

DEP SPECIFICATION

INTERNALS FOR COLUMNS

DEP 31.20.20.31-Gen.

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DESIGN AND ENGINEERING PRACTICE



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TABLE OF CONTENTS

1.	INTRODUCTION	5
1.1	SCOPE	5
1.2	DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS	6
1.3	DEFINITIONS	6
1.4	CROSS-REFERENCES	7
1.5	SUMMARY OF MAIN CHANGES.....	7
1.6	COMMENTS ON THIS DEP	8
1.7	DUAL UNITS.....	8
1.8	NON NORMATIVE TEXT (COMMENTARY).....	8
2.	GENERAL	9
2.1	GENERAL REQUIREMENTS.....	9
2.2	NET FREE (OPEN) AREA.....	9
2.3	COLUMN ATTACHMENTS	10
2.4	ACCESS TO THE COLUMN FOR INSTALLATION AND REMOVAL	11
2.5	MATERIALS OF CONSTRUCTION	12
2.6	SPARES FOR ERECTION	12
2.7	WELDING	12
2.8	BOLTS	12
2.9	HORIZONTAL INSTALLATION AND TRANSPORT OF COLUMNS AND VESSELS.....	13
3.	FRACTIONATING TRAYS.....	14
3.1	PERFORATIONS AND VALVES.....	14
3.2	MECHANICAL REQUIREMENTS	15
3.3	DRAINING AND LEAKAGE.....	19
3.4	INSTALLATION, REMOVAL AND ASSEMBLY	20
3.5	PROVISIONS FOR ACCESS	21
3.6	SPECIFIC TYPES OF FRACTIONATING TRAYS.....	22
4.	DRAW-OFF TRAYS, LIQUID COLLECTORS AND GRAVITY LIQUID DISTRIBUTORS	31
4.1	GENERAL	31
4.2	PROCESS REQUIREMENTS	31
4.3	MECHANICAL REQUIREMENTS	32
4.4	DRAINING AND LEAKAGE	34
4.5	INSTALLATION, REMOVAL AND ASSEMBLY	35
4.6	PROVISIONS FOR ACCESS	36
4.7	SPECIFIC TYPES OF DRAW-OFF TRAYS, LIQUID COLLECTORS AND GRAVITY DISTRIBUTORS	36
5.	PACKING	43
5.1	GENERAL	43
5.2	PROCESS REQUIREMENTS	43
5.3	MECHANICAL REQUIREMENTS	44
5.4	DRAINING AND LEAKAGE	45
5.5	INSTALLATION, REMOVAL AND ASSEMBLY	46
5.6	PROVISIONS FOR ACCESS	46
5.7	SPECIFIC TYPES OF PACKING	47

6.	FEED INLET DEVICES	48
6.1	GENERAL	48
6.2	PROCESS REQUIREMENTS	48
6.3	MECHANICAL REQUIREMENTS FOR LIQUID FEED INLETS	48
6.4	MECHANICAL REQUIREMENTS FOR MULTI PHASE FEED INLETS	49
6.5	MECHANICAL REQUIREMENTS	50
6.6	DRAINING AND LEAKAGE	52
6.7	INSTALLATION, REMOVAL AND ASSEMBLY	52
6.8	PROVISIONS FOR ACCESS	52
6.9	SPECIFIC INLET DEVICES	53
7.	REFERENCES	56

APPENDICES

APPENDIX A	CALMING SECTIONS	57
APPENDIX B	HiFi CALMING SECTIONS.....	58
APPENDIX C	OPEN STRUCTURE SUPPORT BEAM	59
APPENDIX D	TRAY SUPPORT RINGS	60
APPENDIX E	TYPICAL TOTAL DRAW-OFF TRAY WITH SIDE SUMP	62
APPENDIX F	TYPICAL TOTAL DRAW-OFF TRAY WITH CENTRAL TROUGH	63
APPENDIX G	TYPICAL TOTAL DRAW-OFF TRAY WITH TWO TROUGHS.....	64
APPENDIX H	TYPICAL TOTAL DRAW-OFF TRAY FOR HiFi TRAY	65
APPENDIX I	TYPICAL PARTIAL DRAW-OFF TRAY	66
APPENDIX J	TYPICAL SINGLE-DECK DRAW-OFF TRAY WITH TWO TROUGHS.....	67
APPENDIX K	SIZING OF SCHOEPENTOETERS	68
APPENDIX L	LEAKAGE TEST AND TEST CERTIFICATE.....	75
APPENDIX M	LIQUID MALDISTRIBUTION TEST FOR GRAVITY LIQUID DISTRIBUTORS.....	76
APPENDIX N	FIRES IN RANDOM AND STRUCTURED PACKINGS	78



1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for the design, fabrication installation and shop testing of column internals.

Field inspection is excluded from the scope of this DEP (for field inspection, refer to DEP 61.10.08.11-Gen).

In this DEP, Shell Calming Section™ Trays, Shell HiFi™ Trays, Shell ConSep™ Trays, Shell Swirl Tube™ Trays, Shell Schoepentoeter™ and Shell Schoepentoeter Plus™ (which is strictly the correct usage in publications) are, referred to without the Shell prefix or ™ suffix. These are all Shell GSI proprietary internals and may be manufactured only by Manufacturers that have been granted permission to do so by Shell GSI.

