

# गैस टर्बाइन के लिए मानक विनिर्देश

## STANDARD SPECIFICATION FOR GAS TURBINES

|             |          |                                                                             |                |               |                                    |                                 |
|-------------|----------|-----------------------------------------------------------------------------|----------------|---------------|------------------------------------|---------------------------------|
| 2           | 31.03.15 | Revised & issued as standard specification                                  | JSD            | NK            | DB / AKN                           | SC                              |
| 1           | 13.05.08 | Reaffirmed & issued as standard specification                               | JSD            | NK            | VKM                                | VC                              |
| 0           | 24.07.03 | Issued as standard specification<br>(superseding eil spec. 6-41-0041 rev.2) | NK             | KDS           | RK                                 | SKG                             |
| Rev.<br>No  | Date     | Purpose                                                                     | Prepared<br>by | Checked<br>by | Standards<br>Committee<br>Convenor | Standards<br>Bureau<br>Chairman |
| Approved by |          |                                                                             |                |               |                                    |                                 |

**Abbreviations:**

|      |                                                  |
|------|--------------------------------------------------|
| AC   | : Alternating Current                            |
| ANSI | : American National Standards Institute          |
| API  | : American Petroleum Institute                   |
| DC   | : Direct Current                                 |
| EGHP | : Expected Gas Horse Power                       |
| EQC  | : Equipment Qualification Criteria               |
| GG   | : Gas Generator                                  |
| IGHP | : Indicated Gas Horse Power                      |
| ISO  | : International Organization for Standardization |
| NFPA | : National Fire Protection Association           |
| P&ID | : Piping and Instrumentation Diagram             |
| PT   | : Power Turbine                                  |
| PTR  | : Proven Track Record                            |
| QA   | : Quality Assurance                              |
| SS   | : Stainless Steel                                |
| VDR  | : Vendor Data Requirement                        |

**Rotating Equipment Standards Committee**

**Convenor:** Mr Dinesh Bhatia

**Members:** Mr Nalin Kumar  
Mr Tarun Kumar  
Mr Anukul Mandal  
Mr. J.S. Duggal  
Mr K.V.K. Naidu (Projects)

## CONTENTS

|                                                                                     | Page No.  |
|-------------------------------------------------------------------------------------|-----------|
| <b>1 SCOPE .....</b>                                                                | <b>4</b>  |
| 1.2 ALTERNATIVE DESIGNS .....                                                       | 4         |
| 1.3 CONFLICTS .....                                                                 | 5         |
| 1.4 EQUIPMENT QUALIFICATION CRITERIA .....                                          | 5         |
| <b>2 REFERENCES.....</b>                                                            | <b>6</b>  |
| 2.1 REFERENCED STANDARDS .....                                                      | 6         |
| 2.2 COMPLIANCE .....                                                                | 6         |
| <b>4 BASIC DESIGN .....</b>                                                         | <b>6</b>  |
| 4.1 GENERAL .....                                                                   | 6         |
| 4.7 DYNAMICS .....                                                                  | 7         |
| 4.9 LUBRICATION .....                                                               | 7         |
| 4.10 MATERIALS.....                                                                 | 8         |
| <b>5 ACCESSORIES .....</b>                                                          | <b>8</b>  |
| 5.1 STARTING AND HELPER DRIVER .....                                                | 8         |
| 5.2 GEARS, COUPLINGS AND GUARDS .....                                               | 9         |
| 5.3 MOUNTING PLATES .....                                                           | 9         |
| 5.4 CONTROLS AND INSTRUMENTATION.....                                               | 9         |
| 5.6 INLET AND EXHAUST SYSTEMS.....                                                  | 10        |
| 5.7 INSULATION, WEATHER PROOFING, FIRE PROTECTION AND ACOUSTICAL<br>TREATMENT ..... | 11        |
| 5.8 FUEL SYSTEM.....                                                                | 12        |
| <b>6 INSPECTION, TESTING AND PREPARATION FOR SHIPMENT .....</b>                     | <b>14</b> |
| 6.1 GENERAL .....                                                                   | 14        |
| 6.3 TESTING .....                                                                   | 14        |
| <b>7 VENDOR'S DATA.....</b>                                                         | <b>15</b> |
| 7.1 GENERAL .....                                                                   | 15        |
| 7.2 PROPOSALS .....                                                                 | 15        |
| 7.3 CONTRACT DATA .....                                                             | 16        |

## 1 SCOPE

- i. This specification together with the attendant data sheets and other specifications/attachments to inquiry/order covers the minimum requirements for open, simple and regenerative-cycle combustion gas turbine units for use in process plants, utility and pipeline services as mechanical drive, generator drive or process gas generation. All auxiliary equipment required for operating, starting and controlling gas turbine units and for turbine protection is either discussed directly in this specification or referred to in this specification through references to other publications. Specifically, gas turbine units that are capable of continuous service firing gas or liquid fuel or both are covered by this standard.
- ii. Vendor shall make all possible efforts to comply strictly to the requirements of this specification and other specifications/attachments to inquiry/order. In case deviations are considered essential by the vendor (after exhausting all possible efforts) these shall be separately listed in the vendor's proposal under separate section titled as "List of deviations/exceptions to the inquiry document". Deviations shall be listed separately for each document with cross reference to page no./section/clause no./para etc. of the respective document supported with proper reasons for the deviation for purchaser's consideration. Any deviation not listed under the above section, even if reflected in any other portion of the proposal shall not be considered applicable. No deviation or exception shall be permitted without the written approval of the purchaser.
- iii. Compliance with this specification shall not relieve the vendor of the responsibility of furnishing equipment and accessories/auxiliaries of proper design, materials and workmanship to meet the specified start up and operating conditions. In case the vendor considers requirement of additional instrumentation, controls, safety devices and any other accessories/auxiliaries essential for safe and satisfactory operation of the equipment, he shall recommend the same along with reasons in a separate section along with his proposal and include the same in his scope of supply.
- iv. Except as modified here in, the gas turbines and their auxiliaries shall be designed, manufactured, tested and supplied strictly in accordance with **API Standard 616 - Gas Turbines for the Petroleum, Chemical and Gas Industry Services, Fifth Edition, January 2011**.
- v. Except for new paragraphs, the number and title of the paragraphs in the following Modifications to API Standard-616 correspond to the respective sections and paragraphs of the above standard. Paragraphs not addressed in this specification shall be strictly in accordance to **API Standard 616, Fifth Edition, January 2011** requirements.  
The word in parenthesis following the number or title of a paragraph indicates the following:

