

PETRONAS TECHNICAL STANDARDS

MANUAL

INTERNALS FOR COLUMNS

PTS 31.20.20.31

OCTOBER 2011



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This revision of PTS **31.20.20.31 –Internals for columns October 2011 Revision 2** 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 **31.20.20.31 February 2008** will be removed from PTS binder / e-repository from herein onwards.

The custodian of this PTS is:

Name: Wong Wan Xian

Tel. No: 03-27836077

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

Document Approval

	Name	Designation	Date	Signature
Prepared	Marina Mosir	Process Engineer	11 October 2011	
	Farahzila Mohd Sahat	Process Engineer		
	M Fadhly A Ghani	Mechanical Engineer		
Reviewed	Wong Wan Xian	Staff Process Engineer	11 October 2011	
Approved	Zainab Kayat	Custodian Process Engineer	11 October 2011	
Verified	Shahrul Izan Bakti Aziz	Senior Manager, Process Engineering, GTS	25/10/11	
Verified	Saifol Mualim B Ahmad Yahya	General Manager, Engineering, GTS	28/10/11	
Endorsed	Pau Kiew Hui	Senior General Manager, GTS	31.10.11	

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1	Hasni Haron	Zainab Kayat	Feb 2008
2	Wong Wan Xian	Zainab Kayat	Oct 2011

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.

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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.

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1. INTRODUCTION

1.1. SCOPE

This PTS specifies requirements and gives recommendations for the design, fabrication and shop testing of column internals. For field inspection, refer to PTS 61.10.08.11.

The following types of **trays** are covered:

- bubble cap trays;
- grid trays;
- sieve trays
- valve trays
- ADV-P trays
- *ADV-MP trays*

*The following types of **down comers** are covered:*

- *Conventional down comer trays*
- *Down comer distributor trays*

The following types of **liquid collectors** are covered:

- partial draw-off trays;
- total draw-off trays;
- chimney trays;
- gutter arrangement above a bottom compartment
- vane collectors

The following **internals packing** systems are covered:

- structured packing;
- random packing;
- support grids;
- hold-down grids (bed limiter).

The following **feed inlet devices** are covered:

- liquid gravity distributors;
- liquid elbows;
- spray-nozzles;
- Multi-Vane Diffusers.
- *Vapor Horn*

1.2. DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorized 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/Suppliers nominated by them.

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

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 or maintenance 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.

The **Principal** is the party that 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 authorized to act for, and on behalf of, 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 (7).

1.5. CHANGES FROM PREVIOUS EDITION

The previous edition of this PTS was February 2008. Other than editorial editions, the following are the main changes since that edition:

Old section	New section	Change
2.2	2.2	Disclaimer added to highlight the definition of Open Area which may differ between Mass Transfer Practitioner to another.
2.4	2.4	Requirement for manholes design and location added in section 2.4 para 3 and 4.
3.2.1	3.2.1	Requirement for fractionating trays and support load criteria during operational mishap, e.g. liquid-full trays, steam explosions added in section 3.2.1 para 4.

Old section	New section	Change
3.2.4.3	3.2.4.3	Requirement of slotted holes for the beam to accommodate thermal expansion added in section 3.2.4.3 para 2.
-	3.6.2	Mechanical requirements for wire mesh demisters are added in new section 3.6.2.
4.2.5	4.2.5	Criterion for distance between the draw off nozzles to the internals below is inclusive of the bellows to accommodate thermal expansion added in section 4.2.5 para 4.
5.2	5.2	The following statement in section 5.2 para 2 is replaced to : Bed heights above 8 m, or with more than 15 stages may risked liquid mal distribution thus approval of the Principal is required.
6.3.1	6.3.1	Added in section 6.3.1 para 2. Load requirements for liquid feed pipes and supports to accommodate thermal expansion during operating and transient (start up and turndown) conditions
6.4.1	6.4.1	Added in new section 6.4.1. Mechanical requirement of half open pipe to be specified including the diameter, length and exit opening area
6.5	6.5	Added in section 6.5.2 and 6.5.3. Mechanical requirement on levelness and deflection of the feed inlet devices
6.7.2	6.7.2	Connection integrity of feed inlet device assembly added in section 6.7.2 para 2.
6.9.3	6.9.3	Info on Vapor Horn added.
Appendix IX	Appendix IX	Liquid maldistribution range performance test for liquid distributors were change to be in line industry.

