



GS 134-12

PACKAGED GAS TURBINES TO API RP11 PGT

September 1992

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BP GROUP RECOMMENDED PRACTICES AND SPECIFICATIONS FOR ENGINEERING											
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SCOPE AND PURPOSE This BP Group Specification covers requirements for packaged gas turbines. It is for use with data sheets to adapt it for specific applications. It supplements the API standard, defining a number of the optional clauses and substituting, modifying or qualifying certain other clauses in the light of BP experience.											
AMENDMENTS <table border="0"> <thead> <tr> <th>Amd</th> <th>Date</th> <th>Page(s)</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td colspan="4"> </td> </tr> </tbody> </table>				Amd	Date	Page(s)	Description				
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FOREWORD

Introduction to BP Group Recommended Practices and Specifications for Engineering

The Introductory volume contains a series of documents that provide an introduction to the BP Group Recommended Practices and Specifications for Engineering (RPSEs). In particular, the 'General Foreword' sets out the philosophy of the RPSEs. Other documents in the Introductory volume provide general guidance on using the RPSEs and background information to Engineering Standards in BP. There are also recommendations for specific definitions and requirements.

Value of this Guidance for Specification

This Guidance for Specification defines a number of the optional API clauses and may substitute, add to or qualify other API clauses using BP's knowledge and experience worldwide.

Application

This Guidance for Specification is intended to guide the purchaser in the use or creation of a fit-for-purpose specification for enquiry or purchasing activity.

It is a transparent supplement to [API RP11 PGT](#) first edition. The titles and numbering of the text follow those of [API RP11 PGT](#). As a result, gaps in number may occur. Text may qualify, substitute or add to the requirements of [API RP11 PGT](#). Where additional numbered clauses are to be read as an extension to a section or sub-section of [API RP11 PGT](#), text numbering has been extended accordingly.

Text in italics is Commentary. Commentary provides background information which supports the requirements of the Specification, and may discuss alternative options.

This document may refer to certain local, national or international regulations but the responsibility to ensure compliance with legislation and any other statutory requirements lies with the user. The user should adapt or supplement this document to ensure compliance for the specific application.

Specification Ready for Application

A Specification (BP Spec 134-12) is available which may be suitable for enquiry or purchasing without modification. It is derived from this BP Group Guidance for Specification by retaining the technical body unaltered but omitting all commentary, omitting the data page and inserting a modified Foreword.

Feedback and Further Information

Users are invited to feed back any comments and to detail experiences in their application of BP RPSEs, to assist in the process of their continuous improvement.

For feedback and further information, please contact Standards Group, BP Engineering or the Custodian. See Quarterly Status List for contacts.

1. GENERAL

1.1 Scope

This specification covers BP requirements for Packaged Gas Turbines.

The requirements of [API RP11 PGT](#), except as amplified and modified herein, shall be met and an API style data sheet shall be used to give detailed requirements for each specific application.

(Substitution)

1.2 Alternative Designs

Requirements alternative to those prescribed will be acceptable provided that it can be shown to the satisfaction of the purchaser's professional engineer that the required performance and function is attained.

Referenced standards may be replaced by equivalent standards that are internationally or otherwise recognised provided that it can be shown to the satisfaction of the purchaser's professional engineer that they meet or exceed the requirements of the referenced standards.

(Substitution)

1.3 Conflicting Requirements

In case of conflict between various documents, their order of precedence shall be:

- (a) Local Authority or Statutory Regulations.
- (b) The Equipment Requisition or Order.
- (c) Data sheets.
- (d) This Specification
- (e) Referenced industry standards.

(Substitution)

1.4 Definition of Terms

Refer to Appendix A

(Substitution)

1.5 Referenced Publications

Refer to Appendix B

(Addition)



2. BASIC DESIGN

2.1 Site Specific Requirements

2.1.3 Site Rating Conditions

The gas turbine shall be designed to provide site rated power with no negative tolerance at the heat rate and firing temperature quoted.

(Substitution, 2nd Sentence)

It is important to specify minimum loads in addition to maximum loads, to permit correct design of combustors, burners and the fuel control system.

2.1.4 *It is important to specify any requirement for rapid starting and rapid loading from cold, and the frequency of such operation. It generates high thermal stresses and can lead to low cycle fatigue if repeated too often. Lightweight aero-derivatives are generally more tolerant than heavyweight industrial designs, but all will be affected and this potential mode of failure can become life limiting.*

2.1.5 *It is important to specify the rate at which load will be accepted and rejected. It can influence the life of the machine (see 2.1.4) and the design of control systems. It is particularly relevant for generator drives where load changes can be large and rapid.*

2.1.9.1 For equipment installed on floating units the maximum motions including trim, inclination, roll and pitch shall also be specified.

2.1.10 Sound Level

A maximum allowable sound pressure level of 85dB(A) at 1 m from the surface of the package is commonly specified.

