

DEP SPECIFICATION

**GAS TURBINES FOR THE PETROLEUM, CHEMICAL, AND
GAS INDUSTRY SERVICES
(AMENDMENTS/SUPPLEMENTS TO API STD 616)**

DEP 31.29.70.31-Gen.

February 2014

DESIGN AND ENGINEERING PRACTICE

DEM1



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These views are based on the experience acquired during involvement with the design, construction, operation and maintenance of processing units and facilities. Where deemed appropriate DEPs are based on, or reference international, regional, national and industry standards.

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PART I INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for gas turbines for the petroleum, chemical, and gas industry services.

This DEP is based on API 616, Fifth Edition, January 2011. Part III of this DEP amends, supplements and deletes various clauses of API 616. Part III follows the clause numbering of API 616 for easy reference.

All clauses of API 616 not modified by this DEP remain valid as written.

This DEP contains mandatory requirements to mitigate process safety risks in accordance with Design Engineering Manual (DEM) 1 – Application of Technical Standards.

This is a revision of the DEP of the same number dated February 2013; see (1.5) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them. Any authorised access to DEPs does not for that reason constitute an authorization to any documents, data or information to which the DEPs may refer.

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

When DEPs are applied, a Management of Change (MOC) process shall 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.

NOTE: In API STD 616, the term **Vendor** is used. In this DEP, the term **Vendor** shall be understood to mean the Manufacturer/Supplier.

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.

NOTE: In API STD 616, the term **Purchaser** is used. In this DEP, the term **Purchaser** shall be understood to mean the Principal.

The word **shall** indicates a requirement.

The capitalised term **SHALL [PS]** indicates a process safety requirement.

The word **should** indicates a recommendation.

1.4 CROSS-REFERENCES

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

1.5 SUMMARY OF MAIN CHANGES

This DEP is a minor revision of the DEP of the same number dated February 2013. The following are the main, non-editorial changes.

Section/Clause	Change
All	This DEP has been updated to include requirements from DEP 31.29.70.32-Gen. As a result, DEP 31.29.70.32-Gen. can be retired with the publication of Version 38.
All	This version will now align better with API STD 616.
Part III	no SHALL [PS] statements were modified for this version
Part III, 4.10.6	added new clause on Gaskets
Part III, 5.2.1.2	added new clause
Part III, 5.2.2.4	added new clause
Part III, 5.6.1.4	replace units
Part III, 5.6.1.7	add to this clause
Part III, 5.6.1.8	add to this clause
Part III, 5.4.1.9	Removed SHALL [PS]
Part III, 5.6.1.10	add subclauses
Part III, 5.6.1.11	replace years
Part III, 5.6.1.14	delete words
Part III, 5.6.1.15	replace clauses
Part III, 5.6.1.19	add to this clause
Part III, 5.6.1.20	add subclauses
Part III, 5.6.1.23	added new clause
Part III, 5.6.2.1.3	added subclauses
Part III, 5.6.2.1.4	added subclauses
Part III, 5.6.2.1.6	added sentence
Part III, 5.6.2.1.7	added subclauses
Part III, 5.6.2.1.8	replace words and added subclauses
Part III, 5.6.2.1.9	added to the clause
Part III, 5.6.2.2	added to clause
Part III, 5.6.2.3	added to clause
Part III, 5.6.2.4	added to clause
Part III, 5.6.2.5	added to clause
Part III, 5.6.2.6	added to subsections
Part III, 5.6.3.1.5	added subclauses

Section/Clause	Change
Part III, 5.6.3.2.3	delete words
Part III, 5.6.3.4	added new clause
Part III, 5.6.3.5	added new clause
Part III, 5.6.3.6	added new clause
Part III, 5.6.3.7	added new clause
Part III, 5.6.3.8	added new clause
Part III, 5.7.1.1	added to this clause
Part III, 5.7.1.2	added new subclauses
Part III, 5.7.1.4	added new clause
Part III, 7.2.3	Updated the reference table
PART IV	added several new American British, European and International Standards
Appendix 1	Section 9 within the table, added 6 rows about air filter system.
Appendix 3	added new appendix titled "Filter selection recommended configurations"

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be submitted to the Administrator using one of the following options:

Shell DEPs Online (Users with access to Shell DEPs Online)	Enter the Shell DEPs Online system at https://www.shelldeps.com Select a DEP and then go to the details screen for that DEP. Click on the "Give feedback" link, fill in the online form and submit.
DEP Feedback System (Users with access to Shell Wide Web)	Enter comments directly in the DEP Feedback System which is accessible from the Technical Standards Portal http://swwww.shell.com/standards . Select "Submit DEP Feedback", fill in the online form and submit.
DEP Standard Form (Other users)	Use DEP Standard Form 00.00.05.80-Gen. to record feedback and email the form to the Administrator at standards@shell.com .

Feedback that has been registered in the DEP Feedback System by using one of the above options will be reviewed by the DEP Custodian for potential improvements to the DEP.