The downcomers for Calming Section trays and HiFi trays are referred to as Calming Sections and HiFi Calming Sections, respectively.

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

- a) Bubble Cap Trays;
- b) Grid Trays;
- c) Sieve trays;
- d) Valve trays;
- e) Conventional downcomer trays;
- f) Calming Section trays;
- g) HiFi trays;
- h) ConSep trays;
- i) Swirl Tube trays.

The following **separator internals** are covered:

- a) Separation Swirl Tube decks;
- b) Axial cyclones;
- c) Wiremesh demisters.

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

- a) Partial draw-off trays;
- b) Total draw-off trays;
- c) Chimney trays;
- d) Gutter arrangements above a bottom compartment;
- e) Vane collectors.

The following **packing internals** are covered:

- a) Structured packing;
- b) Random packing;
- c) Support grids;
- d) Hold-down grids (bed limiter).

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

- a) Liquid gravity distributors;
- b) Liquid elbows;
- c) Spray-nozzles;
- d) Deflector plates;
- e) Half-open pipes;
- f) Schoepentoeters;
- g) HiFi Schoepentoeters;
- h) Inlet cyclones.

This DEP is a revision of the DEP of the same number dated February 2015; see (1.5) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them. Any authorised access to DEPs does not for that reason constitute an authorisation to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in oil refineries, chemical plants and gas plants. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process shall 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 could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regard to the safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP 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, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General 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 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 it. 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.

The word **may** indicates a permitted option.

1.3.2 Abbreviations

Term	Definition
CSA	Calming section area
CSH	Calming section height
ft.lbs	(Torque) momentum
GSI	Global Solutions International, Inc.
HiFi	High Flow parameter
ID	Inside Diameter
lbf	pound-force
LNG	Liquefied Natural Gas
mil	1 thousandth of an inch
N	Newton
NFA	Net Free Area
SMS(M)	Schoepentoeter - Mist mat - Swirdeck ([secondary] mist mat separator)
TS	Tray Spacing

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section or clause number is shown in brackets (). Other documents referenced by this DEP are listed in (7).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a full revision of the DEP of the same number dated February 2015. The following are the main, non-editorial changes.

Section/Clause	Change
All	Itemized requirements

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be submitted to the Administrator using one of the following options:

Shell DEPs Online (Users with access to Shell DEPs Online)	Enter the Shell DEPs Online system at https://www.shelldeps.com Select a DEP and then go to the details screen for that DEP. Click on the "Give feedback" link, fill in the online form and submit.
DEP Feedback System (Users with access to Shell Wide Web)	Enter comments directly in the DEP Feedback System which is accessible from the Technical Standards Portal http://swwww.shell.com/standards . Select "Submit DEP Feedback", fill in the online form and submit.
DEP Standard Form (other users)	Use DEP Standard Form 00.00.05.80-Gen. to record feedback and email the form to the Administrator at standards@shell.com .

Feedback that has been registered in the DEP Feedback System by using one of the above options will be reviewed by the DEP Custodian for potential improvements to the DEP.

1.7 DUAL UNITS

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

1.8 NON NORMATIVE TEXT (COMMENTARY)

Text shown in italic style in this DEP indicates text that is non-normative and is provided as explanation or background information only.

Non-normative text is normally indented slightly to the right of the relevant DEP clause.

2. GENERAL

2.1 GENERAL REQUIREMENTS

1. The Manufacturer shall confirm with the Principal all necessary information and design data together with lay-out drawings, e.g., showing feed and draw-off nozzle orientation, manhole position, if these are required.

The information is received by the Manufacturer to further specify the design.

2. The Manufacturer's drawings should be submitted to the Principal for approval.
3. The Manufacturer's drawings shall show all constructional details, including the following:

- a. Downcomer and tray panel fastenings
- b. The location, size, fastening of manholes and distributor supports.

The internals Supplier is responsible for ensuring that the mechanical design of the internals, including their supports, is satisfactory for the design conditions indicated on the requisition and/or drawings.

4. The internals Supplier shall make his own calculations
 - a. which shall be signed as approved for construction by Manufacturer's/Supplier's authorised engineer.

However, the requirements specified in the order and requisition prevails if more stringent.

5. The requirements specified in various section of this DEP shall be applicable, unless specified otherwise in the data/requisition sheet or purchase order.

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.

1. The maximum allowable deviation of the NFA shall be plus or minus 0.5% of the column's cross section, or plus or minus 5.0% of the stated NFA, whichever is the smaller.

2.3 COLUMN ATTACHMENTS

1. Column attachments such as support rings, support lugs and drip rings should be designed by the internals Supplier.
2. Column attachments such as support rings, support lugs and drip rings should be supplied and installed by the column Manufacturer.
3. The internals Supplier shall supply the column internal attachment drawings as per agreed schedule to enable the column Manufacturer to meet the delivery date.
4. Drawings of attachments that are welded to the column should be drawn by the column Manufacturer and signed as approved for construction by Manufacturer's authorised engineer.
5. Drawings of attachments that are bolted to the column wall should be drawn by the internals Supplier and signed as approved for construction by Manufacturer's authorised engineer.
6. Each internal part connected to a column attachment or the column wall (such as support beam, Schoepentoeter and tray) should have a connection suitable for the expected thermal expansion (e.g., bolted connections should be applied with a slotted hole).
7. The location and type of connection shall be determined by the internals Supplier.
8. Column internals shall be fastened to support rings and beams to facilitate mounting and dismounting.