2.1.12 *Although gas turbines can burn most fuels it is important that the full range of fuels, composition and calorific value is specified because, once set up, the gas turbine flexibility with respect to fuel is greatly reduced.*

Additionally, fuel composition can affect the rate of deterioration of hot gas path components, and hence time between overhauls and maintenance costs.

2.2 Package Design

2.2.3 Other Equipment

Note that the exhaust system is not included unless specified. It is common practice for the gas turbine vendor or packager to supply up to and including the silencer.

2.2.7 Rating Condition

All components of the package shall be mechanically designed and satisfactory for continuous service at potential maximum power as defined in [API RP11 PGT 1.4.19](#), corresponding to the base load performance characteristics of the gas turbine. They shall also be



satisfactory for intermittent service at potential maximum power corresponding to the peak load characteristics, i.e. components such as couplings, gears and driven machines shall not impose a mechanical limit on the output from the unit.

(Substitution)

See also 2.1.4 of this Specification.

2.2.9 Starting Requirements

Any turning device necessary to meet this requirement shall be provided by the packager.

(Addition)

2.2.10 Temperature/Speed Limits

Rotors shall be capable of withstanding momentary speeds up to 110% trip speed throughout the full firing temperature range. The vendor shall advise the purchaser of any inspections that would be required after such overspeed conditions occurred.

(Addition)

The ability to run above trip speed is of particular importance for electrical generator sets where instantaneous loss of load may occur.

2.2.11 Package Arrangement

Insulation for personnel protection shall be provided by the vendor. Insulation shall be designed so that routine maintenance may take place without damage to the insulation.

(Addition)

2.2.17 Compartment Enclosure(s)

Enclosures will normally be necessary for noise control.

2.2.18 Packaging for offshore installations shall conform with BP Group [GS 134-13](#).

(Addition)

2.3 Gas Turbine Drive Train Mechanical Equipment Components

2.3.1 Gas Turbine Drivers

2.3.1.2 *API 616 will not normally be required. It is too prescriptive for what are highly standardised machines.*

2.3.1.4 Equipment shall be provided for continuous monitoring of vibration, preferably shaft displacement otherwise casing acceleration.

(Addition)



- 2.3.1.5 Rotors shall be capable of safe operation on instantaneous loss of 100% site rated load and the driven inertia, e.g., in the event of failure of the load coupling. The ensuing overspeed shall not cause blades, discs or shafts to fracture or separate.

(Addition)

This requirement may be difficult to meet for a multi-shaft turbine as the inertia of the power turbine may be relatively low. An alternative approach for such machines is to ensure that the probability of shafting, gear or coupling failure is acceptably low. This would require:-

- (a) Confirmation of the integrity of the system when subjected to high torques from mal synchronisation and short circuiting of generators (see clause 2.3.5.4.6).
- (b) Avoidance of shear pin overload protection.
- (c) Flexible membrane couplings to incorporate features to maintain drive in the event of failure of the flexible membranes.

- 2.3.1.6 Rotor blades failure shall precede disc failure in the event of excessive overspeed.

Failed rotor blades shall be contained, preferably by the turbine casing otherwise by an additional containment shield.

(Addition)

It is not usually practical to contain the fragments of a failed disc. Prior failure of blades reduces disc loads and hence probability of disc failure.

- 2.3.1.7 Where the turbine is to operate in a marine atmosphere or with corrosive fuels, full details of rotor and stator blading and coating materials together with experience of their use in similar service shall be furnished by the vendor with the proposal.

(Addition)

2.3.2 Couplings and Guards

- 2.3.2.2 Couplings in the main drive lines shall comply with [API 671](#). They should preferably be of the flexible membrane type, but for alternator applications may be solid.

(Addition)

- 2.3.2.9 Couplings incorporating a spacer piece shall be of a design in which the spacer piece is positively constrained from flying out in the event of failure of the flexible elements.

(Addition)



- 2.3.2.10 Full supporting information shall be provided, to demonstrate that the flexible elements of load and helper drive couplings have an infinite life under all conditions of torque, speed, axial movement, lateral and angular misalignment that can be encountered in normal service and at start-up.
(Addition)
- 2.3.3 *Auxiliary Gears*
- 2.3.3.2 *Accessory drives may incorporate gears and bearings that are lightly loaded in a specific application.*
Gears which are too lightly loaded may experience problems of backlash. In addition rolling element bearings may suffer skidding of the elements rather than rolling if they are too lightly loaded. Therefore check vendor experience with the contract configuration and loading.
- 2.3.4 *Load Gears*
- 2.3.4.1 *API 613 is very conservative. It will normally be better to specify BP Group GS 134-10 which permits alternative cost-effective design. For high pitch line velocities, above 120 m/sec, BP Group GS 134-10 results in more reliable designs.*
- 2.3.5 *Driven Equipment*
- 2.3.5.2.1 *Centrifugal compressors should normally be ordered to BP Group GS 134-5 which incorporates API 617.*
- 2.3.5.2.2 Gas turbine lube oil systems shall be separate from the seal oil systems of compressors handling flammable gases.
(Qualification)
It is impossible to exclude gas totally from the seal oil. If a combined system were used there would be the possibility of introducing flammable gas into the turbine.
- 2.3.5.3.1 *Centrifugal pumps should normally be ordered to BP Group GS 134-4 which incorporates API 610.*
- 2.3.5.4.3 *Generators should normally be ordered to BP Group GS 112-6 and 112-7 which refer to ac generators and packaged generators respectively.*
- 2.3.5.4.6 For generator drive applications all shafts, gears and couplings shall be capable of withstanding 120% of the maximum possible torque generated in the event of a 2-phase short-circuit, without exceeding the allowable yield stress of any component.
(Addition)
- 2.3.5.5 *Reciprocating compressors should normally be ordered to BP Group GS 134-6 which incorporates API 618.*



