

# PETRONAS TECHNICAL STANDARDS

## DESIGN AND ENGINEERING PRACTICE

### VIBRATION CRITERIA FOR ROTATING EQUIPMENT AND AUXILIARIES

PTS 31.29.00.37

OCTOBER 2011



© 2011 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 2011 – 31.29.00.37



|            |                                                           |
|------------|-----------------------------------------------------------|
| PTS No:    | 31.29.00.37                                               |
| PTS Title: | Vibration Criteria For Rotating Equipment And Auxiliaries |

This new PTS 31.29.00.37- Vibration Criteria for Rotating Equipment and Auxiliaries has been developed with reference to PTS 20.133 and incorporating PETRONAS Lessons Learnt, Best Practice and new information issued by relevant industry code and standards.

The previous PTS 20.133 (March 1990) will be removed from PTS binder/ e-repository from herein onwards.

The custodian of this PTS is:

Name: Ir. M Nizam B Ab. Wahab

Tel. No: 03-2783 6174

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

### Document Approval

|                       | Name                    | Designation                             | Date     | Signature |
|-----------------------|-------------------------|-----------------------------------------|----------|-----------|
| Prepared/<br>Reviewed | Ir. Mohd Nizam Ab Wahab | Principal Engineer,<br>Engineering, GTS | 25/10/11 |           |
| Reviewed/<br>Approved | Zaharudin Ariffin       | Custodian Engineer<br>Engineering, GTS  | 27/10/11 |           |
| Verified              | Saifol Mualim           | General Manager,<br>Engineering, GTS    | 1/11/11  |           |
| Endorsed              | Pau Kiew Huai           | Senior General<br>Manager, GTS          | 2.11.11  |           |

### Revision History

| Date     | Version | Description of Updates | Author |
|----------|---------|------------------------|--------|
| Oct 2011 | 0       |                        |        |
|          |         |                        |        |
|          |         |                        |        |

## 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 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

|                   |                                                                                                                                |           |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------|-----------|
| <b>PART I</b>     | <b>INTRODUCTION .....</b>                                                                                                      | <b>5</b>  |
| 1.1               | SCOPE .....                                                                                                                    | 5         |
| 1.2               | DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS .....                                                                 | 5         |
| 1.3               | DEFINITIONS .....                                                                                                              | 5         |
| <b>PART II</b>    | <b>GENERAL INFORMATION .....</b>                                                                                               | <b>6</b>  |
| 2.0               | GENERAL .....                                                                                                                  | 6         |
| 3.0               | DEFINITIONS .....                                                                                                              | 6         |
| 4.0               | TYPES OF EQUIPMENT .....                                                                                                       | 8         |
| 5.0               | AUXILIARY EQUIPMENT .....                                                                                                      | 9         |
| 6.0               | ACCEPTANCE TESTING .....                                                                                                       | 9         |
| 7.0               | INDUCED PIPING VIBRATION .....                                                                                                 | 10        |
| 8.0               | PROCEDURES, REQUIREMENTS AND INSTRUCTIONS .....                                                                                | 11        |
| <b>APPENDICES</b> | <b>.....</b>                                                                                                                   | <b>12</b> |
| <b>APPENDIX A</b> | <b>.....</b>                                                                                                                   | <b>12</b> |
| TABLE 1:          | ELECTRIC MOTORS .....                                                                                                          | 12        |
| TABLE 2:          | CENTRIFUGAL PUMPS .....                                                                                                        | 12        |
| TABLE 3:          | AERO-DERIVATIVE GAS TURBINES .....                                                                                             | 13        |
| TABLE 4:          | INDUSTRIAL GAS TURBINES .....                                                                                                  | 13        |
| TABLE 5:          | RECIPROCATING ENGINES AND COMPRESSORS .....                                                                                    | 14        |
| TABLE 6:          | STEAM TURBINES, ROTARY COMPRESSORS, GENERATORS,<br>HIGH SPEED AND EPICYCLE GEARS, ROTARY PUMPS AND<br>HIGH SPEED BLOWERS ..... | 15        |
| TABLE 7:          | CENTRIFUGAL COMPRESSORS .....                                                                                                  | 16        |
| TABLE 8:          | LOW SPEED INTERDRIVERS AND BEVEL GEAR .....                                                                                    | 17        |
| TABLE 9:          | AERO COOLERS, COOLING TOWER FANS, FIN FANS .....                                                                               | 17        |
| TABLE 10:         | AUXILLIARY EQUIPMENT: SKIDS, VESSELS, COOLERS,<br>CONDENSERS, REFRIGERATION UNITS AND SIMILAR .....                            | 18        |
| <b>APPENDIX B</b> | <b>.....</b>                                                                                                                   | <b>19</b> |
| TABLE 1:          | VIBRATION RECORD STANDARD FORMS .....                                                                                          | 19        |
| FIGURE 1:         | SAMPLE OF MACHINERY VIBRATION SIGNATURE .....                                                                                  | 20        |
| <b>APPENDIX C</b> | <b>CONVERSION INFORMATION .....</b>                                                                                            | <b>21</b> |
| <b>PART III</b>   | <b>REFERENCES .....</b>                                                                                                        | <b>23</b> |

