Critical service can be either a vital or an essential duty or service, according to the text and its intent.

### **Continuous operation**

Continuous operation is an uninterrupted operation by an equipment and its auxiliaries, and its installed spare, for a period of at least 16,000 hours at the specified operating conditions.

### **Intermittent Operation**

Any operation, which is not classed as continuous operation in which it is expected that the equipment will be started/stopped at unspecified intervals, e.g.:

- Automatic starts and stops at intervals by process operated controls;
- Manual starts and stops at intervals by manual control for batch processes.

### **Abrasive Service**

Any service in which there is an expected wear rate of 0.1 mm (0.004 in) or more per year, or where particle sizes exist larger than 100  $\mu\text{m}$  (0.004 in) in quantities exceeding 100 mg/kg (100 ppm by mass).

### **API Standard**

In API Standards referred to in this specification, some clauses with a bullet (\*) at the beginning indicate that either a decision is required or further information is to be provided by the purchaser. Such decisions shall be indicated on the technical specification and/or data sheets; otherwise, they shall be stated in the quotation request (inquiry) or in the purchase order.

### **Referenced Standard**

Is used for the last revision of referenced standard and/or last IPS standard whichever is updated.

## **4. UNITS**

This standard is based on International System of Units, (SI) except where otherwise specified.

## **5. GENERAL REQUIREMENTS**

### **5.1 Range and Variety of Equipment**

Even effort shall be made consistent with sound engineering practice, to minimize the spares stocking of operating companies by rationalizing the variety of makes and types of equipment and auxiliaries selected for any particular project.

This rationalization and minimizing shall be applied stringently as long as it does not interfere with the selection of an optimum equipment for the specified operating conditions and does not increase the equipment's total life cycle costs.

### **5.2 Prototype Equipment**

Selected equipment shall be, in all respects, well within the range of the manufacturer's proven experience, and shall not involve the use or application of any prototype design or components. The Vendor shall list in his proposal all design features or modifications which are not proven in similar machines produced for the last 5 years or which have not acquired at least 16 000 hours in similar operation. These design features or modifications are specifically subject to the Company's approval and proven alternatives may be requested.

### 5.3 Special Operating Requirements

Material requisition/data sheet shall indicate all particular operating requirements that the equipment may encounter, e.g. parallel operation, varying molecular weight of gases (for fans, compressors, and expanders), varying suction or discharge conditions and toxicity level of the fluid media. Special attention shall be given to off-design conditions which may occur during start-up and shutdown procedures associated with the particular process application.

### 5.4 Off-design Conditions

Manufacturers shall demonstrate that equipment shaft and bearing design takes into consideration the hydraulic forces occurring during operation away from the duty point anywhere within the range specified in data sheet.

### 5.5 Complete Unit Responsibility

Driver, driven, gear box, and auxiliaries that make up a complete unit shall be ordered from one manufacturer; the manufacturer of driven equipment is usually selected as the vendor who has the complete unit responsibility.

This manufacturer shall then become responsible for the satisfactory performance of the complete unit under all operating conditions, including starting and acceleration. Further more, this manufacturer, shall warrant and guarantee all equipment and component parts as stipulated in the relevant specification and purchase order.

## 6. DESIGN REQUIREMENTS

### 6.1 General

#### 6.1.1 Noise levels

As a general rule, the noise level of all equipment installed shall not exceed the limits specified in each equipment standard.

In the event that more stringent limits are required, then the sound power or sound pressure limit for equipment with its driver and auxiliaries shall be stated in data sheet, which shall always form part of the requisition. The supplier shall use this data sheet to submit the (guaranteed) sound power levels and/or sound pressure levels of the equipment.

Noise limits shall apply for all operating conditions, and shall have upper tolerance of +0 dB.

Silencing equipment such as silencers and acoustic enclosures may be considered for noisy process equipment. When the Supplier has been selected, details of such silencing equipment shall be agreed upon between the Supplier and the Purchaser. The Purchaser may choose to order silencing equipment separately from the process equipment.

Noise emission of certain silencing equipment (e.g. silencers on vent stacks, acoustic insulation on pipes) is not always the responsibility of any particular equipment supplier, and is the responsibility of the Purchaser. It shall be ensured that such silencing equipment is incorporated in the design and that the relevant data/requisition sheets are prepared.