|                |   |                                                                                                                                          |
|----------------|---|------------------------------------------------------------------------------------------------------------------------------------------|
| (Addition)     | : | An addition to a part or paragraph referred to                                                                                           |
| (Modification) | : | Amplification or rewording has been made to a part of the corresponding paragraph but not a substitution replacing the entire paragraph. |
| (Substitution) | : | A substitution has been made for the corresponding paragraph of the standard in its totality.                                            |
| (New)          | : | A new paragraph having no corresponding paragraph in the Standard.                                                                       |
| (Delete)       | : | This paragraph is deleted.                                                                                                               |

The entire paragraph 1 of API-616 regarding SCOPE (except Note) is substituted by paragraph 1 above.

### 1.2 ALTERNATIVE DESIGNS (Deleted)

**1.3 CONFLICTS (Substitution)**

In case of conflict between this specification and the attendant data sheets, job specifications (if any) and other attached specifications, the following order of precedence shall govern:

1. Equipment Technical Data Sheets.
2. Job specifications (if any)
3. P&ID's (if any)
4. This specification
5. Other Specifications
6. Other referred codes and standards

**1.4 EQUIPMENT QUALIFICATION CRITERIA (New)**

1.4.1 Unless otherwise specified elsewhere, the Equipment Qualification Criteria (EQC) specified vide para 1.3.2 to 1.3.4 of this specification shall be applied for acceptance of the offered gas turbine model.

1.4.2 Vendor shall be an established gas turbine manufacturer having adequate design engineering, manufacturing and testing facilities.

1.4.3 The gas turbine model offered shall be from the existing regular production range of the vendor, and the rating offered shall be based on internationally published rating.

1.4.4 Gas Turbine offered shall be identical in construction (i.e. no. of shafts, no. of stages in each compressor section, no. of stages in each turbine section, mechanical design, material of construction of Blades, Nozzles, Discs and Combustors; Cooling of blades, nozzles & discs; Combustion system ; Starting system ), Type of Turbine Temperature Control and in performance at ISO conditions in terms of Power Rating for the type of fuel specified (liquid and/or gas fuel), heat rate, firing/cycle temperature, power turbine inlet temperature, exhaust temperature, overall pressure ratio, air flow and speed of each shaft as compared to at least ONE (1) unit designed, manufactured, tested and supplied from the proposed manufacturing plant in the last TEN (10) years which has completed ONE (1) year of satisfactory operation at site as on bid due date.

In case all the above parameters are not available from single past reference, more than one reference may be cited to satisfy the above qualification requirement.

In case certain improvements have been done the same can be considered provided the vendor is having field proven experience for the same. Vendor to clearly highlight such improvements and shall furnish information of experience as per Experience Record Proforma enclosed in the enquiry specification to amply prove that the equipment meet the EQC.

As an alternative, vendor may show to the satisfaction of purchaser, that the equipment offered is comprised of modules such as compressor, turbine, etc. each of which individually satisfies the requirements specified above.

**1.4.5 Proven Track Record (PTR)**

Gas Turbine vendor shall complete the Experience Record Proformas as enclosed in the inquiry specification to amply prove that the Equipment offered meet the EQC for technical acceptance.

Turbine vendor may furnish additional information to justify that the EQC is being met. In addition, manufacturer's catalogue and general reference list for all the above equipment shall also be furnished along with the proposal.

## 2 REFERENCES

### 2.1 REFERENCED STANDARDS (Addition)

Following publications shall also form a part of Referenced Standards listed under 2.1 of API – 616:

ANSI B17.1 Keys and key seats

NFPA 37 Stationary Combustion Engines and Gas Turbines.

NFPA 850 Electrical Generating Plants

### 2.2 COMPLIANCE (Substitution)

Vendor shall take measures to comply with governmental codes, regulations, ordinances or rules that are specified in the inquiry document or applicable to the equipment at the proposed location.

## 4 BASIC DESIGN

### 4.1 GENERAL

#### 4.1.3.1 (Substitution)

The gas turbine vendor shall provide turbine full load power (with no negative tolerance) at certified point / specified guarantee point as shown on the datasheet with no positive tolerance on the heat rate (lower heating value for specified fuel).

#### 4.1.3.2 (Deletion)

This clause stands deleted.

#### 4.1.8 (Addition)

The emission suppression system shall be capable of limiting the emissions to the specified levels at all levels of power output from minimum load to full load for all specified fuels. The vendor shall provide a project specific flow diagram, complete with bill of material and a written technical description of the emission suppression system with the proposal.

#### 4.1.10 (Substitution)

Unless otherwise specified, the maximum sound pressure level of the unit when measured at a distance of 1 meter from the skid edge shall not exceed 88 dBA. The vendor shall indicate in the proposal the noise emission data for the unit both in terms of dBA as well as octave band analysis.