## PART I INTRODUCTION

### 1.0 SCOPE

This PTS specifies requirements and gives recommendations for vibration criteria for rotating equipment and auxiliaries.

This specification states the acceptable levels of lateral vibration for rotating, reciprocating equipment and associated auxiliaries, including a section on vibration in piping connected thereto.

This standard may be attached and made a part of individual specifications and drawings or to be used in conjunction with other equipment specifications and standards.

The responsibility for proper interpretation of this standard shall rest upon appointed representative of the Contractor/Principal. It will be the Vendor's responsibility to obtain clarification from the Contractor/Principal's representative, which in all cases shall be final and binding.

### 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 Group, and to Contractors nominated by them.

This PTS is intended for use in oil refineries, chemical plants, gas plants, exploration and production facilities and supply/marketing installations. When PTSs 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 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 to 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 objective of obtaining agreement to follow this PTS as closely as possible.

### 1.3 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 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, and on behalf of, the Principal.

The word **shall** indicate a requirement.

The word **should** indicate a recommendation.

## PART II GENERAL INFORMATION

### 2.0 GENERAL

- 2.1 Requests for substitutions and/or exceptions to this specification shall be submitted in writing, complete with all pertinent - engineering information required for the Contractor/Principal's evaluation.
- 2.2 The Contractor/Principal's duly authorized agents and/or representatives shall be provided with the following privileges:
  - a) Free access to those portions of the Vendor's facilities utilized in any manner for the construction, fabrication or assembly for the equipment to be tested or inspected under this standard.
  - b) When required, the right to review any data which may be related to one or all of the following: material selection, fabrication, assembly, balancing or testing of the manufactured equipment. If a unit is found unacceptable and remedial work is required, information related to machining tolerances and balancing certification, limits utilized or techniques applied may be requested for an "on-the spot" review.
  - c) The right to inspect, tests, and/or witnesses any activities in conjunction with this standard and to reject any work, material or procedure deemed substandard.
- 2.3 The Vendor shall assume the responsibility for and the obtaining of any and all performance warranties on equipment provided to meet this standard.
- 2.4 The Vendor shall be responsible for and assure the Contractor/Principal that vibration levels do not exceed the limits established by this standard as listed in Appendix A under the appropriate tables.

### 3.0 DEFINITIONS

- 3.1 For the purpose of this standard the following shall apply:
  - a) Parameters of amplitude measurement are shown on [Figure 1](#). These measurement units are Metric. (Conversion information as per [Appendix C](#)).