Although torsional vibration must be carefully considered there are no insuperable problems in driving reciprocating compressors.

3. ACCESSORY SYSTEMS

3.1 Starting Systems

3.1.3 *Because it is necessary to accelerate the whole train to self sustaining speed the use of single shaft machines for mechanical drive applications requires careful study.*

3.2 Mounting Systems

3.2.3 Baseplate Design

3.2.3.6 Non-skid decking shall be provided on the top of the baseplate covering all walk and work areas.

(Qualification)

3.3 Enclosure and Fire Protection

3.3.2 Construction

3.3.2.2.2 Doors shall be provided to facilitate rapid safe exit from any part of the enclosure. If necessary escape doors shall be provided in addition to normal access doors.

(Addition)

3.3.2.2.4 All practical lifting facilities for maintenance shall be installed in the enclosure.

(Addition)

3.3.2.2.5 Fixed ladders and platforms shall be provided to give access to any roof mounted equipment requiring routine monitoring or maintenance, e.g. ventilation fans and control valves, lighting and instrumentation.

(Addition)

3.3.2.4 If entry is necessary during operation, emergency lighting shall be installed to allow the safe exit of operators within the enclosure in event of main lighting failure.

(Addition)

3.3.2.5 Hydrocarbon filling points used during operation shall be outside the enclosure.

(Addition)



3.3.2.6 Sound absorption material shall be enclosed in an impervious membrane to prevent adsorption of liquids.
(Addition)

3.3.2.7 For exposed offshore applications the vendor shall quote prices for construction in vendor-standard materials with an alternative in type 316L stainless steel.
(Addition)

The additional cost of stainless steel will be relatively low for enclosures specially designed for the application, eg. those for large aero-derivative engines, or those with a fire rating. For highly standardised designs produced in quantity, deviation from vendor standard materials will be costly and may be difficult to justify.

3.3.3 Fire Protection

3.3.3.1 Fixed fire protection for the engine and other compartments shall be evaluated on a hazard based approach.

Commonly this will comprise a fire detection system, a fire suppression system and under the following circumstances a gas detection system:-

- (i) When gas fuelled.
- (ii) When the driven machinery handles flammable gas.
- (iii) When operating in hazardous areas.
- (iv) When operating in a safe area but where there is a risk of flammable gas being ingested into the combustion air or ventilation air system as a result of accidental leakage from other equipment.

(Substitution)

The need for fixed automatic protection systems in compartments additional to that containing the gas turbine, should be determined by consideration of probability of a fire, likely severity, consequences and the availability of personnel to tackle a fire manually.

3.3.3.2 Halon or other ozone depleting agents shall not be used. Carbon dioxide is acceptable in enclosures which are not normally manned.

Installation of carbon dioxide systems shall comply with [NFPA 12](#) or [BS 5306](#) Part 4.

Installations using carbon dioxide or other inert gases shall incorporate facilities to lock out the firefighting system to permit personnel to enter the enclosure while the machine is in operation. The state of this lock shall be visually indicated locally and in the central control room.



(Qualification)

The gaseous release shall be designed to provide one shot of 34% design concentration in the enclosure. A second shot back up supply may be required if lube oil pumps are kept running for bearing protection during cool down.

- 3.3.3.3 Visual indication of the firefighting system condition shall be provided locally outside the enclosure and on the main control panel.

Indications shall include:-

- (a) System on Automatic Control.
- (b) System on Manual Control.
- (c) System Operated - 1st shot.
- (d) System Operated - 2nd shot (if applicable)
- (e) System Locked Out.

(Addition)

- 3.3.3.4 The primary means of fire detection within engine compartments shall be electro-mechanical rate compensated heat detectors. These detectors shall be located within the ventilation air outlet ducting. Sufficient detectors shall be located in the engine compartment of the package to meet availability and reliability requirements.

To accommodate abnormal operating conditions which might render the detectors located in the ventilation outlet ducting ineffective, additional detectors shall be located under the turbine hood.

Secondary fire detection shall be by optical beam smoke/oil mist detection. This shall primarily be for the detection of a release of lube oil or diesel, or the early stages of combustion. It shall comprise a single detector located in the engine enclosure viewing across the ventilation air outlets. If the view is obstructed the ventilation air ducts shall be fitted with windows and the detectors located external to the unit.

