

DEP SPECIFICATION

# **COMBUSTION GAS TURBINES - SELECTION, TESTING AND INSTALLATION**

DEP 31.29.70.11-Gen.

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**DESIGN AND ENGINEERING PRACTICE**



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## 1. INTRODUCTION

### 1.1 SCOPE

This DEP supplements DEP 31.29.70.31-Gen. and DEP 31.29.70.32-Gen. by providing supporting information for the specification and guidance on its use. It is intended to be used by owners and Engineering Procurement Contractors.

This is a revision of the DEP of the same number dated December 1998; see (1.5) regarding the changes.

### 1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

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This DEP is intended for use in facilities related to oil refineries, chemical plants, gas plants and, where applicable, in exploration and production facilities. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process should be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP 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, the objective being to obtain agreement to follow this DEP as closely as possible.

### 1.3 DEFINITIONS

#### 1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

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

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

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

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

### 1.3.2 Specific definitions

| term                                       | definition                                                                                                                                                                                                                                                                                                                                                                   |
|--------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Vital, Essential and Non-essential service | For definitions and explanation of these services see Appendix 1.                                                                                                                                                                                                                                                                                                            |
| Continuous service                         | A service in which it is not expected that the turbine will have to be stopped/started during normal plant operation.                                                                                                                                                                                                                                                        |
| Intermittent service                       | A service in which it is expected that the turbine will be started/stopped at unspecified intervals, e.g.: <ul style="list-style-type: none"><li>• Automatic starts and stops at intervals by process operated controls;</li><li>• Manual starts and stops at intervals by manual control for batch processes.</li></ul>                                                     |
| Hostile environment                        | Locations where the air is contaminated with aerosols, salt, sand or dust, e.g. offshore or in a desert area.                                                                                                                                                                                                                                                                |
| Prototype                                  | A prototype is a design of gas turbine or component whose leading engine has not yet achieved 98% reliability over 25 000 fired hours, or where the total population of identical gas turbines has achieved less than 100 000 fired hours.<br><br>NOTE: In this definition it is the gas turbine itself that is considered and not the entire package unit with auxiliaries. |
| Availability*                              | The availability of a gas turbine is defined as the sum of the service hours (i.e. the period in which the unit is producing useful energy) divided by the sum of service hours plus total outage hours, and is expressed as a percentage.                                                                                                                                   |
| Reliability*                               | The reliability of a gas turbine is defined as the sum of the service hours (i.e. the period in which the unit is producing useful energy) divided by the sum of service hours plus forced outage hours, and is expressed as a percentage.                                                                                                                                   |
| ISO rating*                                | The ISO rating of a gas turbine is its rating at 15 °C ambient temperature, 1013.25 mbar atmospheric pressure and 60% relative humidity, with zero inlet and exhaust pressure losses.                                                                                                                                                                                        |
| NOTE:                                      | * The above three definitions are independent of the requirements for a service life of 20 years and for at least 3 years of uninterrupted operation, as specified by DEP 31.29.60.30-Gen. and DEP 31.29.60.31-Gen.                                                                                                                                                          |

### 1.3.3 Gas Turbine Definitions

| term                                     | definition                                                                                                                                 |
|------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| Industrial type single shaft gas turbine | Arrangement in which the turbine shaft that is connected to the driven equipment is also connected to the gas turbine air compressor shaft |
| Industrial type two-shaft gas turbine    | Arrangement in which the turbine shaft that is connected to the driven equipment is not connected to the gas turbine air compressor shaft  |
| Heat rate (kJ/kWh)                       | A measure of engine efficiency and is equal to 3600 divided by efficiency (when efficiency is given in decimal form)                       |

For aeroderivative type multi-shaft gas turbine different shaft arrangement are available:

- Two-shaft arrangement consisting of:
  - o Gas generator (GT air compressor coupled to HP turbine stage) plus a free running power turbine driving the load; or
  - o Gas generator (GT HP air compressor coupled to HP turbine stage) plus a power turbine driving the GT LP compressor stage and the load.
- Triple-shaft arrangement consisting of:
  - o Gas generator (GT HP air compressor coupled to HP turbine stage) plus an IP turbine driving the IP compressor plus a free running power turbine driving the load; or
  - o Gas generator (GT HP air compressor coupled to HP turbine stage) plus an IP power turbine driving the IP GT compressor plus a LP turbine driving the GT LP compressor stage and the load.