#### 4.1.11 (Substitution)

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

|                                           |   |                                                    |
|-------------------------------------------|---|----------------------------------------------------|
| Velocity over heat exchanger surface      | : | 1.5 - 2.5 m/sec.                                   |
| Maximum Allowable Working Pressure (MAWP) | : | $\geq 8.0 \text{ kg/cm}^2\text{g}$                 |
| Test Pressure (Hydrostatic)               | : | $= 1.5 \times \text{MAWP}$                         |
| Maximum Pressure Drop                     | : | $1.0 \text{ kg/cm}^2$                              |
| Maximum Inlet Temperature                 | : | $33^\circ\text{C}$                                 |
| Maximum Outlet Temperature                | : | $45^\circ\text{C}$                                 |
| Maximum Temperature Rise                  | : | $12^\circ\text{C}$                                 |
| Fouling Factor on Water Side              | : | $0.0004 \text{ m}^2 \text{ hr}^\circ\text{C/kcal}$ |
| Shell Side Corrosion allowance            | : | 3.2 mm                                             |

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

- 4.1.13 (Substitution)  
The arrangement of the equipment, including piping, ducting, coolers, pumps, controls and other auxiliaries shall be developed by the vendor. The arrangement shall provide adequate clearance areas and safe access for operation and maintenance. Clearance areas and suggested maintenance areas shall be marked in the layout drawing .
- 4.1.16 (Addition)  
The vendor shall furnish, in the proposal, a list of all components of gas turbine and auxiliaries which require regular periodical inspection and maintenance. Procedure for inspection and handling the equipment components (including Gas Turbine Modules) for maintenance shall be fully described. Weight and dimensions of components which need to be dismantled and transported for the purpose of inspection/maintenance shall be indicated in the proposal. Vendor shall make recommendations as to the handling and maintenance facilities to be provided by the purchaser.
- 4.1.18 (Addition)  
Vendor shall carryout the activity mentioned under sl. No. "a" of this paragraph and where their supervision is specified during erection / commissioning, vendor shall carryout checks mentioned under sl. No. b, c and d of this paragraph.
- 4.1.21 (Addition)  
Flat rating of gas turbines is not permitted.
- 4.7 DYNAMICS**
- 4.7.2.15 (Modification)  
Gas turbines with a new, modified bearing and rotor configuration or Prototype gas turbine designs shall not be offered, hence this section is not applicable.
- 4.7.4 Vibration and Balancing**
- 4.7.4.3.4 (Modification)  
The words 'if specified' stand deleted.
- 4.9 LUBRICATION**
- 4.9.7 (Substitution)  
Oil system shall comply with the requirements of Chapter 1 & 2 of API - 614, 4th edition.
- 4.9.8 (Modification)  
The word "Purchaser" to be substituted by, "the Vendor having responsibility of the complete unit".
- 4.9.9 (New)  
Lube oil system shall be provided with AC or DC Electric motor driven emergency oil pump to supply lube oil gas turbine during coast down & cool - off. The dedicated emergency power supply system (i.e. battery bank for DC motors or battery bank + inverter for AC motor) shall also be supplied by vendor for above pumps.  
Turbine control system shall have provisions to
- (i) Monitor emergency oil pump performance at every turbine start, and periodically thereafter (once in 12 hrs).

- (ii) Continuously monitor emergency power supply system circuit for their availability during turbine operation.

Unsatisfactory pump performance or emergency power supply circuit condition shall be annunciated and shall trip the turbine.

#### 4.10 MATERIALS

##### 4.10.4.6.2 (Modification)

The words 'if specified' stand deleted.

##### 4.10.4.7.1 (Substitution)

The vendor shall specify the type of non-destructive testing such as radiography, ultrasonic testing, magnetic particle inspection or dye-penetrant inspection carried out by the vendor on welds as per the vendor's standard QA plan.

### 5 ACCESSORIES

#### 5.1 STARTING AND HELPER DRIVER

##### 5.1.1 General

##### 5.1.1.1 (Addition)

All starter and helper driver shall be suitable for satisfactory operation with the specified electrical power characteristics, inlet and exhaust steam/air/gas pressure and temperatures, the specified fuel in case of internal combustion engines or micro gas turbines, as applicable. The power output of starter and helper driver shall not be considered while declaring the gas turbine power output.

##### 5.1.1.10 (Addition)

The gas for the starter shall not be extracted from the fuel system. The Vendor shall furnish a separate connection and piping system from the starter to his battery limit as defined in the enquiry/contract.

Exhaust from a gas expansion starter shall not be connected to any common vent system.

Lubrication systems for the gas starter shall not require any operator's attention on the lubricant oil levels.

##### 5.1.3 Turning Equipment

##### 5.1.3.1 (Substitution)

A turning gear or ratchet device shall be furnished, if required, to avoid rotor deformation after a tripout or during prolonged periods of shutdown. For single-shaft turbine, the turning gear shall be sized to turn the entire train. Engagement on shutdown before the rotor has come to stop shall be positively prevented if this could damage the turning device or the turbine. Disengagement shall be automatic when the rotor accelerates during start-up. Vendor shall describe the complete turning gear equipment along with its operation, speed, duration of use etc.

## 5.2 GEARS, COUPLINGS AND GUARDS

### 5.2.1 Gears

#### 5.2.1.3 (Substitution)

The Load gears shall have rating (gear rated power) as a minimum equal to the potential maximum power of the gas turbine. For power generation service the load gear shall be capable of withstanding the worst case of alternator fault conditions.

### 5.2.2 Couplings and Guards

#### 5.2.2.3 (Addition)

For power generation service, the generator load coupling shall be capable of withstanding the worst case of generator fault conditions.

#### 5.2.2.6 (New)

Coupling spacer length shall allow removal and replacement of bearings and seals without disturbing main equipment casings, first piece of load equipment or load gear.

#### 5.2.2.7 (New)

Coupling shall be balanced as per method 2 of **API Standard 671**.

## 5.3 MOUNTING PLATES

### 5.3.1 General

#### 5.3.1.1 (Substitution)

The gas turbine unit, as well as its starting equipment, lubrication system and other auxiliaries shall be furnished with baseplates.

#### 5.3.1.2.5 (Addition)

Mounting surfaces that are not to be grouted shall be coated with a rust preventive immediately after machining.

#### 5.3.1.2.9 (Substitution)

Anchor bolts and foundation bolts shall be furnished by the vendor.

### 5.3.2 Base Plate

#### 5.3.2.3 (Modification)

The words "if specified" shall be read as "Unless otherwise specified".