Consideration shall be given to installation of a voting system for the primary and secondary fire detectors to provide automatic initiation of control action. As a minimum detectors shall alarm in the central control room.

Smoke detectors shall be provided in control cabins.

(Addition)

Past practice required three primary heat detectors to permit a two-out-of-three voting system. Reviews are taking place to establish whether sufficient security can be achieved from a two-out-of-two system.

The set point of the detectors shall be determined in conjunction with the package vendor to minimise spurious alarms while providing adequate protection.



Additional heat detectors under the turbine hood may be required because of abnormal operating conditions, e.g. operation with enclosure doors open, may render the detectors fitted in the ventilation outlets ineffective. The number and control functions of these detectors should be the same as for those used in the ventilation air outlet. For cost minimisation these detectors may be installed on the same control loop as those used in the ventilation air outlet.

Operation of a single detector should alarm in the central control room.

Coincident operation of two out of three detectors should initiate shutdown of the gas turbine, shutdown of the ventilation system including dampers, release of the fire suppressing medium, and alarm in the central control room.

3.3.3.5 The primary means of gas detection for gas fuelled turbines shall be gas detectors located in the outlet of the enclosure ventilation system.

Gas detection installed for reasons (ii), (iii) or (iv) of clause 3.3.3.1 shall have gas detectors at combustion and ventilation air inlets. Adjacent inlets may be covered by a single detector.

Detectors shall be infrared point or beam type.

(Addition)

Sufficient detectors should be provided at each location to meet the availability and reliability requirements. Control logic should be as follows:-

- | | |
|--------------------|----------------------------|
| - Any 1 at 20% LEL | - Low gas alarm in CCR |
| - Any 1 at 60% LEL | - Automatic control action |
| - Any 2 at 20% LEL | - automatic control action |

Automatic control action should comprise:-

- | | |
|-----------------------|-----------------------------------|
| - Detection at inlet- | Stop machine |
| | - Isolate fuel |
| | - Stop vent fans |
| | - Close gas dampers (if provided) |
| | - Alarm in CCR |
| - Detection at outlet | Stop machine |
| | - Isolate fuel |
| | - Vent fans to full speed |
| | - Alarm in CCR |

3.3.3.7 The fire and gas detection system on the turbine shall be integrated with the purchaser's overall fire and gas detection system.

(Addition)

To facilitate plant-wide standardisation it may be preferable to free-issue detectors to the packager.

3.3.3.9 A firewall shall be installed between an open gas turbine (without enclosure) and its driven machine if the driven machine handles a



flammable fluid. Removable sections shall be included to facilitate maintenance.

(Addition)

3.3.4 Ventilation and Purging

3.3.4.1 Enclosures containing components with high surface temperatures and which are at risk from the ingress of flammable gas, shall be ventilated at a rate of at least 90 changes per hour. Two 100% fans shall be provided. Such enclosed spaces may be considered non-hazardous when the ventilation system is in operation.

Enclosures sub-divided into areas with differing hazard classifications shall have pressure gradients established such that non-hazardous areas are at least 50 N/ m² above Zone 2 which in turn are at least 50 N/ m² above Zone 1.

(Addition)

3.3.4.6 The turbine ventilation control system shall ensure that the enclosure and ventilation ducting is purged to achieve at least five complete changes of air before any start attempt or before energizing of any electrical equipment not meeting the unventilated area classification requirements.

(Addition)

The object of this requirement is to ensure that the enclosure and ducting are free of flammable vapour before any start attempt is made.

3.3.4.7 The ventilation system shall incorporate fire dampers at the air inlet and outlet, which shall be controlled from the fire and gas protection system.

(Addition)

3.3.4.8 For offshore applications all metallic air path components of the intake system shall be type 316L stainless steel.

(Addition)

3.4 Air Inlet Systems

3.4.1 General

3.4.1.2 The vendor shall provide all walkways, handrails, platforms and ladders required for access for operation and maintenance.

(Qualification)



3.4.1.2a Anti-icing systems

Precipitation icing may occur when water in suspension in the atmosphere encounters cold surfaces in the air intake on which it may freeze. The danger is small provided the normal arrangements for preventing ingress of snow, rain or spray are made. Since the cooling of the metal surfaces depends upon the acceleration of the air in the inlet the maximum temperature depression is about 4°C. Thus even without protection precipitation icing can only occur with ambient temperatures in the range 0-5°C.

Condensation icing occurs when water vapour in the atmosphere condenses and freezes as a result of the cooling on entry. Thus icing can only occur at temperatures less than 5°C and conditions of high relative humidity. At temperatures less than -9°C the moisture content of the air is not sufficient to cause icing problems. As a guide, with ambient temperatures in the range -9 to 5°C icing will only occur if the relative humidity is greater than 65%.

Some geographical locations have never experienced icing, eg. N. North Sea. Local experience should be used as a guide to the application of anti-icing.

3.4.1.2c The need for insect screens is site dependent. It may be that swarms of insects are only encountered on a few days each year but the installation of insect screens could still be justified.

