TECHNICAL SPECIFICATION

COMBUSTION GAS TURBINES (WITH REFERENCE TO API STANDARD 616: Second Edition, June 1982)

DEP 31.29.70.31-Gen.

March 1985
(DEP Circulars 12/97 and 32/99 have been incorporated)

DESIGN AND ENGINEERING PRACTICE

USED BY

COMPANIES OF THE ROYAL DUTCH/SHELL GROUP

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PART I INTRODUCTION

This specification is a revision of an earlier publication with the same number published in January 1976. It gives the minimum technical requirements for combustion gas turbines for mechanical drives, electric power generator drives, pipeline transmission service and processing units. It is intended for use in oil refineries, chemical plants, gas plants, and in exploration, production and new ventures.

This specification gives SIPM/SICM amendments and supplements to API Standard 616, Second Edition of June 1982: 'Type H Industrial Combustion Gas Turbines for Refinery Services'. It shall be used in conjunction with data/requisition sheet DEP 31.29.70.93-Gen.

As a rule the requirements of this specification shall be adhered to. However, national and/or local regulations may exist in which some of the requirements are more stringent. The contractor shall determine by careful scrutiny which of the requirements are more stringent and which combination of requirements will be acceptable as regards safety, economic and legal aspects.

In all cases the contractor shall inform the principal of any deviation from the requirements of this specification which is considered to be necessary, in order to comply with national and/or local regulations. The principal may then negotiate with the authorities concerned with the object of obtaining agreement to follow this specification as closely as possible.

Unless otherwise authorized by SIPM, the distribution of this specification is confined to companies belonging to or managed by the Royal Dutch/Shell Group, and to contractors and manufacturers/suppliers nominated by them.

All publications referred to in this specification are listed in Part IV.

Part V comprises the appendices to this specification.

PART II GENERAL

PART II.1 GENERAL INFORMATION

This specification is written in five parts of which Part III, the principal part, gives the SIPM amendments and supplements to API Std 616, Second Edition, June 1982.

Problems stemming from the publication of revisions or amendments to the above standard in 1983 or subsequent years by the American Petroleum Institute shall be referred to the principal.

Combustion gas turbines shall conform to API Std 616 as amended or supplemented by this specification.

For ease of reference, the format of Part III uses the section and principal paragraph numbering of API Std 616 and is supported by subject headings. Clauses and paragraphs in API Std 616 not mentioned shall remain unaltered.

Where cross references are made, the number of the section/ sub-section/clause of this specification referred to is shown in brackets.

A bullet (•) in the margin against certain clauses in API Std 616 indicates that a decision by the principal is required. These decisions shall be indicated directly on data/requisition sheet DEP 31.29.70.93-Gen., when provisions are made for them. Otherwise they shall be indicated on the data/requisition sheet(s) under the heading 'Additional Requirements', or stated in the purchase order.

A 'G' in the margin indicates that the information is related to API type G modular or aircraft derivative gas turbines.

PART II.2 DEFINITIONS

For the purpose of this specification, the following definitions shall hold:

Shall and **Should** - the word 'shall' is to be understood as mandatory and the word 'should' as strongly recommended to comply with the requirements of this specification.

The **Principal** is the party which initiates the project and ultimately pays for its design and construction.
The Principal * will generally specify the technical requirements.
The Principal may also include an agent or consultant, authorized to act for the Principal.

* For Group operating companies having a service agreement with SIPM or SICM, the term Principal shall be taken as referring to SIPM - MFEE/21 or EP/23.

The **Contractor** is the party which carries out all or part of the design, engineering, procurement, construction and commissioning for the project.
The Principal may sometimes undertake all or part of the duties of the Contractor.

The **Purchaser** is the party which buys the combustion gas turbine and its auxiliaries for its own use or as agent for the owner. The Purchaser may be either Principal or Contractor.

The **Manufacturer/Supplier/Vendor** is the party which manufactures or supplies equipment and services to perform the duties specified by the Contractor.

PART III AMENDMENTS/SUPPLEMENTS TO API STANDARD 616

SECTION 1 GENERAL

1.1 SCOPE

Delete this clause and replace by:

This specification covers the minimum requirements for open, simple and regenerative cycle combustion gas turbine units for mechanical drives or generator drives.

Industrial gas turbines designated Type H by the American Petroleum Institute and covered by API Std 616, and modular or aircraft derivative gas turbines designated Type G by the API, are both covered by this specification. Clauses of this specification valid for type G only are indicated by a 'G' in the margin.

All necessary auxiliary equipment is included directly or by reference in this specification.

1.3 CONFLICTING REQUIREMENTS

Delete this clause and replace by:

In the case of conflict between documents relating to the inquiry or order, the following priorities shall apply:

- first priority : purchase order and variations thereto
- second priority : data/requisition sheets and drawings referred to
- third priority : this specification.

1.4 DEFINITION OF TERMS

1.4.1 Add the following definitions:

Overall cycle efficiency

The overall cycle efficiency shall be expressed as a percentage of the lower heating value of the fuel which appears as mechanical work at the turbine coupling under ISO rated conditions. Losses through internal ducting, regenerator, etc., shall be taken into account when calculating the overall cycle efficiency.

Single-shaft gas turbine

A gas turbine in which the power turbine and the hot gas generator are combined mechanically on to a single shaft.

Two-shaft gas turbine

A gas turbine which has no mechanical connection between the power turbine and the hot gas generator, thus permitting the power turbine to rotate on its shaft independently of the hot gas generator.

This definition does not exclude hot gas producers with more than one air compressor driven by separate turbine elements.

Modify the following definitions:

Site rated power

Site rated power is the power developed by the gas turbine, operated in a clean condition, including clean air filters and air compressor at rated firing temperature, rated speed and rated site conditions of inlet temperature, inlet pressure, exhaust back pressure and specified fuel composition.

The site rated power shall be regarded as the guaranteed power capability of the gas turbine and shall be the power available at the gas turbine load coupling after extracting parasitic losses such as fuel and lubricant pumps, internal speed changers, etc.

Turbine trip speed

The turbine trip speed shall be 110% of the rated speed or 105% of the maximum continuous speed of the driven equipment, whichever is lower.

1.5 REFERENCED PUBLICATIONS

Delete from this clause:

- API Std 615: Sound Control of Mechanical Equipment for Refinery Services. The additional publications referred to in this specification are listed in Part IV.

SECTION 2 BASIC DESIGN

2.1 GENERAL SERVICE CONDITIONS

2.1.1 Delete this clause and replace by:

The gas turbine and its auxiliaries shall meet the requirements stated in the purchase order and specified in the data/requisition sheets.

All equipment, including auxiliaries, shall be designed to achieve continuous operation between the following events:

- combustor inspections at 10 000 hours
- hot gas path inspection at 20 000 hours
- overhaul at 40 000 hours.

NOTES:
- Overhaul shall include the exchange of the hot gas generator of modular or aircraft derivative gas turbines.
- The above periods are minima. The principal and the manufacturer may agree to different periods depending on the principal's maintenance philosophy.

2.1.2 Delete this clause and replace by:

Gas turbine units shall be suitable for periods of idleness of several months' duration under the specified site conditions, without requiring any special maintenance procedures.

2.1.3 Add to this clause:

Unless otherwise specified, the required speed range of two-shaft turbines shall be from 75% to 105% of rated speed.

There shall be a margin of at least 7% between the power demand of the driven equipment and the site rated power of the gas turbine. This margin provides an allowance for performance degradation due to fouling, etc., during periods of continuous operation.

2.1.5 Delete this clause and replace by:

The design shall permit the rapid starting of the gas turbine from a cold condition. Restarting shall be possible at any time after a spurious trip without either a cool-down or a warm-up period prior to loading.

Barring or turning gear to prevent bowing of shafts during cool-down shall require the approval of the principal, see also (3.1.3).

2.1.7 Delete this clause and replace by:

Noise control

Gas turbines shall be designed to minimize the generation of noise and, when installed on site, shall not exceed the noise limits described in (2.1.7.2).

2.1.7.1 Add the following clause:

All definitions, notations, measuring equipment, measuring procedures, test reporting, calculation methods and calculation procedures shall be in accordance with OCMA publication NWG-1.

2.1.7.2 Add the following clause:

The sound pressure level in dB (re 20 μPa) shall not exceed 87 dB(A) for the gas turbine, or 90 dB(A) for the gas turbine and its driven equipment, at any measuring point distant 1 m from the equipment surface, unless otherwise specified.

If the equipment produces impulsive and/or narrow band noise, the above limits shall be taken 5 dB(A) lower, thus 82 dB(A) for the gas turbine and 85 dB(A) for the gas turbine + driven equipment.

Noise levels shall have an upper tolerance of + 0 dB.

The above requirements apply in the absence of reverberation and background noise from other sources, and for all operating conditions.

In the event that more stringent limits apply, these will be indicated on data/requisition sheet DEP 31.10.00.94-Gen. which always forms part of the requisition. In such cases, the equipment shall not exceed the more stringent of the sound power and sound pressure limit stated in the requisition.

2.1.7.3 Add the following clause:

Where excessive noise from equipment cannot be eliminated by low-noise design, the vendor shall submit his proposals for acoustic treatment for approval by the principal. See also DEP 31.10.00.95-Gen. and DEP 31.10.00.96-Gen. For acoustic insulation of piping and ducting, see DEP 31.46.00.31-Gen.

2.1.7.4 Add the following clause:

Information to be submitted with tender:

The vendor shall state, as requested, either the sound pressure level distant 1 m from the surface of the equipment in octave bands and in dB(A), or the maximum sound power level of the equipment in octave bands and in dB(A) in data/requisition sheet DEP 31.10.00.94-Gen. The vendor shall complete and return the data/requisition sheets DEP 31.10.00.95-Gen., DEP 31.10.00.96-Gen. and indicate any other special silencing measures applied in order to obtain the levels submitted.

2.1.8 Delete this clause and replace by:

Cooling water systems shall be designed for the conditions specified in the data/requisition sheet, but shall be at least suitable for a working pressure of 5 bar(g).

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

2.1.11 Delete this clause and replace by:

All electrical components and installations shall be suitable for the area classification and grouping specified in the requisition.

2.1.13 Add to this clause:

G The hot gas generator of a modular or aircraft derivative gas turbine shall be easily removable. The supplier shall demonstrate that a competent crew can remove the hot gas generator and replace it with a spare hot gas generator in eight hours from shutdown to start-up. The supplier shall provide all instructions, tools, lifting tackle, rigs and fixtures to achieve such replacement.

2.1.15 Delete this clause and replace by:

The combined performance of the gas turbine and its driven equipment shall be the responsibility of the vendor.

2.1.16 Delete this clause and replace by:

The gas turbine manufacturer shall review and comment upon the proposed arrangement of the installation, particularly upon the arrangement for fuel gas supply, ducting lay-out, drive coupling arrangement, instrumentation, controls, baseplates and foundations.

2.1.17 Delete this clause and replace by:

The site climatic and installation conditions shall be stated in the data/requisition sheets. The gas turbine shall be suitable for operation under the specified conditions. Any winterizing, enclosures, weather or sun protection required by the manufacturer shall be included in the package.

