

PETRONAS TECHNICAL STANDARDS

DESIGN AND ENGINEERING PRACTICE

COMBUSTION GAS TURBINES – SELECTION, TESTING AND INSTALLATION

PTS 31.29.70.11

DECEMBER 2010



© 2010 PETROLIAM NASIONAL BERHAD (PETRONAS)

All rights reserved. No part of this document may be reproduced, stored in a retrieval system or transmitted in any form or by any means (electronic, mechanical, photocopying, recording or otherwise) without the permission of the copyright owner

PTS Circular 2010 – 31.29.70.11



PTS No:	31.29.70.11
PTS Title:	Combustion Gas Turbine – Selection, Testing and Installation

This PTS 31.29.70.11- Combustion Gas Turbine – Selection, Testing and Installation has been updated and has incorporated PETRONAS Lessons Learnt, Best Practice and new information issued by relevant industry code and standards. This PTS is still valid and with editorial changes only.

The previous version of this PTS 31.29.70.11 (December 1998) will be removed from PTS binder / e-repository from herein onwards.

The custodian of this PTS is:

Name: Zaharudin Ariffin

Tel. No: 03-2783 6231

Please direct any questions regarding this PTS to the above-named.

Document Approval

	Name	Designation	Date	Signature
Prepared/ Reviewed	Zaharudin Ariffin	Principal Engineer, Engineering, GTS	01/12/10	
Reviewed/ Approved	MK Shrivastava	Custodian Engineer Engineering, GTS	01/12/10	
Verified	Pau Kiew Huai	General Manager, Engineering, GTS	2/12/10	
Endorsed	Sazali Hamzah	Senior General Manager, GTS	10/12/10	

Revision History

Date	Version	Description of Updates	Author
Mar 1985	0		
Dec 1998	1		
Dec 2010	2	Periodic Review	ZA

PREFACE

PETRONAS Technical Standards (PTS) publications reflect the views, at the time of publication, of PETRONAS OPU/Divisions.

They are based on the experience acquired during the involvement with the design, construction, operation and maintenance of processing units and facilities. Where appropriate they are based on, or reference is made to, national and international standards and codes of practice.

The objective is to set the recommended standard for good technical practice to be applied by PETRONAS' OPU/Divisions in oil and gas production facilities, refineries, gas processing plants, chemical plants, marketing facilities or any other such facility, and thereby to achieve maximum technical and economic benefit from standardization.

The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where PTS may not cover every requirement or diversity of condition at each locality. The system of PTS is expected to be sufficiently flexible to allow individual operating units to adapt the information set forth in PTS to their own environment and requirements.

When Contractors or Manufacturers/Suppliers use PTS they shall be solely responsible for the quality of work and the attainment of the required design and engineering standards. In particular, for those requirements not specifically covered, it is expected of them to follow those design and engineering practices which will achieve the same level of integrity as reflected in the PTS. If in doubt, the Contractor or Manufacturer/Supplier shall, without detracting from his own responsibility, consult the owner.

The right to use PTS rests with three categories of users:

- 1) PETRONAS and its affiliates.
- 2) Other parties who are authorized to use PTS subject to appropriate contractual arrangements.
- 3) Contractors/subcontractors and Manufacturers/Suppliers under a contract with users referred to under 1) and 2) which requires that tenders for projects, materials supplied or - generally - work performed on behalf of the said users comply with the relevant standards.

Subject to any particular terms and conditions as may be set forth in specific agreements with users, PETRONAS disclaims any liability of whatsoever nature for any damage (including injury or death) suffered by any company or person whomsoever as a result of or in connection with the use, application or implementation of any PTS, combination of PTS or any part thereof. The benefit of this disclaimer shall inure in all respects to PETRONAS and/or any company affiliated to PETRONAS that may issue PTS or require the use of PTS.

Without prejudice to any specific terms in respect of confidentiality under relevant contractual arrangements, PTS shall not, without the prior written consent of PETRONAS, be disclosed by users to any company or person whomsoever and the PTS shall be used exclusively for the purpose they have been provided to the user. They shall be returned after use, including any copies which shall only be made by users with the express prior written consent of PETRONAS.

The copyright of PTS vests in PETRONAS. Users shall arrange for PTS to be held in safe custody and PETRONAS may at any time require information satisfactory to PETRONAS in order to ascertain how users implement this requirement.

