

PETRONAS TECHNICAL STANDARDS

DESIGN AND ENGINEERING PRACTICE

RECIPROCATING COMPRESSORS (AMENDMENTS/ SUPPLEMENTS TO API 618)

PTS 31.29.40.31

NOVEMBER 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 – 31.29.40.31



PTS No:	31.29.40.31
PTS Title:	Reciprocating Compressors (Amendments/ Supplements to API 618)

This PTS 31.29.40.31- Reciprocating Compressors (Amendments/ Supplements to API 618) 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 31.29.40.31 (December 1999) will be removed from PTS binder / e-repository from herein onwards.

The custodian of this PTS is:

Name: Uppala Sivarama Krishnaiah

Tel. No: 03-2783 6637

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

Document Approval

	Name	Designation	Date	Signature
Prepared/ Reviewed	Uppala Sivarama Krishnaiah	Staff Engineer, Engineering, GTS	26/11/10	
Reviewed	Ir. M Nizam Ab Wahab	Principal Engineer, Engineering, GTS	26/11/10	
Reviewed/ Approved	MK Shrivastava	Custodian Engineer Engineering, GTS	26/11/10	
Verified	Pau Kiew Huai	General Manager, Engineering, GTS	30.11.10	
Endorsed	Sazali Hamzah	Senior General Manager, GTS	03/12/10	

Revision History

Date	Version	Description of Updates	Author
May 1988	0		
Dec 1999	1		
Nov 2010	2	Periodic Review	USK

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' OPUs 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

PART I	INTRODUCTION	5
1.1	SCOPE.....	5
1.2	DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS.....	5
1.3	DEFINITIONS	5
1.4	CROSS-REFERENCES.....	5
PART II	GENERAL INFORMATION	6
PART III	AMENDMENTS/SUPPLEMENTS TO API 618	8
1.	GENERAL	8
2.	BASIC DESIGN	8
3.	ACCESSORIES	22
4.	INSPECTION, TESTING, AND PREPARATION FOR SHIPMENT	31
5.	VENDOR'S DATA	33
APPENDIX D	REPAIRS TO GRAY AND NODULAR IRON CASTINGS	34
APPENDIX H	MATERIAL SPECIFICATIONS FOR MAJOR COMPONENT PARTS	35
APPENDIX I	FIGURES AND SCHEMATICS	36
PART IV	REFERENCES	37

APPENDICES

APPENDIX 1	DISTANCE PIECE VENTING AND DRAINING FOR ARRANGEMENTS C and D	40
------------	---	----

PART I INTRODUCTION

1.1 SCOPE

This PTS specifies requirements and gives recommendations for reciprocating compressors.

Excluded from the scope of this PTS are air-cooled utility air ("tool air") compressors that discharge at 8.6 bar (ga) or below.

This PTS is based on API 618, fourth edition, June 1995. Part III of this PTS amends, supplements and deletes various clauses of API 618.

This PTS is a revision of the PTS of the same number dated May 1988.

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 PETRONAS or managed by a Group company, and to Contractors and Manufacturers nominated by them (i.e. the distribution code is "F", as defined in PTS 00.00.05.05).

This PTS is intended for use in oil refineries, chemical plants, gas plants and 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, environmental, 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

For the purposes of this PTS the following definitions shall apply:

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

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

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

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

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 (Part IV).

PART II GENERAL INFORMATION

This PTS is written in four parts, of which Part III gives amendments and supplements to API 618, fourth edition, June 1995. Wherever reference is made to API 618, it shall be understood to mean API 618 as amended/supplemented by this PTS.

For ease of reference, the clause numbering of API 618 has been used throughout Part III of this PTS. Clauses in API 618 which are not mentioned remain valid as written.

A bullet (•) in the margin against certain clauses in API 618 indicates that a decision by the Principal is required. This PTS addresses the decisions required by many of the API 618 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 618

1. GENERAL

1.3 CONFLICTING REQUIREMENTS

Replace this clause by:

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

- upper level : purchase order and variations thereto;
- second level : data/requisition sheets and drawings;
- third level : this PTS.

1.4 DEFINITIONS OF TERMS

Add new term:

1.4.38 Hazardous service

Hydrogen service and very toxic service.

Add new term:

1.4.39 Hydrogen service

All process conditions with a hydrogen partial pressure greater than 0.7 MPa (7 bar (abs)).

Add new term:

1.4.40 Very toxic service

service with substances that are very hazardous for the environment or human health, as specified in PTS 01.00.01.30 (which also identifies "toxic" substances by reference to chemical substances databases)

1.5 REFERENCED PUBLICATIONS

1.5.1 *Add to this clause:*

Standards referenced by this PTS are listed in (Part IV).

2. BASIC DESIGN

2.1 GENERAL

2.1.1 *In the first sentence, delete the word "expected"*

Add to this clause:

If the Vendor proposes to supply prototype equipment then the quotation shall state that the offered equipment is a prototype and it shall be accompanied by sufficient data for the Principal to thoroughly investigate its suitability for the intended duty.

NOTE: Equipment is not considered to be prototype if at least 3 units of similar type and size have each accumulated an uninterrupted operating time of at least 8000 hours in a duty similar to that pertaining to the enquiry in question.