2.1.18 Add the following clause:

Gas turbine ratings shall be well within the manufacturer's actual experience and shall not exceed the limits of his design and experience. Flat rating of gas turbines, allowing for a constant power irrespective of ambient temperature, compensating for the increased firing temperatures at high ambients by reduced firing temperatures at low ambient temperature, is not permitted.

2.2 PRESSURE CASINGS

2.2.1 Delete this clause and replace by:

The hoop-stress values used in the design of the casing shall not exceed the values given for maximum allowable stress in tension specified in the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, or BS 5500 as amended/supplemented by DEP 31.22.10.32-Gen., at the maximum operating temperature of the materials used. The material certification and testing, welding, casting and repair requirements of these specifications shall apply, but no other sections of the referenced documents.

2.2.4 Add to this clause:

The gas turbine casing shall be designed to contain failed blades, discs or components ejected from a ruptured part which could cause hazard to life or property. Otherwise, containment shields shall be provided by the manufacturer.

2.2.7 Delete this clause and replace by:

Suitable inspection ports shall be provided in the casing to allow internal visual examination of the compressor, combustion chambers, nozzles and blading in the hot gas path, using flexible or rigid fibre optic inspection devices. Adapters and guide tubes for fibre optic inspection shall be provided by the manufacturer.

Inspection ports shall be readily accessible without the need to dismantle any component or accessory, and their location shall be shown on the manufacturer's drawings. The internal area which may be viewed from each port shall also be shown on the drawings.

2.2.9 Add to this clause:

Field balancing by adding weights to couplings is prohibited.

2.3 COMBUSTORS AND FUEL NOZZLES

2.3.2 Add to this clause:

Combustion chamber liners shall be replaceable without the removal of major casing components.

2.3.3 Add to this clause:

Fuel nozzles shall be designed for the fuel specified. The manufacturer shall provide satisfactory proof that the proposed nozzles can withstand coking and fouling by combustion products.

For viscous liquid fuels, air atomization is preferred.

2.3.4 Delete this clause and replace by:

Dual-fuel nozzles shall be provided with air or gas purge to the liquid fuel nozzle when the gas turbine is running on gas fuel alone. The air supply may be taken from the turbine air compressor bleed system, or from a separate air compressor. A piston-type check valve shall be installed in the liquid fuel supply to each nozzle to prevent escape of the purge air through the fuel drain system.

2.3.6 Add the following clause:

When specified, fuel nozzles shall be equipped with water or steam injection to suppress NO_X emission. The water shall not be injected directly into the fuel supply but via separate nozzles or orifices strategically placed in the fuel nozzle. The supplier shall provide a full description of the system proposed.

2.4 CASING CONNECTIONS

2.4.8 Add the following clause:

Drain connections shall be provided appropriately positioned for the removal of spent crank soak washing liquids and any accumulated liquid fuel (3.5.6.11).

2.5 ROTATING EQUIPMENT

2.5.1 Shafts

2.5.1.2 Add to this clause:

The requirements of this clause shall not apply to gas turbine designs with the following

features:

- If the mounting of the proximity probes is such that they are inaccessible for replacement or recalibration without disassembly of any major component of the gas turbine.

G - The shafts run in rolling element bearings.

2.5.2 Rotors

Add the following clauses:

2.5.2.3 On gas turbines for generator drives, rotors shall be mechanically designed to withstand safely and without failure the transient torques produced in the event of a generator short circuit. The transient torques considered shall not be less than 200% of full-load torque. Out-of-phase synchronization and full-load rejection shall also be considered in the design of the rotating components.

2.5.2.4 In the event of an order for a number of gas turbines, all of the same rating, all rotors shall be interchangeable.

2.5.3 Discs and blading

Add the following clauses:

2.5.3.4 G Power turbine blading and nozzles shall have a design life in excess of 100 000 hours at the rated turbine inlet temperature and speed.

2.5.3.5 The design of the core or film cooling system for the hot gas path rotating and fixed blading shall be submitted with the proposal.

2.5.3.6 Adjustable stator blades shall be mounted in trunnions and bushes of fluorocarbon plastic or sintered antifriction materials. Joints in the actuation mechanism shall be lubricated and sealed for life.

2.5.3.7 Rotor blades shall be moment-balanced and all marked to allow field retrofitting of the blades without the need to rebalance the rotor. Moment-balancing data shall be furnished with the operating manuals.

2.5.3.8 Gas turbines specified in the data/requisition sheets for operation in a hostile environment shall have the turbine air compressor rotor and stator blades of non-corroding material or shall have non-corrodible coating. The manufacturer shall furnish full details of rotor, stator blading and coating materials.

2.6 SEALS

Add the following clauses:

2.6.4 Air-cooled seals shall be provided wherever there is a risk that hot combustion products may enter bearings or other components containing lubricants which are likely to char when exposed to the combustion product temperature. Sealing air may be extracted from an appropriate stage of the combustion air compressor. The manufacturer shall include in his supply any coolers that may be required for the sealing air, see DEP 31.21.70.31-Gen. Placing the coolers in the combustion air intake may be done only with the purchaser's approval.

Losses incurred by the extraction of air for sealing or cooling purposes shall be taken into account when calculating the overall cycle efficiency.

The manufacturer shall assure the purchaser that the sealing air extraction position in the turbine air compressor does not create unacceptable aerodynamic disturbance of the air compressor blades.

2.6.5 G In the case of a gas turbine incorporating an aircraft derivative hot gas producer and requiring air cooling to the seals of the power turbine, the air required shall be taken from the hot gas producer air compressor.

2.7 DYNAMICS

2.7.1 Critical speeds

2.7.1.4 Delete this clause and replace by:

At critical speeds the overall unfiltered peak-to-peak amplitude of vibration, including run-out, shall not exceed 1 $^1/_2$ times the vibration limit given in (2.7.2.5).

2.7.2 Vibration and balance

2.7.2.5 Delete this clause and replace by:

Under all operating conditions specified in the data/requisition sheet, including starting, operation, routine and emergency stopping the maximum vibration severity as defined in ISO 2372 measured at any measuring point shall not exceed the allowable values for class IV machinery in any direction or frequency.

Gas turbines fitted with shaft relative displacement proximity probes shall achieve an overall peak-to-peak unfiltered amplitude of vibration, including run-out, not exceeding 50 µm or a value obtained from the following expression, whichever is the least value:

$$A = 10 \times \sqrt{75000 / n}\ , \text{ where:}$$

A = peak-to-peak amplitude, µm

n = rated speed or maximum continuous speed, whichever is higher, r/min

The above limits of vibration shall apply to each radial bearing where relative vibration is measured, at any speed within the operating range up to maximum continuous speed.

2.8 BEARING AND BEARING HOUSINGS

2.8.9 Delete this clause and replace by:

Bearing housings shall be designed to accommodate the requirements of (2.5.1.2) and (2.9).

2.8.11 Add new clause:

G Rolling element bearings used on rotors or auxiliary drives shall comply with the following criteria:
- the manufacturer is able to demonstrate proven application of the proposed bearing design(s)
- the life of the proposed bearings, as determined by service, load, lubrication, etc., is more than 30 000 hours
- the design does not propose the use of a single-groove ball bearing to support idler gears or trunnions
- each rotating component is supported by at least two independent bearings.

2.9 VIBRATION AND AXIAL POSITION DETECTORS

2.9.1 Delete this clause and replace by:

Non-contacting radial vibration and axial position probes and monitors shall be installed, if specified, in accordance with API Std 670 as amended/supplemented by DEP 32.31.09.31-Gen.

2.9.2 Delete this clause and replace by:

For case-mounted vibration detection device requirements, see (3.4.6.6).

2.9.3 Add the following clause:

Each rotor shall be provided with facilities for the installation of a keyphaser probe.

2.10 LUBE OIL SYSTEMS

2.10.2 Delete this clause and replace by:

Lubrication systems shall comply with API Std 614 as amended/ supplemented by DEP 31.29.60.32-Gen.

Add the following clauses:

2.10.3 The same lubricating oil from a common supply system shall be used for the combustion gas turbine, the driven equipment and the speed changers, except as otherwise agreed by the purchaser. Only commonly available mineral lubricants shall be specified.

2.10.4 G Lubrication systems for hot gas producers designed for synthetic fire retardant lubricants shall comply with the requirements of this specification. The design of the synthetic lubricating oil system shall be such that mingling of this lubricant with any other is positively prevented. The oil tank filler shall be such that only a special filling apparatus can be used for lubricant replenishment. The replenishment vehicle, filters and pumps shall be furnished by the vendor.

2.10.5 For variable speed gas turbines two identical AC electric motor driven pumps shall be provided, one running and one standby.

The arrangement of the installation shall be such that with both pumps running simultaneously, the lubricating oil pressure does not rise above 85% of the maximum design pressure of the system.

2.10.6 A separate DC pump shall be provided for supplying lubricating oil for post-shutdown cooling, where required by the manufacturer's design. The manufacturer shall supply nickel-cadmium batteries with sufficient capacity for the duration of post lube, together with a battery charger.

2.10.7 The lubricating oil tank shall be of sufficient capacity for eight minutes retention time at the design oil pump flow rate. All independent lubricating oil tanks shall be interconnected such that there is throughflow from gravity drains to the pump inlets, and equalization of the vapour spaces.
All tanks shall have access hatches of sufficient size for adequate inspection and cleaning of all parts of the tanks.

2.10.8 Atmospheric vents from the lubricating oil tanks shall be open to the atmosphere, piped by the purchaser to a strategic location. The manufacturer shall furnish a vertical straight length of finned tube for attachment directly above the oil tank. The finned tube section shall be surmounted by a coalescing-type flame trap. The flame trap shall have an 11 mm OD separate return line to the oil tank.

2.11 MATERIALS

2.11.1 General

2.11.1.1 Add to this clause:

Materials for components in contact with gas containing hydrogen sulphide shall conform to the requirements of NACE Standard MR-01-75.

2.11.1.8 Delete this clause and replace by:

Steel plate for pressure-containing parts shall comply with the requirements of the ASME Boiler and Pressure Vessel Code, Section VIII or with BS 5500 as amended/supplemented by DEP 31.22.10.32-Gen.

2.11.2 Castings

2.11.2.4 Delete this clause and replace by:

Amended per Circular 12/97

The repair of leaks and defects in pressure-containing castings by peening or burning-in, or by impregnation with plastic or cement compounds, is not permitted.

Repair by welding or by plugging shall be undertaken only when permitted by the material specification, and then only in accordance with the procedures detailed below:

- Repair by welding.

  Weldable grades of castings may be repaired by welding subject to the following criteria:

  - Approval of the principal shall be obtained before any major weld repair is carried out. A major weld repair is either removal of more than 50% of the wall thickness, or a length of more than 150 mm in one or more directions, or the total surface area of all repairs exceeding 20% of the casting.

    Castings subject to a major repair shall be inspected by the purchaser's representative, who shall be notified in accordance with paragraph 4.1 of API Std

616.

- All repairs shall meet the inspection requirements and acceptance standards for the original material.
- For steel castings, the repair welding procedure and the repair welder's qualifications shall be in accordance with ASTM A 488. Repair procedures shall be approved by the principal.
- The total quantity of weld metal deposited shall be less than 10% of the mass of the casting.
- After weld repair, castings shall be suitably heat-treated, if specified in the material specification. A major weld repair shall always be followed by a suitable heat treatment.
- Details of all major weld repairs and the heat treatment shall be recorded and reported to the principal.