#### 6.1.2 Material

Material selection shall be made based on relevant applicable specifications specified, preferably American code or standard materials. However, equivalent grade of materials produced in other recognized country CODES such as, DIN, JIS, BS, AFNOR, and UNI may also be used and each material on the drawings shall be identified by corresponding ASTM or AISI designation.

#### 6.1.3 Electrical

All electrical components and installations shall be suitable for the specified area classification and grouping to be prepared separately and shall comply with the requirements of IPS-E-EL-110.

#### 6.1.4 Pressure vessels

Pressure vessels as an auxiliary of rotary machinery, shall be designed in accordance with ASME Code Sec. VIII. ASME Code Stamp is not mandatory.

#### 6.1.5 Lubricants and lubrication

Special type lubricants are not acceptable. Equivalent type lubricants shall be submitted. Whenever specified or applicable, lubrication system shall comply with API Std. 614 and IPS-M-PM-320.

#### 6.1.6 Couplings

Unless otherwise specified in data/requisition sheets, dry-flexible disk coupling with stainless steel disks shall be provided. Couplings shall comply with requirements of API Std. 671 and IPS-M-PM-310.

#### 6.1.7 Gear units

Whenever specified or applicable, Special purpose Gear shall comply with requirements of API Std. 613 and IPS-M-PM-300. General Purpose Gear shall comply with requirements of API Std. 677.

#### 6.1.8 Instrumentation

For selection of instrumentation vendor Standard instrument may be employed, if they are installed within the confines of machinery skid and are well proven experientially. However, final selection of vendors of such instruments shall have approval of the Company prior to placement of order, with exception of special instruments to be selected by manufacturer.

Alarm and shutdown contacts for rotary machinery shall be normally closed (energized) and open (de-energized) to alarm and trip. The control and instrumentation system shall protect personnel and equipment against injury or loss under all conditions of operation or malfunction.

#### 6.1.9 Winterization

Equipment shall be winterized and heat-conserved according to IPS-E-PR-420.

#### 6.1.10 Vents and Drains

All vents and drains of machineries shall be equipped with valves.

#### 6.1.11 Heat exchangers

Heat exchangers shall comply with IPS-G-ME-220 and TEMA class "C". Unless otherwise specified, all water cooled heat exchangers shall have inhibited admiralty brass tubes with naval brass tube sheets.

Coolers on flushing lines of centrifugal pumps (MFR Std. construction) will have carbon steel or

Stainless steel body and stainless, duplex stainless steel or monel coil.

#### 6.1.12 Equipment Selection from Spare Part Optimization Viewpoint

Every effort shall be made to optimize the spares stock levels that need to be kept by the Company by rationalizing the variety of makes and types of driven equipment, drivers and auxiliary equipment selected for any particular project. This rationalization shall be applied stringently provided it does not interfere with the selection of optimal equipment for the specified operating conditions.

### 6.2 Pumps

#### 6.2.1 Centrifugal pumps

Centrifugal pumps for process services shall comply with requirements of API Std. 610 and IPS-M-

PM-105.

Fire water pumps shall comply with IPS Std. M-PM-125 and NFPA No. 20, Latest Edition.

Centrifugal pumps for other general services shall meet requirements of ISO 5199 as supplemented by IPS-M-PM-115.

Some additional requirements which should be considered when specify a pump is set out below.

**6.2.1.1 Wear rings**

Special wear-ring construction, including provision for clean fluid flushing, may be considered for pumps in abrasive services, where the pump manufacturer is able to demonstrate reliability of his design in comparable duties. For abrasive fluid services, wear rings with hard material shall be used.

**6.2.1.2 Mechanical seals**

With certain exceptions, e.g. pumping sandy crude oil, when a clean flush is not available, mechanical seals shall be applied for all duties. Other exceptions are pumps in intermittent operation on less essential duties, in water service, in fire-fighting pumps and in cooling water pumps.

Normally, hydraulically-balanced seals with stainless steel seal end plates shall be applied. Shaft sleeves shall be provided with all mechanical seals.

Where leakage of the pumped liquid to the atmosphere is prohibited, requirements of API Std. 682, on using tandem seal or double seal shall be followed.