#### 5.3.2.10 (New)

Baseplate(s) shall be provided with drip containment and low point drains

#### 5.3.2.11 (New)

Unless otherwise specified lifting frames/spreader bar alongwith slings and shackles shall be supplied by the vendor to permit single point lift capability.

## 5.4 CONTROLS AND INSTRUMENTATION

### 5.4.2 Control Systems

#### 5.4.2.1 (Substitution)

The starting and loading control system for the turbine - driven equipment package may be semi automatic (two push button start) or fully automatic (single push button start), as specified. The starting cycle of the turbine shall be automatic.

The commissioning of accessories, auxiliaries and driven equipment; starting and loading sequence of turbine - driven equipment package shall be as follows:

- (a) Semiautomatic start (Two push Button Start), if specified shall require only two actions by the operator. On pressing the first switch, the system shall sequentially commission the accessories & auxiliaries (including that of driven equipment), prepare the driven equipment for start-up. Completion of these activities will be signalled by "Train ready to start" indication / message on the panel. Pressing the second switch will commit the turbine to the complete starting and speed / load control sequence.
- (b) Automatic (Single Push Button) start shall require only a single action by the operator to sequentially commission accessories & auxiliaries, prepare the driven equipment for start and to initiate the complete starting and loading sequence.

#### **5.4.6 Electrical Systems**

##### **5.4.6.6 (Modification)**

Electrical materials shall be given the treatments as specified in 5.4.6.6.1 and 5.4.6.6.2.

#### **5.4.7 Instrumentation**

##### **5.4.7.8 Vibration and Position Detectors**

###### **5.4.7.8.2 (Modification)**

The words 'if specified' stand deleted.

###### **5.4.7.8.3 (Modification)**

The words "if specified" stands deleted.

###### **5.4.7.8.4 (Modification)**

The words "if specified" stands deleted.

###### **5.4.7.8.6 (Modification)**

The words "if specified" stands deleted.

### **5.6 INLET AND EXHAUST SYSTEMS**

#### **5.6.1 General**

##### **5.6.1.15 (Substitution)**

Corrosion protection of the filter housing and elements, ducting and silencer is required. Unless otherwise specified all metallic air path components shall be of Type 304 stainless steel.

#### **5.6.2 INLET SYSTEMS**

##### **5.6.2.1 Inlet Filters**

###### **5.6.2.1.6 (Addition)**

Vendor shall also furnish in the proposal filter performance data such as design flow rate, pressure drop in clean condition and pressure drop at which filter cleaning/change out is recommended for each stage of filtration as well as for overall filter.

- 5.6.2.1.7d (Addition)  
High overall differential pressure transmitter for trip (2 no's. with unit shutdown on activation by either of the transmitter).
- 5.6.2.1.9 (Addition)  
Unless otherwise specified, supporting steel work and facilities for access and maintenance is to be supplied by the Vendor.
- 5.6.2.5 **Inlet Silencers**
- 5.6.2.5.2 (Addition)  
Silencers shall be flanged and sufficiently rigid to be supported only by the end flanges when mounted in a horizontal or vertical duct system.
- 5.6.2.6 **Inlet Coolers**
- 5.6.2.6.1 **Evaporative Coolers**
- 5.6.2.6.1.1 (Addition)  
Unless otherwise specified evaporative coolers shall not be used in air inlet to gas turbine.
- 5.6.2.6.1 **Inlet Air Cooler Heat Exchanger**
- 5.6.2.6.1.1 (Addition)  
Unless otherwise specified Inlet Air Cooler Heat Exchanger shall not be used in air inlet to gas turbine.
- 5.7 **INSULATION, WEATHER PROOFING, FIRE PROTECTION AND ACOUSTICAL TREATMENT**
- 5.7.4 **Acoustical Treatment**
- 5.7.4.1 (Substitution)  
Vendor shall furnish acoustical treatment to meet the requirements of Clause 4.1.10 of this specification
- 5.7.5 **Enclosures**
- 5.7.5.1 (Modification)  
The words "if specified" shall be read as "Unless otherwise specified"
- 5.7.5.3 (Addition)  
Enclosures should have facilities (like mono-rail, chain-pulley blocks and accessories etc.) for removal of Gas Generator and Power Turbine either as one unit or individually.
- 5.7.5.3.2 (Addition)  
Access ways shall be lockable
- 5.7.5.6 (Substitution)  
(i) Each enclosure shall be fitted with two no. (one working + one standby) fans driven by explosion proof electric motors, to preclude build up of a hazardous atmosphere and to maintain the air temp inside the enclosure less than 60<sup>0</sup> C in the most severe climatic and load conditions. Ventilation system shall include air filtration and silencing equipment. Ventilation air shall be taken from safe area and shall be discharged in a safe area. Ventilation filters shall be provided with differential pressure indication and high differential pressure alarm. Fans shall be arranged in parallel configuration to facilitate

isolation and removal of a fan without interruption in turbine operation.

**Note :-**

Purchaser may consider higher temperature in certain zones of the enclosure, provided the vendor proves to the satisfaction of the purchaser that the design/constructional features are such that these hot zones are physically isolated by partitions from other areas of the enclosure and that the equipment, electrical systems, instruments and instrumentation systems (including cabling, wiring, piping/tubing) and the fluid lines in these zones are suitable for the vendor's stated higher temperature (including the temperature settlement during emergency shutdown of the turbine and simultaneous shutdown of ventilation system). Vendor shall also have adequate proven track record to establish the provenness of such claims.

Vendor shall also detail out the safety features incorporated in the system to prevent injury to operators, in case the doors of these partitions are opened either for routine monitoring/investigating or accidentally.