- Repair by plugging

  Cast grey iron or nodular iron may be repaired by plugging within the limits specified in ASTM A 278, ASTM A 536 or ASTM A 395, respectively. The drilled holes for plugs shall be carefully examined with dye penetrant to ensure removal of all defective material.

  All necessary repairs not covered by ASTM shall be subject to approval by the principal, who shall be informed of the need for plugging before any repair is carried out.

  Details of all repairs shall be recorded and reported to the principal.

2.11.3 Forgings

Delete this clause and replace by:

Material selection for compressor and turbine disc forgings shall be approved by the principal.

2.11.4 Welding

2.11.4.1 Delete this clause and replace by:

Welding materials shall be in accordance with the current list of approved welding consumables published by Lloyd's Register of Shipping, American Bureau of Shipping, Controlas or other internationally acknowledged bodies.

Final approval of welding consumables shall be through satisfaction of the requirements set down in the welding procedure qualification tests.

NOTE: Welding consumables are approved either (i) by being on a recognized list, or (ii) by meeting the requirements of the welding procedure qualification tests.

Some consumables may not satisfy (i), newer consumables for instance, for which testing techniques/procedures have not yet been finalized whereby they can be type approved, but satisfaction of (ii) makes them acceptable. The approval rests with the party responsible for approval of the welding procedure qualification tests.

For ferritic steels intended for welding, the upper limit of the carbon range (in the check analysis) should not exceed 0.23%. However, for forgings this may be relaxed to 0.25%.

2.11.5 Delete this clause and replace by:

Low temperature

For operating temperatures below 0 °C, selected materials shall have an impact strength sufficient to qualify under the minimum impact energy requirements, see DEP 30.10.02.31-Gen.

2.11.6 Material inspection

2.11.6.1 Delete this clause and replace by:

Casting surfaces shall be examined visually by the manufacturer and shall be free from adhering sand, scale, cracks and hot tears.

Other surface discontinuities shall meet the visual acceptance standards specified in MSS

SP-55.

2.11.6.3 Add to this clause:

Following visual inspection, magnetic particle inspection shall be carried out on all surfaces after final machining.

The magnetic particle inspection method shall be in accordance with ASTM E 709.

2.11.6.4 Add the following clauses:

Dye-penetrant inspection shall be used only when magnetic particle inspection is not feasible. Dye-penetrant inspection method shall be in accordance with ASTM E 165.

Acceptability of defects shall be based on a comparison with the reference photographs given in ASTM E 125. For each type of defect, the degree of severity shall not exceed the limits given in the table in 2.11.6.3.

2.11.6.5 Full non-destructive inspection shall be carried out on all critical areas, such as abrupt changes in section, weld ends, the junction of risers, gates or feeders to the casting and areas of high stress.

The purchaser and the manufacturer shall agree prior to inspection the critical areas and the type of non-destructive testing which shall be applied.

Radiographic inspection shall be applied wherever possible, and the procedure shall be in accordance with ASTM E 94.

Radiographs shall be interpreted in accordance with ASTM E 186, ASTM E 280 or ASTM E 446, whichever is applicable. For each type of defect, the degree of severity shall not exceed the values in the following table:

Thickness mm	Gas and blow holes	Sand spots and inclusions	Internal shrinkage	Cracks and hot tears
			Types 1, 2, 3 or 4	
Below 25	2	2	2	
25 - 50	3	3	2	Not allowed
50 - 114	3	3	2	
Over 114	3	3	2	

Where radiography is not possible, ultrasonic inspection shall be used and shall be in accordance with ASTM A 609.

For each range of wall thickness, the level of acceptance shall be in accordance with the following table:

Thickness mm	Acceptance level
Below 50	2
50 - 100	3
Over 100	4

2.11.7 Miscellaneous

2.11.7.1 Add the following clause:

Manufacturer's standard nameplates shall be affixed to all gas turbines.

The text on nameplates shall be in English and the data shall be in SI units, unless otherwise specified.

The information on nameplates shall include the year of manufacture.

SECTION 3 ACCESSORIES

3.1 STARTING AND HELPER DRIVES

3.1.1 General

3.1.1.4 Delete this clause and replace by:

Starting steam turbines shall be general-purpose steam turbines conforming to API Std 611 as amended/supplemented by DEP 31.29.60.30-Gen.

3.1.1.5 Delete this clause and replace by:

Helper steam turbines shall be special-purpose steam turbines conforming to API Std 612 as amended/supplemented by DEP 31.29.60.31-Gen.

3.1.1.6 Add to this clause:

Electric motor drives shall comply with DEP 33.66.05.31-Gen.

3.1.1.8 Add to this clause:

Starter drives shall be declutched when the gas turbine is running and re-engagement shall be prevented before the gas turbine rotor is completely stationary.

3.1.1.9 Add the following clause:

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 limit of supply.

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

Lubrication for gas expansion starters shall be taken from the common lubricating oil supply system for the gas turbine. Systems requiring operator attention for starter lubricant oil levels are not permitted.

3.1.1.10 Add the following clause:

Starting equipment located within the air intake plenum shall have all bolts and fastenings wire-locked to prevent inadvertent loosening or detachment.

3.1.2 Ratings

3.1.2.1 Add to this clause:

Starting driver ratings shall be within the experience range of the manufacturer and shall not exceed the design limits.

Starting driver ratings shall allow the continuous cranking for crank soak washing of the gas turbine air compressor, followed by three consecutive starts.

3.1.3 Turning equipment

3.1.3.1 Add to this clause:

Means shall be provided for manually turning all rotors for maintenance and alignment checks. The design shall prevent inadvertent starting of the turbine whilst the turning or barring gear is in place. See also (2.1.5).

3.2 GEARS, COUPLINGS AND GUARDS

3.2.1 Gears

3.2.1.2 Add to this clause:

All transmission gears, auxiliary gears and speed changers shall comply with standards agreed between the principal and the manufacturer.

3.2.1.3 Add to this clause:

The potential maximum power of the gas turbine shall be calculated in a clean and new condition, at maximum permissible turbine inlet temperature and minimum ambient temperature at the maximum continuous speed.

3.2.1.4 Add to this clause:

Auxiliary drives which are no part of a particular configuration shall be removed from the gas turbine.

Gears and bearings running unloaded whilst the gas turbine is running are not permitted.

3.2.2 Couplings and guards

Number existing clause 3.2.2.1 and add the following clauses:

3.2.2.2 Dry diaphragm-type load couplings with hydraulic fit of the hubs to tapered shaft ends are preferred. Alternatively, couplings may be flange-mounted.

3.2.2.3 Spacers of adequate length shall be provided to allow removal of coupling hub and driven equipment bearing and seals without disturbing the shafts.

3.2.2.4 Flexible pin and bush couplings are not permitted for any main or accessory drive.

3.2.2.5 Internal couplings for starters and accessories may be the manufacturer's standard. The type and manufacture shall be stated in the proposal for confirmation of acceptance.

3.3 MOUNTING PLATES

Delete this entire paragraph and replace by:

3.3 BASEPLATES

3.3.1 The gas turbine unit with starting equipment, lubrication system and other auxiliaries shall be supported by a single rigid steel baseplate, unless otherwise specified. The base-plate shall be a continuous structural member designed to support the driven equipment.

3.3.2 When transportation restrictions limit the size, the base-plates may be fabricated in sections. Mating surfaces shall be machined and dowelled for accurate assembly, creating a single rigid structure at the installation site.

3.3.3 All baseplates shall be designed for installation on a flat unprofiled foundation and the mounting pads on the bottom of the baseplate shall be in one horizontal plane.

3.3.4 For installation on concrete foundations, baseplates shall be designed for supporting by the 'Chock-and-Block' method, as described and shown in Appendix 2 of this specification.

3.3.5 All load-carrying structural members shall have accessibility for grouting and all necessary shims, soleplates and levelling screws shall be provided by the vendor. Grouting is not permitted between mounted equipment and the baseplate.

3.3.6 The baseplate shall be sealed on its underside to maintain ventilation pressure within the enclosure and to prevent oil spillage spreading from the mounted equipment. All voids shall have a flanged drain not less than 50 mm NW.

3.3.7 Lubricating oil tanks may be accommodated within the base-plate framework, if the arrangement complies with (2.10) and the rise in oil temperature does not create misalignment.

3.3.8 Offshore/steel structure applications

3.3.8.1 For offshore application, and for installation on a steel support structure, the baseplate shall be designed for three-point mounting.

3.3.8.2 The alignment of the equipment mounted on the baseplate shall not be disturbed by any movement or flexing of the supporting structure.

3.3.8.3 All connecting cabling and pipework shall be anchored to the baseplate to prevent misalignment caused by piping or cabling movements.

3.3.9 Lifting arrangements

When lifting the baseplates, complete with all equipment mounted, beam deflection shall not exceed $\frac{1}{1200}L$, where

L = total length of the beam.

Each baseplate or section shall have an adequate number of lifting lugs.

3.3.10 Levelling/alignment

3.3.10.1 The final levelling and alignment of the gas turbine, accessories and driven equipment shall be between the equipment supports and the previously levelled and secured baseplates.

3.3.10.2 All equipment supports and pedestals shall be fitted with horizontal jacking screws and vertical levelling screws to facilitate alignment.

3.3.11 Equipment supports

3.3.11.1 Gas turbine supports shall allow freedom for expansion of the turbine casing without disturbing the alignment with the driven equipment. Diaphragm or link-type supports are preferred to sliding supports with key location.

3.3.11.2 G Hot gas producer supports shall be designed to absorb the end thrust as the hot gas producer expands and to prevent distortion of the interconnecting hot gas duct to the power turbine.

3.3.11.3 Pedestals requiring either heating or cooling for controlling the effects of thermal expansion

require the approval of the principal.

3.3.12 Painting

3.3.12.1 Painting for baseplates shall be in accordance with DEP 30.48.00.31-Gen.

3.3.13 Decking/walkways

For parts requiring maintenance or operation access the vendor shall provide decking, walkways and platforms, unless otherwise specified.

3.3.14 Anchor bolts

Anchor bolts shall be provided by the vendor, unless otherwise specified.

3.4 CONTROLS AND INSTRUMENTATION

Delete paragraphs 3.4.1 and 3.4.2 of this chapter and replace by:

3.4.1 General

3.4.1.1 Controls and instrumentation shall conform, where applicable, to the requirements of DEP 32.31.09.31-Gen. Control oil systems shall comply with API Std 614, as amended/supplemented by DEP 31.29.60.32-Gen.

3.4.1.2 Primary instrumentation elements shall be mounted within the limits of the baseplate(s) of the gas turbine and its driven equipment. All signal processing and monitoring shall be performed within a separately mounted control panel.

3.4.1.3 The instrumentation and control system may require signals from primary elements outside the vendor's scope of supply. Conversely, the vendor's instrumentation and control system may be required to supply information to the purchaser's control system. In such cases, the vendor shall liaise with the purchaser regarding these interface requirements.

3.4.1.4 All instrumentation shall be readily accessible and rigidly supported. Vibration isolation shall be considered for all base-mounted instruments and gauge boards.

