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Guidance on Industry Standard for Column Internals

GIS 46-040

BP GROUP
ENGINEERING TECHNICAL PRACTICES

Foreword

This is the first issue of Engineering Technical Practice (ETP) BP GIS 46-040. This Guidance on Industry Standard (GIS) is based on parts of heritage documents from the merged BP companies as follows:

Arco

ES 41-89 Fractionating Trays.

Amoco

AOC 98C-18-93 Trays and Miscellaneous Internals.

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1. Scope

This GIS provides guidance on industry standard for the design, fabrication supply, testing, and installation of trays, packings, and other column internals.

Quality Assurance

Verification of the vendor's quality system is normally part of the pre-qualification procedure, and is therefore not specified in the core text of this specification. If this is not the case, clauses should be inserted to require the vendor to operate and be prepared to demonstrate the quality system to the purchaser. The quality system should ensure that the technical and QA requirements specified in the enquiry and purchase documents are applied to all materials, equipment and services provided by sub-contractors and to any free issue materials.

2. Normative references

The following normative documents contain requirements that, through reference in this text, constitute requirements of this technical practice. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this technical practice are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies.

American Society of Mechanical Engineers (ASME)

- | | |
|--------------------|--|
| ASME BPVC Sec VIII | Boiler and Pressure Vessel Code, Rules for Construction of Pressure Vessels. |
| ASME BPVC Sec IX | Boiler and Pressure Vessel Code, Welding and Brazing Qualifications. |

British Standards Institute (BSI)

- | | |
|-----------|--|
| BS EN 287 | Approval testing of welders for fusion welding. |
| BS EN 288 | Specification and approval of welding procedures for metallic materials. |
| PD 5500 | Unfired fusion welded pressure vessels. |

3. Terms and definitions

For the purposes of this GIS, the following terms and definitions apply:

gravity distributor

liquid distributor using only hydrostatic head

manufacturer

manufacturer of column internals

owner

the operator of the column

random packing

packing manufactured as discrete elements distributed randomly



structured packing

ordered packing manufactured from pressed sheet metal sheets

4. Symbols and abbreviations

For the purpose of this GIS, the following symbols and abbreviations apply:

AISI	American Iron and Steel Institute.
FRI	Fractionation Research Incorporated.
VDU	Vacuum Distillation Unit.

5. Column trays**5.1. General arrangement and size requirements**

- a. For vessel of 840 mm (33 in) diameter and larger, tray panels, downcomer sections and other tray components shall be of sectional construction with sections removable through the vessel manways.
- b. If a lifting beam is not available within the column, formed deck sections shall have a maximum component weight of 50 kg (110 lb) and a maximum length of 3 000 mm (118 in).
- c. A minimum number of plate sections shall be used in the floors of downcomers and accumulator trays.
- d. If a lifting beam facility can be provided within a column, the length and weight restrictions shall be governed by the ability to install sectional components with the vessel in both the horizontal and vertical.

The factors that govern the maximum weight/length are those necessary to ensure safe working in a confined space.

- e. Tray components shall be designed to permit installation and removal from the topside.

To design the internals to be installed from both sides is an expensive addition that should be avoided unless absolutely necessary.

- f. Tray spacing requirements shall be in accordance with Table 1

Table 1 – Tray spacing

Location	Spacing
Above top tray	A minimum of 1,5 times the normal tray spacing
Feed tray	Normal tray spacing plus 150 mm (6 in); or tray spacing plus nozzle diameter, whichever is greater.
Shell manhole	Manhole internal diameter plus 150 mm (6 in) or the design tray spacing, whichever is greater.

The feed tray spacing should not be less than 600 mm (24 in).

- g. For vessels smaller than 840 mm (33 in) diameter, cartridge tray assemblies shall be provided and the vessel shall be flanged to permit installation and withdrawal of the cartridge.

Cartridge trays are invariably assembled in the fabrication shop.



5.2. Fractionator tray design details

- a. Bubble Cap Trays - If offered as an alternate, the seller's standard bubble cap design shall be subject to approval by BP. If bubble caps are secured by bolting, double nutting shall be provided.
- b. Sieve tray deck hole sizes should normally be selected between 4 mm and 12 mm (5/32 in and 1/2 in) diameter. Larger hole sizes shall be used if a fouling or corrosive service is specified. The ratio of the hole pitch to hole diameter shall be a minimum of 2,0.

Hole layout shall be a triangular pitch with the base perpendicular to the fluid flow. The tray deck is normally designed with a 50 mm (2 in) calming zone adjacent to the inlet downcomer. However, if the tray flood levels are high, then the use of calming zones may need to be restricted in order to maximise the tray active area.