2. GENERAL

2.1. GENERAL

This PTS specifies basic requirements and recommendations. To further specify the design, the Manufacturer should normally receive data/requisition sheets or an order giving all the information and design data together with lay-out drawings, e.g., showing feed and draw-off nozzle orientation, manhole position, etc., if these are required.

Manufacturer's drawings shall be submitted to the Principal for approval and shall show all constructional details, including down comer and tray panel fastenings and the location, size and fastening of manholes and distributor supports.

The internals Supplier shall be responsible for ensuring that the mechanical design of the internals, including their support, is satisfactory for the design conditions indicated on the requisition and/or drawings. The internals Supplier shall make his own calculations, for which he is fully responsible. However, the requirements specified in the order and requisition shall prevail if more stringent.

2.2. NET FREE (OPEN) AREA

The Net Free Area (NFA) of a column internal is the ratio of the total hole area (for vapour passage) to the column's cross-sectional area expressed as a percentage. The maximum allowable deviation of the net free area shall be plus or minus 0.5 % of the column's cross section, or plus or minus 5.0 % of the stated net free area, whichever is the smaller.

Disclaimer: The industry generally has other definition for Open Area and Free Area. The definitions of NFA, Open Area and Free Area should have to be checked, as it may differ between Mass Transfer internals Supplier.

2.3. COLUMN ATTACHMENTS

Column attachments such as support rings, support lugs and drip rings which are permanently welded to the shell shall be designed by the internals Supplier but shall be supplied and installed by the column Manufacturer. To this end, the internals Supplier shall supply column internal attachment drawings in sufficient time to enable the column Manufacturer to meet his delivery date. Internal's Supplier tower attachment drawing shall include acceptable installation tolerances and method of welding. The column Manufacturer should make drawings of attachments that are welded to the column. Drawings of attachments that are bolted to the column wall should be drawn by the internals Supplier.

Each internal part connected to a column attachment or the column wall (support beam, Multi-Vane Diffuser, tray etc.) should have a connection suitable for the expected thermal expansion, e.g., bolted connections should be applied with a slotted hole. The location and type of connection shall be determined by the internals Supplier.

Column internals shall be fastened to support rings and beams in such a way that they can be easily mounted and dismantled.

In all cases, the owner/operator of the hardware will be allowed to provide construction details of attachments welded to the column wall to sub-contractors and equipment suppliers for maintenance or debottlenecking purposes without breaching any technology secrecy or non-use agreements.

2.4. ACCESS TO THE COLUMN FOR INSTALLATION AND REMOVAL

A manhole in the top column shell ring, a blind flange or a flanged head should be provided to allow column internals to be installed and removed. For columns with a diameter larger than 2.0 m, a top dome with a top flange should be considered. For columns with a diameter between 1.0m and 2.0 m, the more economical of the two options should be chosen. A top dome should have a diameter of at least 1.0 m, but no more than 1.5 m or half the column diameter. The height of a top dome shall be at least twice the top dome diameter. Access to the column via a manhole in the top column shell ring is preferred.

Manholes should be provided for *the installation and access* other column internals. The internal diameter of manholes should be at least 610 mm, but in any case shall not be less than 460 mm.

One man way should be located 900 mm above the bottom head seam and another man way should be 450 mm above the top tray if there is no top flange or top dome. To facilitate access to the column internals, column manholes should be located as follows:

- *Vessels with fewer than 60 trays: manhole spaced every 20 trays*
- *Vessels with 60 to 120 trays: manhole spaced every 30 trays*
- *Vessels with more than 120 trays: manhole spaced every 40 trays*
- *Vessels with internal compartments or with components obstructing egress from one section to another should have a manhole in each section.*
- *In close proximity to the multi vane diffuser or half-open pipe or a spray distributor so that safe access can be gained to the internals*
- *Above a feed tray*
- *Above a gravity liquid distributor*
- *Below draw-off trays*
- *In the flash zone*

Internal access to manways shall be taken into consideration: provisions such as hand grips or stair cages shall be provided as needed depending on the level of the tray versus the location of the manway.

If a manhole is installed between two column internals, the clearance between the manhole and the internal above or below should be at least 150 mm. The internals Supplier shall verify that the manholes and top flange or top dome necessary for the installation of the column internals will be provided on the column.

2.5. MATERIALS OF CONSTRUCTION

Materials of construction shall be as specified on the data/requisition sheet or in the order.