- (ii) Each fan shall be sized for atleast 125% of design flow rate required to keep enclosure temperature below 60°C.
- (iii) Unless otherwise specified, enclosures of Gas Turbines driving electric generators installed in safe area shall be maintained at a negative pressure of atleast 5 mm of water column (with only one fan operating) and of Gas turbines for mechanical drive application installed in a hazardous area shall be maintained at a positive pressure of atleast 5 mm of water column (with only one fan operating). Vendor shall furnish calculations for heat rejection by turbine and equipments inside the enclosure, heat transfer to ventilation air, expected pressure drops in the entire ventilation path, fan sizing etc for purchaser's review.
- (iv) Enclosure shall be furnished with enclosure air temperatures indicators, differential pressure indicators, and alarm & trip transmitters for high enclosure air temperature and abnormal enclosure pressure.
- (v) Ventilation/purging flow shall enter/leave the enclosure via flanged port(s). Ventilation inlet and exhaust ports shall be provided with fire suppression medium dampers and the required back draft/balance dampers.
- (vi) If a cool down ventilation is required to prevent damage to the gas turbine, auxiliary systems or instrumentation within the enclosure; a separate DC back-up fan or emergency AC back-up power for normal ventilation fans shall be provided. The dedicated emergency power supply system (i.e. battery bank for DC back-up fan or battery bank + inverter for normal fan) shall also be supplied by vendor. Vendor shall also supply charging arrangement for battery banks. Performance of the back-up fan, if provided, shall be checked at every turbine start and at regular intervals during turbine operation. Back-up power system health shall be continuously monitored. Any malfunction of back-up fan or back-up power system shall shutdown the turbine.

## 5.8 FUEL SYSTEM

### 5.8.1 General

#### 5.8.1.2 Fuel Gas System (Addition)

Fuel gas system shall consist of the following:

##### 1. Gas Turbine Fuel Gas System

Gas turbine fuel gas system shall be gas turbine vendor's standard proven system suitable for the fuel gas properties specified. This shall include necessary pressure and temperature monitors/gauges, low fuel pressure transmitters, a manifold and nozzles, fuel shut off valve (and vent valve) for actuation by emergency devices, a

fuel governor valve for normal control purposes, fuel gas pressure regulator & safety valve, and necessary instrumentations, control & safety devices. This system shall be totally skid mounted inside the gas turbine enclosure. Fuel gas pressure regulator & safety valve may also be a part of Fuel gas treatment skid, if the same is recommended by the vendor as per their standard safety norms.

2. Fuel Gas Treatment System

- (i) Fuel gas treatment system shall be console type and shall be mounted off skid.
- (ii) This system shall be designed for ISO rating of the gas turbine or maximum potential power of gas turbine or to meet the turbine starting and acceleration requirements whichever is highest.
- (iii) Irrespective of the fuel supply conditions as stated in the enquiry document, vendor shall design the fuel treatment skid considering the supply gas to be 100% saturated with hydrocarbons and water vapours at the specified supply pressure-temperature conditions.
- (iv) The fuel gas treatment system shall be designed to deliver clean, dry gas to the turbine fuel system with the degree of superheat as recommended for the subject turbine/gas generator. However, as a minimum the super heat considered shall be 20°C above the water and or hydrocarbon dew point.
- (v) Fuel gas treatment system shall have the following minimum features. Any additional feature recommended by the vendor for safe operation of the system and the turbine shall be included in the vendor's scope:
  - (a) Twin knockout pots with demister pads. Each knockout pot shall have level controller, automatic drain valves with manual bypass, level gauges, low level & high level transmitters with alarms, safety valves and continuous flow transfer valves.
  - (b) Twin filters (2 micron) with differential pressure indicators and high differential pressure alarms, and continuous flow transfer valves.
  - (c) Fuel gas super heater to provide the required degree of super heat considering the gas inlet as fully saturated. The super-heater shall be controlled by thyrister panel with energy controller to control the heater output from 0 to 100 per cent in step-less control. The super heater shall be of SS-300 series material and design temperature of heater shall be greater than 150°C.
  - (d) Transfer valves shall have carbon steel body with stainless steel plug, and if applicable a plug jacking device.
  - (e) Complete fuel gas system downstream of filters shall be in stainless steel construction including piping.
  - (f) All pressure vessels in fuel gas system and in other auxiliary system of the gas turbine shall be designed as per section VIII, Division 1 of the ASME code.
  - (g) All the shut-off/ isolation valves in main line and in vent line shall be tight shut-off (TSO) type with leakage class VI.
- (vi) The following controls and safety shall be provided for the fuel gas treatment skid:
  - (a) The skid shall be provided with automatic shut down valves at inlet & outlet of the skid and a vent valve connected to flare.
  - (b) For all gas turbine shut downs:
    - Fuel gas supply to the turbine shall be shut off and the trapped gas within the treatment skid as well as in the piping between the skid and turbine shall be vented out.
    - Thyrister panel output shall be zero.
    - Heater electric supply shall be cut off.
  - (c) High/High-High fuel gas temperature alarms shall be provided along with heater supply cut off at high-high fuel gas temperature alarm.
  - (d) Heater skin temperature high alarm shall be provided.
  - (e) Contactors shall be heavy duty. (AC-3 duty or higher)

3. Bypass & Vent valve: A fuel bypass valve and vent valve for purging the fuel gas line prior to light off shall be provided
4. Fuel gas booster system: If the fuel gas pressure required by the vendor is higher than that available, fuel gas booster (i.e. compression) system will be furnished by the vendor. Vendor's proposal shall include complete details of such compression system. The reliability and availability of fuel gas compressor system shall be equal or higher than that of the Gas Turbine. Fuel gas booster compressor offered shall be either centrifugal compressor as per API standard 617 or rotary compressor as per API standard 619 or reciprocating compressors as per API standard 618. In case reciprocating compressor is being offered as fuel gas booster, 2 nos. (1working + 1standby) compressor each sized for 100% capacity shall be supplied. The fuel gas booster compressor shall normally be driven by Electric motor.  
[Note: In case of oil lubricated reciprocating/ oil flooded rotary compressor, the allowable oil contamination in the discharge fuel gas shall be as gas turbine vendor standard.]

5.8.2.2.3 (Modification)

The words "if specified" shall be read as "if required by vendor".