For maintenance or debottlenecking purposes, the Principal is allowed to provide Subcontractors and equipment Suppliers construction details of attachments welded to the column wall without breaching any technology secrecy or non-use agreements.

2.4 ACCESS TO THE COLUMN FOR INSTALLATION AND REMOVAL

1. A manhole in the top column shell ring with a blind flange or a flanged head should be provided to allow column internals to be installed and removed.
2. For columns with a diameter larger than 2.0 m (6 ft – 6 in), a top dome with a top flange should be provided.
3. For columns with a diameter between 1.0 m (3 ft – 3 in) and 2.0 m (6 ft – 6 in), the most economical of Options 2.4 item1 or 2.4 item 2 should be chosen.
4. A top dome should have a minimum diameter of 1.0 m (3 ft – 3 in).
 - a. The maximum dome diameter should not exceed 1.5 m (5 ft) or half the column diameter (whichever is less).
5. The height of a top dome shall be at least twice the top dome diameter.
6. Other than 2.4 item 1, additional manways should be provided as follows:
 - a. one manway should be located 900 mm (36 in) above the bottom head seam;
 - b. one manway should be located 450 mm (18 in) above the top tray, if there is no top flange or top dome;
 - c. for column diameter < 2.0 m (6.6 ft), manways spaced every 30 trays;
 - d. for 2.0 m (6.6 ft) < column diameter < 4.0 m (13.1 ft), manways spaced every 20 trays;
 - e. for column diameter > 4.0 m (13.1 ft), manways spaced every 15 trays;
 - f. vessels with internal compartments or with components obstructing egress from one section to another should have a manway in each section;
 - g. in close proximity to the Schoepentoeter or half-open pipe or a spray distributor so that safe access can be gained to the internals;
 - h. above a feed tray;
 - i. above a gravity liquid distributor;
 - j. below draw-off trays;
 - k. in the flash zone.
7. The internal diameter of manholes should be at least 610 mm (24 in), but in any case not be less than 460 mm (18 in).
8. To facilitate internal access to manways, hand grips or stair cages shall be provided depending on the level of the tray versus the location of the manway.
9. The internals Supplier should verify that the manholes and top flange/ top dome necessary for the safe installation of the column internals be provided on the column.

2.5 MATERIALS OF CONSTRUCTION

1. Materials of construction shall be as specified on the data/requisition sheet or in the purchase order.
2. Corrosion allowance shall be as specified on the data/requisition sheet or in the purchase order.
3. Gaskets for sealing of column internals shall be as specified on the data/requisition sheet.

Gaskets are tape or braided rope fabricated from asbestos-free material suitable for the processing environment.

4. The minimum thickness of gasket tape shall be 1.5 mm (1/16 in).
5. Gasket material shall be used for internal flange connections and bubble cap gaskets.

A list of typical gasket material is specified as follows:

- Polytetrafluoroethylene (PTFE);
- Fibreglass;
- Graphite;
- Aramid;
- Graphite filled (spiral wound, Camprofile).

6. Rubber-impregnated glass fibre rope should not be used.

2.6 SPARES FOR ERECTION

1. Refer DEP 70.10.90.11-Gen. for requirement on spares.
2. The Manufacturer shall ensure that contingencies/ spare parts as recommended by Principal are available during erection.
3. The Principal shall authorize any undercutting of indicated contingencies.
4. When not specified by Principal, 5% extra material may be considered as a contingency for the following component parts of each size and type:
 - a. valves, bolts, nuts, clamps, wedges and washers, (subject to minimum 4 pieces);
 - b. jointing materials, e.g., gaskets, packing, (subject to minimum 1 piece).

2.7 WELDING

The welding of column internal support rings and attachments to the wall of a new column is the responsibility of the column Manufacturer.

2.8 BOLTS

1. Alloy steel bolts shall be ≥ 10 mm (3/8 in) diameter.
2. Carbon steel bolts shall be ≥ 12 mm (1/2 in) diameter.
3. Bolt threads should be metric in accordance with the relevant ISO standard,
4. Bolt length should be chosen so that after the nut(s) have been tightened, only 2-3 threads are exposed.
5. If shims are applied for levelling, threading may be longer to cover the complete shim range.

2.9 HORIZONTAL INSTALLATION AND TRANSPORT OF COLUMNS AND VESSELS

Internals are more frequently installed in the shop of the column or vessel Manufacturer before being shipped to site.

1. When installation of the internals is done with the vessel or column in horizontal position, then precautions should be taken to ensure that internals are installed as per specified procedure and damage during transport is avoided.

Some internals (e.g., gravity distributors, packings) can only be installed after erection of the column on site.

2. Some general guidelines apply to horizontal installation and transport of internals:
 - a. Clamps with “grip” fixation (hook bolts or hook clamps) should be used in combination with type II support rings to mount the internals (normal CS trays), if movement during transport is possible. (Appendix D).
 - b. Structured packing should be installed after erection of the column on site.
 - c. If (2.9 item 2.b) is not possible, the packing support and hold down grids should be bolted onto the supports with hook bolts or hook clamps such that movement of the packing elements during manipulation and/or transport of the column is avoided.