3.4.1.5 The control and instrumentation system shall protect personnel and plant against injury or loss under all conditions of operation or malfunction. The monitoring and supervisory instruments shall provide information for the diagnosis of the gas turbine health during operation and for warning of deterioration of its condition.

3.4.2 Control systems and condition monitoring

3.4.2.1 The gas turbine shall have a fully self-contained control system including:

- a fully automatic start-up, which may be initiated from a single push button or by a remote signal
- automatic acceptance of load, including adjustment of speed as necessary
- adjustments to speed or load in response to a remote signal
- manual adjustments of speed or load from the control panel.

The control system shall not permit a turbine inlet temperature in excess of the maximum allowable temperature with increasing ambient temperature.

3.4.2.2 The control system shall utilize all solid-state programmable logic, unless otherwise agreed by the principal. The program shall be tape- or floppy-disc loaded, and shall not utilize logic elements with burnt-in programs which can only be reprogrammed in the manufacturer's works.

The program shall include the logic for both the gas turbine and its driven equipment and shall cover all functions of start/run/stop and monitoring.

3.4.2.3 Suitable barriers shall be provided between the logic system and the interconnecting cabling to prevent spurious signals from affecting the controls.

3.4.2.4 The complete program shall be available to the purchaser. It shall be field reprogrammable, except for certain critical functions which may be protected by the manufacturer with the agreement of the purchaser.

3.4.2.5 An instrumentation system shall be furnished for on-line monitoring of the health and performance of the gas turbine and its auxiliaries. The scope of the monitoring system shall be agreed between the principal and the manufacturer.

3.4.2.6 The vendor shall cooperate with the purchaser in furnishing baseline information and in developing monitoring techniques relevant to the equipment concerned.

3.4.3 Starting control systems

3.4.3.1 Add to this clause:

During the start-up sequence the control system shall provide for a purge period of sufficient duration for three to five complete changes of air during the start-up procedure to purge the air filter, the gas turbine, the exhaust system and any exhaust heat recovery equipment prior to admitting fuel to the combustors and activating the igniters. The purge period shall be active irrespective of the mode of starting.

3.4.3.2 The starting sequence shall be monitored by an annunciator panel which shall indicate each stage of the start-up in sequence. If there is a failure in starting the gas turbine, the controls shall initiate a normal shutdown procedure for the gas turbine and its driven equipment, and shall lock the train out of service. The sequence annunciator shall hold at the state at which failure occurred.

3.4.3.3 An off-local-remote selector switch shall be provided, the function of which shall be, respectively:

- to prevent the turbine from being started
- to allow the turbine to be started only from the control panel
- to allow the turbine to be started by a remote signal or from the gauge board.

3.4.4 Governor and fuel control systems

3.4.4.4 Delete this clause and replace by:

For single-shaft gas turbines the control range shall be from maximum continuous speed to 90% of rated speed. For two-shaft gas turbines the control range shall be as stated in (2.1.3).

3.4.4.10 This clause shall apply.

3.4.4.12 Delete this clause and replace by:

The fuel control system shall have a separate shutoff valve to positively stop all fuel flow to the gas turbine under any shutdown condition. The shutdown valve shall not open until all permissives have been satisfied to commence firing the gas turbine, including the purge period (3.4.3.1).

3.4.4.13 Add to this clause:

The vent from this valve shall not be connected to any other venting or blowdown system.

3.4.5 Instrument and control panels

3.4.5.1 Add to this clause:

All manual operations for starting, stopping, load or speed changing and monitoring specified herein shall be achieved from the front of the control panel.

3.4.5.2 Delete reference to conduit for electrical and instrument wiring in this clause.

Add the following clause:

3.4.5.2 The control panel will be installed in a control room designated as a safe area, unless the purchaser specifies otherwise.

3.4.6 Instrumentation

Delete all clauses of this section and replace by:

3.4.6.1 Monitoring systems

3.4.6.1.1 All monitoring instruments, sensors and pick-ups shall be suitable for field checking and calibration during operation of the gas turbine or shall be duplicated to enable individual items to be removed for checking and calibration without affecting the integrity of the monitoring system. Duplicates shall be installed alongside the corresponding items.

3.4.6.1.2 Safety devices shall be fitted within the monitoring system to prevent malfunction of any component of the gas turbine unit creating a hazard to personnel or property.

3.4.6.1.3 Unless otherwise specified, for each malfunction there shall be a prewarning of the alarm condition (A), indicating a deteriorating condition, and of the shutdown condition (SD), when conditions have deteriorated to an extent that it is unsafe to continue operating the gas turbine.

3.4.6.2 Gas flow path temperatures

3.4.6.2.1 Instrumentation shall be provided to monitor flow path temperature at the following locations:

1 - air compressor inlet

2 - air compressor outlet

3 - power turbine nozzle inlet

4 - power turbine exhaust diffuser.

3.4.6.2.2 At least two temperature detectors shall be provided for locations 2 through 4, and at location 4 there shall be one detector opposite each burner or combustor. Each detector shall be suitable for the operating temperature at the point of application, and the vendor shall state the maximum allowable spread of temperature at each hot location.

3.4.6.2.3 Temperature detectors shall be installed in thermowells, if practicable, and shall be removable without disturbing the turbine operation.

3.4.6.2.4 The output from each detector shall be displayed on the control panel. The indicators for multiple detection points shall record the average temperature of all locations and allow interrogation of the maximum temperature spread and of the deviation at any point. The indicator shall provide an alarm and shutdown at preset average temperature deviation and maximum spread of temperature.

3.4.6.3 Gas flow path pressures

3.4.6.3.1 Pressure indication shall be provided at the following locations:

1 - air compressor inlet

2 - air compressor outlet

3 - exhaust outlet.

All the above sensors shall be transmitters, if not otherwise specified.

3.4.6.3.2 The signal from each transmitter shall display the corresponding pressure on the control panel.

3.4.6.4 Vibration detection devices

3.4.6.4.1 All vibration detection devices mounted on the gas turbine shall be suitable for the prevailing temperatures. Equipment mounted on the hot parts of the turbine shall have an operating temperature of not less than 250 °C. Field amplifiers, proximitors, etc., shall be installed in steel or cast aluminium boxes, according to the requirements of the area classification, to protect them against mechanical damage.

3.4.6.4.2 G For rolling element bearings or where the mounting of a probe is such as to make it inaccessible for calibration and maintenance without dismantling any part of the gas turbine, case-mounted accelerometers shall be used. Brackets shall be designed to accept accelerometers for vibration measurement in the radial, longitudinal and tangential planes, and shall be mounted in accessible positions giving a satisfactory response to rotor vibration. Each bracket shall have space for attachment of a calibration accelerometer. The natural frequency of response of any bracket shall exceed twice the highest blade passing frequency.

3.4.6.4.3 Vibration read-out instrumentation shall be mounted on the control panel. It shall provide for a continuous analogue read-out of the rms velocity of vibration and for preset alarm and shutdown signals. Unconditioned signal output, including the keyphasers, shall be available at jack connections on the panel face.

3.4.6.5 Speed measurement

3.4.6.5.1 Speed measurement shall be by non-contacting electronic pick-up.

3.4.6.5.2 Speed of all gas turbine rotors shall be measured and indicated on the control panel. Separate speed pick-ups shall be used for overspeed trip devices.

3.4.6.6 System cabling

3.4.6.6.1 All wiring and cabling for instrument installation shall be in accordance with DEP 32.37.20.31-Gen.

3.4.6.6.2 All wiring on the gas turbine package within the limits of the baseplate shall be executed in armoured cable. Conduit systems are not permitted for this application.

3.4.6.6.3 All connections to purchaser's system shall be marshalled into conveniently located junction

boxes, segregated according to function and hazardous area classification.

3.4.6.6.4 All leads to thermocouples, resistance temperature detectors and vibration monitors on the gas turbine shall be protected by armoured flexible sleeving supplied as a factory-made unit with the detecting element. The leads shall be of sufficient length to be taken directly to a junction box on the baseplate. Each lead shall be protected throughout its length by a rigid steel tube, the bore of which shall be at least twice the maximum outside diameter of the connector on the lead which must pass through it. The tube shall terminate as close to the detecting element and the junction box as is practicable, consistent with providing maximum protection to the lead and flexibility. Both ends of each tube shall be terminated with soft plastic grommets.

3.4.6.6.5 Communications between the gas turbine and the principal's instruments and controls shall be via the control panel.

3.4.6.6.6 All cabling between the gas turbine and the control panel shall be furnished. Each cable shall be in a single length of 200 m without splices, and shall be factory-prewired with plug connectors to mate with corresponding female sockets at the gas turbine and the control panel. All cable routes shall contain not less than 10% spare cores, and the spare cores shall be terminated at the terminal strips in the junction boxes on the gas turbine and control panel.

3.4.6.6.7 The entire assembly of cabling, wiring and connections to panel-mounted instruments shall be tested prior to delivery.

3.4.6.6.8 The cabling within the gas turbine acoustic enclosure shall be of a suitable type to withstand the enclosure temperature.

3.4.6.7 Gauge board

3.4.6.7.1 A locally mounted gauge board shall be furnished to provide indication, inter alia, of the following:

- fuel pressure
- lubricant oil pressure
- control oil pressure
- hydraulic oil pressure
- differential pressure across the air filter
- hot gas producer speed
- power turbine speed
- driven equipment indicators (as agreed with purchaser)
- unit status light.

3.4.6.7.2 The gauge board may be part of the acoustic enclosure. Instruments shall comply with the area classification specified in the requisition. If there is no acoustic enclosure the gauge board shall be a freestanding steel panel mounted on the baseplate at a location agreed with the purchaser.

3.4.6.7.3 Local emergency shutdown buttons shall be fitted to the face of the gauge board and at strategic locations to be agreed with the principal.

3.4.7 Alarms and shutdowns

This section shall apply.

3.4.7.1 Table 3 is deleted and replaced by Appendix 1.

3.4.7.6 This clause shall apply.

3.4.7.7 Delete this clause and replace by:

The type of circuit energization for alarm and shutdown shall be agreed with the principal and shall comply with the requirements for the entire plant in which the gas turbine is to operate.

3.4.7.9 Delete this clause and replace by:

All alarm and shutdown devices shall have test isolation switches. It shall be possible to test the entire alarm and shutdown loop, including the primary element without shutting down the gas turbine. The method of protection of the function test switches shall be agreed with the

purchaser.

Add the following clauses:

3.4.7.10 The normal shutdown procedure shall not use the Emergency Shutdown (ESD), but shall allow the gas turbine to shut down in accordance with a controlled program. The program shall provide for any necessary post-shutdown lubrication, and where applicable, shall maintain the ventilating system of the acoustic enclosure in operation.

3.4.7.11 All electricity supplies shall remain alive after normal shutdown of the gas turbine.

3.4.7.12 Detection of an ESD condition shall stop the gas turbine immediately by closing the fuel supply valves.

3.4.7.13 Emergency shutdown shall be initiated by any of the situations listed for ESD action in Appendix 1.

3.4.7.14 The ESD system shall be capable of accepting push buttons and an ESD command from the purchaser's control system.

3.4.8 Electrical systems

Delete this section in its entirety and replace by:

3.4.8.1 The electrical power installation shall comply with DEP 33.64.10.30-Gen. All electrical equipment shall comply with the area classification. The area classification of the gas turbine installation will be stated in the requisition.

