

PETRONAS TECHNICAL STANDARDS

DESIGN AND ENGINEERING PRACTICE

TECHNICAL SPECIFICATION

MINIMUM REQUIREMENTS FOR STRUCTURAL DESIGN AND ENGINEERING

PTS 34.00.01.30

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This revision of PTS **34.00.01.30 – MINIMUM REQUIREMENTS FOR STRUCTURAL DESIGN AND ENGINEERING** has been updated to incorporate PETRONAS Lessons Learnt, Best Practice and new information issued by relevant industry code and standards. All updates in the document are highlighted in italic font.

The previous version of this PTS **34.00.01.30 (July, 1998)** will be removed from PTS binder/ e-repository from herein onwards.

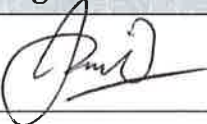
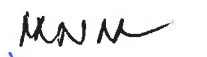
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PREFACE

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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 standardisation.

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.

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1. INTRODUCTION

1.1 SCOPE

This PTS specifies requirements and gives recommendations for structural design and engineering.

This PTS is also applicable to jetties and platforms but these special structures will normally need additional requirements to be specified separately.

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

It is intended for use in oil refineries, chemical plants, gas plants, and where applicable, in exploration, production and new ventures.

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 the PETRONAS group and to Contractors nominated by them.

This PTS is intended for use by all involved in the creation, maintenance and use of PTS.

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

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 or maintenance of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** 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** indicates a requirement.

The word **should** indicates a recommendation.

2. DESIGN LOADS AND CRITERIA

2.1 GENERAL

The loads which shall be taken into account in the design of structures are described below. The various combinations of these loads to be used in the calculations are given in (2.14).

2.2 STRUCTURE PROPER

The dead weight of the structure shall be calculated, including the weight of any fireproofing.

2.3 ROTATING AND STATIC EQUIPMENT

2.3.1 Weight of Rotating and Static Equipment

The weight of rotating and static equipment shall be derived as far as possible from Vendor data and shall include controls, auxiliary machinery, piping, insulation on equipment and related piping, etc.

2.3.2 Various Load Combinations

The following load combinations of rotating and static equipment shall be included in the calculations.

2.3.2.1 Empty Weight of Rotating and/or Static Equipment

This is the dead weight of the equipment, including insulation, fire protection, protective layers, internals etc., and shall be derived from Vendor data.

See note 5, Table 1 - Load Combination A to E.

2.3.2.2 Operating Weight of Rotating and/or Static Equipment

This is the empty weight (incl. internals) of vessels, columns, etc., plus the weight of their maximum contents during operation of the plant.

2.3.2.3 Hydrostatic Test Load of Rotating and/or Static Equipment

When hydrostatic pressure testing of equipment is required at site, the weight of this equipment completely filled with water shall be incorporated in the design of the supporting structure.

When more than one piece of equipment is supported by one structure, the structure need only be designed on the basis that one piece of equipment will be tested at any one time, and that the others will either be empty or still in operation.

2.4 CRANE LOADS AND MOVING LOADS

The proposed crane load criteria applicable to cranes also apply to other lifting facilities such as monorails and hoists. Crane loads shall be assumed at their maximum values including lifting capacity (*operational capacity and test load level*) as well as the maximum horizontal loads caused by braking or acceleration.

At least one road leading to the main process or distribution area(s) shall be designated as a heavy equipment route and bridges/culverts including other underground facilities shall be designed for the maximum expected loading condition caused by transportation of heavy equipment.

For the design of each structural element the most unfavourable position of the crane or other moving loads shall be considered. For moving loads an appropriate impact factor shall be applied according to the following guideline:

Loads applied due to cranes and moving sources shall not be less than the following (Ref.:ANSI/ASCE 7-95 CL 4.10 or BS 449 Part 2 - 1969 Chapter 3):

	Electric Operation	Hand Operation
Vertical impact loads - increase maximum wheel loads by:	25 %	10 %
Horizontal forces on rails - taken as a percentage of the rated capacity of the crane and the weight of the hoist and trolley		
Transverse to each rail:	10 %	5 %
Horizontal forces on rails - taken as a percentage of the maximum wheel loads of the crane:		
Along the rails:	10 %	5 %

2.5 LIVE LOADS (IMPOSED LOADS)

The following live loads shall be taken into account:

- For floors, platforms, walkways and staircases used for operational/maintenance purposes, the loads shall be derived from Vendor data with a uniformly distributed minimum load of 5.00 kN/m² or a minimum single point load of 7.5 kN, whichever is the more unfavourable for the structural element(s) under consideration.
- For floors, platforms, walkways and staircases used for access only, 2 kN/m² or a single point load of 3 kN, whichever is the more unfavourable for the structural element(s) under consideration.
- For roofs accessible for inspection and repair only, 1 kN/m². In addition all roof members shall be checked for a single load of 2 kN.
- For railings a horizontal force of 1 kN at any one point.
- For buildings see PTS 34.17.00.32 and PTS 34.17.10.30.