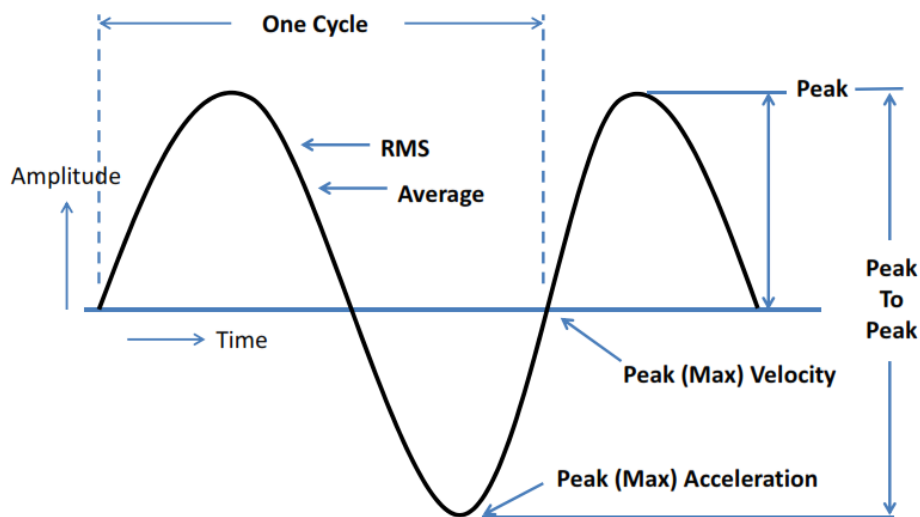


FIGURE 1

- b) **Vibration:** An oscillating or alternating motion of a mass caused by a force applied at regular or irregular intervals and measured by amplitude, a frequency and a phase angle.
- c) **Amplitude:** The magnitude of the oscillating vibratory motion measured either as the displacement, velocity or acceleration of the mass.
- d) **Displacement:** Actual movement of a mass from a rest position, expressed in microns (0.001 mm) peak to peak.
- e) **Velocity:** The rate of change of displacement with respect to time, the maximum speed of a point or position on a vibrating mass, rotor element or unit that is normally expressed as RMS mm/s.
- f) **Acceleration:** The rate of change of velocity with respect to time usually stated as peak G's (gravity units) 0.9810 mm/s<sup>2</sup> are gravitational constants used in converting peak acceleration (mm/s<sup>2</sup>) values to gravity units. From a practical standpoint, acceleration is the maximum rate of increase or decrease of the speed of a vibrating mass considering its structure and/or moving components.
- g) **Frequency:** The number of cycles of the vibrating mass per unit of time stated in cycles per minute (c/min) or cycles per second (c/s). By international agreement, Hertz (Hz) is the unit of frequency and equivalent to cycles per second.
- h) **Phase:** The position of the vibrating object (such as a rotor, shaft, sheave, gear, etc.) at any given instant with respect to a reference at some fixed point (bearing housing, case, cover guard, etc.) normally displayed by an oscilloscope, stroboscopic light or a remote phase meter (electromagnetic pickup or photocell).
- i) **Critical Speed:** The frequency or speed of a rotating mass system (pump impellers, couplings, pinion gears, compressors, rotors, etc.) that corresponds to a resonant frequency of the system.
- j) **Resonance:** Marked increased in vibration amplitude that occurs when the frequency of an exciting or forcing oscillation (such as an unbalanced rotor) corresponds to the natural frequency of the unit or system.
- k) **Simple Harmonic Motion:** A vibratory movement that is repetitious with respect to time i.e. normally considered not containing complex signals and usually described as pure sinusoidal.
- l) **RMS Level:** A root mean square measure of vibration amplitude that takes the time history into account and gives a value that is directly related to the energy content of the signal (an indication of possible destructive capabilities).
- m) **Filtered (Filter In):** Oscillating disturbances that have been separated on the basis of their frequencies with a vibration analyzer.
- n) **Unfiltered (Filter Out):** Vibration having its frequency components distributed over a broad frequency band. Readings taken with the "filter out" is used for entering tables found in [Appendix A](#).
- o) **Seismic Pickup:** A transducer or sensing device consisting of a moving coil in a permanent magnetic field with voltage output that is directly proportional to the pickup case velocity. This system simulates a fixed point in space (for reference) to determine equipment vibration amplitudes.
- p) **Non-Contact Pickup:** Also called a proximity probe - a device that is capable of measuring distance or a change thereof between any electrical conductive surface and