3.4.8.2 Electricity supply

3.4.8.2.1 The supply voltage and frequency of instruments and controls, emergency shutdown, fire and gas detection system, lighting and power will be stated in the requisition. Uninterruptible power supplies will be available on site for instruments and controls, fire and gas detection, emergency shutdown and emergency lighting.

3.4.8.2.2 If equipment for the gas turbine requires other voltages and frequencies than specified by the purchaser, the vendor shall provide appropriate transformer-rectifier systems, batteries and circuit breakers.

3.4.8.3 Starters and switchgear

3.4.8.3.1 The purchaser shall provide switchgear for power electricity, and for all motors, heaters, etc., which will be controlled from a motor control centre.

3.4.8.3.2 The vendor shall make provision for transmitting signals from the control panel for opening and closing the motor control centre switchgear as appropriate for the turbine control logic.

3.4.8.4 Power cabling

3.4.8.4.1 Power cabling to motors and heaters will be run directly from the motor control centre to the motor or heater terminal boxes without intermediate junction boxes. The vendor shall provide routes and supports for the purchaser's site-run cabling.

3.4.8.4.2 All other site-run cabling shall terminate at junction boxes located at the edge of the baseplate, at a location agreed with the purchaser. The size of junction box cable gland for the purchaser's cable shall be agreed with the purchaser.

3.4.8.5 Area classification for acoustic enclosures

3.4.8.5.1 Independent of the area classification and grouping specified in the requisition, the acoustic enclosure surrounding a gas turbine shall be regarded as a Zone I area in accordance with the IP Code, when the ventilation system is inactive. Electrical equipment within the enclosure either shall be deenergized when the ventilation system is inactive or shall be suitable for a Zone I area. The enclosure shall be regarded as a safe area when the ventilation system is in operation.

3.5 PIPING AND APPURTENANCES

3.5.1 General piping, see DEP 31.38.01.31-Gen.

3.5.1.5 Add to this clause:

Screwed and seal-welded connections or socket welding connections shall not be used.

3.5.1.7 Delete this clause and replace by:

Connections for flammable or toxic fluids shall be flanged.

3.5.1.8 Add to this clause:

Piping smaller than $^3/_4$ inch shall not be used, except for instrument lines downstream of the first shutoff valve.

Carbon steel piping of $^3/_4$, 1 and 1 $^1/_2$ inch shall be minimum schedule 80 and 300 lb rating.

3.5.1.9 Add to this clause:

Metallic hose installation shall be designed such that the hose is neither kinked nor able to chafe against other objects in service.

3.5.1.15 Add to this clause:

For operating temperatures below 0 °C, piping materials shall comply with (2.11.5).

3.5.2 Delete this paragraph with all its clauses and replace by:

Oil piping

3.5.2.1 Lubricating oil, control oil and fuel oil piping around the gas turbine shall be arranged to prevent a hazardous situation developing from oil leaking or spraying onto hot turbine insulation in the event of a pipe or pipe joint failure.

Where this requirement cannot be met by selected routing of the pipework, appropriate baffle plates shall be installed to prevent a hazard as described from occurring.

3.5.2.2 All supply piping downstream of filters shall be seamless stainless steel AISI 316L. Schedule 40S shall be used for sizes 3 in. and smaller, and schedule 10S shall be used for larger sizes.

Pressure piping downstream of filters shall be free from internal obstructions that could accumulate dirt, and shall be TIG welded.

All fittings downstream of filters shall be AISI 316L, excluding the filter changeover valve and the bodies of isolation and control valves.

3.5.2.3 G All lubricating oil drains from bearing housings and gear transmissions, and the drains from oil systems, shall be fitted with $^1/_2$ in. NPT plugged connections for later installation of magnetic chip detectors by the principal.

3.5.3 Instrument piping

Amended per Circular 32/99

Delete this clause and replace by:

Instrument connections shall comply with DEP 32.31.00.32-Gen.

3.5.5 Delete this paragraph and replace by:

Miscellaneous piping

3.5.5.1 Fuel piping shall comply with (3.5.2), where applicable.

3.5.5.2 All fuel piping on the skid shall be fabricated by bending and welding as far as possible. Connections to equipment shall be flanged. If tubing is used, connections shall be flanged. Alternatively, cone and seat type ferrules, brazed or welded to the tubing, may be used.

3.5.5.3 Flexible elastomer O-ring seals are not permitted in any part of the fuel system.

3.5.5.4 Vent and drain connections from the fuel system shall be separately routed to the edge of

the baseplate.

3.5.5.5 Drains to remove crank soak washing liquids shall terminate with a flanged ball valve at the edge of the baseplate (2.4).

3.5.6 Inlet and exhaust systems

3.5.6.2 Delete this clause and replace by:

The gas turbine manufacturer shall supply the inlet air filter with housing, duct work, plenum chamber and expansion joint at gas turbine intake, the silencers and all associated supporting structural steelwork.

When specified in the requisition an anti-icing system shall be furnished (3.5.6.12)

3.5.6.5 Add to this clause:

Lifting davits, platforms, access ladders and airtight doors shall be furnished for maintenance of the inlet air filter media during operation of the turbine.

3.5.6.6 Add to this clause:

All construction downstream of the last filter shall comprise continuous welding. Threaded fastenings shall be either wirelocked or incorporate friction inserts.

3.5.6.9 Add the following clauses:

Blow-in doors bypassing the air filter in the event of high differential air pressure shall be installed when specified by the principal. The air filter and ducting shall be designed to withstand all forces generated at the maximum allowable air intake shutdown differential pressure.

3.5.6.10 Air intake plenums shall be fitted with wired glass windows and interior lighting to allow for on-stream inspection of the gas turbine air inlet.

3.5.6.11 The vendor shall furnish means for cleaning the air compressor, either by on-line dry particle or off-line crank soak washing.

For crank soak washing, one portable solvent mixing and injection system shall be furnished for each gas turbine installation. Each gas turbine shall be provided with fixed spray rings and spent fluid drain valves. The vendor shall ensure that the starter is continuously rated for crank soak washing.

For dry particle cleaning, the vendor shall provide the injection devices. The vendor shall recommend the type of dry particle cleaning agent to be used.

3.5.6.12 Anti-icing systems, when specified in the requisition

Anti-icing systems to warm the air entering the gas turbine inlet air filter shall be set to operate automatically between ambient temperatures of -5 °C and +3 °C, or whenever hoar frost conditions are expected.

The following anti-icing systems are approved:

- direct injection of gas turbine air compressor bleed air
- separately fired tubular heat exchanger
- exhaust gas heated tubular heat exchanger.

The recirculation of gas turbine exhaust gases directly into the air inlet is not permitted, unless the gas turbine fuel has a methane content in excess of 95% and is free from sulphur compounds.

Air heat exchanger material shall be AISI 316L stainless steel.

Full details of the proposed anti-icing system shall be submitted with the tender.

3.5.6.13 Exhaust systems

The gas turbine manufacturer shall furnish the complete exhaust system from the gas turbine exhaust flange, including expansion bellows, ducting supports and thermal insulation. The stack shall have a height of at least 12 m above the turbine centre line and shall be designed to prevent direct rain ingress into the exhaust collector.

To prevent exhaust gases escaping into the turbine room, or acoustic enclosure, all drains from the exhaust collector shall terminate in a water trap. The trap shall be of sufficient height to maintain a water column not less than 110% of the maximum exhaust back pressure. Means shall be provided for replenishing the sealing water. The trap shall be furnished by the vendor and installed by the purchaser.

Vents, breathers, etc., shall not be piped into the exhaust stack.

3.5.6.14 Exhaust systems for gas turbine installations utilizing exhaust heat recovery shall be designed for the full back pressure of the heat recovery unit.

Ducting shall be designed to withstand distortion under the maximum expected back-pressure without leaking.

3.5.7 Filters

3.5.7.1 Delete this clause.

3.5.7.2 Delete this clause and replace by:

The air filtration system shall be as specified in the data/ requisition sheets, to provide the filtration standard required under the specified environmental conditions. The air filter supplier shall be approved by the purchaser. Notwithstanding the foregoing, the air filter shall be guaranteed to remove 95% of all particles 2 μm and larger, and 99% of all particles 10 μm and larger in the atmospheric air intake. The vendor shall state the allowable air approach velocity on the active face of the filter intake, and the respective velocities in all stages of the air filtration system. The pressure drop in the as new, clean condition shall be guaranteed.

3.5.7.3 Delete this clause and replace by:

The purchaser will specify in the requisition the minimum requirements for air filtration for marine environments.

3.5.7.4 Delete this clause.

3.5.7.5 Delete this clause and replace by:

Air filter systems shall include:

- a rain hood with vertically upward air flow to the first stage filtration intake
- a coarse metal bird and heavy debris screen
- ladders and platforms (3.5.6.5)
- a local differential pressure indicator and pressure differential alarm switches over each stage.

3.5.7.6 Delete this clause and replace by:

On land installations, the air filter shall be mounted such that the elevation to the underside of the rain hood is not less than three metres above grade level.

3.5.7.7 Delete this clause and replace by:

The air filter and its housing shall be an integral unit designed and supplied by the air filter vendor. The air filter house shall have a single-piece roof, fabricated from either a single piece of plate, or continuous fillet welding. The roof shall be sloped to shed rainwater. Roofs comprising bolted or similarly fastened sections with mastic sealant are prohibited. Joints between the air filter and filter house shall be fully airtight. Joints requiring greater than 2 mm thickness of sealant will be rejected by the purchaser.

Add the following clauses:

3.5.7.9 All internal cladding downstream of the air filter shall be fabricated in AISI type 316L stainless steel.

3.5.7.10 Media-type filters shall permit media renewal with the gas turbine on load without hazard to personnel.

3.5.7.11 Roller blind filter media of any type shall not be used.

3.5.7.12 The complete air filter assembly within the filter house shall be erected for inspection in the

vendor's works. Where specified by the purchaser, a smoke test for air leaks shall be conducted.

3.5.8 Silencers

3.5.8.1 Delete this clause and replace by:

Inlet and exhaust silencers shall be furnished where necessary to meet the requirements of (2.1.7).

3.5.8.2 Add to this clause:

Air intake silencers installed downstream of the intake filters shall be fabricated from AISI type 316L stainless steel.

3.5.8.3 Add to this clause:

The baffle packing material shall be non-combustible and verminproof. It shall not contain asbestos.

3.6 INSULATION, WEATHERPROOFING, FIRE PROTECTION AND ACOUSTIC TREATMENT

3.6.1 Insulation

Add the following clauses:

3.6.1.3 Insulating materials shall be non-combustible and shall not contain asbestos.

3.6.1.4 Insulated surfaces shall be mechanically protected, preventing saturation of the insulation by inadvertent oil leaks or damage to the insulation material.

3.6.2 Weatherproofing

Add to this clause:

The vendor shall submit with his proposal details of the winterizing procedure.

3.6.3 Delete this section and replace by:

Fire protection

3.6.3.1 General

3.6.3.1.1 The vendor shall provide a suitable fire detection and protection system, in compliance with the requirements of DEP 80.47.10.31-Gen. The system shall be approved by the principal.