2.1.2 *Replace this clause by:*

2.1.2.1 Noise Control

The Contractor shall comply with PTS 31.10.00.31 and thereby communicate to the Manufacturer the specified equipment noise limitations by using data sheet PTS 31.10.00.94, which forms part of the requisition. The Manufacturer is responsible for assuring that these equipment noise limitations have been specified.

2.1.2.2 Information to be submitted with the tender

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

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

2.1.3 *Replace the first sentence of this clause by:*

Unless otherwise specified in the data/requisition sheets, liquid-cooling systems for lube oil, cylinders and piston rod packing shall be designed for the following conditions on the coolant side:

Modify in this clause:

Fouling factor on the coolant side: 0.25 m².K/kW

2.1.4 *Add to this clause:*

The application of variable speed drive systems (VSDs) requires the approval of the Principal.

2.1.5 *Replace this clause by:*

All equipment shall be designed to run safely to the relief valve setting including accumulation (see also 3.6.4.5).

2.1.7 *Replace this clause by:*

All electrical components and installations shall be suitable for the area classification, gas grouping and temperature classes specified by the Principal in the data/requisition sheets.

2.1.8 *Replace the word "minimise" by the word "prevent"*

2.1.11 *Replace the first sentence of this clause by:*

The combined performance of the compressor and its driver under all operating conditions shall be the responsibility of the Vendor. The combined unit (or complete package, if applicable) shall perform substantially as well on its permanent foundation as it did on the Manufacturer's test stand.

2.1.12 *Replace this clause by:*

The Purchaser will specify the equipment's normal operating point and all applicable other operating points such as start up, loading and unloading duration, regeneration. Due consideration of these operating points shall be taken when selecting valves.

Unless otherwise agreed by the Purchaser, negative tolerances shall not apply.

2.1.13 *Add to this clause:*

NOTE: In accordance with Appendix B, this power tolerance refers to the required power at Manufacturer's rated capacity.

2.1.14 *Replace the last sentence of this clause by:*

The unit and its auxiliaries shall be suitable for start-up, operation and periods of idleness under these specified conditions.

Add to this clause:

For compressors installed in unheated areas, entirely or partly exposed to the atmosphere, the following minimum requirements shall be provided for:

- (i) Dust-tight and water-tight enclosure of the crankcase and distance pieces, vented and purged when required.
- (ii) If winterising is required, the heating facilities should include crankcase, oil lines, lubricators and cooling liquid conduits, drains and vents.
- (iii) Complete drainage facilities of all cooling liquid spaces and lines.

2.1.15 *Add to this clause:*

The Vendor shall use SI units in the data sheets, in the proposal and in written guarantees regarding performance of the equipment.

Add new clause:

2.1.17 The complete compressor unit shall be able to withstand the effects of a fully loaded shutdown of the unit against the safety relief valve set pressure.

In the case of an electrical motor driver (either fixed or variable speed), the complete unit shall be able to withstand the effects of a 2-phase short circuit.

The complete unit shall be capable of a restart with full opposite residual voltage.

2.2 ALLOWABLE SPEEDS

Add to this clause:

Compressor speeds and corresponding average piston speeds shall be limited to the following values:

Installed power	Maximum compressor speed	Maximum average piston speed
150 kW and lower	500 r/min	5 m/s
150 - 250 kW	420 r/min	5 m/s
250 kW and higher	375 r/min	4 m/s

The average piston speed in compressors handling saturated hydrocarbon gases and in non-lubricated compressor cylinders shall not exceed 3.5 m/s.

The maximum speed of vertical labyrinth piston-type compressors shall be 420 r/min, irrespective of the installed driver power.

A "high speed compressor" may only be utilised for non-critical "oil field" applications in production areas, with a maximum discharge pressure of 80 bar (ga), and where the drive system would have to include a gear unit in order to adhere to the above-mentioned speed limits. The maximum allowable speed of a "high speed compressor" shall be 1000 r/min, with a maximum average piston speed of 4 m/s. The application of a "high speed compressor" is subject to the approval of the Principal.

2.3 ALLOWABLE DISCHARGE TEMPERATURE

2.3.1 *Replace the first two sentences of this clause by:*

The maximum predicted discharge temperature shall not exceed 140 °C. For non-lubricated service the maximum predicted discharge temperature shall not exceed 130 °C. These temperature limits do not apply to relief valve setting conditions or to labyrinth compressors.

These limits apply to all operating and load conditions.

2.3.2 *Replace the last sentence of this clause by:*

Air compressors and oxygen compressors shall not be (piston/packing) lubricated. This also applies to oxygen-bearing gases with an oxygen content of 21% volume or greater and to oxygen-bearing gases where the oxygen partial pressure is 10 bar or higher.

Add to this clause:

Each cylinder shall have its own dedicated temperature measuring point for alarm, and one for trip purpose, which shall be located as close as possible to the cylinder discharge valves.

2.4 ROD LOADINGS

2.4.1 In the last sentence, after the words "relief valve" add the words "(including the required over-pressure)".

Add to this clause:

In the proposal the basis for the Manufacturer's figure shall be provided, including details of related critical stress areas. (See 3.6.4.5 for relief valve set pressures).