3.4.1.2d An on-line water washing system should be specified (in addition to an off-line system) if use of an off-line system would impose serious operational limitations. The effectiveness of on-line systems will usually be inferior to that of off-line systems but regular use can extend intervals between off-line washing.

It must be recognised that on-line washing may be impractical for some engines.

3.4.1.7 Fittings used to secure components that are replaceable on-stream shall be manufactured from non-corroding materials.

For off-shore applications all metallic air path components shall be type 316L stainless steel.

(Substitution)

For offshore installations with a long operational life the additional capital cost of stainless steel over carbon steel will usually be justified by the reduction in maintenance. However, for highly standardised packages using carbon steel as standard, and for installations with a short operational life, the additional cost of stainless can be relatively high and would need to be justified for each case.

3.4.1.8 Corrosion protection for carbon steel systems should meet the requirements of BP Group [GS 106-2](#).

3.4.1.11 [API RP11 PGT](#) makes no reference to blow-in doors for protection against implosion and starvation of the turbine in the event of filter icing or plugging. Installation of such doors should be avoided whenever possible as their use can cause rapid deterioration of the turbine, particularly offshore. The need for them can normally be avoided by use of self cleaning filters plus anti-icing if appropriate, backed up by high differential pressure alarms and trips.



If their installation is essential they should be of the power operated type as gravity designs have proved unreliable in making a good seal particularly in strong winds. Heated door seals are required if there is a danger of water freezing and preventing operation.

3.4.2 Inlet Filters

3.4.2.1 Filter systems shall be of a design well proven for the environment specified on the data sheet.

For offshore installation they shall include features to remove drilling mud, cement dust, shot blast material and diesel exhaust fumes.

(Addition)

Broadly there are two types of filter, inertial type high velocity filters and media type filters. There can be a blurring of the distinction in that media pre-filters may be fitted to inertial type separators.

Media type filters may be fitted with self-cleaning arrangements which generally involve back flow and may be termed 'huff and puff'.

The inertial type separator depends upon high air velocity and therefore tends to be relatively compact and light compared to the media type, an advantage if space and weight are at a premium.

The inertial type filter is effective against liquids but depends upon the vanes to catch the liquid and lead it away. These vanes are prone to clog in the presence of dirt such as drilling mud and cement and therefore for offshore application a media pre-filter may be necessary.

Media filters operate with low air velocity and therefore tend to be relatively large and heavy. Routine maintenance involves replacing the media which may or may not be cleanable. In dusty environments a self-cleaning filter is likely to be almost essential.

Both types have given satisfactory service in the North Sea..

3.5 Exhaust System

3.5.1 Note that the exhaust system is not included unless specified.

3.5.2 Exhausts shall not pass under lubricating, control or fuel oil systems, under control panels or the gas turbine mounting plate.

(Qualification)

3.6 Piping

3.6.1 General

3.6.1.3 *API RP11 PGT* Table 1 requires stainless steel pipework for lube-oil systems. However carbon steel should be considered if it is vendor standard backed by



satisfactory operating experience, is protected beneath the package enclosure, and if it results in a significant capital cost saving.

3.7 Oil Systems

3.7.1 As suggested in [API RP11 PGT](#) it may not be appropriate to specify [API 614](#) for gas turbine oil systems. This is because these are generally developed and standardised for individual machines. However if [API 614](#) is specified then BP Group [GS 134-3](#) should also be specified.

3.7.3 See 2.3.5.2.2

3.7.5 Shaft driven oil pumps shall be sized to deliver a minimum of 110% train requirements when operating at minimum governing speed.

(Addition)

To avoid the need to operate auxiliary or standby pumps under normal operating conditions.

3.7.8 The turbine (and driven machines) shall be able to run down and cool down following a trip from full load on loss of ac power, without damage to bearings and other equipment. The vendor shall supply emergency lube oil equipment, such as dc pump and batteries, if required.

(Addition)

For an offshore application the emergency lube oil equipment should remain operating following a red shutdown, to safeguard against machinery damage. In these circumstances the emergency equipment should be suitable for Zone 1 operation.

The emergency pump should also be kept running in the event of fire in the enclosure. Operating procedures should include a requirement to assess the cause of any fire and if necessary shut down the pump manually.

3.8 Fuel Systems

3.8.1 General

3.8.1.4 All pipework downstream of the final filter shall be stainless steel.

(Qualification)

This implies that if the final filter is in the purchaser's system, all vendor pipework shall be stainless steel.

3.8.1.5 Fuel systems handling hydrogen sulphide, shall meet the requirements of BP Group [GS 136-1](#) (incorporating [NACE MR-01-75](#)).

(Addition)



3.8.1.6 Unless protected by relief valves, the entire fuel system shall be designed to the same pressure rating as the fuel supply main.

(Addition)

3.8.1.7 Fuel systems shall include a manual isolating valve and spade immediately after the purchaser's connection.

(Addition)

For maintenance.

