MANUAL

INTERNALS FOR COLUMNS

DEP 31.20.20.31-Gen.

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DESIGN AND ENGINEERING PRACTICE

PREFACE

DEP (Design and Engineering Practice) publications reflect the views, at the time of publication, of:

Shell International Oil Products B.V. (SIOP)
and
Shell International Exploration and Production B.V. (SIEP)
and
Shell International Chemicals B.V. (SIC)

The Hague, The Netherlands,

and other Service Companies.

They are based on the experience acquired during their involvement with the design, construction, operation and maintenance of processing units and facilities, and they are supplemented with the experience of Group Operating companies. 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 design and engineering practice applied by Group companies operating an oil refinery, gas handling installation, chemical plant, oil and gas production facility, or any other such facility, and thereby to achieve maximum technical and economic benefit from standardization.

The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where DEPs may not cover every requirement or diversity of condition at each locality. The system of DEPs is expected to be sufficiently flexible to allow individual operating companies to adapt the information set forth in DEPs to their own environment and requirements.

When Contractors or Manufacturers/Suppliers use DEPs 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, the Principal will expect them to follow those design and engineering practices which will achieve the same level of integrity as reflected in the DEPs. If in doubt, the Contractor or Manufacturer/Supplier shall, without detracting from his own responsibility, consult the Principal or its technical advisor.

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1) Operating companies having a Service Agreement with SIOP, SIEP, SIC or other Service Company. The use of DEPs by these Operating companies is subject in all respects to the terms and conditions of the relevant Service Agreement.

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All administrative queries should be directed to the DEP Administrator in SIOP.

NOTE: In addition to DEP publications there are Standard Specifications and Draft DEPs for Development (DDDs). DDDs generally introduce new procedures or techniques that will probably need updating as further experience develops during their use. The above requirements for distribution and use of DEPs are also applicable to Standard Specifications and DDDs. Standard Specifications and DDDs will gradually be replaced by DEPs.

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APPENDICES

1. INTRODUCTION

1.1 SCOPE

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

This DEP is a revision of the DEP of the same number dated August 1988. The previous title was “Trays for columns”; this revision updates the requirements for trays and has been extended to also include packed sections.

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

- bubble cap trays;
- grid trays;
- sieve trays;
- valve trays;
- trays with conventional downcomers;
- trays with normal calming section downcomers;
- trays with HiFi calming section downcomers;

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;
- HiFi Schoepentoeters.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIOP and SIEP, the distribution of this DEP is confined to companies forming part of the Royal Dutch/Shell Group or managed by a Group company, and to Contractors and Manufacturers/Suppliers nominated by them (i.e. the distribution code is "F", as defined in DEP 00.00.05.05-Gen.).

This DEP is intended for use in oil refineries, chemical plants, gas plants and, where applicable, in production facilities.

If national and/or local regulations exist in which some of the requirements may 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 as regards safety, 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 with the object of obtaining agreement to follow this DEP 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.

1.4 CROSS-REFERENCES

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

2. GENERAL

2.1 GENERAL

This DEP specifies basic requirements and recommendations. To further specify the design the Manufacturer will normally receive data requisition sheets DEP 31.20.20.93-Gen. 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), if these are required. For draw-off trays, data requisition sheet DEP 31.20.20.94-Gen. shall be used.

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

The internals Supplier is 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 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.

2.3 COLUMN ATTACHMENTS

Column attachments such as support rings, support lugs and drip rings 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. Drawings of attachments that are welded to the column should be made by the column Manufacturer. 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, schoepentoeter, 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 dismounted.

2.4 ACCESS TO THE COLUMN FOR INSTALLATION AND REMOVAL

A top flange or a top dome with a top flange should be provided to allow passage of column internals. Columns with a diameter smaller than 1.0 m should be designed with a top flange. 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 1.0 and 2.0 m, the most 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.

Manholes should be provided for 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.

To facilitate access to the column internals, column manholes should be located as follows:

- every 15 to 20 fractionating or contacting trays;
- next to a schoepentoeter;
- below a spray distributor;
- above a gravity liquid distributor;

- below draw-off trays;
- in the bottom compartment/sump of the column;
- in the flash zone;
- at the top of the column if there is no top flange or top dome.

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 3 mm ceramic fibre rope or glass fibre rope, both of which can be used up to 500 °C. Rubber impregnated glass fibre rope should not be used.

2.6 SPARES FOR ERECTION

Of the following component parts an excess percentage of each size and type shall be furnished to serve as spares during erection:

Valves, bolts, nuts, clamps, wedges, washers, etc.	minimum 10%; with not less than 4 pieces
Jointing materials (gaskets, packing)	minimum 25%, with not less than 1 piece

2.7 WELDING

Welding of column internal parts shall be performed according to procedures by welders qualified in accordance with 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 and carbon steel bolts shall be not smaller than 12 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 such that after the nut(s) have been tightened only 2 to 3 threads are exposed.

3. FRACTIONATING TRAYS

3.1 PROCESS REQUIREMENTS

3.1.1 Perforations and valves

Fractionating tray perforations and valves 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 at least two rows of perforations (sieve holes or valves) for the liquid flow coming out of the bottom of the downcomer to the outlet weir of the tray below.