Corrosion allowance, if any, shall be as specified on the data/requisition sheet or in the order.

Gaskets for sealing of column internals, if required, shall be specified on the data/requisition

sheet. Gaskets shall be 2 mm ceramic fibre rope or glass fibre rope, both of which shall be suitable up to 500 °C. Rubber impregnated glass fibre rope should not be used.

2.6. SPARES FOR ERECTION

PTS 70.10.90.11 shall apply. The Manufacturer shall ensure that sufficient spare parts are available during erection. The Principal shall authorize any undercutting of indicated contingencies. As a general guide, 5 % extra material may be specified as a contingency for the following component parts of each size and type:

- valves, bolts, nuts, clamps, wedges, washers, etc., with not less than 4 pieces;
- Jointing materials, e.g, gaskets, packing, etc., with not less than 1 piece.

2.7. WELDING

Qualified welders shall weld column internal parts in accordance with procedures in ASME IX or the applicable pressure vessel code. The welding of column internal support rings and attachments to the wall of a new column shall be the responsibility of the column Manufacturer.

2.8. BOLTS

Alloy steel bolts shall be not smaller than 10 mm diameter. Bolt threads shall be metric in accordance with the relevant ISO standard unless otherwise specified on the data/requisition sheet or order. Bolt length should be chosen so that after the nut(s) have been tightened, only 2 to 3 threads are exposed. If shims are applied for levelling, threading may be longer to cover the complete shim range

3. FRACTIONATING TRAYS

3.1. PERFORATIONS AND VALVES

Fractionating tray perforations and valves (floating and fixed) shall be as evenly spaced as practicable. The perforating pattern should be rectangular or triangular at the internals Supplier's discretion but shall be approved by the Principal. There should always be a minimum of two rows of perforations (sieve holes or valves) for the liquid flow coming out of the bottom of the down comer to the outlet weir of the tray below. The triangular pattern should be specified so that liquid bypassing is minimized which means that the base of the triangle is perpendicular to the flow direction.

Punched fractionating tray perforations shall be burr free, and punched downwards. Protruded holes shall only be used if specified in the data/requisition sheet.

Fixed or floating valves can be used for High performance valve, and conventional down comer valve trays. The type and number of valves and the orientation (if applicable) shall be specified on the data/requisition sheet and shall be confirmed with the Principal.

The pitch of conventional valves (measured centre to centre) shall be not less than 1.5 times the diameter of the valve cap.

3.2. MECHANICAL REQUIREMENTS

3.2.1. Loads

Unless otherwise stated on the data/requisition sheet or in the order, fractionating trays and supports shall be designed to withstand the following forces:

- the weight of liquid (either hot process liquid or water, whichever is the heavier) equivalent to a height of two times the weir height with a minimum of 1000 N/m²;
- a maximum operating load in an upward direction of 2000 N/m at maximum working temperature evenly distributed over the entire fractionating tray surface.
- Own weight of tray
- areas under down comers - the greater of 314kg/m² or a head of water one half the height of down comer
- draw off pans - the greater of 700kg/m² or a head of water to the top of the pan
- total draw-off pans - the greater of 700 kg/m² or a head of water to the top of the vapor riser or weir overflow

Trays are directly above and below a flashing feed should be designed with 700 kg/m². Apart from the requirements above, the fractionating trays shall be capable of absorbing the loads resulting from installation and maintenance activity. These loads shall be taken as 1000 N downward (equivalent to the weight of one man working on the assembly).

For sieve, valve, bubble cap and grid trays the maximum downward and upward deflection under operating loads for structural components shall be designed for a concentrated live load of 135 kg at any point based on the allowable stress at 38 C. The design shall be based on fully corroded thickness of the structural component (i.e thickness excluding total corrosion allowance.)

In cases where these loads can easily be exceeded due to an operational mishap, e.g. liquid-full trays, steam explosions etc., more stringent load criteria shall apply. In these cases the following maximum loads should be used:

Downward: The weight of the hot process liquid if the tray spacing is completely filled.

Upward : 6900 Pa (1 psi) maximum for steam explosions only. Although damage cannot be avoided in this case, tray panels shall be clamped onto the supports. Special clamps shall be used to minimize damage to support beams and rings. As an alternative the use of one or more explosion doors may be considered. Size is typically 80 % of the perforated area with a minimum of 5 % of the active tray area of the column's cross sectional area. Explosion doors are only used in combination with a high uplift design of 6900 N/m² .