3.6.3.1.2 Fixed automatic water deluge systems are not permitted on gas turbine installations. Where the plant/location has a fire water ring main, only manually operated water monitors shall be used.

3.6.3.1.3 Gas turbines installed in open buildings shall be provided only with ultraviolet fire detection equipment.

3.6.3.2 Ultraviolet flame detectors

3.6.3.2.1 Ultraviolet flame detectors shall be positioned strategically such that the combined fields of view of the detectors cover the entire gas turbine installation.

3.6.3.2.2 Two detectors shall be installed at each position with a dual-voting system for both the detector heads. Individual detectors may initiate an alarm. Coincident detection by two or more heads shall initiate:

- fire alarm
- shutdown of the gas turbine
- shutdown of the ventilation system
- release of extinguishant into the enclosure
- initiation of the appropriate alarm.

Test facilities shall be provided to perform, either manually or automatically from the control panel, an integrity test and a functional test of not only the circuit, but also the detector head.

3.6.3.3 Compensated rate of heat rise fire detectors

3.6.3.3.1 Compensated rate of heat rise detectors shall be positioned close to the air outlet of the ventilation system.

3.6.3.3.2 Two detectors shall be installed at this position, with a dual-voting system for both detector heads. Action following activation of the detector heads shall be in accordance with (3.6.3.2).

3.6.3.4 Flammable gas detectors

3.6.3.4.1 Flammable gas detectors shall be installed in the inlet and outlet of the ventilation air system and in the combustion air intake to the gas turbine.

3.6.3.4.2 Three detectors shall be installed at each of the above three locations. The set point for alarm shall be at 20% of lower flammable level (LFL) and shutdown shall be at 60% LFL.

3.6.3.4.3 The detectors in the combustion air intake to the gas turbine shall be mounted inside a fast extraction loop, as shown in Appendix 3 of this specification, and shall be accessible from the air filter walkways or access ladders.

3.6.3.4.4 Coincident detection of gas at 60% LFL by two or more detectors in the combustion air intake shall shut down the gas turbine, but the ventilation system shall remain in operation. However, should there be a coincident detection of gas at 60% LFL in the air inlet of the ventilation system, the ventilation fans shall also shut down.

3.6.3.4.5 Extinguishant shall not be discharged upon gas detection within the enclosure.

3.6.3.5 Detection system integrity

3.6.3.5.1 When specified, the fire and gas detection system furnished for the gas turbine installation shall provide alarm signals into the purchaser's overall fire and gas protection system on site. In this case the detection equipment shall be compatible with the purchaser's supervisory equipment on site.

3.6.3.5.2 Unless otherwise specified, the vendor shall furnish a freestanding fire and gas detection panel, to be located in the control room. This panel shall have facilities for testing the integrity of each detector circuit and for testing the functional integrity of each detector head, to be performed either manually or automatically.

3.6.3.5.3 To initiate the appropriate action upon activation of one or more detectors, facilities shall be provided for communicating the alarm and shutdown signals required by this specification to the gas turbine control panel.

3.6.3.6 Fire extinguishing systems

3.6.3.6.1 The fire extinguishing system shall be designed basically in accordance with the codes of the National Fire Protection Association. The extinguishant shall be Halon 1211 (BCF).

3.6.3.6.2 Each compartment of the enclosure shall have its own containers of extinguishant, each with its release mechanism. Each release mechanism shall be suitable for automatic actuation (via the fire detection system), for remote manual actuation by means of a push button in the control room, and for manual actuation by mechanical means from a position local to the enclosure. A test valve shall be installed downstream of the release valves of each release mechanism.

Should it prove necessary for an operator to discharge additional extinguishant into a compartment in the enclosure, the release piping for all compartments shall be interconnected via a manually operated, normally closed, shutoff valve.

3.6.3.6.3 Upon detection of fire within the enclosure, the extinguishant in the compartment concerned shall be released only after a lapse of ten seconds after the sounding of the alarm. This allows time for personnel within the area to make their escape and for the ventilation system to shut down.

3.6.3.6.4 A 'two-shot' system shall be installed, whereby an initial charge of extinguishant is injected instantaneously into the compartment in order to inert the atmosphere as rapidly as possible, followed by the slow release of a second and equal quantity of extinguishant to maintain an inert atmosphere for a sufficient period to allow overheated components to cool below the auto-ignition temperature of the combustible material.

3.6.3.6.5 The release mechanism shall consist of two valves installed in parallel. The valves may be actuated by either a nitrogenor air-operated actuator signalled by a solenoid.

3.6.3.6.6 Means shall be provided for testing the quantity of extinguishant in each container and for testing the pressurizing medium. A manual shutoff valve shall be provided upstream of the release valves with a limit switch annunciating within the control room that the extinguishant system is out of action.

3.6.3.6.7 Facilities shall be provided for testing the entire fire extinguishant system, both mechanically and electrically, without actual discharge of extinguishant into the protected enclosures.

3.6.3.6.8 Automatically actuated dampers or shutters in the ventilation system shall not be used.

3.6.3.6.9 All apertures in the baseplate and any potential source of leakage of extinguishant through the lower part of the protected enclosure shall be positively sealed.

3.6.3.6.10 To ensure the safety of operation and maintenance personnel, the following requirements shall be met:

- alarm lamps shall be provided on the outside of the enclosure and on the main control

panel to indicate:

- extinguishant system normal (green)
- extinguishant release (flashing red)
- extinguishant electrically isolated (white)

- additional flashing indicators and/or audible alarms shall be positioned in prominent positions within the protected area to signal extinguishant released and initiated by the actual release of the extinguishant
- for each compartment, a two-position switch (lockable in each position) shall be provided on the outside of the enclosure and on the main control panel, the positions being marked:
  - extinguishant release 'inhibited'
  - extinguishant release 'auto'
- to permit personnel to enter compartments protected by automatic extinguishant release systems, a release inhibit switch shall be provided at the entrance to the compartment. Inhibition of the release system shall be annunciated on the main control panel. Should a compartment entrance be opened inadvertently without first inhibiting the release system, there shall be an annunciation on the main control panel and also an alarm shall sound at the entrance to the compartment.

3.6.3.7 Enclosure surveillance

3.6.3.7.1 When specified by the purchaser, a closed-circuit television camera shall be installed within the acoustic enclosure. Zoom, pan and tilt controls shall be provided, operated from the control room.

The camera shall utilize low light image intensification.

3.6.4 Acoustic treatment

Delete this section in its entirety and replace by:

3.6.4.1 This section shall refer to acoustic enclosures for the gas turbine. Acoustic treatment of the gas turbine air intake and exhaust is covered in (3.5.8).

3.6.4.2 Acoustic enclosures shall be furnished for the gas turbine in order to limit the noise emitted to meet the requirements of (2.1.7).

3.6.4.3 All acoustic enclosures shall be adequately ventilated with fresh, filtered air. The ventilation system shall provide for 20 air changes per hour. Alternatively, it shall be designed to ensure that the temperature at any point within the enclosure does not exceed 12 °C above ambient temperature, whichever requires the greater flow of ventilating air.

3.6.4.4 The arrangement for circulating the ventilating air within the enclosure shall prevent local overheating of components.

3.6.4.5 The ventilating air shall be filtered by means of an inertia stage with extract air and a second renewable media filter stage. Two 100% duty ventilating fans, one running and one stand-by, shall be furnished to either pressurize or evacuate the acoustic enclosure in order to fulfil the area classification requirements specified in (3.4.8.5).

3.6.4.6 Enclosures surrounding equipment requiring operator attention shall be adequately lit to enable all operations to be safely undertaken. Emergency lighting shall be installed to allow the safe exit of operators within the enclosure in the event of main lighting failure. The emergency lighting shall be connected into the purchaser's emergency lighting circuit.

3.6.4.7 Acoustic enclosures shall have hinged and removable doors or panels to provide access for maintenance. The roof of the enclosure shall be a single, continuously welded steel plate. Mechanical joints with fasteners and seals are not permitted. Where applicable, the arrangements for maintenance shall allow the exchange of major components, see (2.1).

3.6.4.8 Escape doors shall be provided to allow the safe exit of personnel from within the enclosure in the event of an emergency. Such doors shall be fitted with an internal panic bar and shall be strategically placed to allow safe exit from any part of the enclosure.

3.6.4.9 Acoustic enclosures shall be provided with the following detector systems:

- ultraviolet type flame detectors
- compensated rate of heat rise fire detectors
- flammable gas detection
- closed-circuit television, when specified.

The detector systems shall be in accordance with (3.6.3).

3.6.4.10 The acoustic enclosure shall be fitted with a fire extinguishing system in accordance with (3.6.3.6).

3.7 FUEL SYSTEM

3.7.1 General

3.7.1.1 Add to this clause:

The manufacturer shall confirm the suitability of the intended fuels for the system proposed, and shall provide evidence of his experience with burning fuels of a similar quality and composition.

The manufacturer shall state in his proposal if any treatment is considered necessary for the intended fuels. If a separate fuel is required for the combustion igniters, full details shall be included in the proposal. Full details of the fuel system shall be furnished with the proposal.

3.7.1.2 Modify this clause:

The twin Y-type strainers in this clause shall be replaced by twin demister-separators with both manual and automatic drain valves.

3.7.1.3 Add to this clause:

The preferred method of atomization of ASTM D 2880 Grade 3-GT and heavier liquid fuels is by means of an air blast. The system shall include an atomizing air compressor.All necessary piping and components for flushing the fuel system with a light distillate fuel oil upon shutdown, and for use during starting if required, shall be included.

Facilities shall be provided for safe control and subsequent draining of the liquid fuel from the fuel nozzles and liquid fuel manifold in the event of an emergency shutdown.

3.7.1.5 Add to this clause:

The gas turbine shall have the ability to start on either fuel. When running on gas fuel alone, the liquid fuel nozzles shall be either air or gas purged, with positive shutoff of the liquid fuel supply. The dual-fuel nozzles and governor system shall allow smooth transfer from one fuel to another and back under all conditions of turbine load. Full details of the proposed dual-fuel system shall be submitted at the tender stage.

3.7.1.6 Add the following clause:

Where the vendor has no operating experience with the fuel specified by the purchaser, a combustion test shall be undertaken before manufacture commences. For gas fuels with a lower heating value less than 30 MJ/m^3, a combustion test is mandatory.

The vendor shall demonstrate satisfactory performance of the gas turbine on the contract fuel or a blend which simulates the properties of the contract fuel. During the combustion test, all modes including starting, running, acceptance and rejection of load shall be demonstrated to the satisfaction of the purchaser.

The condition of the fuel nozzles and the hot path shall be inspected after the combustion test.

3.7.2 Gaseous fuel

3.7.2.1 Add to this clause:

Gas fuel will be supplied at a pressure, temperature and hydrocarbon and water dew point agreed with the manufacturer.

The manufacturer shall state the maximum variation which can be accepted in composition, heating value, Wobbe index, hydrocarbon and water dew points, and in pressure and temperature for the fuel intended.

3.7.2.2 Delete the last sentence of this clause and replace by:

The permissible contaminant levels and concentrations of corrosive agents shall be agreed between the purchaser and the manufacturer, with particular regard to solids, alkali metals and total sulphur content.

3.7.3 Liquid fuel

3.7.3.2 Add to this clause:

Liquid fuel will be supplied at a pressure and temperature and filtered to a quality agreed with the manufacturer.