Provision shall be made to ensure optimal operating conditions for the mechanical seal. Means by which this is to be achieved shall be indicated in the data sheet by reference to the appropriate plan in API Std. 682. The pump and seal manufacturer shall confirm the suitability of the plan selected.

Only a fixed orifice shall be used to restrict the circulation of the flushing fluid.

Where the pumped liquid contains abrasives, a clean flushing medium from an external source compatible with the pumped fluid should be used.

Cyclones in flushing lines shall be used only for low concentrations of high-density solids, where there is a clearly marked difference in density between the liquid and the solids. Strainers are not acceptable in the re-circulation line.

Cyclones integral with the pump casing are not permitted.

The pump Manufacturer is responsible for the co-ordination of engineering and installation of the selected seal and sealing system.

**6.2.1.4 Quench fluid**

A quench fluid shall be used under the following conditions:

- Where leakage of liquid to atmosphere could become a potential source of fire hazard.
- Where leakage of liquid to atmosphere could endanger personnel due to toxicity.
- Where the pumped liquid would crystallize on exposure to atmosphere.

**6.2.1.5 Selection**

The choice of pump depends mainly on the operating pressure, differential head, operating temperature, volumetric flow rate, physical characteristics of the pumped liquid, suction specific

speed and NPSHA. If more than one pump type is considered technically suitable, the final selection should be based on a life cycle cost evaluation, taking into account standardization, efficiency, suction specific speed, NPSH margin and minimum flow.

Upward nozzle orientation for centrifugal pumps with horizontally split casings should be avoided.

## 6.2.2 Rotary positive displacement pumps

Rotary pumps shall conform to the requirements of API Std. 676 and IPS-M-PM-140.

Pumps shall be selected well within the manufacturer's actual field experience of limits of operating temperature and maximum working pressure, available materials of construction, pumps speed and pumped liquid properties.

### 6.2.2.1 Bearings

In order to keep the number of shaft seals to a minimum, rotary pumps handling clean, abrasive-free non-corrosive liquids with lubricating properties should be provided with internal bearings lubricated by the pumped liquid.

In all other cases, pumps shall be provided with oil-lubricated bearings and timing gears in separate housings. Constant level sight feed oilers shall be provided.

## 6.2.3 Positive displacement pumps-reciprocating

Reciprocating pumps shall conform to the requirements of API Std. 674 and IPS-M-PM-130.

Some additional requirements which should be considered when specifying reciprocating pumps are set out below.

## 6.2.4 Positive displacement pumps-controlled volume

Controlled volume pumps shall conform to the requirements of API Std. 675 and IPS-M-PM-150.

Pumps shall be selected well within the manufacturer's actual field experience of limits of operating temperature and maximum working pressure, pump speed and pumped liquid properties.

Diaphragm pumps with direct mechanical actuation shall not be selected.

Some additional requirements which should be considered when specifying controlled volume pumps are set below:

### 6.2.4.1 Diaphragms

In the event that atmospheric release of product or contamination of product by hydraulic fluid is not permitted, double diaphragm pumps shall be specified and diaphragm failure indication shall be provided.

## 6.3 Compressors and Fans

### 6.3.1 Centrifugal/Axial geared Compressors

Centrifugal/Axial compressors shall comply with requirements of chapters one and two of API Std. 617 and IPS-M-PM-170.

#### 6.3.1.1 Drivers

The required type of driver shall be specified together with the relevant specifications with which it shall comply.

The most economical method for the capacity control of centrifugal and axial compressors (to achieve maximum turndown ratio) is speed variation. The type of variable-speed driver should be selected with account being taken of utility balance and compressor turndown ratio, in terms of both capacity and speed. Variable speed drivers may be selected from:

- Steam turbines
- Variable speed electric motors (VSDS), dual speed electric motors
- Fluid drive couplings, torque converters
- Gas turbines (two-shaft design)
- Gas engines and diesel engines

For constant-speed compressor units, capacity control can be achieved by suction throttling or recycle systems. Variable inlet guide vanes shall only be considered for air and clean non-corrosive gases.

#### **6.3.1.2 Moisture separator**

Where liquid may be present in the gas stream, installation of adequate moisture separators following intercoolers or at the inlet of process machines shall be required.

#### **6.3.1.3 Fouling Service Application**

For axial and centrifugal compressors operating in fouling services, the coating of internals may be considered. Due to the non-stick surface of the coating, fouling can be minimized. In view of the relatively high temperature used during the application process of the coating, details of such coatings processes shall be mutually agreed upon between the compressor Manufacturer and the Company.