Note: Where applicable, due regard shall be given to the allowable reduction of live loads for multi-storey buildings or open structures under maximum wind load conditions.

For the design of each structural element the live loads shall be applied in the most unfavourable pattern (checkerboard-type loading).

The supports of heat exchangers with removable bundles shall be calculated on a pulling force of 200% of the weight of the bundle unless the bundles are pulled by means of a mechanical device which acts on the principle of equilibrium of forces.

2.6 WIND LOADS

Wind loads shall be determined in accordance with Appendix 1 of this PTS unless otherwise stipulated by national and/or local regulations, see (1.2).

The wind can blow in any direction and the most unfavourable case shall be considered.

For overhead pipe tracks of 4 m wide or less, the wind load on the three largest pipes shall be taken into account. For overhead pipe tracks of over 4 m wide, the wind load on the four largest pipes shall be taken into account.

2.7 SNOW LOAD, ICE LOAD, SAND LOAD AND WATER LOAD

Where necessary, snow, ice and sand load shall be taken into account. The load shall be derived from local regulations or experience.

Load due to rainwater accumulation shall also be taken into account.

Note: The maximum rainwater accumulation load with the drain pipes or down spouts blocked shall be assessed.

2.8 DYNAMIC LOADS

A detailed design and vibration analysis shall be made in accordance with the following requirements:

2.8.1 Static deformation

The static deformation for rotating equipment foundations shall be calculated and shown to be within the limits stated by the Vendor of the equipment. The calculations shall include, but not be limited to, the following causes of deformation:

- shrinkage and creep of concrete;
- temperature effects caused by radiation and convection of heat or cold generated by machinery, piping and ducting;
- elastic deformation caused by changing vapour pressure in condensers;
- elastic deformation caused by soil settlement or elastic compression of piles.

2.8.2 Vibration analysis

A three-dimensional vibration analysis for rotating equipment foundations shall be made and shall show that the dynamic amplitudes will not exceed the lower of the following values; see also (2.8.6):

- the maximum allowable values stated by the Manufacturer of the equipment;
- the amplitude (single amplitude) which causes the effective velocity of vibration to exceed:
 - a. 2 mm/s at the location of the machine-bearing housings
 - b. 2.5 mm/s at any location of the structure

Note: The effective velocity is defined as the square root of the average of the square of the velocity, velocity being a function of time. In the case of a pure sinusoidal function the effective velocity is 0.71 times the peak value of the velocity.

2.8.3 Exciting force

For the vibration analysis of structures and foundations of rotating equipment (subject to vibrations), the exciting forces shall be taken as the maximum values that, according to the Vendor of the equipment, will occur during the lifetime of the equipment.

2.8.4 Schematic mechanical model

The vibration calculation shall be based on a mechanical model wherein the weights and elasticity of both structure and foundation and the weight of the equipment are represented in an appropriate way.

2.8.5 Frequencies

All natural frequencies below 2 times the operating frequency for reciprocating equipment and below 1.5 times the operating frequency for rotating equipment shall be calculated.

It shall be demonstrated that the amplitudes of the natural frequencies between 0.35 and 1.5 times the operating frequency are within the allowable values even assuming that resonance occurs due to differences between the actual structure and the assumed model. In this case a reasonable amount of damping should be estimated.

The natural frequency of the supporting structure shall not coincide with any resonant frequency of the equipment.

2.8.6 Dynamic amplitudes

The dynamic amplitudes of any part of the foundation including any reciprocating compressor shall be limited to a peak to peak amplitude of less than 50 μm or as otherwise specified by the Principal or Manufacturer/Supplier of the rotating equipment.

2.9 EXPLOSION AND IMPACT LOADS

Explosion and impact loads shall be included in the design, if required by the Principal or local standards.

Note: Impact loads may be due to explosions or collisions.

2.10 THERMAL EFFECTS

2.10.1 Thermal loads

When thermal expansion results in friction between equipment and supports, the friction force shall be taken as the operating load on the support times the applicable friction coefficient given in the table below.

Surfaces	Friction coefficient
Steel to steel (not corroded)	0.30
Stainless steel to PTFE	0.08
PTFE to PTFE	0.08
Graphite to graphite	0.15

Note: The maximum sliding bearing pressures of the above materials shall be taken into account.

In the design of pipe supporting beams, the horizontal slip forces exerted by expanding or contracting pipes on steel pipe racks shall be assumed to be 15 % of the operating weight on the beam. These 'slip forces' shall not be distributed to the foundations.