Notes: GT = Gas Turbine  
HP = High Pressure  
IP = Intermediate Pressure  
LP = Low Pressure

### 1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets ( ). Other documents referenced by this DEP are listed in (10).

### 1.5 SUMMARY OF MAIN CHANGES

This DEP is a revision of the DEP of the same number dated December 1998. The following are the main, non-editorial changes.

| Old section | New section | Change                                |
|-------------|-------------|---------------------------------------|
|             | 1.3.3       | Gas Turbine Definitions               |
|             | 1.5         | Summary of main changes               |
|             | 1.6         | Comments on this DEP                  |
| 5.          |             | Noise Level: Complete content removed |
| 7.2         |             | Materials Certification: Deleted      |
| 8.4         |             | Diesel Engines: Deleted               |
|             | 11.1.3      | Power Augmentation                    |

| Old section | New section | Change                                                           |
|-------------|-------------|------------------------------------------------------------------|
| 12.3        |             | Shutters: Deleted                                                |
| 13.1        |             | General: Deleted                                                 |
| 13.2        | 13.1        | Ventilation Dampers: Renumbered                                  |
| 13.3        | 13.2        | Extinguishing Systems: Renumbered                                |
| 13.4        | 13.3        | Enclosure Surveillance: Renumbered                               |
| 14.4        |             | Area Classification within Acoustic Enclosures: Deleted          |
| 15.5        |             | Power Augmentation: Moved to 11.1.3                              |
| App. 2      |             | Gas Turbine Enclosure Ventilation: Deleted                       |
| App. 3      |             | Typical Arrangement for Bolting Baseplate to Foundation: Deleted |
| App. 4      | App. 2      | Exhaust Stack Rain Catcher: Renumbered                           |
| App. 5      | App. 3      | Gas Turbine Washing: Renumbered                                  |

Nearly all other sections have been updated applying the following rules:

- Equipment design, manufacturing and testing requirements have been moved to the applicable DEP Specification
- Superfluous text has been removed
- References to DEP's without added value have been removed
- Alignment with the new DEP requirements has been applied
- ESSA requirements have been applied

#### 1.6 COMMENTS ON THIS DEP

Comments on this DEP may be sent to the Administrator at [standards@shell.com](mailto:standards@shell.com), using the DEP Feedback Form. The DEP Feedback Form can be found on the main page of "DEPs on the Web", available through the Global Technical Standards web portal <http://www.shell.com/standards> and on the main page of the DEPs DVD-ROM.

## 2. GENERAL REQUIREMENTS

### 2.1 SELECTION AND EVALUATION

The selection of gas turbines and the technical evaluation of bids from gas turbine Manufacturer/Suppliers shall be based on the requirements of this DEP together with DEP 31.29.70.31-Gen.

NOTE: DEP 31.29.70.31 Gen. covers both industrial heavy duty gas turbines, Type H, and modular or aero-derivative gas turbines, Type G, as designated by the American Petroleum Institute.

The selection of combustion air intake and exhaust systems and the technical evaluation of bids from combustion air intake and exhaust systems Manufacturer/Suppliers shall be based on the requirements of this DEP together with DEP 31.29.70.32-Gen.

NOTE: DEP 31.29.70.32 Gen. covers gas turbine combustions air intake and exhaust systems for onshore, offshore and coastal applications.

Since there is continuing development in gas turbine design, and improvement of efficiency, care should be taken to ensure that prospective Manufacturer/Suppliers do not exceed the proven ratings of their respective designs in their efforts to achieve competitive tenders.

The examination and evaluation of tenders for gas turbines for hostile environments shall be rigorous. In particular, a specific air quality assessment should be conducted to determine the dust particle size, concentration/type of particular pollutants and local climate in order to specify and select the best filtration requirements for such environments.

### 2.2 RANGE AND VARIETY OF GAS TURBINES

Every effort shall be made to minimise the level of spares by rationalising the variety of makes and types of gas turbines, the associated drives and auxiliary equipment. The rationalisation of variety and minimisation of spares, however, shall not prevent selection of the most suitable gas turbine for the specified operating conditions and shall not increase the total cost of ownership (TCO).

### 2.3 PROTOTYPE GAS TURBINES

Selected equipment shall be within the range of the Manufacturer's proven experience and shall not involve the use of prototype designs or components, except where pre-approved by the Principal.