(Temporary) beams or stiffeners can be installed if necessary to avoid (local) deformation of the column, internals (HiFi CS trays) and/or the packing if the column or vessel is transported in horizontal position.

- d. Filling of a bed of dumped packing rings should be done after erection of the column on site.
 - e. Separator internals may be installed with the vessel in the horizontal or vertical position before transport to site.
 - f. If separator internals are installed, internals should be bolted onto the vessel attachments.
 - g. If (2.9, Item 2 f) is not possible, hook bolts or hook clamps shall be used in combination with Type II support rings or open mistmat supports (standard drawing S20.030).
 - h. Internals should be inspected after erection of the column/vessel on site.
3. The temporary beams or stiffeners should be marked and removed after erection of the column on site.
4. Internals Suppliers should have their own procedures available.
5. Internals Suppliers' procedures should be approved by the Principal.

3. FRACTIONATING TRAYS

3.1 PERFORATIONS AND VALVES

1. Fractionating tray perforations and valves (floating and fixed) should be evenly spaced.
2. The perforating pattern should be rectangular or triangular at the internal Supplier's discretion.
3. The perforating pattern proposed by Supplier should be approved by the Principal.
 - a. The distribution pattern of the perforations should be optimized and larger non perforated areas (e.g., support ring, tray panel divisions) avoided.
 - b. There should be a minimum of two rows of perforations (sieve holes or valves) between the bottom of the downcomer and the outlet weir of the tray below.
 - c. The triangular pattern should be specified so that the base of the triangle is perpendicular to the flow direction (to minimise liquid bypass).
4. Punched fractionating sieve tray perforations shall be burr side up, except that:
 - a. the holes for Shell Snap-in valves shall be burr side down to facilitate mounting the valves;
 - b. the punch direction for (R)V1 valves or equivalent may be burr side up or burr side down.
5. Protruded holes shall not be used unless specified on the data/requisition sheet.
6. The bubbling area underneath the Calming Section discharge slots of a HiFi tray shall not be perforated with sieve holes.
7. For fixed and floating valves, the whole tray panel shall be perforated, unless specified differently on the data/requisition sheet.

Fixed or floating valves can be used for Calming Section valve, HiFi valve, and conventional downcomer valve trays.

8. The type and number of valves and the orientation (if applicable) should be specified on the data/requisition sheet.
9. The type, number of valves and orientation shall be re-confirmed with the Principal if trays operate beyond 90% of maximum useful capacity.
10. The pitch of floating valves (measured centre to centre) should be ≥ 1.5 times the diameter of the valve cap.

For some valve types, the diameter of the valve cap is larger than the diameter of the hole in the tray.

11. The following guidelines for perforation of HiFi tray panels apply:
 - a. Tray panels (fixed and floating valves) shall be fully perforated including below the downcomers and downcomer slots,

For sieve trays perforating below the downcomer slots is not allowed.
 - b. Distance of centre of first row of holes (sieves, floating valves only) to the outlet weir shall be minimized.
 - c. If not perforated below the downcomers or slots, the distance of the centre of the first row of holes from the vertical projection of the Calming Section slots or downcomer bottom at the tray below shall be $\frac{1}{2}$ pitch of that tray.

The pitch is defined as the distance between the perforations perpendicular to the Calming Section outlet weir.

3.2 MECHANICAL REQUIREMENTS

3.2.1 Loads

3.2.1.1 General

1. Fractionating trays and supports shall be designed to withstand the forces described in (3.2.1.2) and (3.2.1.3).

3.2.1.2 Normal service

1. Design loads for normal service are as follows:
 - a. for Calming Section trays: a maximum downward operating load equal to their own weight plus the weight of water (equivalent to a height of the weir + 50 mm (2 in) + water full downcomers ($= 0.75 \times \text{CSA} \times \text{CSH}$), with a minimum of 1000 Pa (0.15 psi));
 - b. for conventional downcomer trays: a maximum downward operating load equal to their own weight plus the weight of water (equivalent to a height of the weir + 50 mm (2 in) + downcomers filled with water up to 50% of TS, with a minimum of 1000 Pa (0.15 psi);
 - c. for Grid tray in non-fouling services: the own weight plus a maximum downward operating load of the tray of 1500 Pa (0.22 psi);
 - d. a maximum upward load of 2000 Pa (0.30 psi) at maximum working temperature evenly distributed over the entire fractionating tray surface.
2. Tray assemblies shall be capable of supporting their own weight plus a concentrated load of 1350 N (300 lbf) located at any trusses on the tray at ambient temperature.

The maximum allowable stress permitted under this condition is at ambient temperature.

3.2.1.3 Heavy duty

1. In cases where the loads for Calming Section and conventional downcomer trays can easily be exceeded due to an operational mishap (e.g. liquid full trays, steam explosions), the following maximum loads should be used:
 - a. downward: The own weight plus the weight of the hot process liquid if the tray spacing is completely filled;
 - b. upward: 6900 Pa (1 psi) maximum;
 - i. Tray panels should be clamped onto the supports.
 - ii. Hook bolts (C bolts) or hoke clamps (in combination with type II support ring) should be used.
 - iii. As an alternative, the use of one or more explosion doors may be considered.

Size of explosion doors is typically 80% of the total hole area for vapour passage with a minimum of 5% of the active tray area.

- iv. There should be at least one door per beam area.

Explosion doors are only used in combination with a high uplift design of 6900 Pa (1 psi).