TABLE OF CONTENTS

1.	INTRODUCTION	6
1.1	SCOPE.....	6
1.2	DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS.....	6
1.3	DEFINITIONS.....	6
1.4	CROSS-REFERENCES.....	7
2.	GENERAL REQUIREMENTS	8
2.1	SELECTION AND EVALUATION.....	8
2.2	RANGE AND VARIETY OF GAS TURBINES.....	8
2.3	PROTOTYPE GAS TURBINES.....	8
2.4	OPERATING REQUIREMENTS.....	8
2.5	SPARES INVENTORY.....	8
2.6	COMPLETE UNIT RESPONSIBILITY.....	9
3.	TYPE SELECTION	10
3.1	GENERAL.....	10
3.2	SITE-RATED POWER.....	10
3.3	STANDARD PACKAGES.....	111
4.	INSTALLATION	12
5.	NOISE LEVELS	144
5.1	LIMITS.....	144
5.2	INFORMATION TO BE SUBMITTED WITH THE TENDER.....	144
5.3	GENERAL.....	144
6.	OIL TANK VENTS	155
7.	MATERIALS	166
7.1	GENERAL.....	166
7.2	MATERIALS CERTIFICATION.....	166
8.	STARTING DRIVES	177
8.1	GENERAL.....	177
8.2	GAS EXPANSION STARTERS.....	177
8.3	HYDRAULIC MOTORS.....	177
8.4	DIESEL ENGINES.....	177
9.	FOUNDATIONS, BASEPLATES AND MOUNTINGS	188
10.	CONTROLS AND INSTRUMENTATION	19
10.1	GENERAL.....	199
10.2	CONDITION MONITORING SYSTEM.....	199
11.	INLET AND EXHAUST SYSTEMS	20
11.1	AIR INTAKE SYSTEM.....	20
11.2	EXHAUST SYSTEM.....	20
11.3	EXHAUST EMISSION.....	21
12.	COMBUSTION AIR FILTRATION	222
12.1	GENERAL.....	222
12.2	ANTI-ICING SYSTEMS.....	222
12.3	SHUTTERS.....	233
13.	FIRE PROTECTION	244
13.1	GENERAL.....	244
13.2	VENTILATION DAMPERS.....	244
13.3	EXTINGUISHING SYSTEMS.....	244
13.4	ENCLOSURE SURVEILLANCE.....	244
14.	ACOUSTIC ENCLOSURES	255
14.1	GENERAL.....	255
14.2	ACCESSIBILITY.....	255

14.3	VENTILATION.....	255
14.4	AREA CLASSIFICATION WITHIN ACOUSTIC ENCLOSURES	266
15.	FUELS AND FUEL SYSTEMS	277
15.1	FUEL SELECTION.....	277
15.2	GAS FUELS AND SYSTEMS	277
15.3	LIQUID FUELS AND SYSTEMS.....	288
15.4	DUAL FUEL SYSTEMS	288
15.5	POWER AUGMENTATION.....	288
16.	INSPECTION AND TESTS	299
16.1	GENERAL	299
16.2	TEST REQUIREMENTS	299
17.	REFERENCES	30

APPENDICES

APPENDIX 1	DEFINITIONS AND EXAMPLES OF VITAL, ESSENTIAL AND NON-ESSENTIAL SERVICES	322
APPENDIX 2	GAS TURBINE ENCLOSURE VENTILATION	333
APPENDIX 3	TYPICAL ARRANGEMENT FOR BOLTING BASEPLATE TO FOUNDATION	344
APPENDIX 4	EXHAUST STACK RAIN CATCHER.....	355
APPENDIX 5	GAS TURBINE WASHING	366

1. INTRODUCTION

1.1 SCOPE

This PTS specifies requirements and gives recommendations for the type selection, testing and installation of combustion gas turbines for mechanical and generator drives and for hot gas generation.

This PTS is a revision of the PTS of the same number dated December 1998.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by PETRONAS, the distribution of this PTS is confined to companies forming part of or managed by PETRONAS, and to Contractors and Manufacturers/Suppliers nominated by them (i.e. the distribution code is "C", as defined in PTS 00.00.05.05).

This PTS is intended for use in oil refineries, chemical plants, gas plants and, where applicable, in exploration and production facilities.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this PTS the Contractor shall determine by careful scrutiny which of the requirements are the 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 PTS 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 PTS as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party which 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/Vendor** is the party which manufactures or supplies the turbine and provides associated back-up services to perform the duties specified by the Contractor.

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

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.: - automatic starts and stops at intervals by process operated controls; - manual starts and stops at intervals by manual control for batch processes.
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. 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 PTS 31.29.60.30 and PTS 31.29.60.31.

1.4 CROSS-REFERENCES

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

2. GENERAL REQUIREMENTS

2.1 SELECTION AND EVALUATION

The selection of gas turbines and the technical evaluation of bids from gas turbine Vendors shall be based on the requirements of this PTS together with PTS 31.29.70.31.