Criteria for the design of internals for these heavy-duty conditions shall be indicated on the data requisition sheets.

3.2.2. Deflections

For sieve, valve, bubble cap and grid trays the maximum downward and upward deflection under operating load shall not be more than 1/900 of the internal column diameter.

3.2.3. Levelness

The tilt of fractionating trays and gravity liquid distributors shall not exceed 0.3 % of the column diameter, or 6 mm, whichever is the smaller. Local depressions and bulges in panels shall not exceed 6 mm from the nominal plane. The tolerances of the support rings inside the vessel and the proper erection of the vessel on site largely determine the levelness of trays. Refer to PTS 31.22.10.32 and PTS 31.22.20.31 for minimum requirements.

3.2.4. Fractionating tray supports

3.2.4.1. Rings

Stacked trays shall be installed in columns with a nominal diameter of up to 800 mm. For columns with a nominal diameter of 800 mm and above, support rings shall be welded to the column wall, see [\(5.3.4\)](#). For support rings, reference is made to [\(Appendix II\)](#).

A minimum of 19mm overlap shall be provided between the support ring and Outer Diameter (OD) of trays, decks and grids.

The depth of supporting members traverse to the direction of flow shall not exceed 20% of the vertical distance between trays.

The depth of supporting members normal to the direction of flow shall not exceed 25% of the vertical distance between trays.

3.2.4.2. Panel Supports

Load bearing trusses for inlet and active panels can be either loose channels or integrally formed into the panels. Active panels can be connected to each other using tongue and groove construction with a bolting connection for every 600 mm across the connection joint.

3.2.4.3. Beams

Minimum material thickness shall be 3 mm.

To accommodate thermal expansion, slotted holes shall be used for mounting the beams onto the supports. The Vendor of the internals shall specify the slot length on the basis of transient conditions, i.e the maximum temperature difference that can occur between the column shell and the internals during startup or turndown. Unless otherwise specified, the difference between the maximum operating temperature and ambient shall be used for that calculation.

Supporting beams shall not restrict liquid and vapor communication on the trays. The total height of any support beam shall be minimized on the basis of economic considerations.

On trays equipped with conventional down comers, the main support beams shall be parallel to the direction of liquid flow.

Major beams have to be directly connected to the beam support clips welded to the shell. For minor support beams on conventional down comer trays, where beams are perpendicular to the direction of liquid flow, the following shall apply:

The beam shall occupy not more than one third of the space between the trays, as defined by:

$$A_{\text{beam}} / (D \times TS) < 1/3$$

Where:

A_{beam} = area of beam, horizontally projected, m² ;

D = internal diameter of column, m;

TS = tray spacing, m.

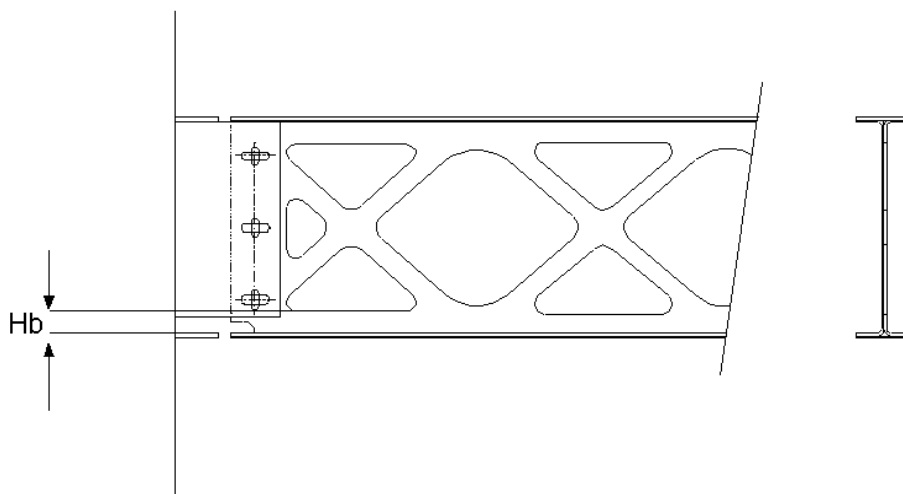
If this criterion cannot be met with a solid beam, an open type of beam or a lattice type shall be used, such as an I-type beam with holes therein or an open work construction as shown in(Appendix I).