5.8.2.5.1 (Addition)

The "Fuel Gas Treatment System" shall be supplied by the vendor.

5.8.3.14 (Modification)

Words "by the Purchaser" are replaced by "by the Vendor"

## 6 INSPECTION, TESTING AND PREPARATION FOR SHIPMENT

### 6.1 GENERAL

6.1.5 (Addition)

The vendor shall notify the purchaser not less than 4 weeks before the date the equipment will be ready for test. The date shall be reconfirmed by the vendor at least one week before the scheduled date of test.

### 6.3 TESTING

6.3.1.2 (Modification)

Detailed procedures for all running tests shall be submitted atleast 12 weeks before the first scheduled test.

6.3.1.3 (Modification)

For witnessed or observed test vendor shall give advance notice to purchaser as per clause 6.1.5 above.

#### 6.3.2 Hydrostatic Test

6.3.2.1 (Substitution)

All Pressure containing parts (including that of auxiliaries), exclusive of gas turbine casing and combustors, shall be tested hydrostatically.

#### 6.3.4 Mechanical Running Test

6.3.4.1 (Substitution)

The requirements of 6.3.3.1.1 through 6.3.3.1.12 shall be met before the mechanical running test of the gas turbine (combined Gas generator & power turbine) is performed.

6.3.4.1.6 (Modification)

The words 'if specified' stand deleted.

6.3.4.4.2 (Modification)

The words 'if specified' stand deleted.

6.3.4.5 **Gas Generator Test (New)**

Each gas generator shall be subjected to a mechanical running and performance test in accordance with the manufacturer's standard.

Gas generator shall be operated at speeds from idle to maximum continuous speed in speed increments allowing the unit to stabilise at each point and necessary mechanical and performance data shall be recorded. Gas generator shall be run for 15 minutes at a speed 1% below the trip speed. The test shall establish the mechanical integrity and EGHP / IGHP (Expected / Indicated Gas Horse Power) capability of the unit.

6.3.5.1 **Performance test**

(Modification)

The first sentence of this clause stands revised to: "Unless otherwise specified, the machine shall be tested in accordance with ASME Performance Test Codes 1 and 22."

**7 VENDOR'S DATA**

**7.1 GENERAL**

7.1.1 (Modification)

The information to be furnished by the vendor is specified in 7.2, 7.3 and purchaser's Vendor Data Requirements as included in the inquiry document.

Vendor shall complete and forward the document 'Vendor Data Index & Schedule/ Document Control Index (DCI)' to the purchaser. (Destination & Contact persons as per order).

**7.2 PROPOSALS**

7.2.1 **General (Substitution)**

In addition to data specified in 7.2.2 through 7.2.4, the vendor's proposal shall as a minimum include the following:

- a) All data sheets, drawings and documents listed under "PRINTS WITH QUOTE" in the Vendor Data Requirement Form enclosed in the inquiry.
- b) Vendor's confirmation/comments on post-order Vendor Data Requirements (Type of Documents, no. of prints and date needed) indicated in Vendor Data Requirement forms data sheets and specs.
- c) List of recommended commissioning spares included in the offer.
- d) List of mandatory spares (where specified by the purchaser) included in the offer.
- e) List Of Spare Parts For Two Years Normal Operation

This list shall be made separately for each item including auxiliaries and drivers in the form of a table & shall show

- i) Part name, description and number.
- ii) Quantity installed in one unit.
- iii) Quantity recommended per unit for 2 years normal operation.
- iv) Quantity recommended for number of units of an item as specified in the inquiry.
- v) Quantity recommended as insurance for the number of units of an item

specified in the inquiry.

- f) An itemised list of special tools included in the offer.
- g) Any start-up, shutdown or operating restrictions required to protect the integrity of the equipment.
- h) Any limitations of vendor's test-facility to carryout the specified tests.
- i) A specific compliance statement that the scope of supply, the offered equipment/systems and all its components are in strict accordance with the data sheets, job specifications, this specifications and all other attachments, except for specific deviation as listed in the proposal.

Unless a specific deviation/exception is taken by the vendor in the proposal, it will be understood that final equipment/system shall be designed, fabricated, tested and supplied in accordance with Purchaser's specified requirements as covered in the inquiry or order.

### 7.2.3 Technical Data

#### 7.2.3(i) (Addition)

Vendor shall also furnish a consolidated list of all consumables which are required or need to be replaced/replenished periodically (like lube oil, seal oil, greases, chemicals, any cleaning agent, additives etc.) indicating the total quantity required for the period of commissioning/startup and one year continuous operation of the unit.

#### 7.2.3(m) (Substitution)

A list of installations, prepared in a manner so as to give explicit evidence that the equipment offered meets the specified minimum manufacturing and experience requirements.

#### 7.2.3 (y) (New)

Expected noise levels in dBA for each individual component as well as for overall train when measured at any point one meter away from the machine(s)/enclosures.

#### 7.2.5 Deleted.

### 7.3 CONTRACT DATA

#### 7.3.1 General (Substitution)

##### 7.3.1.1 Drawings and data as required after purchase order has been specified in Vendor Data Requirement (VDR). Vendor to note that the drawing/document descriptions/titles as given in the Vendor Data Requirement are generic in nature. It is possible that against one drawing/document specified there are several drawings to be furnished by the vendor or vice versa.

Vendor to note that, the submission of all post order drawing & documents shall be done through EIL Electronic Document Management System (eDMS) portal. Vendor shall complete & forward the Document Control Index (DCI) to the purchaser (Destination & contact person as per order) through above eDMS portal.

This document shall list out in consolidated form all drawings and documents required by purchaser vide VDR as included in the purchase requisition. Any other data, drawing/document as specified in Data Sheets and Specifications shall also be included by the vendor in the DCI. Against each drawing/document, vendor shall populate their list of document indicating the vendor's drawing numbers, titles, Rev. No. and schedule of submission.

This shall be the first document to be submitted by vendor within two weeks of order.