PTS 31.29.70.31 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.

Since there is continuing development in gas turbine design and improvement of efficiency, care should be taken to ensure that prospective Vendors 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 particularly 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.

Vendor shall be responsible for conducting the air quality assessment and the resultant required adaptation of the filter design.

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.

This rationalisation shall be applied stringently provided it does not prevent selection of the most suitable gas turbine for the specified operating conditions and does not increase the total cost of ownership (TCO).

2.3 PROTOTYPE GAS TURBINES

Selected equipment shall in all respects be within the range of the Manufacturer's proven experience and shall not involve the use of prototype designs or components.

The development of gas turbines is largely centred on the development of hot parts and their thermal capabilities. Specific focus is therefore required on the Manufacturer's experience of these parts and the proposed firing temperature.

The Vendor shall list in his proposal all changes which are not proven in similar machines produced over the last 5 years or with which less than 100 000 fired hours have been accumulated in all machines.

Any change is subject to Principal's acceptance and proven alternatives may be requested.

2.4 OPERATING REQUIREMENTS

All particular 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. Special attention shall be given to 'off-design' conditions which may occur during start-up and shutdown procedures associated with the particular applications of the gas turbine. The exhaust mass flow and temperature under part-load conditions are important considerations for gas turbines in combined heat and power installations, 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, will 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 could be worthwhile to share gas generators or spare rotors with other users or to enter into a procurement initiative whereby the Vendor 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 necessary.

Spare gas generators or rotors shall be stored in nitrogen-pressurised metal containers. The pressurised containers are supplied as original equipment by the gas turbine Vendors.

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. By mutual agreement with the Principal, the driver Vendor 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.

As a general rule for process applications, the industrial gas turbine is preferred to the aero-derivative gas turbine. The latter should not be excluded if the total cost of ownership is expected to be lower or if allowable mass and available space are limited, such as in offshore or oil field applications. 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.

Aero-derivative gas turbines require premium gas and liquid fuels. If the gas turbine fuel may be a crude oil, residual fuel oil, very lean gas, refinery mix gas or a gas that is subject to changes of Wobbe Index of more than 10%, then industrial gas turbines shall be specified.

For mechanical drive applications where a wide range (70% to 100%) speed control is required, the selection of a two-shaft industrial gas turbine, if available in the power range, shall be given preference.

For generator drives, a single-shaft industrial gas turbine should be selected, since the greater inertia inherent in this type gives improved frequency stability and it is simpler and more easily maintained.

The use of aero-derivative or two-shaft industrial gas turbines as generator drives requires careful matching of governor and alternator characteristics in order to achieve satisfactory frequency stability. A load co-ordination study should be undertaken before proceeding with such applications.

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.

Apart from the ambient condition deratings, the 'site rating' should be adequate to cover losses due to:

API 617 power margin for centrifugal compressors	4%
Unrecoverable gas turbine losses	
• air compressor fouling	2%
• ageing	3%
Inlet system (including air filter) and outlet losses (each)	2%
Waste heat recovery units in exhaust	2%
Main gearbox	2%
Driven auxiliaries (normally included in the ISO rating)	

Note: For process compressors in a fouling duty, additional margin may be required to cover future efficiency losses.

As a general rule there shall be a power output margin of at least 10% between the demand of the driven equipment and the power of the on-site gas turbine when in new and clean condition to cover fouling, wear and tear and control margin. Note that the power extracted by the auxiliaries, directly driven from the gas turbine, is not always included in the Vendor's standard information sheets.

Having established the site rating for the gas turbine, the ISO rating of the gas turbine can be calculated to serve as a guide for comparing the available makes and models of the gas turbine type suitable for the application.

ISO ratings of the various makes and models shall be clearly correlated with the load envisaged, since Manufacturers tend to indicate different ratings for base load, peak load, reserve peak load etc., in combination with gas or liquid firing, sometimes also with a reduced lifetime for gas turbine blading and components in the hot gas path.

A flat rating, where the power output offered is independent of ambient temperature, is not acceptable. Flat rating offered by some Vendors assumes a constant power output irrespective of ambient temperature, compensating for the increased firing temperatures at high ambients by reduced firing temperatures at low ambient. The life of a gas turbine is determined by the creep life of critical hot parts which decreases rapidly with cumulative operating hours at the highest firing temperature.

3.3 STANDARD PACKAGES

Gas turbines are generally offered as standard packaged prime movers developing a rated power at a rated speed, and are not normally custom-built to meet the user's particular power requirements.

API RP 11 PGT gives general requirements and limitations in applying these standard turbine designs.