2. grid tray in fouling services shall be designed for their own weight plus a maximum downward operating load on the tray of 6900 Pa (1 psi);
3. criteria for the design of internals for heavy-duty conditions shall be indicated on the data requisition sheets.

Dedicated load criteria are used for the special, high capacity, trays and separator internals. These are given in the subsequent sections (3.6.4) through (3.6.7).

3.2.2 Deflections

1. For sieve, valve, bubble cap and grid trays, the maximum downward or upward deflection (when operated within their normal operating window) shall not be more than 1/900 of the internal column diameter.
2. At the maximum operating load [refer to (3.2.1)], no permanent deformation and/or damage shall occur.

3.2.3 Levelness

1. The tilt of fractionating trays and gravity liquid distributors shall not exceed 0.3% of the column diameter, or 6 mm (1/4 in), whichever is the smaller.
2. Local depressions and bulges in panels shall not exceed 6 mm (1/4 in) from the nominal plane.
3. Refer to DEP 31.22.00.31-Gen. for tolerances on levelness of trays.

The tolerances of the support rings inside the vessel and the proper erection of the vessel on site largely determine the levelness of trays.

3.2.4 Thermal expansion and differential thermal expansion design scenarios

1. For mechanical design of the internals, the following scenarios shall be considered:
 - a. expansion from cold winter ambient temperature to operating temperature;
 - b. contraction from hot operating temperature to cold winter ambient;
 - c. contraction from hot summer ambient temperature to cold operating temperature, (LNG);
 - d. expansion from cold operating temperature to hot summer ambient (LNG);
 - e. differential temperature between column shell and internals/beams;
 - f. differential expansion due to different metallurgies of the various internals, supports and column.
2. Thermal expansion requirements for support beams and support rings are discussed in more detail in (3.2.5).

3.2.5 Fractionating tray supports

3.2.5.1 Rings

1. Stacked trays (or cartridge trays) should be installed in columns with a nominal diameter of up to 800 mm (32 in).
2. For columns with a nominal diameter of 800 mm (32 in) and above, support rings shall be welded to the column wall, refer (5.3.4).
3. A minimum of overlap (Figure D.1, Size C) between tray panels and support ring should be provided. Refer to (Appendix D) for support ring details.

3.2.5.2 Panel supports

1. The panels of Calming Section trays shall be self-supporting.
2. The height of reinforcement rims shall not exceed one-quarter of the tray spacing for panels that are perpendicular to the liquid flow.
3. The height of reinforcement rims may be increased to one-third of the tray spacing for panels that are parallel to the liquid flow direction.

3.2.5.3 Beams

1. Minimum material thickness shall be 3 mm (1/8 in).
2. A minimum of overlap (Figure D.1, Size C) between tray panels and support beam(s) should be provided. Refer to (Appendix D) for support beam details.
3. Support beams shall accommodate thermal expansion under different operating scenarios.
 - a. A thermal expansion resulting from temperature differences between the support beam and the column shell shall be accommodated for following operating scenarios:
 - i. the beam is expanding more than the shell (typically for start-up conditions);
 - ii. the beam is reducing in length more than the column shell, as typically occurs when the column is shut down.
4. To accommodate thermal expansion, slotted holes shall be used for mounting the beams onto the supports, with following additional requirements:
 - a. two washers and double nutted;
 - b. the first nut fixed hand tight;
 - c. the second nut fixed with a torque wrench using a recommended torque of 1.9 Nm – 2.6 Nm (46 ft.lbs – 62 ft.lbs), dependent on the bolt size used.
5. The Manufacturer/Supplier 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 shutdown) and allowing expansion at both ends of the beam.
 - a. The maximum difference between the operating temperature and ambient temperature shall be used for the slot length calculation.
6. Completely tightened beams applied as “transport connection” shall be loosened during final site installation and installed as per (3.2.5.3 item 4).
7. The transport connections shall be marked yellow on the connection.
8. Support beams shall not restrict the liquid and vapour communication on the trays.
9. The support beams shall have sufficient stiffness to overcome the friction in their connections to the supports without deformation.
10. The total height of any support beam shall be minimised.

11. For minor support beams on conventional downcomer trays (where beams are perpendicular to the direction of liquid flow), and for the main beams on Calming Section and HiFi trays, the following requirements shall be met:
- a. The beam shall occupy not more than one third of the space between the trays, as defined by Equation-1:

$$\frac{A_{\text{beam}}}{D \times TS} < \frac{1}{3} \quad \text{Eq. 1}$$

where:

A_{beam} = area of beam, horizontally projected, m² (ft²);
D = internal diameter of column, m (ft);
TS = tray spacing, m (ft).

- b. If the criterion in (3.2.5.3, item 11.a) cannot be met with a solid beam, an open type of beam should be used, such as an I-type beam with holes therein or an open work construction as shown in (Appendix C).
12. If a C-type beam with separation segments is used, each segment of the beam should be provided with a draining facility.
13. Where draining of the separation segment is not possible, a drain hole of at least 12 mm (1/2 in) should be drilled in the bottom of the C-type beam.
14. The number of tray support beams for Calming Section trays, as presented in Table 3.1, may be used as a general guide.