**No drawing shall be taken up for review till DCI for the inquiry/order is finalized by vendor.**

- 7.3.1.2 All transmittal letters (covers), drawings and data shall have a title block (in addition to vendor's standard title block) which shall as a minimum contain the following contract information:
- Purchaser's and Consultant's Corporate Name
  - Project Name.
  - Equipment Name and Item No.
  - Purchase Order No.
  - Purchase Requisition No.
- Title Block on drawings shall be placed on the lower right hand corner.
- 7.3.1.3 Data specified in the VDR is minimum requirements of Purchaser. Any additional document/data required or requested by Purchaser for engineering or construction shall also be made available by the vendor.
- 7.3.1.4 Whether or not specified the vendor shall furnish the following, before shipment:
- As built running clearances and when applicable; thrust bearing, radial bearing and seal running clearances.
  - A supplementary list of spare parts other than those included in his original proposal. The supplementary list shall include recommended spare parts, cross-sectional or assembly type drawings, parts numbers, materials, prices and delivery period. The vendor shall forward this supplementary list to the purchaser promptly after receipt of the reviewed drawings and in time to permit order and delivery of parts before field start-up.
  - A parts list for all equipment supplied. The list shall include pattern, stock, or production drawing numbers and materials of construction. The list shall completely identify each part so that the purchaser may determine the interchangeability of the parts with other equipment furnished by the same manufacturer. Standard purchased items shall be identified by the original manufacturer's name and part number.
  - At least 8 weeks before shipment, the vendor shall submit his preservation, packaging and shipping procedures to the purchaser's for his review.
- 7.3.2 **Drawings (Substitution)**
- 7.3.2.1 The time-frame within which the drawings are to be submitted by vendor are specified in Purchaser's inquiry/order.
- 7.3.2.2 The purchaser's review of the vendor's drawings shall not constitute permission to deviate from any requirements in the purchase order/specifications unless specifically agreed upon in writing. After the drawings have been reviewed, certified copies shall be submitted by vendor as a part of final documents (Technical Data Manual/Mechanical catalogues) in the specified quantity. All drawings must be clearly legible and shall be submitted A4 or A3 paper sizes (except overall layout/ Foundation/ GA drawings which shall be submitted in A2 paper sizes). Documents in higher paper size shall be submitted in exceptional circumstances or as indicated in the enquiry/ contract document(s).
- 7.3.2.3 **General Arrangement Drawing**
- A general arrangement drawing shall contain as a minimum the following information:
- Outline dimensions (minimum three views) (all principal dimensions).
  - Allowable forces and moments on suction and discharge nozzles.
  - Location (in all three planes), size, type, rating and identification of all purchaser's interface connections including those of vents, drains lubricating oil, sealing fluid, cooling water, steam & Electrical/Instrumentation.
  - Direction of rotation viewing from the driving end.
  - Weight of each assembly/component.
  - The weight & location of center of gravity of the heaviest assembly/components that must be handled for erection.
  - Identification, Weight and dimensions of the heaviest assembly/subassembly/ component required to be handled for maintenance.

- viii) Maintenance clearances and dismantling clearances.
- ix) Speeds of Driven Equipment and driver and driver rating.
- x) Layout of auxiliary equipment and operating platform.
- xi) Make, Type and size of couplings and the location of guards and their coverage.
- xii) A list of reference drawings if any.
- xiii) A list of any special weather-protection and climatic features.

#### 7.3.2.4 Foundation Drawings

A foundation drawing shall indicate complete information required for foundation design by purchaser including the following:

- i) Foundation bolt sizes, pipe sleeve details, pocket sizes and locations.
- ii) Type of grout material, its recommended make & grade.
- iii) Static weight of each skid/independently grouted item and location of center of gravity of each of such skid/items in all three planes.
- iv) Weight distribution for each bolt/subsole plate location and total static weight.
- v) Dynamic loading caused due to various items grouted independently.
- vi) The direction and magnitude of unbalance forces and moments generated by each such item at the worst operating condition and short circuit moments of motor drivers/generators.
- vii)  $GD^2$  value of each item resolved to driver speed.
- viii) Maximum permissible amplitude of vibration on the foundation at base level.
- ix) Total mass of rotating parts.
- x) Suggested dynamic factor and ratio of foundation weight to weight of skid/equipment as per vendor experience.

#### 7.3.2.5 Layout Drawing (For multi-skid packages)

This drawing shall contain as a minimum the following information:

- i) Layout of all skid/equipment and their auxiliaries, vessels, control panels, exchangers etc. Vendor shall furnish an optimised layout (considering the space allocated, site wind conditions, area classification, the type of equipment located in the vicinity etc.) indicating elevation and dimension of skids/equipment.
- ii) Minimum spacing required between the various skids/equipment and between the skids and the walls/columns/roof for an easy accessibility and maintenance.
- iii) Layout for water piping, trenches for water piping, cable tray/trenches layout.
- iv) Piping arrangement and piping support arrangement/location for piping in vendor's scope.
- v) Layout for auxiliary equipment and operating platform details.
- vi) Specification for crane/mono rail (including suggested mono rail layout) recommended for maintenance and height of the lifting hook from the centreline of equipment.

#### 7.3.2.6 Field Alignment Diagram

The diagram shall indicate the relative displacement to be kept between the centrelines of various equipment, at the time of installation, so that under normal running conditions the equipments get fully aligned. This relative displacement should be decided on the basis of centreline temperature rise data of driver, gear box/transmission system, driven equipment.

#### 7.3.2.7 Heat Exchanger Drawings

Heat exchanger drawing and data shall include heat and mass balance data, details of provisions for separating and withdrawing the condensate, construction details, cross sections & general arrangement drawings of heat exchangers, vendor's recommendations regarding provision for support and piping expansion.