2.4.4 *Add to the last sentence:*

"for all applicable loading steps."

2.5 CRITICAL SPEEDS

2.5.2 *Replace the first sentence of this clause by:*

For compressor units involving either a VSDS or a geared motor driver or turbine driver, the Vendor shall perform a torsional analysis of the complete compressor/(gear)/driver system.

Add to this clause:

If these separation margins cannot be met, the Vendor shall perform an additional response analysis in order to prove that the stress levels at resonance conditions are within well proven limits of the Manufacturer.

Additionally, for compressors with a VSDS, the Vendor shall perform a response analysis of the rotating system during all possible resonance conditions which may occur during run-up and within the complete operating speed range. All possible excitation frequencies and consequent torques shall be considered.

In every response analysis the resulting stresses in the relevant components shall be calculated using a maximum modal damping of 1%. (Modal damping is defined as the damping ratio between the total combined structural and material damping and the critical damping of the system under consideration).

In strength calculations the Manufacturer shall give due consideration to the combined effect of static stresses, alternating bending and torsional stresses as well as the effect of stress raisers, such as stress concentration factors and notch sensitivities. The Manufacturer shall indicate the most highly stressed locations in the system and the safety factor applied at these locations. Safety factors shall be clearly defined.

2.6 COMPRESSOR CYLINDERS

2.6.1.1 *Replace the second sentence of this clause by:*

The MAWP shall be at least equal to the specified relief valve setting plus required over pressure.

2.6.1.2 *Replace this clause by:*

Unless otherwise specified in the data/requisition sheet, horizontal cylinders shall be provided, which shall have top suction and bottom discharge.

When vertical cylinders are specifically allowed, e.g. for dry gases, these shall be designed so that complete drainage of the cylinder is possible.

2.6.1.4 *Replace this clause by:*

Step piston or tandem cylinder arrangements are not permitted.

Add new clause:

2.6.1.6 The cylinder bore diameter shall not exceed 800 mm.

2.6.2 CYLINDER APPURTENANCES

2.6.2.1 *Add to this clause:*

Piston rod run-out shall be measured directly adjacent to the cylinder packing case flange.

2.6.2.3 In the first sentence of this clause, delete the words "Unless otherwise specified,"

2.6.2.4 *Delete this clause.*

2.6.2.5 *Replace this clause by:*

The running bore of cylinder liners shall be between 0.2 and 0.6 μm Ra, whether lubricated or dry.

Note: Wear ring suppliers shall advise the required surface roughness to achieve maximum lifetime of the proposed rings.

2.6.2.6 *Delete this clause.*

2.6.2.7 *Add to this clause:*

Adequate clearance shall be provided to permit the use of torque wrenches, including multipliers for torque values over 300 Nm. If hydraulically tensioned studs are provided, a steel cover shall be fitted to protect the extended threaded stud end.

2.6.2.10 *Add to this clause:*

Studs threading for pressure retaining parts such as cylinder and valve port covers shall be rolled or ground.

2.6.2.11.2 *Replace this clause by:*

Cap screws shall not be used

2.6.2.11.4 *Add to this clause:*

the application of hydraulic bolt tensioning shall be possible for:

- class 1500 flanges, DN 150 and larger;
- class 2500 flanges, DN 100 and larger.

2.6.3.1.3 *Delete this clause.*

2.6.3.3 *Replace item (a) by:*

- a. Coolant inlet temperatures shall be maintained at least 6 K above the inlet gas temperature (and at least 10 K above the inlet gas temperature for wet and saturated gas). These limits do not apply to "bone dry" gases.

2.6.3.4 *Add to this clause:*

Cooling water jackets for once-through systems shall have removable covers of ample dimension for cleaning purpose.

2.6.3.5 *Replace this clause by:*

When specified in the data/requisition sheet, a self-contained, closed loop jacket coolant system shall be furnished. It shall meet the requirements of 2.6.3.5.1 through 2.6.3.5.4. The scope of supply shall be in accordance with, but not necessarily limited to, Figure G-1, Plan D, of Appendix G.

The coolant system shall be such that the temperature limits in 2.6.3.5.1 and 2.6.3.5.2 are met under all specified operating conditions, including start-up, shutdown and other transients. Coolant systems shall be designed in accordance with the limits of (2.1.3).

Add new clause:

2.6.3.5.4 Pumps in the cooling system shall be centrifugal pumps and shall be of the vertical close-coupled type, unless other types are approved in the data/requisition sheet. Pumps shall be in accordance with PTS 31.29.02.30

2.6.4 CYLINDER CONNECTIONS

2.6.4.2 *Replace this clause by:*

Studs shall be supplied. Cap screws shall not be used.

2.6.4.3 *Replace this clause by:*

Gasket contact surfaces and, where used, ring joints shall be in accordance with ASME B16.5 or ASME B16.47.

2.7 VALVES AND UNLOADERS

2.7.1 *Replace this clause by:*

The average inlet gas velocity shall be computed for each cylinder end as follows:

$$V = D/A$$