### **6.3.2 Integrally Geared Centrifugal Compressors**

Integrally geared Centrifugal compressors shall comply with requirements of chapters one and three of API Std. 617 and IPS-M-PM-170.

#### **6.3.2.1**

Packaged high-speed integrally geared centrifugal compressors may be considered for plant air, instrument air, inert gas and clean non-corrosive process gas duties.

Single-stage integrally geared high-speed compressors may be considered for clean process applications. Having the design advantages of a centrifugal compressor, integrally geared compressors shall have preference over reciprocating types.

### **6.3.3 Expander-compressors**

Expander-compressors shall comply with requirements of chapters one and four of API Std. 617 and IPS-M-PM-170.

### **6.3.4 Reciprocating compressors**

Reciprocating compressors shall conform to the minimum requirements of API Std. 618 and IPS-M-PM-220. Some additional requirements that should be considered in specifying a reciprocating compressor and filling in data/requisition sheets are set out below.

#### **6.3.4.1 Type of compressors**

In the data/requisition sheets it shall be specified whether a vertical-type or a horizontal-type of compressor is required.

For non-lubricated duties, which are normally preferred, an extra long distance piece is required to prevent transfer of lubricating oil into the cylinder.

All anticipated process conditions and transients (e.g. re-start after shutdown) shall be specified in detail so that the optimum compressor can be selected and the drive power requirements can be correctly stipulated.

For corrosive and toxic duties, a two compartment distance piece suitably purged and vented, is required to prevent the gases entering the crank case of the compressor along the piston rod.

### 6.3.4.2 Pulsation damping equipment

Detrimental pulsations and vibrations shall be controlled for satisfactory levels of piping vibration, compressor performance, valve life, and operation of equipment sensitive to flow pulsation. Following basic techniques shall be used:

- I. System design based on analysis of the interactive effects of pulsations and the attenuation requirements;
- II. Utilization of pulsation suppression devices; (such as: pulsation filters and attenuators; volume bottles, with or without internals; choke tubes; orifice systems; and selected piping configurations)
- III. Mechanical restraint design; including type, location, and number of pipe and equipment clamps and supports.

A third party consultant jointly with the equipment manufacture shall design features of piping and sizing of suppression devices.

### 6.3.4.3 Drivers

The type of driver required shall be specified together with the appropriate specification to which it shall conform.

Anticipated process variations, such as start-up and abnormal operating conditions, shall be specified in detail so that the compressor manufacturer can size the driver correctly.

Electric motors are the drivers of first choice.

For high speed compressors (above 1000 rpm), an induction type electric motor with a spacer type coupling may be specified.

Gear transmissions should not be selected. As turbine drives invariably require a gear unit, this type of driver should be restricted to those cases where the available power source makes such a selection unavoidable.

Variable-speed frequency-controlled electric motor drives may be selected as well as gas engines or diesel engines. The minimum allowable speed for adequate lubrication and rod load reversals shall be verified.

### 6.3.4.4 Instrumentation for measurement and control

The type of capacity control will be specified. Adjustable speed electric motor drivers can be considered for capacity control. The use of variable volume clearance pockets for capacity control is not favored and its application requires the explicit approval of the company.

The use of reverse flow control by means of adjustable spring-loaded suction valves should only be used in clean gas service and at suction pressure where reliable operation has been demonstrated.

### 6.3.4.5 Alarm and shutdown

**6.3.4.5.1** Alarm and shutdown devices for high vibration shall be provided with all reciprocating gas compressors.

**6.3.4.5.2** Reciprocating gas compressors shall be provided with high or low cooling water temperature alarm for each cylinder outlet and high level alarm if moisture separators are provided.

### 6.3.5 Rotary-type positive displacement compressors

Rotary-type positive displacement compressors shall conform to the minimum requirements of API Std. 619 and [IPS-M-PM-220](#).

Some additional requirements that should be considered in specifying a rotary-type compressor and filling in data/sheets are set out below.

### 6.3.5.1 Shaft sealing

The labyrinth-type seal shall be specified for non-toxic and non-flammable gases; the mechanical contact type for non-corrosive hydrocarbons, and the liquid-film type for all other duties. The usual sealing liquid is oil. The application of other liquids, e.g. water, shall be subject to the explicit approval of the Company.