3.8.1.8 The vents and drains for each fuel system shall be separate from any other fuel or other system vents and drains.

(Addition)

3.8.2 Gaseous Fuel

3.8.2.3 Fuel Gas System

3.8.2.3.1 If the maximum dewpoint of the fuel gas is less than 20°C below the minimum site ambient temperature the vendor shall supply the following additional equipment.

(i) Liquid knockout drum or filter separators with demisting facilities, drains, level gauge, level alarm.

(j) Heat tracing and insulation downstream of the last knockout vessel.

(k) Drains at all low points.

(l) Venting and warm-through facilities.

(Addition)

It is important that gaseous fuel is free of liquid hydrocarbons because liquid will impinge on metal surfaces in the hot gas path where it will burn and cause damage.

3.8.2.3.1(d) The shut off valves shall have facilities for remote and local manual tripping.

At least one shut off valve shall be located outside any enclosure.

(Addition)

3.8.3 Liquid Fuel

3.8.3.1(d) The shut off valves shall have facilities for remote and local manual tripping.



At least one shut off valve shall be located outside any enclosure.

(Addition)

3.9 Controls and Instrumentation

3.9.1 General

3.9.1.6 The turbine governor, controls and instrumentation shall conform to BP Group [GS 130-2](#).

(Addition)

3.9.1.7 Controls and instruments located within ventilated enclosures shall be suitable for any transient temperature rise following ventilation failure.
(Addition)

3.9.1.10 Except for generator drives, the control range of two-shaft machines shall be from trip speed to 95% of the minimum speed required for any specified operating case or 70% rated speed, whichever is the lower. Speeds are those of the power turbine.

(Addition)

3.9.1.11 The control system shall prevent flame-out of the turbine during sudden full load rejection when operating on any of the specified fuels.

(Addition)

3.9.1.12 The control system shall limit shaft speed to below the overspeed trip setting on sudden loss of full load.

(Addition)

3.9.2 Starting Control

3.9.2.2 The start sequence shall provide a purge period long enough to purge the entire exhaust system (including the stack) before the unit is fired.

The purge volume is typically equivalent to between three and five times the volume of the entire exhaust system.

A key operated off-local-remote selector switch shall be provided on the control panel. It shall respectively: prevent the turbine from being started; allow it to be started from the control panel; or allow it to be started, stopped and controlled from a remote signal.

Emergency shutdown push buttons shall be provided on each turbine control panel and locally on each side of the turbine and inside any enclosure.

(Addition)



3.9.3 Instrument and Control Panel

3.9.3.1 The packager shall furnish a control panel housing all logic circuits, indicators, recorders, programmable logic controllers, VDU's, status lights, start and stop buttons and selector switches.

All communication between the gas turbine and the purchaser's instruments and controls shall be via the control panel. The control panel shall have a marshalling cubicle for connections into the purchaser's system. Digital signals shall be by way of voltage-free contacts.

(Qualification)

Control panel location must be agreed with the vendor. Arrangements commonly considered are as follows:

- (a) *In a local equipment room mounted on the machinery skid.*
- (b) *On an open skid, singly or common with that of other identical units, for separate mounting.*
- (c) *In a Central Control Room.*

Whenever possible vendor standard arrangements should be used. Specially engineered arrangements can incur high extra costs.

3.10 Electrical Systems

3.10.8 Electrical equipment shall comply with BP Group [GS 130-2](#).

(Addition)

3.10.9 Electrical equipment in an enclosure that may be operated before that enclosure is purged or with the ventilation system out of commission shall be suitable for the maximum hazard classification encountered. This applies particularly to ventilation fan motors, emergency or standby pump motors, lighting and power tool sockets.

(Addition)

4. INSPECTION TESTING AND PREPARATION FOR SHIPMENT

4.1 General

Verification of the vendor's quality control system is normally part of the pre-qualification procedure and is therefore not specified in the core text of this specification. If this is not the case, clauses should be inserted requiring the vendor to operate and be prepared to demonstrate the quality system to the purchaser.



Further suggestions may be found in the BP Group RPSEs Introductory Volume.

- 4.1.4 The vendor shall table his internal inspection and test plan as the basis of discussion to agree the extent of purchaser participation in the inspection and testing.

(Substitution)

Purchaser participation will need to be agreed on an individual job basis recognising factors such as:-

- *The maturity of the design.*
- *The criticality of the machine with respect to operation and safety.*
- *Experience in the production and test facility where the machine will be built and tested.*
- *Previous experience with the vendor.*

Any requirement for inspection by an independent authority as might arise from statutory or insurance reasons should be taken into account.

It should be recognised that the basic gas turbine is a relatively complex and highly rated machine, built to a standard design by production methods that are usually well established. Assuming the competence of the vendor has been established as satisfactory by previous experience or by audit, then detailed inspection of materials and intermediate manufacturing steps are unlikely to be justified. Emphasis should instead be placed on witnessing the mechanical and performance tests on the assembled machine.