Table 3.1 Number of tray support beams for Calming Section trays

Column diameter, D _c [m]	Column diameter, D _c [ft]	Number of beams
< 2.5	< 8.2	0
2.5 ≤ D _c < 5.2	8.2 ≤ D _c < 17.1	1
5.2 ≤ D _c ≤ 7.8	17.1 ≤ D _c ≤ 25.6	2
D _c > 7.8	D _c > 25.6	3
D _c > 11	D _c > 36.1	≥3

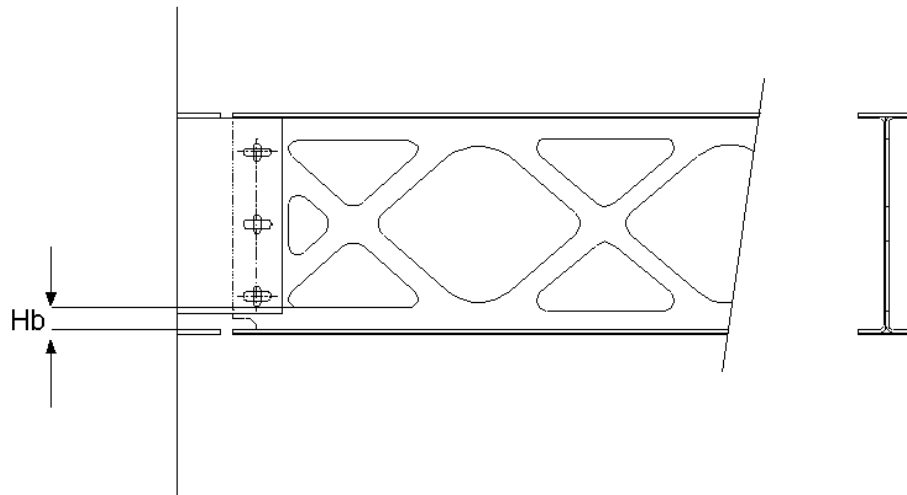
HiFi trays up to a diameter of 8 m (26 ft) will normally have one central support beam. For a column diameter < 3 m (10 ft), a support beam is only needed if mechanical strength requirements cannot otherwise be met.

If no beam is applied, review of the drawings by the Principal is strongly recommended.

15. For columns with a larger diameter than specified in Table 3.1, the Principal should be consulted if no details on the HiFi tray support beams are specified in the requisition.
16. Optionally 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.
- a. Combined beams may be applied for column diameters smaller than 6.0 m (20 ft), subject to approval by Principal.
17. If a combined beam is used, it shall occupy not more than 1/3 of the free space.

18. The height of the edge/obstruction below the support beam openings ("Hb" in Figure 3.1) should be less than the weir height of the tray below.
19. Hb shall not exceed a height of 35 mm (1-3/8 in) so as not to hamper the liquid cross-flow on that tray.
20. The Principal shall be consulted if the requirements for a combined beam cannot be met.

Figure 3.1 Open structure combined support beam



3.3 DRAINING AND LEAKAGE

3.3.1 Draining

Drain holes are not required on sieve or valve trays, except for trays with seal pans or inlet weirs.

1. Each seal pan shall have at least one drain hole with a diameter of 10 mm (3/8 in) to permit draining of the liquid hold-up.
2. Drain holes in recessed seal pans shall be located downstream or on the tray side of the downcomer so that any vapour passing through the holes will not by-pass the tray above.
3. Inlet weirs shall have a 12 mm (1/2 in) hole at the base to drain into the tray.
4. Seal pans underneath Calming Sections shall have a drain hole of 12 mm (1/2 in) diameter.

3.3.2 Leak tightness

1. The tightness of Calming Sections and conventional downcomers shall be as specified in (3.6.1 Table-3.2 and item 10).
2. Bubble cap trays should be able to hold liquid up to weir or riser height.
3. Bubble cap trays should be capable of passing the leakage test as described in (Appendix L).

3.4 INSTALLATION, REMOVAL AND ASSEMBLY

3.4.1 Fractionating tray installation and removal

1. To facilitate installation and maintenance, fractionating trays shall be made in sections which can pass through manholes or the top dome of the column.
2. Stacked trays shall be designed to permit installation and removal from top.
3. All fractionating trays shall be designed to permit installation and removal from the top.
4. All fractionating tray parts shall have durable markings (in paint or ink) with reference to the erection plan from which the internals can be identified.
5. For stainless steel parts, the paint or ink shall be chloride-free.
Refer DEP 30.48.00.31-Gen. for painting details.

3.4.2 Fractionating tray assembly

1. Fractionating tray parts size should be maximised to reduce the number of joints.
*For mechanical fastening, bolts and quick fasteners (wedge/clamps) are allowed.
Bolted connections are preferred for the sake of standardization.*
2. Wedge/clamp style fasteners should be used for:
 - a. larger column diameters (> 1.5 m (5 ft));
 - b. if there is a particular reason (such as fouling/corrosion/exotic materials) for a given application;
 - c. for like for like replacement;
Note that bolted joints are preferred for panels with fixed valves.
3. Sufficient clearance to facilitate assembly on site should be allowed.
4. Bolted joints shall be used for the following:
 - a. to attach support beams to cleats;
 - b. to attach downcomer plates in columns with conventional downcomers;
 - c. to attach auxiliary internals.
5. Connections to beams or cleats that are considered essential by the Manufacturer to the integrity of the column internal construction; shall be secured by suitable means.
 - a. Bolted connections to beams or cleats shall be secured by means of tack welding the nut to the bolt, or by employing a second nut.
6. The maximum allowable difference in level between two adjacent panels shall be 2 mm (0.08 in).
7. For grid trays, the maximum allowable vertical displacement of adjoining bars shall be 3 mm (1/8 in).
8. Internal distribution pipes shall have flanged connections, refer to standard drawing S 10.016.
 - a. Indicated flange thicknesses should be used as a guideline only.
 - b. Indicated flange thicknesses may be minimised for all nominal pipe sizes on the basis of mechanical requirements and the materials of construction.
 - c. For spray headers, standard flanges (ASME 150#) should be used.
9. For floating valve trays, round or rectangular valves shall be used.
10. For (tray panel) replacement jobs, snap in valves should be replaced by RV1 valves or equivalent.