SECTION 4 INSPECTION AND TESTS

4.2 INSPECTION

4.2.1 Delete item 1 of this clause and replace by:

The manufacturer shall provide certificates to verify that the materials of construction meet the requirements of the material specifications and are in accordance with the purchase order.

Add the following clauses:

4.2.1.1 The different types of certificate which shall be used are distinguished as follows.

- Type A

  Certificates by which the manufacturer confirms that the product supplied corresponds to the specification, on the basis of test results taken from the in-production testing of products of the same material and same manufacturing method as the delivery concerned.

- Type B

  Certificates by which the manufacturer's inspector confirms that the product supplied corresponds to the specification, on the basis of tests carried out on purchaser's equipment itself or on standard-specified test specimens related to that equipment.

  The necessary testing shall have been carried out by a testing centre which is independent of production in the manufacturing works and which has the necessary facilities at its disposal. When the independence of the testing centre cannot be established, a Type C certificate shall be submitted.

- Type C

  Certificates as described under Type B with the additional requirement that the tests shall be witnessed by an independent inspector who shall be approved by the principal.

  Certificates shall be valid only when stamped and signed by this independent inspector.

4.2.1.2 All certificates shall contain the following information:

- name of manufacturer
- purchase order number and date
- manufacturer's order number
- identification number of certificate and its date of issue
- material specification(s)
- dimensions in SI units, unless otherwise specified or applicable
- material charge number, batch number or heat-lot number
- mechanical properties recorded from tests results
- chemical composition recorded from chemical analyses
- NDT methods and results, where applicable
- heat treatment procedures, furnace charge number and heat treatment records, where applicable
- such supplementary or additional information as may be required.

All Type C certificates shall contain the following additional information:

- name of the independent inspector who has witnessed the tests
- the independent inspector's identification symbol.

Unless otherwise specified, materials covered by Type C certificates shall be hard-die stamped with a symbol identical with the identification symbol of the independent inspector, using low-stress dies.

4.2.1.3 As a minimum, materials certificates in accordance with Type A are required for carbon steel pressure-containing parts with a design temperature below 400°C.

4.2.1.4 As a minimum, material certificates in accordance with Type B are required for carbon steel pressure-containing parts with a design temperature of 400 °C and above, for rotor shafts, discs and blading, for stationary blading and nozzle rings, and for the main nuts and bolts.

4.2.1.5 Material certificates in accordance with Type C are required for pressure-containing parts of low and high alloy steels.

4.2.6 Add the following clauses:

Marking

4.2.6.1 Marking is required for component parts certified under material certificates Type B and Type C.

Parts with a wall thickness above 5 mm, except items made of austenitic stainless steel or nickel alloys, shall be legibly marked by hard-die stamping on to a painted background, and at a point clearly visible later. Pipes should be marked at a point approximately 250 mm from one end.

Only low-stress stamps shall be used for hard-die stamping, and the stamps shall be round-nosed with a minimum radius of 0.25 mm.

Items made of austenitic stainless steel or nickel alloys and parts with a wall thickness below 5 mm shall be marked by stencil with a water-insoluble ink without metallic pigments, sulphur, sulphides or chlorides which could harmfully affect the material.

4.2.6.2 The stamping/marking shall include:

- manufacturer's symbol (stamp to be identical with the symbol on the certificate)
- the third-party agency identification stamp Type C only, stamp shall be identical with the stamp/mark on the certificate
- material and product identification
- charge or batch number
- heat treatment chart or furnace charge reference number, where applicable
- heat treatment symbol or code, where applicable
- NDT symbol or code, where applicable
- size and schedule
- hydrostatic test pressure in bar, where applicable.

NOTE: Where the size of the fitting does not permit complete marking, the identification marks may be omitted in the reverse order presented above, or another form of identification may be used with the agreement of the purchaser.

4.3 TESTS

4.3.1 General

4.3.1.6 Add the following clause:

Overspeed test

An overspeed test of at least 115% of the maximum continuous speed shall be undertaken for a minimum period of 3 minutes upon all rotor discs, complete with blading.

After the overspeed test, rotor discs shall be checked for cracks and defects by magnetic particle inspection.

4.3.2 Hydrostatic tests

4.3.2.1 Add to this clause:

The water used for hydrostatic testing shall be fresh and clean, and shall be wetted by a suitable wetting agent.

4.3.3 Mechanical running test

4.3.3.2 Add to this clause:

During the run test, the gas turbine shall run for at least 30 minutes at the minimum lubricating oil temperature, and for 30 minutes at the maximum lubricating oil temperature as dictated by the climatic conditions given in the requisition. During the tests, the performance of the gas turbine shall be monitored, especially for vibration and maintenance of the specified lubricating oil pressures and temperatures.

4.3.3.3 Delete last sentence and insert:

Unfiltered vibration readings shall not exceed the limits of (2.7.1.4) and (2.7.2.5).

4.3.3.5 Delete this clause and replace by:

The test shall verify that rotor lateral resonances conform to (2.7.1). The determination of lateral resonances shall be recorded on start-up and coast down with the slow roll (300-600 r/min) total run-out (electrical and mechanical) subtracted by vectorial run-out compensation of proximity probe read-out.

This recorded shaft relative data shall include speed, peak- to-peak displacement and phase.

For gas turbines fitted with accelerometers, the peak-to-peak velocity of vibration at each location shall be recorded. The signal at any increase in vibration severity shall be analysed and recorded using a fast Fourier transform analyser.

4.3.3.6 Delete this clause and replace by:

If any critical speed or rotor resonance falls within the specified operating range, or fails to meet the separation margin requirement, rotor insensitivity shall be demonstrated in accordance with 2.7.1.10 of API Std 616 as amended by this specification.

4.3.3.7 Add to this clause:

4. The baseline data for the on-stream monitoring of the health and performance of the gas turbine and its auxiliaries, see (3.4.2), shall be obtained from the data recorded by the manufacturer during the testing of the equipment. Details of the precise information required, which shall include temperature, pressure and flow profiles, vibration spectra and alignment data, shall be agreed with the purchaser.

   The vendor shall be responsible for collecting all the baseline data required, and for presenting it in a separate volume of the operating manuals. These baseline data shall also be obtained and data collected during a complete unit test if such a test is specified.

4.3.3.11 Add the following clauses:

Response tests

For gas turbines driving alternators, tests shall be carried out to demonstrate the governor and turbine response at acceptance and rejection of load in 25, 50, 70 and 100% load steps. 4.3.3.12 The gas turbine need not to be dismantled after the mechanical running test, unless it has failed to meet the specified performance.

Flexible fibre optics shall be used as much as possible for inspection after tests and photographic records shall be made where applicable.

4.3.3.13 Spare rotors purchased with the gas turbine shall be given a mechanical run test in the turbine.

4.3.3.14 G Modular hot gas producers shall be performance-tested in accordance with ISO 2314.

4.3.4 Optional tests and inspections

Delete item 1 of this clause and replace by:

1. Performance test

Gas turbines shall be tested against a dynamometer in accordance with ISO 2314.

Delete item 2 of this clause and replace by:

2. Complete unit test

A complete unit or string test of the gas turbine complete with the driven equipment and all control auxiliary and accessory equipment under control of the contract control panel shall be carried out. All functions of the complete package shall be demonstrated to the satisfaction of the purchaser.

The intake air filter, waste heat recovery equipment and exhaust silencer may be omitted from this test with the agreement of the purchaser.

G For gas turbines utilizing modular hot gas producers, a slave hot gas producer may be used instead of the contract hot gas producer.

The complete unit test shall be undertaken prior to delivery. The site of the complete unit test shall be by agreement with the purchaser. The vendor shall remain responsible for the equipment throughout the complete unit test, and afterwards until the purchaser agrees to accept delivery.

The complete unit test shall be performed under the full load conditions for the driven equipment. This requirement for full load conditions may be waived by agreement with the purchaser if there is a likelihood of hazard, or if it is impracticable to dispose of the energy generated. In such cases, the test shall be a mechanical spin test of the complete gas turbine package at the highest practical load. (4.3.4) The test shall include a continuous run at maximum operating speed for a period of not less than 4 hours, following stabilization of temperatures and pressures.

All protection devices shall be demonstrated, including release of fire extinguishant. The capability of the acoustic enclosure in containing the extinguishant shall be demonstrated. Carbon dioxide may be substituted for the contract extinguishant for this test.

Add to this clause:

9. Air filter tests

The air filter and intake duct assembly shall be erected as a complete unit in the manufacturer's works. All normal openings shall be sealed, and a smoke test shall be carried out at 1.2 kPa gauge internal pressure. There shall be no visible leakage from any joints.

The mechanical and electrical operation of the air filter cleaning mechanism, if fitted, shall be demonstrated to the satisfaction of the purchaser.

4.4 Preparation for shipment

4.4.2 Delete this clause and replace by:

Preparation for shipment shall be in accordance with the requisition, the purchase order and variations thereto.

All packing and preservation shall provide suitable protection for storage on site for a period of 6 months under the ambient conditions specified without any further protection.

All instruments and delicate components shall be demounted, preserved and packed separately.

G Aircraft derivative hot gas producers shall be demounted and preserved in accordance with the manufacturer's instructions and shipped in the manufacturer's original packing. The hot gas producer shall not be reinstalled in the gas turbine until the complete installation is ready for commissioning.

SECTION 6 VENDOR'S DATA

6.1 PROPOSALS

6.1.1 Add to this clause:

The vendor shall complete the data/requisition sheet(s) to the furthest extent possible and include this in his proposal.

6.1.3 Add to this clause:

12 The first and second critical speed of all rotors.

13. Campbell diagrams for all blading.

6.2 CONTRACT DATA

6.2.3 Installation and instruction manuals

Add the following clause:

6.2.3.6 The manual shall contain information regarding acceptance/ rejection criteria for wear and tear inside the turbine, e.g. acceptable crack length in blades, combustors, transmission pieces and other critical parts, unacceptable excessive clearances, etc.

PART IV REFERENCES

**Amended per
Circular 12/97**

In this specification, reference is made to the following publications.

NOTE: The latest issue of each publication shall be used together with any amendments/supplements/revisions to such publications, unless otherwise stated.

It is particularly important that the effect of revisions to international, national or other standards shall be considered when they are used in conjunction with DEPs, unless the standard referred to has been prescribed by date.

Metallic materials - Requirements for equipment for low-temperature service, and for equipment containing liquefied gas or lethal substances	DEP 30.10.02.31-Gen.
Painting and coating for new construction projects	DEP 30.48.00.31-Gen.
Equipment noise limitation	DEP 31.10.00.94-Gen. **
Vent/blow-down/air-flow/in-line silencers	DEP 31.10.00.95-Gen. **
Rotating equipment acoustic enclosures	DEP 31.10.00.96-Gen. **
Air-cooled heat exchange equipment (Amendments/Supplements to API 661)	DEP 31.21.70.31-Gen.
Pressure vessels (Amendments/ supplements to BS 5500)	DEP 31.22.10.32-Gen.
General-purpose steam turbines (Amendments/supplements to API Std 611)	DEP 31.29.60.30-Gen.
Special-purpose steam turbines (Amendments/supplements to API Std 612)	DEP 31.29.60.31-Gen.
Lubrication, shaft-sealing and control oil systems for special-purpose application (Amendments/supplements to API Std 614)	DEP 31.29.60.32-Gen.
Gas turbines	DEP 31.29.70.93-Gen. **
Shop fabrication of steel piping	DEP 31.38.01.31-Gen.
Acoustic insulation for pipes, valves and fittings	DEP 31.46.00.31-Gen.