### 7.3.2.8 P&I Diagrams (with Bill of Materials)

Vendor shall supply P&I Diagrams along with Bill of Materials of each system in the vendor's scope of supply or specified in the order. P&I Diagram shall indicate the system details, location of various auxiliaries, instruments, controls and safety devices as required. Line sizes, piping class, valve sizes and class shall be clearly marked on the P&ID. Vendor's scope and purchaser's scope shall be clearly demarcated. Each item shall be identified by an item No./item tag no., which shall correspond to the item no. shown on the bill of materials. The bill of materials shall include item number, normal value, set value, range, quantity per unit, make and other specifications as applicable. Legends adopted shall be indicated either at the bottom of drawing or on a separate drawing. The legends shall be as per ISA.

### 7.3.2.9 Cross-sectional Drawing with Bill of Materials

The vendor shall supply cross-sectional or assembly type drawings for all equipment furnished showing all parts, design assembly and running clearances, and balancing data required for erection and maintenance. Each part shall be numbered which shall correspond to the part number on the bill of materials. The bill of materials shall include the part no., name of component, materials quantity installed per unit & sizes where applicable (say for bolts, nuts, rings, gaskets etc.). All boughtout items shall also be indicated with make and brief specifications. A separate cross-sectional drawing showing installation and setting dimensions for the seals shall be furnished.

### 7.3.6 Technical Data Manual/Mechanical Catalogues (Substitution)

7.3.6.1 Technical Data Manual/Mechanical Catalogue is a compilation of "as built" drawings and data, manufacturing and test records, installation, operating and maintenance instructions.

7.3.6.2 Not later than two weeks after successful completion of all specified tests, the vendor shall furnish the required number of Technical Data Manual/Mechanical Catalogues for the equipment, any auxiliaries and instruments that the vendor is providing. The Technical Data Manual/Mechanical Catalogue shall include the following documents as a minimum:

- i) All drawings and data as listed in the vendor data index & schedule. (For drawings, where purchaser's approval is required, the final certified drawings shall be attached.) Sections shall be organised in a manner that data & drawings related to one subject is grouped together such as Mechanical, Electrical, Instrumentation etc.
- ii) All manufacturing, inspection and test data and records.
- iii) Installation and Instruction Manual

The vendor shall provide sufficient written instructions, including a cross-reference list of all drawings, to enable the purchaser to correctly install the equipment and prepare the equipment for start-up. It shall include any special information required for proper installation that is not on the drawings, special alignment or grouting procedures, utility specifications (including quantity) and all installation data. It shall also contain the following information:

- a) Instructions for erecting, piping, aligning (including the expected thermally induced shaft centreline shift between normal site ambient temperature position and that at normal equipment operating temperature).
- b) A description of rigging procedures, including the lifting of the assembled equipment, and methods of disassembly, repair, adjustment, inspection and reassembly of the equipment and auxiliaries.
- c) Pre-commissioning/commissioning/functional test procedures and acceptance criterion.
- iv) Operation and Maintenance Manual  
This manual shall provide sufficient written instructions and data to enable purchaser to correctly operate and maintain the equipment ordered. It shall include a section to cover special instructions for operation at extreme environmental and/or extreme operating conditions. The following shall be included in this manual:

- a) Instructions covering start-up, normal shutdown, emergency shutdown, operating limits and routine operational procedures.
- b) A description of equipment construction features and the functioning of component parts or systems (such as control, lubrication, sealing systems etc.).
- c) Outline and sectional drawings, schematics and illustrative sketches in sufficient details to identify all parts and clearly show the operation of all equipment and components and the methods of inspection and repair. Standardised sectional drawings are acceptable only if they represent the actual construction of the equipment.
- d) The following maintenance information:
  - 1. Maximum and minimum bearing, labyrinth and seal clearances including any other clearance between moving and stationary parts of the equipment affecting proper running and maintenance of the equipment.
  - 2. Instructions for measuring and adjusting cold clearances, shaft runout, concentricity etc.
  - 3. Rotor float allowance.
  - 4. Interference fits on parts that are required to be removed or replaced for maintenance of normally consumable spares.
  - 5. Information for Rotor Balancing.
  - 6. Lubricating schedules indicating recommended grades of oil, their properties, replacement period etc.
  - 7. Normal maintenance procedure.
  - 8. Preventive maintenance schedules and criterion for replacement of parts.
  - 9. Trouble-shooting procedures.
- e) The following reassembly information:
  - 1. Bolting sequence and torque values for all bolts affecting equipment performance/integrity/safety.
  - 2. Reassembly Sequences together with required inspection checks.
  - 3. Adjustment procedures to achieve required positions, clearances, float and so forth.
  - 4. Detailed procedures for pre-operational checks, including settings and adjustments.
  - 5. Seals and coupling installation procedures.
  - 6. Parts list indicating cross-sectional drawings of various assemblies and sub-assemblies, part numbers, materials of construction (ASTM) etc. to facilitate identification of parts and for procurement of spares.
- v) Following information shall also be included in the Technical Data Manual/Mechanical Catalogue:
  - a) Storage instructions for storing and preserving the equipment (including driver and all the auxiliary units) at the plant site before installation of the same.
  - b) Instructions for preserving the equipment after it has been installed. This is particularly required in cases where a long time gap is expected between equipment installation and commissioning.
  - c) Field performance test procedures and acceptance criterion.

- 7.3.6.3 Technical Data Manual/Mechanical Catalogue shall be in Hard board folder(s) of size 265 mm x 315 mm and shall not be more than 90 mm thickness; it may be of several volumes and each volume shall have a volume number, index of volumes & index of contents of that particular volume.
- 7.3.6.4 Title sheet (Top sheet) of each volume of Technical Data Manual/Mechanical Catalogue shall contain the contract information as defined under 7.3.1.2 besides the volume number.
- 7.3.6.5 In case order contains more than one item, separate dedicated Technical Data Manual/Mechanical Catalogues shall be submitted for each item.
- 7.3.4.6 Two (2) sets of Final / “As-Built” drawings / documents shall also be submitted as electronic files on secondary storage media (CD-ROM / DVD-ROM disks).