The development of gas turbines is largely centred around the development of hot parts and their thermal capabilities. Specific focus shall therefore be directed to assessment of the Manufacturer's experience of these parts and the proposed firing temperature.

### 2.4 OPERATING REQUIREMENTS

All operating requirements that the gas turbines may need to fulfil shall be specified in the data/requisition sheet.

Parallel operation, if required, shall be stated.

'Off-design' conditions, which may occur during start-up and shutdown procedures associated with the particular applications of the gas turbine shall be specified in the inquiry.

The exhaust mass flow and temperature under part-load conditions are important considerations for gas turbines in co-generation and combined cycle applications, especially if exhaust heat is to be used for steam raising without supplementary firing of the boiler.

### 2.5 SPARES INVENTORY

A spares inventory comprising either a recommended range of individual components or a complete gas generator and/or rotors, or a combination of both, shall be dictated by the required plant availability.

In some cases, holding a complete spare gas generator may be more economical in the longer term than holding individual components.

Alternatively, it may be advantageous to share gas generators or spare rotors with other users or to enter into a procurement initiative whereby the Manufacturer/Supplier stocks the parts and guarantees immediate availability.

If service centres are locally available and are prepared to maintain an adequate level of spares in stock, a smaller spares inventory may be required.

Spare gas generators and/or rotors shall be stored in nitrogen-pressurised metal containers. The pressurised containers shall be supplied as original equipment by the gas turbine Manufacturer/Suppliers.

Procurement of additional operational spares should be considered for gas turbines located in regions, locations or countries, where quick access to parts and services by Manufacturer/Suppliers can be challenging (e.g. Iraq). This requirement should be stated in the enquiry requisition data sheet in consultation with the Principal.

## 2.6 COMPLETE UNIT RESPONSIBILITY

The complete unit, i.e. gas turbine, driven equipment and all auxiliary equipment, including lubrication, control and instrumentation systems, shall be ordered from one responsible party.

For a mechanical drive configuration this shall be the driven equipment Manufacturer. Where agreed, by mutual agreement with the Principal, the driver Manufacturer/Supplier may be responsible for the total train.

For an electrical generator drive configuration a complete package may be ordered from the gas turbine Manufacturer, or from a packager or its associates, who have been approved for this purpose by the Principal.

### 3. TYPE SELECTION

#### 3.1 GENERAL

There are two types of combustion gas turbine:

- Industrial combustion gas turbines, designated Type H by the API, and
- Aero-derivative gas turbines, designated Type G by the API.

The choice for an industrial gas turbine or an aero-derivative gas turbine shall be based on the total cost of ownership evaluation. The latter should not be excluded if allowable mass and available space is limited, such as in offshore or oil field applications.

Fully packaged, modular and / or trailer mounted Gas Turbine and Control units shall require special consideration for use in challenging locations, such as Iraq, where 'on-site' construction activity is required to be minimized. This requirement should be stated in the enquiry requisition data sheet in consultation with the principal.

The reliability and availability of the specific gas turbine under consideration shall be key criteria for determining the plant on-stream time and the total cost of ownership.

If the gas turbine fuel may be a crude oil, residual fuel oil, or a gas that is subject to changes of Wobbe Index of more than 20%, then industrial gas turbines shall be specified.

In the case of a mechanical drive application, an industrial gas turbine shall be the preferred selection. The selection of a two-shaft industrial gas turbine, if available in the power range, shall be made.

For generator drives, a single-shaft industrial gas turbine shall be preferred, since the greater inertia inherent in this type gives improved grid stability and it is simpler and more easily maintained. However, if based on TCoO evaluation, an aero-derivative gas turbine is the best choice or a multi shaft design the only available design, the grid stability shall be analysed against the gas turbine control response capabilities.

Recuperative (regenerative) gas turbines should only be considered if the selected recuperative heat exchanger has proven reliable in similar applications. With the increasing need for environmentally friendly operation and optimum efficiency, waste heat recovery from the hot gas for steam generation or process heating should be considered. It shall be ensured that failure of the waste heat recovery unit and/or its control system does not adversely affect process or power reliability and availability.

#### 3.2 SITE-RATED POWER

The site conditions of elevation, humidity and ambient temperature shall be taken into consideration together with the type of fuel (gas/liquid) and combustors and the power requirements of the driven equipment in order to arrive at a realistic site-rated power (rating) of the gas turbine.