1.7 DUAL UNITS

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

1.8 NON NORMATIVE TEXT (COMMENTARY)

Text shown in italic style in this DEP indicates text that is non-normative and is provided as explanation or background information only.

Non-normative text is normally indented slightly to the right of the relevant DEP clause.

PART II GENERAL

Part III of this DEP is written in the form of amendments and supplements to API 616, Fifth Edition, January 2011. Wherever reference is made to API 616, it shall be understood to mean API 616 as amended/supplemented by this DEP.

For ease of reference, the clause numbering of API 616 has been used throughout Part III of this DEP.

Clauses in API 616 which are not mentioned shall remain valid as written.

A bullet (•) in the margin against certain clauses (paragraphs) in API 616 indicates that a decision by the Principal is required. This DEP addresses the decisions required by most of the API 616 bullet clauses. The remaining decisions shall be indicated directly on the relevant data/requisition sheet 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.

PART III AMENDMENTS/SUPPLEMENTS TO API 616

1 Scope

1.1 General

Replace this clause with:

This standard covers the minimum requirements for:

- Open, simple and regenerative cycle combustion gas turbine units for mechanical drives or generator drives.
- Industrial gas turbines, modular or aeroderivative gas turbines.
- Land based, offshore and mobile trailer mounted gas turbine units.

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

1.2 Alternative Designs

Add to this clause:

Alternative designs require Principal approval.

1.3 Conflicts

Replace this clause with:

In the event of conflict between documents relating to the inquiry or purchase order, the following hierarchy of documents shall apply:

- First level : Local rules and regulations
- Second level : Purchase order and variations thereto
- Third level : Data/requisition sheets and drawings
- Fourth level : SPEP (if applicable)
- Fifth level : This DEP
- Sixth level : API 616, Fifth Edition, January 2011

Any apparent conflict between the requirements of this DEP and any other relevant document in the purchase order shall be notified to the Principal for clarification purposes.

2 References

2.1 Normative References

Add to this clause:

The additional standards referred to in this DEP are listed in (Part IV).

3 Terms, Definitions, Acronyms, Abbreviations, and Symbols

3.55 *Replace this clause with:*

Site rated power: The shaft power developed by the gas turbine when it is operated in a new and clean condition, including clean air filters and air compressor at site rated firing temperature, rated speed and site conditions of air inlet temperature, air 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.

3.61 Trip speed

Add to this clause:

For multi shaft engines, 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.

For single shaft engines the turbine trip speed shall be mutually agreed between the Vendor and the Principal.

Add the following definitions:

3.66 Single-shaft industrial type 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.

3.67 Two-shaft industrial type 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.

3.68 Multi-shaft aeroderivative type gas turbine

3.68.1 Two-shaft arrangement consisting of:

- Gas generator (GT air compressor coupled to HP turbine stage) plus a free running power turbine driving the load; or
- Gas generator (GT HP air compressor coupled to HP turbine stage) plus a power turbine driving the GT LP compressor stage and the load

3.68.2 Triple-shaft arrangement consisting of:

- 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
- 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: 1) GT: Gas Turbine
2) HP: High Pressure
3) IP: Intermediate Pressure
4) LP: Low Pressure

3.69 Heavy duty gas turbine

This gas turbine is designed originally for the large power industry as a single shaft turbine; including the two-shaft designs derived from it.

3.70 Light duty gas turbines

This gas turbine is designed for power generation and/or mechanical drive applications for industries other than the power industry, and is mainly available as two-shaft designs; some designs are also available in single or multi-shaft.

3.71 Aeroderivative gas turbines

This gas turbine design is derived from the flight engine industry, whereby the fan is replaced by a power turbine for driving a load, for some designs plus air booster.

3.72 Hybrid gas turbines

This gas turbine design combines industrial and aeroderivative technologies in to a multi-shaft design gas turbine.

4 Basic Design

4.1 General

4.1.5 *Replace the second sentence of this clause with:*

Where only one operating speed is specified for an application, the speed range for single shaft machines shall be mutually agreed between the Vendor and the Principal, and the speed range for two or more shaft machines shall be 55 % (from 50 % to 105 % of rated speed).

4.1.6 *Add to this clause:*

This period between major overhauls, when running on natural gas fuel, at base load, shall be at least:

- 48,000 hours for heavy duty gas turbines
- 32,000 hours for light industrial gas turbines
- 25,000 hours for aeroderivative gas turbines

4.1.7 *Replace in this clause in the third sentence the word "purchaser" with the word "Principal"*

4.1.8 *Add to this clause:*

In order to meet the requirements specified in the requisition data sheets, proven NO_x, CO and SO_x reduction measures shall be applied. Dry low emission combustors or catalytic combustors of proven design shall be used for emission reduction. Only if even greater emission reduction is required should additional systems in the GT exhaust be considered.

4.1.9 *Add to this clause:*

In case of water/steam injection application, the Vendor shall include in his proposal the impact on maintenance intervals.