More detailed attention to materials and construction might be justified for items designed specifically for the particular job such as some of the ancillary systems and packaging. Inspection of these should also include checks on accessibility and functionality.

4.3 Testing

4.3.1 General

4.3.1.1 Minimum test requirements shall be as follows:-

- (a) Hydrostatic tests as clause 4.3.2 of API.
- (b) Gas generator test (if applicable) as clause 4.3.3 of API.
- (c) Complete unit mechanical run test as clause 4.3.4 of API RP11 PGT and this specification.
- (d) For dual fuel engines, demonstration of the change-over from gas to liquid and vice-versa.



- (e) Sound level test on the first machine of each type, size and configuration for a particular order.
- (f) Smoke test on the air filter and intake duct assembly at a pressure of 1.2 kPa(g).
- (g) Mechanical and electrical operation of any air filter cleaning mechanism.
- (h) Functional tests on the enclosure to demonstrate:-
 - (i) Correct pressures and air flow rates.
 - (ii) Adequate cooling of components. A temperature survey of each compartment shall be undertaken.
 - (iii) Satisfactory fan operation and auto change-over to standby.
 - (iv) Sealing of each compartment and the enclosure as a whole. For this a smoke test shall be carried out at a pressure of 1.2 kPa(g) internal pressure.

(Substitution)

Vendor's standard testing practices should be adopted whenever possible as special requirements can be expensive and incur significant delays. Practices differ significantly from vendor to vendor depending on the type of turbine, type of driven machine, power, and facilities available. Test programmes should be developed taking into account the following:

- (a) *An essential objective of every test programme should be to check the assembly and functioning of each package. This is the purpose of the 'Complete Unit No-Load Mechanical Running Test' of 4.3.4, together with the ancillary equipment functional checks listed in 4.3.1.1 of this specification. The package should be complete as far as practical, including driven machine and oil systems, plus control systems and other ancillaries if possible.*
- (b) *Load should be as high as practical (notwithstanding the 'No-Load' title). For small units full load may be possible with standard test facilities.*
- (c) *If the 'Complete Unit No-Load Mechanical Running Test' is comprehensive, the 'Auxiliary Equipment Tests' and 'Gas Generator/Power Turbine Mechanical Running Test' of [API RP11 PGT](#) clauses 4.3.5.1 and 4.3.5.2 will not normally be necessary, unless they are vendor standard.*
- (d) *For relatively new designs the 'Gas Generator/Power Turbine Performance Running Test' of [API RP11 PGT](#) 4.3.5.3 may be justifiable to check performance. If multiple units are being ordered, such test would normally be limited to the first one.*



- (e) *For units that are to be installed in a remote location where logistics of supplying support services are onerous, eg. offshore, packages should be substantially complete before test, and tests should be at high loads. However, for offshore units there can be cost and programme benefit from performing some of these tests at the module fabrication yard rather than at the gas turbine vendor's facility.*

4.3.4 Complete Unit No-load Mechanical Running Test

- 4.3.4.2.1 The equipment shall be operated at idling speed and at speed increments of approximately 10% of maximum continuous speed from minimum governor setting to the maximum continuous speed. Operation at each speed shall continue until bearing lube oil temperatures and shaft vibrations have stabilised.

(Substitution)

- 4.3.4.3.2 The sweep of vibration amplitudes versus frequencies shall be carried out at each speed identified in clause 4.3.4.2.1.

(Addition)

- 4.3.4.3.5 Seal vents shall be checked for excessive air flows and oil content.

(Addition)

- 4.3.4.4.1 On completion of testing, sufficient dismantling will be required to permit complete inspection of all hydrodynamic bearings. Additional dismantling will be required for inspection of other components such as shaft seals and internal labyrinths if the testing has given rise to doubts on the integrity of such components.

(Substitution)

4.3.5 Optional Tests

4.3.5.4 Full Pressure/Full Load/Full Speed Test

Load tests on variable speed turbines shall include vibration sweeps as [API RP11 PGT](#) clause 4.3.4.3.2 at operating conditions selected to encompass the full range of speeds and powers expected in service.

4.3.5.5 Electrical Generator Test

Load tests on alternator drive turbines shall include response tests to demonstrate the governor and turbine response at acceptance and rejection of load in 25, 50, 75 and 100% load steps.

The response will be in accordance with an agreed standard, typically NEMA SM24.

Vibration sweeps in accordance with [API RP11 PGT](#) 4.3.4.3.2 shall be carried out at 0, 25, 50, 75 and 100% load.



4.3.5.6 *Torsional vibration measurements should be specified if any of the first N critical speeds fall within the running speed range, where N is the number of casings in the train.*

4.3.5.9 *Spare-Parts Test*

It is generally worth testing spare parts since this ensures that they are dimensionally compatible and correctly balanced.

In the case where single spares are being ordered for a number of units consideration should be given to at least assembling the spares into each casing.