For rotary-type compressors, dry gas seals may be considered only if a proven service record is submitted by vendor.

Restrictive-ring type seals are not favored and their application is subject to the explicit approval of the Company.

### 6.3.6 Packaged integrally geared, centrifugal plant and instrument air compressors

Packaged integrally geared, centrifugal plant and instrument air compressors shall comply with the requirements of API Std. 672 and [IPS-M-PM-180](#).

The operating data and conditions together with the additional requirements for the packaged unit shall be specified in the data/requisition sheets.

### 6.3.7 Centrifugal fans

Centrifugal fans shall comply with the requirements of API Std. 673. For special purpose and general purpose applications, requirements of [IPS-M-PM-230](#) and [IPS-M-PM-235](#) shall be complied respectively.

Some additional requirements which should be considered in specifying a centrifugal fan and filling in data/requisition sheets are set out below.

#### 6.3.7.1 Type of fan

The fan shall be of the overhung type, if the actual inlet flow is less than approximately 80-100 m<sup>3</sup>/s. For larger flows a double inlet, between-bearings fan may be considered; the later type is subject to explicit approval by the Company if the inlet temperature is above 200 °C.

#### 6.3.7.3 Shaft sealing

The required type of shaft seal will be specified in the data sheet.

In general the labyrinth type seal is required for non-flammable, non-corrosive, non-toxic gases at ambient temperature. An inert gas sealing system may be considered if leakage (either air to inside or gas to outside) is not allowed for process reasons.

For high-temperature services (above 200°C) a restrictive ring or labyrinth type shaft seal, including a sealing gas system is preferred.

If a maximum sealing effect is required, mechanical contact type seals may be considered, but this type of seal **may** not be specified for service above 200 °C.

#### 6.3.7.4 Bearings

In general hydro-dynamic bearings (radial and thrust) shall be specified for fans in the following services:

- Driver rating above 100 kW.
- High-temperature fans.
- Fans in vital or essential duties.

For fans in other services anti-friction bearings may be specified.

### 6.3.8 Reciprocating compressors for utility and instrument air services

Reciprocating compressors for utility and instrument air services shall meet the requirements of API Std. 680, 1<sup>st</sup> edition entitled "Packaged Reciprocating Plant and Instrument AIR compressors for General Refinery Service" and [IPS-M-PM-211\(1\)](#).

## 6.4 Turbines

### 6.4.1 Steam turbines

Steam turbines are divided into two categories according to their size and usage:

- General-purpose steam turbines, and
- special-purpose steam turbines.

Independently of the above two categories, steam turbines can be classified on the basis of their working principles:

- Impulse or action turbines. where steam expansion occurs only in the nozzles or in the stationary blades, not both, and
- Reaction turbines where steam expansion occurs in both the stationary and the rotating blades.

With the impulse-type turbine, close clearances at the blade tips are not essential. Inter-stage labyrinths over the diaphragms and shaft seal labyrinths are on relatively small diameters, so the leakage losses are correspondingly small, even with increased clearances. This makes this type of turbine especially suitable for quick starting from relatively cold stand-by conditions.

There is also a preference for this type of turbine wherever rapid changes in steam and/or load conditions can be expected. Impulse turbines achieve higher efficiencies at low volumetric flow coefficients than can be obtained with reaction turbines, so are preferred when small volumetric flows must be combined with low speeds, for example to avoid the use of gearbox.

For high-speed special-purpose turbines, with speeds in excess of 8000 r/min and in back pressure or topping services, the reaction-type turbine is preferred because it is more efficient for these conditions.

The advantages and disadvantages of each type should be evaluated for every application.

#### 6.4.1.1 General-purpose steam turbines

These turbines can be horizontal or vertical and are used to drive equipment that is usually spared, that is relatively small in size (power) or is in non-critical service. Examples are drivers for pumps, which are spared, and drivers for fan and small generators.

These turbines are intended for application where steam conditions will not exceed 42 bar absolute pressure or 400°C steam inlet temperature, or both, and where the speed will not exceed 6000 revolutions per minute. **General-purpose steam turbines shall comply with the requirements of API Std. 611 and [IPS-M-PM-240](#).**

##### 6.4.1.1.1 Lubrication

The lubrication system shall may be pressurized, non-pressurized (ring-oiled) with cooling, or non-pressurized without cooling. In addition to the manufacturer's recommendations, the following guidelines shall be followed when making the selection.