**Amended per
Circular 32/99**

Instruments for measurement and control	DEP 32.31.00.32-Gen.
Instrumentation for equipment packages	DEP 32.31.09.31-Gen.
System cabling	DEP 32.37.20.31-Gen.
Electrical engineering guidelines	DEP 33.64.10.30-Gen. *
Electric motors	DEP 33.66.05.31-Gen.
Fire-protection systems and equipment	DEP 80.47.10.31-Gen. *

* In preparation.
** Data/requisition sheet

AMERICAN STANDARDS

General-Purpose Steam Turbines for Refinery Services	API Std 611 Second Edition, 1982
Special-Purpose Steam Turbines for Refinery Services	API Std 612 Second Edition, 1979
Lubrication, Shaft-Sealing and Control Oil Systems for Special-Purpose Applications	API Std 614 First Edition, 1973
Sound Control of Mechanical Equipment for Refinery Services	API Std 615 First Edition, 1973
Type H Industrial Combustion Gas Turbines for Refinery Services	API Std 616 Second Edition, 1982
Air-Cooled Heat Exchangers for General Refinery Services	API Std 661 Second Edition, 1978
Noncontacting Vibration and Axial Position Monitoring System	API Std 670 First Edition, 1976

Issued by
American Petroleum Institute,
Publications and Distribution Section,
2102 L Street Northwest,
Washington, DC 20037, USA

Gray Iron Castings for Pressure-Containing Parts for Temperatures Up to 650 °F (345 °C)	ASTM A 278
Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures	ASTM A 395
Qualification of Procedures and Personnel for the Welding of Steel Castings	ASTM A 488
Ductile Iron Castings	ASTM A 536
Ultrasonic Examination of Carbon and Low-Alloy Steel Castings	ASTM A 609
Gas Turbine Fuel Oils	ASTM D 2880
Radiographic Testing	ASTM E 94
Reference Photographs for Magnetic Particle Indications on Ferrous Castings	ASTM E 125
Liquid Penetrant Inspection	ASTM E 165
Reference Radiographs for Heavy-Walled (51 to 114 mm) Steel Castings	ASTM E 186
Reference Radiographs for Heavy-Walled (114 to 305 mm) Steel Castings	ASTM E 280
Reference Radiographs for Steel Castings up to 51 mm in Thickness	ASTM E 446

Magnetic Particle Examination	ASTM E 709

Issued by
American Society for Testing and Materials,
1916 Race Street,
Philadelphia, Pa. 19103, USA

ASME Boiler and Pressure Vessel Code	Section VIII Pressure Vessels

Issued by
American Society of Mechanical Engineers,
345 East 47th Street,
New York, NY 10017, USA

Quality Standard for Steel Castings for Valves, Flanges and Fittings and OtherPiping Components - Visual Method	MSS SP-55

Issued by
Manufacturers Standardization Society of the Valve and Fitting Industry,
5203 Leesburg Pike, Suite 502,
Falls Church, Virginia 22041, USA

Sulfide Stress Cracking Resistant Metallic Material for Oil Field Equipment	NACE Standard MR-01-75 (1980 Revision)

Issued by
National Association of Corrosion Engineers,
1440 South Creek,
Houston, Texas 77084, USA

BRITISH STANDARDS

Unfired Fusion Welded Pressure Vessels	BS 5500: 1982

Issued by
British Standards Institution,
2 Park Street, London W1A 2BS, England

OIL COMPANIES MATERIALS ASSOCIATION Noise Procedure Specification	OCMA publication NWG-1 Revision 2, 1980

Issued by
Heyden and Son Ltd.,
Hillview Gardens, London NW4 2JQ, England

INTERNATIONAL STANDARDS

Gas Turbines - Acceptance Tests	ISO 2314
Mechanical Vibration of Machines with Operating Speeds from 10 to 200 rev/s - Basic for specifying evalution standards	ISO 2372

Issued by
Central Secretariat of ISO,

1, rue de Varembé,
1211 Geneva 20, Switzerland

Copies to be obtained through national standards organizations

PART V APPENDICES

APPENDIX 1 INSTRUMENT FUNCTIONS

Function	Local indicator	Gauge board	Panel indicator	Panel recorder	Alarm	Shut down	ESD
1. Pressure							
Air filter differential	X (1)		X		H		
Compressor discharge	X						
Gas fuel	X	X			L	LL	
Liquid fuel supply	X	X			L	LL	
Liquid fuel to nozzles	X				L		
Atomizing air	X				L		
Lube oil	X	X			L (2)	LL	
Hydraulic oil	X				L	LL	
Lube oil filter differential	X				H		
Instrument air						LL	
2. Temperature							
Air compressor intake	X		X				
Air compressor discharge			X				
Power turbine first stage nozzle inlet			X				
Gas turbine exhaust			X	X	H	HH	
Gas turbine exhaust ΔT					H	HH	
Fuel supply	X						
Lube oil tank	X				H		
Lube oil after cooler	X		X		H	HH	
Each journal bearing			X		H		
Each thrust bearing			X		H	HH	
Acoustic enclosure	X		X				
3. Flow							
Fuel			X	X			
4. Level							
Lube oil tank(s)	X				L		
Fuel gas scrubber	X				H	HH	
5. Vibration							
Proximity probes, X, Y at each journal bearing			X		H	HH	
Accelerometers, six channels			X		H	HH	
6. Fire, gas protection							
Fire detection			X		H	(3)	X
Gas detection			X		H	HH	
Manual ESD			X				X
7. Speed							
Gas producer			X			HH	
Power turbine			X	X		HH	
8. Flame failure			X		X	X	
9. Overspeed						X	
10. Starting clutch failure to disengage						X	

(1) Over each stage local
(2) Start aux. lube oil pump
(3) The emergency lube oil pump shall remain in operation

Nomenclature:

- For alarm and shutdown functions:

  ESD = Unit emergency shutdown

  H = High

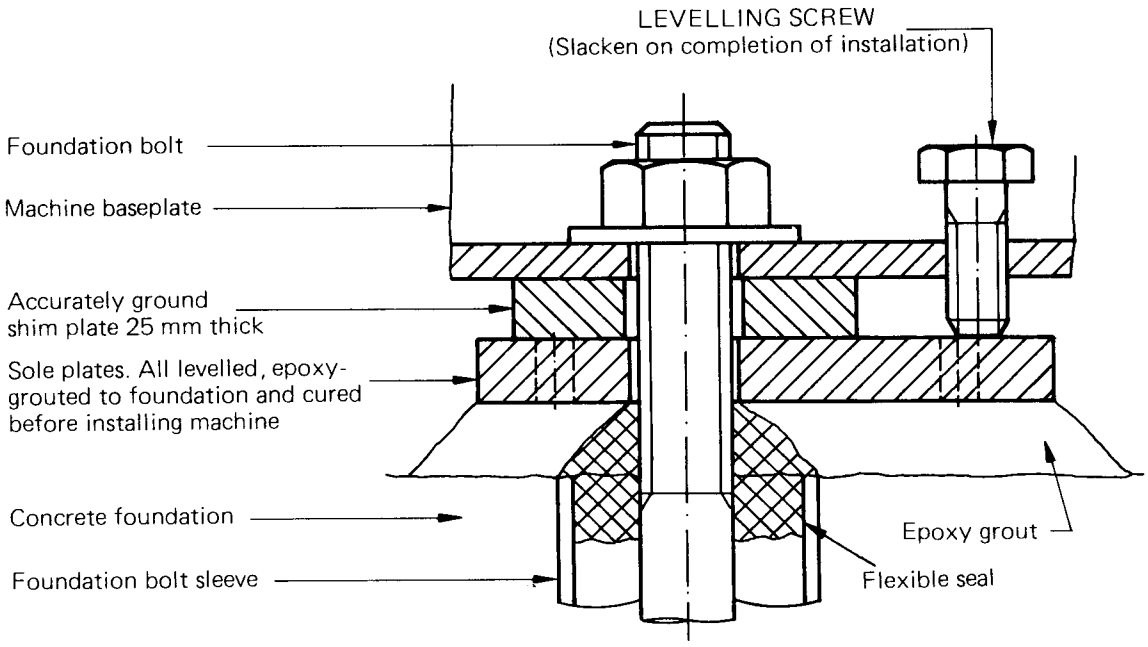
  HH = Unacceptably high

  L = Low

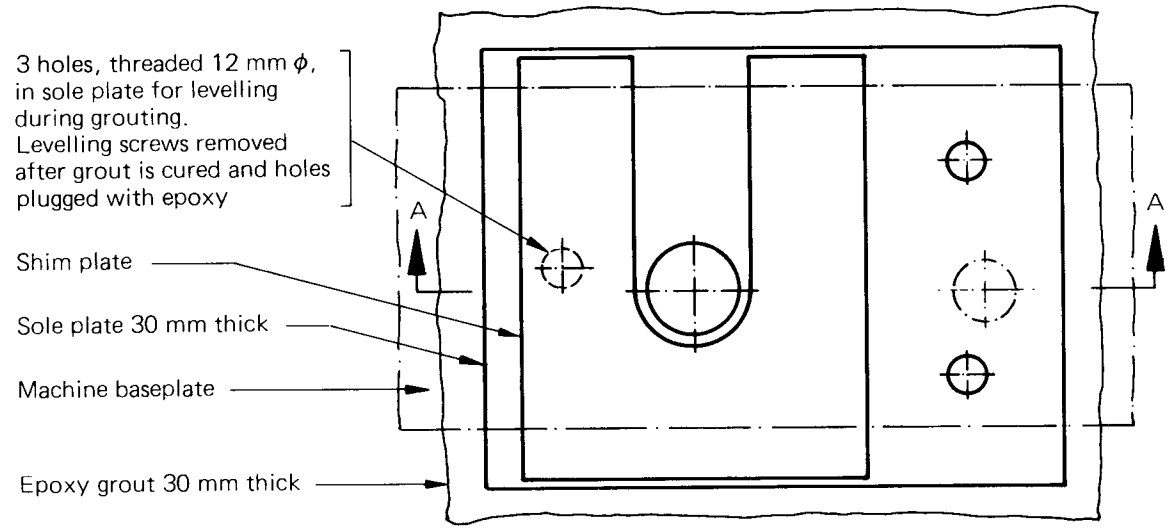
  LL = Unacceptably low

- 'X' indicates that this function is required as described in the specification. See text of specification for detailed requirements.

APPENDIX 2 TYPICAL ARRANGEMENT FOR BOLTING BASEPLATE TO FOUNDATION



SECTION A – A



PLAN
(Baseplate omitted for clarity)

Notes:
1. Intermediate supports between foundation bolt locations as necessary.
2. Upon final levelling of machine measure exact shim thickness required and grind accordingly.
3. Fill remaining voids with Portland cement grout.

APPENDIX 3 GAS TURBINE ENCLOSURE VENTILATION