5. PACKAGER'S DATA

5.1 Proposals

The following additional data shall be included in the proposal:-

- (a) Blade and rotor containment information requested in 2.3.8.1 of this specification.
- (b) Details of materials for rotor, stator blading and blade coatings, together with experience in similar environments with similar fuels to those specified.
- (c) Limitations on fuel supply pressure, temperature and viscosity together with any requirements for fuel treatment and special starting fuels.
- (d) For electric generation service the vendor shall supply sufficient information regarding machine response characteristics in order that the purchaser can carry out a preliminary system stability study on the whole power supply system.
- (e) Time between overhauls for both base and peak rate operation.
- (f) Maintenance schedules and typical maintenance plans for each overhaul including lifting arrangements.

(Addition)

5.2 Contract Data

The following technical data, in addition to that listed in [API RP11 PGT](#), shall form part of the contract data for approval:-

- (a) For electric generation service the vendor shall supply sufficient information regarding machine response characteristics in order



that the purchaser can carry out a final system stability study on the whole power supply system.

- (b) Details of calculations showing the effects of alternator short circuit referred to in Section 2.3.5.4.6 of this Specification.
- (c) Flexible membrane coupling supporting information as described in 2.3.2.10 of this Specification.
- (d) Detailed test schedules for the mechanical running test, all optional tests within the scope of supply, and the instrument panel test. These shall list all separate test activities with durations, measurements to be made, instruments to be used with associated calibration procedures, inspections to be carried out, and driver and coupling provision.

For performance tests, the schedule shall contain sufficient information to define the test completely and permit agreement on guiding principles as required by the agreed test code. It shall include statement of objectives, instrumentation, limitations on test and deviations from test code rules, methods of computation, and estimates of possible errors.

(Addition)

5.2.5 Installation, Operation and Maintenance Manuals

5.2.5.3 Instrument manuals are to include a schedule of tests of trips and alarms with procedures for carrying these out.

(Addition)



DEFINITIONS AND ABBREVIATIONS

Definitions

Standardised definitions may be found in the BP Group RPSEs Introductory Volume.

Vendor	The main supplier of the machinery, including items designed and manufactured by others, to which this Specification applies.
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<i>Note:</i>	<i>Any specific application of the terms and the responsibilities of the parties defined above is a matter for the relevant Conditions of Contract.</i>
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Abbreviations

ac	Alternating current
API	American Petroleum Institute
BS	British Standard
CCR	Central control room
dc	Direct current
NACE	National Association of Corrosion Engineers
NEMA	The National Electrical Manufacturers Association
NFPA	National Fire Protection Association.
VDU	Visual display unit



LIST OF REFERENCED DOCUMENTS

A reference invokes the latest published issue or amendment unless stated otherwise.

Referenced standards may be replaced by equivalent standards that are internationally or otherwise recognised provided that it can be shown to the satisfaction of the purchaser's professional engineer that they meet or exceed the requirements of the referenced standards.

API RP 11 PGT , First Edition	Recommended practice for packaged combustion gas turbines
API Std. 610	<i>Centrifugal Pumps for General Refinery Service</i>
API Std. 613	<i>Special-Purpose Gear Units for Refinery Services</i>
API Std. 614	<i>Lubrication, Shaft-Sealing and Control-Oil Systems for Special-Purpose Applications</i>
API Std. 616	<i>Type H Industrial Combustion Gas Turbines for Refinery Services</i>
API Std. 617	<i>Centrifugal Compressors for General Refinery Service</i>
API Std. 618	<i>Reciprocating Compressors for General Refinery Services</i>
API Std. 671	Special-Purpose Couplings for Refinery Service
BS 5306 Part 4	Specification for Carbon Dioxide Systems.
NACE MR-01-75	Standard material requirements - sulphide stress cracking resistant metallic materials for oilfield equipment
NEMA SM 24	<i>Land Based Steam Turbine Generator Sets 0 to 33,000 kW</i>
NFPA 12	Standards for carbon dioxide extinguishing systems
BP Group GS 106-2	<i>Painting of metal surfaces</i> (was BP Std. 141)
BP Group GS 112-6	<i>AC Generators</i> (was BP Std. 224 Part 1)
BP Group GS 112-7 (was BP Std. 224 Part 2)	<i>Generation Packages</i>
BP Group GS 130-2	Instrumentation and electrical equipment for rotating machinery



(was BP Std. 128).

BP Group [GS 134-3](#)

*Lubrication, shaft sealing and control oil systems for special purpose applications to API 614
(was BP Std .190).*

BP Group [GS 134-4](#)

*Centrifugal Pumps to API 610
(was BP Std. 195)*

BP Group [GS 134-5](#)

*Centrifugal Compressors to API 617
(was BP Std. 196)*

BP Group [GS 134-6](#)

*Reciprocating Compressors to API 618
(was BP Std .197)*

BP Group [GS 134-10](#)

*Special Purpose Gear Units to API 613
(was BP Std 202)*

BP Group [GS 134-13](#)

*Packaging of rotating machinery for offshore use.
(was BP Std 205)*

BP Group [GS 136-1](#)

*Materials for sour service to NACE Standard MR-0175
(was BP Std 153)*