- For turbines with speeds above 3600 r/min, pressurized lubrication shall be specified.
- For turbines with speeds of 3600 r/min and below, the choice of lubrication system depends mainly on the inlet steam temperature and the developed power, as indicated in the following diagram:

**Whenever specified or applicable, lubrication system shall comply with requirements of API Std. 614 and [IPS-M-PM-320](#).**

**6.4.1.2 Special-purpose steam turbines**

These are horizontal turbines and are used to drive equipment that is usually not spared, that is relatively large in size (power) or is in critical service. Examples are drivers for centrifugal compressors or generators.

The application of these turbines is neither limited by steam conditions nor by speed.

Special-purpose steam turbines shall comply with the requirements of API Std. 612 and [IPS-M-PM-250](#).

When drawing up the requirements, special attention shall be given to off-design conditions which may occur during start-up or shutdown procedures associated with the driven equipment.

Unless otherwise specified, mechanical type trip device are not acceptable.

**6.4.1.2.1 Couplings**

A flexible coupling between the turbine driver and the driven equipment shall be supplied by the manufacturer responsible for coordinating the turbine with the driven equipment.

**6.4.1.2.2 Governor**

Mechanical/hydraulic governors driven by a helical gear or worm drive are not recommended. In such cases, an electrical/ hydraulic governor should be specified.

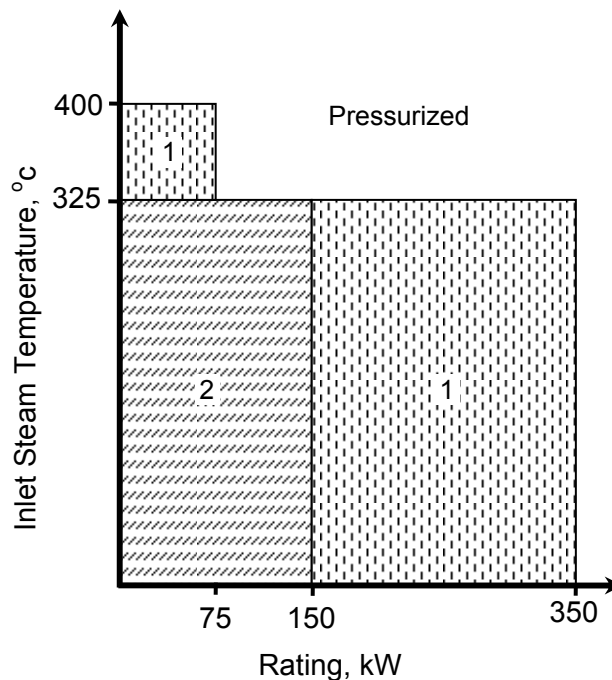
**6.4.1.2.3 Piping and appurtenances**

If the turbine is driving a centrifugal compressor handling gases containing hydrogen Sulphide, the turbine control oil and the lubricating oil for the turbine and compressor shall be separated from the compressor seal oil to avoid their contamination.

In such cases, combined turbine control oil and lubricating oil system with a separate seal oil system shall be specified.

**6.4.2 Gas turbines**

Gas turbines shall comply with the requirements of API Std. 616 and [IPS-M-PM-260](#).



- 1 : Non-pressurized. Ring-oiled with cooling
- 2 : Non-pressurized. Ring-oiled without cooling

#### 6.4.2.1 Site-rated power

The site conditions of elevation, humidity, and ambient temperature shall be taken into consideration together with the power requirements of the driven equipment in order to arrive at a realistic site-rated power (rating) of the gas turbine. This 'site rating' should be adequate to cover losses due to:

- Gas turbine air compressor fouling (estimate for a maximum of 4% on average 2%).
- Intake and exhaust systems.
- Exhaust heat exchanger.
- Main gearbox.

There shall be power output margin of at least 7% between the demand of the driven equipment and the power of the gas turbine at site when in new and clean condition. Note that the power extracted by the auxiliaries, directly driven from the gas turbine, is not always included in the vendor's standard information sheets.