11. When replacing snap in valves, the net free area shall be changed to keep the dry pressure drop, capacity and turndown of the trays the same, subject to approval by the Principal.
12. Shell Snap-in valve should not be used, due to the high risk of mechanical damage.
13. For new designs, Snap in valves should be used if specified on the data/requisition sheets.
14. If Snap in valves are used, the following shall be followed:
 - a. To prevent mechanical damage, Shell Snap-in valves shall not be mounted on trays until the trays have been installed in the column.
 - i. Snap-in valves shall be inserted by the application of even pressure by a hand on a valve placed squarely in the tray hole.
 - ii. Snap-in valves shall not be driven in by a hammer, mallet or other blunt instrument.
 - iii. Damaged Shell Snap-in valves shall be discarded and replaced by new ones.
 - 1). Shell Snap-in valves shall not be re-used because the legs could have been overstressed and lost their resilience.

3.5 PROVISIONS FOR ACCESS

1. Fractionating trays and fittings shall be designed so that the tray is accessible for cleaning, gas freeing, inspection and maintenance.
2. Access to fractionating trays not served by column manways, should be provided by means of bolted manways in the trays.
3. The column Manufacturer shall ensure that a man can pass through the manways of the fractionating trays as installed.
4. Tray manways should have a minimum opening of 320 mm x 500 mm (13 in x 20 in).

Where this is impossible for construction reasons, the use of smaller manways are subject to the approval of the Principal.
5. If no access manway for tray is possible, the cover plate of the tray shall be split.
6. If the clearance between the tray deck and the bottom of the main supporting beams of the tray above is less than 400 mm (16 in), tray manways shall be installed on each side of the beams.
7. For HiFi trays, the Manufacturer shall provide suitable access to the tray below on both sides of the beam.
8. On Calming Section trays, manways should not be located directly underneath Calming Sections of the tray above.
 - a. When locating underneath the calming section is unavoidable, the column Manufacturer should check the requirement of removing part or all of a Calming Section or baffle.
9. Bolting and unbolting of tray manways should be possible from both sides of the tray.
10. If access from either side of the tray is not possible (e.g., in the case of small-diameter HiFi trays), the requirement specified in (3.5 item 8) may be relaxed subject to approval of the Principal.
11. Exposed edges of trays at locations accessible to people shall be bevelled or rounded off, e.g., at manways and top edges of weirs.

3.6 SPECIFIC TYPES OF FRACTIONATING TRAYS

3.6.1 Calming Section trays

1. Calming Sections shall be manufactured in one piece, as shown in (Appendix A), unless a division is needed due to column manhole restraints.
They are evenly distributed on the tray as specified in the requisition and/or drawing.
2. Minimum material thickness of the tray panels shall be 2 mm (14 ga, 0.08 in).
3. No parts of the tray shall have a material thickness of less than 1.5 mm 1/16 in).
4. Minimum lateral distance between two adjacent Calming Sections shall be 420 mm (17 in) (centre to centre).
5. A minimum of two rows of perforations shall be included between adjacent Calming Sections.
6. Calming Sections shall have a box-type construction as illustrated in (Appendix A).
7. The following tolerances for Calming Section trays shall apply:

Table 3.2 Tolerances for Calming Section trays

Length at top of weir	±	5 mm (0.2 in)
Width at top of weir	+	5 mm (0.2 in)
	–	0 mm (0 in)
Height of weir above tray	±	2 mm (0.08 in)
Height of baffle above tray	±	10 mm (3/8 in)
Depth below tray	±	5 mm (0.2 in)
Length at bottom	±	10 mm (3/8 in)
Width at bottom	±	5 mm (0.2 in)
Seal pan depth/clearance	+	5 mm (0.2 in)
	–	0 mm (0 in)

8. The following tolerances on the area indicated in data/requisition sheet may be allowed:

Slot area + 10%

Calming Section area + 10%
9. The space for fastening the downcomer to the tray panel, between the ends of the downcomer and the tray support ring, shall be 15 mm (5/8 in) maximum.
In principle, the Calming Section discharges liquid only through the slots or seal pan provided for that purpose.
10. The total area of openings other than the slots or seal pan in the Calming Section that might lead to leakage of liquid or vapour, shall not exceed 1.0% of the open area in the downcomer bottom.
11. Any gap in a seam shall not be wider than 1.0 mm. (0.04 in).
12. The Calming Section assembly should be done by welding.
 - a. Welding can be stitch or spot welding as long as the requirements for mechanical strength, leaktightness and mechanical tolerance are met.