If a C-type beam with separation segments is used, each segment of the beam should be provided with a draining facility. Where draining of the segment is not possible, a drain hole of at least 12 mm should be drilled in the bottom of the beam.

For column diameters larger than 6.0 m, a combined beam (for two fractionating trays) may be fitted. In this case, the height of the support beam is equal to the tray spacing. If required, and if approved by the Principal, combined beams may also be applied for column diameters smaller than 6.0 m.

If a combined beam is used, it shall occupy not more than 1/3 of the free space. Furthermore, the height of the edge/obstruction below the support beam openings (" H_b " in Figure 3.1) should be less than the weir height of the tray below; in any case, H_b shall not exceed a height of 35 mm so as not to hamper the liquid cross-flow on that tray. The Principal shall be consulted if these requirements cannot be met.

Figure 3.1 Open structure combined support beam



3.3. DRAINING AND LEAKAGE

3.3.1. Draining

Except for trays with seal pans or inlet weirs, drain holes are not required on sieve or valve trays. Each seal pan should have at least one drain hole with a diameter of 10 mm to permit draining of the liquid hold-up. Drain holes in recessed seal pans shall be located downstream or on the tray side of the downcomer so that any vapor passing through the holes will not bypass the tray above. Inlet weirs shall have a 13 mm hole at the base to drain into the tray.

3.3.2. Leak tightness

The tightness of conventional down comers shall not exceed 1.0% of open area in the down comer bottom. Any gap in a seam shall not be wider than 1.0 mm. Bubble cap trays should be able to hold liquid up to weir or riser height and therefore should be capable of passing the leakage test as described in (Appendix VIII).

3.4. INSTALLATION, REMOVAL AND ASSEMBLY

3.4.1. Fractionating tray installation and removal

To facilitate installation and maintenance, fractionating trays shall be made in sections which shall pass through manholes or the top dome of the column.

Stacked trays shall be designed to permit installation and removal through the column top.

Unless otherwise specified, all fractionating trays shall be designed to permit installation and removal from top or bottom.

All parts should have durable markings, in paint or ink, relating to the erection plan from which the internals can be unmistakably identified.

3.4.2. Fractionating tray assembly

Generally, parts shall be made as large as possible in order to reduce the number of joints.

Fractionating tray panels shall be joined together and to the supports by means of a suitable quick fastening system. Bolted joints should be avoided. Sufficient clearance to facilitate assembly on site shall be allowed for.

Bolted joints may only be used to attach support beams to cleats, to attach downcomer plates in columns with conventional downcomers, and to attach auxiliary internals.

Connections to beams or cleats that is essential to the integrity of the column internal construction shall be secured. Bolted connections shall be secured by means of tack welding the nut to the bolt, or by employing a second nut.

The maximum allowable difference in level between two adjacent panels shall be 2 mm.

Internal distribution pipes shall have flanged connections, refer to Standard Drawing S 10.016. Indicated flange thicknesses should be used as a guideline only and may be minimized for all nominal pipe sizes on the basis of mechanical requirements and applied materials of construction.

3.5. PROVISIONS FOR ACCESS

Fractionating trays and fittings shall be designed so that the tray is easily accessible for cleaning, gas freeing, inspection and maintenance.

Access to fractionating trays not served by column manways shall be provided by means of bolted manways in the fractionating trays.

The column Manufacturer shall ensure that a man can pass through the manways of the fractionating trays as installed.

Whenever possible, tray manways shall have a minimum opening of 380 mm x 500 mm. Where this is impossible for construction reasons, the use of smaller manways shall be subject to the approval of the Principal. The manway shall not be smaller than 270 mm x 450 mm. If no manways possible, the cover plate of the tray shall be split.

If the clearance between the tray deck and the bottom of the main supporting beams of the tray above is less than 400 mm, tray manways shall be installed on each side of the beams.

If trays have multiple passes, each pass should be equipped with one manway.

If a tray uses a major beam to split active area and the distance between the bottom of the major beam chord and the tray below is less than 350 mm then the tray should be equipped with a manway opening on each side of the major beam to allow for man crossing below the beam. All manways to be align vertically throughout the column

For the sake of flexibility, bolting and unbolting of tray manways should be possible from both sides of the tray. If access from one side is impossible, this requirement may be relaxed if approved by the Principal. In case tray spacing is less than 450 mm all trays shall be designed for topside installation and removal. Topside installation and removal require using welded nuts.