4.1.10 *Add to this clause the following new clauses:*

4.1.10.1 The maximum sound pressure level at 1 m (3 ft) distance of all equipment shall be 85 dB(A).

4.1.10.2 The Vendor shall submit with the tender guaranteed sound power levels and sound pressure levels of the equipment, together with any other relevant information as requested in the data sheet, DEP 31.10.00.94-Gen. The Manufacturer shall indicate what special silencing measures, if any, are proposed in order to meet the specified levels.

4.1.10.3 If noise enclosures are supplied, full and easy access to the equipment for maintenance purposes shall be ensured by means of an appropriate design.

4.1.14 *Replace this clause with:*

All electrical components and installations SHALL [PS] be suitable for Zone 2, Gas Group II (Class I, Group D, Div. 2) or the area classification and grouping as specified in the requisition, whichever is more stringent.

4.1.18 *Delete in this clause in the third paragraph the word "If specified"*

4.1.21 *Add to this clause:*

Flat rating of gas turbines, i.e., allowing for a constant power irrespective of ambient temperature, by compensating the increased firing temperatures at high ambient temperatures with reduced firing temperatures at low ambient temperatures, is not permitted.

Add new clause:

4.1.24 A gas turbine or its flange to flange 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, require approval of the Principal.

4.2 Pressure Casings

4.2.4 *Replace second sentence of this clause with:*

Casing designs and/or guard designs SHALL [PS] be provided to contain all blade-off events and the subsequent collateral damage, but not disk burst or overhung shaft failure.

4.2.8 *Add to this clause:*

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.

4.3 Combustors and Fuel Nozzles

4.3.2 *Delete NOTE*

4.3.3 *Add to this clause:*

For viscous liquid fuels, preference shall be given to air atomisation.

4.3.4 *Replace this clause with:*

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 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.

Add new clauses:

4.3.8 If 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 Vendor shall provide a full description of the system proposed.

4.3.9 For engines that require in situ combustion liner exchange, the combustion chamber liners shall be replaceable without the removal of major casing components.

4.4 Casing Connections

4.4.5 *Add to this clause:*

All piping and tubing less than 20 mm (3/4 in) shall be clearly indicated in the manufacturer's proposal for review and approval of the Principal.

4.4.5.1 *Add to this clause:*

Cast iron flanges shall only be used in case it is an integral part of the component. In piping systems, no cast iron flanges are allowed.

Add new clause:

4.4.8 Flanged drain connections shall be provided, appropriately positioned for the removal of spent crank soak washing liquids and any accumulated liquid fuel.

4.5 Rotating Elements

4.5.1 Shafts

4.5.1.1 *Add to this clause:*

On gas turbines for generator drives, rotors SHALL [PS] be mechanically designed to withstand safely and without failure the transient torque produced in the event of a generator short circuit. The transient torque considered shall not be less than 600 % of full-load torque. Out-of-phase synchronisation shall also be considered in the design of the rotating components.

4.5.2 Rotors

Add new clauses:

4.5.2.4 If a number of gas turbines are ordered, all of the same rating, all rotors shall be interchangeable.

4.5.2.5 The rotor, excluding blading shall have a design life in excess of 200,000 hours at rated turbine inlet temperature and speed.

4.5.3 Disk and Blading

4.5.3.1 *Add to this clause:*

Rubbing shall not affect the internal cooling and sealing air flows or cause hot gas bypasses around components such that turbine operation must be discontinued.

Add new clauses:

4.5.3.6 For aero-derivative gas turbines, power turbine blading and nozzles shall have a design life in excess of 100,000 hours at the rated turbine inlet temperature and speed.

4.5.3.7 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.

4.6 Seals

Add new clause:

4.6.3 Air-buffered seals shall be provided wherever there is a risk that hot combustion products may enter bearings or other components containing lubricants. The Manufacturer shall include in his supply any coolers that may be required for the sealing air. Placing the coolers in the combustion air intake is not permitted.

4.7 Dynamics

4.7.2 Lateral Analysis

4.7.2.2 *Add to this clause:*

The critical speed and separation margin values resulting from the most unfavourable combination of the parameters under (4.7.2.4) shall be used to verify compliance with the criteria in (4.7.2.15).

4.7.2.4 *Add new item k):*

k) The intention to use damper bearings (generic term for any viscous damping element, whether located in series with the bearing or elsewhere on the shaft) shall be identified in the proposal.

- If damper bearings are applied, the Supplier shall provide damped unbalance response and stability analyses comparing the dynamic behaviour of the rotor-bearing system with and without the damper functioning.
- With the damper bearings not functioning, API 616 Sections 2.6 and 6.3.4 shall be met.
- The Supplier shall provide design, construction details and rotordynamic coefficients of the proposed damper bearings for review.
- For damper bearing designs where O-rings are used, the O-ring shall be designed to function solely as a sealing element. The rotor weight shall be supported by other means.
- The Manufacturer shall supply an experience list of damper bearings of similar type and size that have been used on similar sizes of machines, bearing spans, and operating speeds.