13. The Calming Section baffle should be bolted onto baffle support lugs, which are spotwelded into the Calming Section.
14. Alternative assembly techniques for the Calming Section and the baffle are subject to approval by the Principal.

3.6.2 HiFi trays

1. HiFi Calming Sections shall be manufactured in one piece, as shown in (Appendix B), unless a division is needed due to column manhole restraints.
2. Tolerances on the main dimensions and the requirements for leak tightness are as described in (3.6.1 Table-3.2 as applicable).
3. Minimum material thickness of the tray panels shall be 2 mm (0.08 in).
4. No parts of the tray shall have a material thickness of less than 1.5 mm (1/16 in).
5. Baffles shall be fitted to all except the corner downcomers.
6. Vertical plates shall support the baffles.
7. If the baffles are not connected to the HiFi Calming Section ends, the first baffle support (nearest to the HiFi support beam) shall be placed 100 mm (4 in) from the Calming Section end.
8. The last baffle support (closest to the column wall) shall be positioned 100 mm (4 in) from the end of the smaller of the two long sides of the HiFi Calming Section.
9. The two outer baffle supports shall have a clearance of 200 mm (8 in) from the bottom of the HiFi Calming Section.
10. Intermediate baffle supports should be minimised.
 - a. The maximum distance between baffle supports should be 600 mm (24 in) intervals extending to 100 mm (4 in) above the Calming Section bottom.
11. Baffle supports shall be placed so that the number of slots or slot groups in between baffles is the same.
12. The maximum space between the ends of the HiFi Calming Sections and the support ring or beam for fastening shall be:
 - a. 10 mm (3/8 in) to the edge of the beam;
 - b. 20 mm (3/4 in) to the edge of the support ring.
13. If no central support beam is used, the minimum distance between the end of the HiFi Calming Section and the column centreline should be 50 mm (2 in).
14. On single downcomer HiFi trays installed in small columns with a diameter ≤ 1.5 m (5 ft), one HiFi-like segmental downcomer shall be installed per tray.
 - a. The HiFi-like segmental downcomer should be constructed as a segmental box.
 - b. The segmental box shall have a clearance of minimum 15 mm (5/8 in) from the column wall.
 - i. In columns with a diameter ≤ 800 mm (32 in) where accessibility is difficult, a full (expandable) support ring with a width of 15 mm (5/8 in) shall be used.
 - ii. For larger diameter columns, the width of the tray support ring at the location of the segmental downcomer shall be reduced to 15 mm (5/8 in).

The HiFi Calming Section assembly is done via welding. Stitch or spot welding is allowed as long as requirements for mechanical strength, leaktightness and mechanical tolerance can be met. The Calming Section baffle is bolted onto the baffle supports provided.

3.6.3 Conventional downcomer trays

1. Minimum material thickness of the tray panels shall be 2 mm (0.08 in) or 14 gauge.
2. No parts of the tray shall have a material thickness of less than 1.5 mm (1/16 in).
3. For tolerances on the main dimensions and the requirements for leak tightness, refer (3.6.1, Table-3.2 as applicable).

The sealpan of the downcomer of the bottom tray often acts as a trap for debris.

4. One or more drainhole(s) of 25 mm (1 in) should be used as long as the downcomer leak tightness criterion as specified in (3.6.1) (total downcomer leak < 1% of downcomer open bottom area) is not violated.

3.6.4 ConSep trays

1. The ConSep tubes should be tack welded to the swirler.
2. The swirler should be tack-, spot- or stitch welded to the ConSep swirl deck.
3. Tolerances on the main dimensions and the requirements for leak tightness shall be as described in (3.6.1, Table-3.2 as applicable).
4. The bottom plate of the swirl tube box and the vertical walls shall be fully seal welded.
5. The box flanges and the swirl deck downcomer flanges shall be provided with gaskets.
6. Total leak area of the ConSep box shall be less than 15 mm² per swirl tube installed.
7. The mechanical load and installation criteria for ConSep trays shall be as follows:
 - a. a maximum downward operating load equal to the own weight plus the weight of water (equivalent to a height of the weir + 50 mm (2 in) + liquid full downcomers ($= 0.75 \times CSA \times CSH$), with a minimum of 1000 Pa (0.15 psi);
 - b. a maximum upward load of 6900 Pa (1 psi) at maximum working temperature evenly distributed over the entire fractionating tray surface.
8. Tray assemblies shall be capable of supporting their own weight plus a concentrated load of 1350 N (300 lbf) located at any trusses on the tray at ambient temperature.

The maximum allowable stress permitted under this condition is at ambient temperature.

Deflection criteria as defined in (3.2.2) apply.

9. Special flagbolts shall be used to install the trays onto the support rings since the trays are only accessible from one side.
10. Interference with the ConSep box and the support ring should be avoided.

3.6.5 Contacting Swirl Tube trays

1. Contacting Swirl Tube trays and tray panels shall be leak tight installed on the (expandable) tray support rings.
2. Prefabricated gaskets shall be used on the tray support ring and in between the tray panel flanges.
3. The -gasket material shall be specified in the data/requisition sheets.
4. The flanges of the liquid feed and outlet pipes shall be provided with prefabricated gaskets to ensure leak tight installation.
5. If expandable tray support rings are used, the method of sealing should use a braided ceramic rope enclosed in a chamber, as illustrated in Figure 3.2.