Having established the site rating for the gas turbine, the ISO\* rating of the gas turbine can be calculated to serve as a guide for comparing the available makes and models of the gas turbine type suitable for the application being considered.

**\* The ISO rating of a gas turbine is its rating at 15°C ambient temperature, at 1013.25 mbar and 60% relative humidity, with zero inlet and exhaust pressure losses.**

#### 6.4.2.2 Standard packages

Gas turbines are generally offered as standard packaged prime movers developing a rated power at a rated speed, and are not normally custom-built to the particular power requirements desired by the user. Improved overall efficiency will be obtained by matching process train size to the power available from a Standard packaged gas turbine prime mover.

#### 6.4.2.3 Controls and instrumentation

Gas turbine manufacturers supply a complete control and monitoring system with their gas turbines as an intrinsic part of the package. It is not possible to dispense with their control system because it contains such essential items as the governor control, fuel scheduling, combustion monitoring and gas turbine safety circuits. The process or driven equipment controls are frequently integrated with the gas turbine control panel.

The gas turbine control panel shall be capable of receiving signals from the plant control panel. The plant control system shall also be capable of receiving signals from the gas turbine control panel.

#### 6.4.2.4 Air intake system

The location of the combustion air intake requires careful consideration if the life of the gas turbine is not to be curtailed, satisfactory access shall be provided and no undue hazard shall be created.

The air intakes for the combustion air should be as close to the gas turbine as possible. Long intake ductwork imposes a severe power penalty due to pressure loss.

It is essential to ensure that the entire air intake system is completely leak-free.

#### 6.4.2.5 Exhaust system

The exhaust stack should terminate at a sufficient height to prevent re-circulation of the hot gas plume into either the combustion air intake or the ventilation air intake. The design of the exhaust stack shall prevent rain ingress into the gas turbine exhaust collector.

For offshore platforms, it is necessary to ensure that the hot gas plume cannot be re-circulated into other areas of the platforms under any of the weather conditions likely to be experienced and that

no hazard can be created to the helicopter flight paths. In most cases, model testing will be needed to ensure that these requirements are met.

#### **6.4.2.6 Combustion air filtration**

High-quality combustion air is essential if the gas turbine performance is to be maintained. Contaminants in the combustion air stream cause fouling, corrosion, premature blade and hot gas path failure in severe contamination conditions.

All air filters shall have upward air intakes fitted with a rain hood. This is most effective in reducing rain and snow ingress into the air filter.

#### **6.5 Mixers**

Mixers shall meet the requirements of IPS-M-PM-330.

Some additional requirements which should be considered in specifying a mixer and filling in data/requisition sheets are set below.

**6.5.1** Tank mixers for crude oil tanks shall be of automatic variable angle type design.

**6.5.2** The mounting flange of tank mixers shall be of such a size (where possible), that enabling them to be mounted on the tank's nozzle.

The IPS Standards reflect the views of the Iranian Ministry of Petroleum and are intended for use in the oil and gas production facilities, oil refineries, chemical and petrochemical plants, gas handling and processing installations and other such facilities.

IPS publications are based on internationally acceptable standards and include selections from the options stipulated in the referenced standards. They are also supplemented by additional requirements and/or modifications based on the experience acquired by the Iranian Petroleum Industry and the local market availability. The options which are not specified in the text of the standards are itemized in data sheet/s, so that, the user can select his appropriate preferences therein.

The IPS standards are therefore expected to be sufficiently flexible so that the users can adapt these standards to their requirements. However, they may not cover every requirement or diversity of conditions of each project or work.

For such cases, an addendum to IPS Standard shall be prepared by the user which elaborates the particular requirements of the user. This addendum together with the relevant IPS shall form the job specification for the specific project or work.

The users of IPS publications are therefore requested to send their views and comments, including any addendum prepared for particular cases to the Ministry of Petroleum, Standards and Research Organization. These comments and recommendations will be reviewed by the relevant technical committee and will be incorporated in the formal revision of the relevant IPS. The IPS publications are reviewed and revised approximately every five years.

#### IRANIAN PETROLEUM STANDARDS

No. 19, Street 14, North kheradmand Karimkhan Avenue, Tehran, Iran

Tel: 66153055 88810460 Fax: 88810462 Email:

[petrostand@nioc.org](mailto:petrostand@nioc.org)