Hole sizes larger than 25 mm (1 in) are more likely to weep, restrict capacity, and cause a lower efficiency. They are not normally used.

- c. Holes in sieve trays shall be formed with the punch exit on the upper side of the tray. The tray design and the systems applied during manufacture and installation shall ensure that this requirement is met for all deck sections. Burrs on sieve tray holes that would cause injury to personnel, shall be removed.
- d. On sieve and valve trays hole area shall be uniformly distributed in the contacting area approximating equilateral triangular pitch. Hole area per tray shall be within $\pm 1\%$ of the sieve or valve hole area specified.
- e. In the closed position the valve shall not make full peripheral contact with the tray deck. If recommended by the vendors, flat valves need to be approved by BP.

Valve caps should be provided with an indentation that prevents such peripheral contact and thus helps to prevent the valve from sticking closed.

In the past, flat valves have been used by some sites to offer a higher turndown.

- f. Trays having more than two passes should be designed for equal bubbling area per pass rather than equal flow path length per pass subject to a minimum flowpath length of 450 mm (18 in).
- g. If possible, the use of partially blocked weirs should be used to obtain a uniform L/V load per pass.

In some multi pass designs this may cause problems with meeting minimum manway dimensions. In such cases this should be discussed with the owner.

- h. To the extent possible, three pass trays should be avoided. Selection of three pass trays should be discussed with BP. If used, trays with 3 or more passes should be designed and optimised with vapour and liquid balancing features.

These would include blocked weirs and varying downcomer clearances to help balance the tray V/L loads. They may also include combined liquid and vapour equalising ducts. The design should be discussed with BP.

- i. Standard sieve tray performance data shall be specified on an FRI basis. See clause 10.2 for guarantee requirements.

It is recognised that proprietary trays using sieve decks are designed according to the manufacturer's own procedures and in this case the basis used for calculating jet flood, entrainment, maximum sustainable loading and downcomer backup shall be provided to the purchaser.

- j. If the column is to be used offshore, the trays should be designed such that they operate satisfactorily within the sway tolerances approved by BP.



In the absence of stated tolerances, a sway of $\pm 0,009$ radians ($\pm 0,5$ degrees) may be assumed in addition to the conventional fabrication tolerances used although it will be necessary to consider motion in all six axes and, to some extent, the accelerations and periods of motion. It is the responsibility of the manufacturer to ensure that the hydraulic design meets these criteria.

- k. Tray design jet flood limits for conventional trays are defined in Table 2.

Table 2 – Maximum design tray jet flood limits

Tray Type	New Columns	Revamps	Vacuum Columns
Sieve	80%	85%	75%
Valve	80%	85% - 90%	77%
Notes:			
1. Sieve tray flood calculations by FRI rating method.			
2. Valve tray flood calculations by BP method.			
3. Above flood limits are based on a system factor of 1,0.			
4. Valve tray revamps above 85% should be reviewed by BP.			

With newer designs of High Capacity Trays, operating data shows that it is possible to operate at levels above 85% jet flood. High Capacity trays have been fairly widely used in BP and for revamps where operating limits are being pushed, specialist help should be sought for the design and review of the drawings.

- l. Downcomer clear liquid back-up shall be limited to a maximum percent of tray spacing plus weir height as listed in Table 3 below. These limits are applicable for a system factor of 1,0 (i.e. non foaming systems).

Table 3 – Downcomer backup criteria

System Pressure		Maximum % Liquid Backup
Barg	psig	
< 2,0	< 30	60
2,0 to < 5,5	30 to < 80	55
5,5 to < 10	80 to < 150	50
10 to 14	150 to 200	45
> 14	> 200	40

- m. If the design liquid loading on a straight segmental overflow weir is less than 0,9 litre/min. cm (0,6 USGPM/in), 'picket fence' type overflow weirs shall be provided.
1. The minimum horizontal distance between pickets shall be 50 mm (2 in).
 2. The minimum vertical height of picket above the weir shall be the lower of 200 mm (8 in) or $1/3^{\text{rd}}$ of the tray spacing.
 3. The effective weir rate at normal design flows shall be not less than 0,9 litre/min. cm (0,6 USGPM/in).
- n. If the method of weir attachment is such that gaps could be left between the weir plate and the shell wall and/or between the weir plate and the tray weir edge, slide plates shall be provided to seal these gaps.
- o. For conventional trays with sloped or stepped downcomers, the bottom downcomer area shall not be less than 50% of the top downcomer area.

In many cases the difference is 20-40%. An exception to this is some types of High Capacity trays. This should be discussed with BP.