Punched fractionating tray perforations shall be burr side up. An exception is made, however, for the holes for Shell snap-in valves which shall be burr side down, to facilitate mounting of the valves. Protruded holes shall only be used if specified in the data requisition.

The bubbling area underneath the HiFi calming section slots (plus a strip of 10 mm around the projection of the slots on the fractionating tray) of a HiFi calming section sieve tray should not be perforated with sieve holes.

Snap-in valves are to be used for Normal or HiFi Calming Section valve trays, unless otherwise specified on the data requisition. For conventional downcomer trays other types of valves may be used. If other valves are to be used for conventional downcomer trays the type and number of valves shall be confirmed with the Principal.

The pitch of snap-in or other valves (measured centre to centre) shall be not less than 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.

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 a maximum operating load in an upward and downward direction of 2 000 N/m^2 at maximum working temperature evenly distributed over the entire fractionating tray surface.

Apart from the requirements above, the fractionating trays shall be capable of absorbing the loads expected during installation and maintenance. These loads shall be taken as 1 000 N downward (equivalent to the weight one man working on the assembly).

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 1/800 of the internal column diameter with a maximum of 6 mm.

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.

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).

For support rings, reference is made to Appendix 4.

3.2.4.2 Panel supports

The panels of normal calming section trays shall be self-supporting, the height reinforcement rims not exceeding 100 mm.

3.2.4.3 Beams

Minimum material thickness shall be 3 mm.

Liquid and vapour communication on trays shall not be restricted by the supporting beams of the tray above. The total height of any support beam shall not exceed one half of the tray spacing.

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

For minor support beams on conventional downcomer trays, which beams are perpendicular to the direction of liquid flow, and for the main beams on normal and HiFi calming section trays the following shall apply:

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

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

where A_{beam} = area of beam, horizontally projected, m^2

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 shall be used, such as an I-type beam with holes therein or an open work construction as shown in Appendix 3.

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

Unless otherwise specified in the requisition, for normal calming section trays the following shall apply:

Table 1 required number of beams for a normal calming section tray

Column diameter, D_c [m]	Required number of tray support beams
< 2.5	0
$2.5 \leq D_c < 5.2$	1
$5.2 \leq D_c \leq 7.8$	2
$D_c > 7.8$	3

HiFi calming section trays up to a diameter of 8 m will normally have one central support beam. For columns with a larger diameter, the Principal should be consulted if no details on the HiFi calming section tray support beams are specified in the requisition.

For column diameters larger than 6.0 m a combined beam (for two fractionating trays) may be fitted.

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 vapour passing through the holes will not by-pass the tray above. Inlet weirs shall have a 13 mm hole at the base to drain into the tray. Seal pans underneath normal Calming Sections shall have a drain hole of 6 mm diameter.

3.3.2 Leaktightness

The tightness of calming sections and conventional downcomers is specified in section 3.6. 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 11.

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 the top.

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. Similarly normal and HiFi calming section downcomers shall be attached with a suitable quick fastening system. 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 which are 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. For grid trays the maximum allowable vertical displacement of adjoining bars shall be 3 mm.

Internal distribution pipes shall have flanged connections, refer to Standard Drawing S 10.016.

To prevent mechanical damage Shell snap-in valves shall not be mounted on trays until the trays have been installed in the column.

Note: Snap-in valves shall be inserted by the application of even pressure by a hand on a valve placed squarely in the tray hole.
Snap-in valves must not be driven in by a hammer, mallet or other blunt instrument. Damaged snap-in valves shall be discarded and replaced by new ones. They shall not be re-used since the legs may have been overstressed and may have lost their resilience.

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 manholes shall be provided by means of bolted manholes in the fractionating trays.

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

Whenever possible tray manholes shall have a minimum opening of 320 x 500 mm. Where this is impossible for construction reasons, the use of smaller manholes shall be subject to the approval of the Principal. The manhole shall not be smaller than 270 x 450 mm. If no manhole is 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 manholes shall be installed on each side of the beams.

For HiFi calming section trays, the column Manufacturer shall ensure suitable access to the tray below on both sides of the beam.

On calming section trays manholes are preferably not located directly underneath calming sections of the tray above. Where this is unavoidable, the column Manufacturer shall check whether it is necessary for part or all of a calming section or baffle to be made removable.

For the sake of flexibility, bolting and unbolting of tray manholes should be possible from both sides of the tray.

Exposed edges of trays at locations where people may have access shall be bevelled or rounded off, e.g. at manholes and top edges of weirs.

3.6 SPECIFIC TYPES OF FRACTIONATING TRAYS

3.6.1 Normal Calming Section trays

Normal calming sections shall be manufactured as one piece, and they shall be evenly distributed on the tray as specified in the requisition and/or drawing. Minimum material thickness of the tray panels shall be 2 mm and no parts of the tray shall have a material thickness of less than 1.5 mm. Minimum lateral distance between two adjacent calming sections is 420 mm (centre to centre) and maximum panel length is 2 500 mm. Preferred panel width is 350 mm.

At least two rows of perforations shall be included between adjacent normal calming sections.

Normal calming sections have a box-type construction as shown in Appendix 1. The following tolerances, in millimetres, shall apply:

Length at top of weir	±	10
Width at top of weir	±	5
Height of weir above tray	±	5
Height of baffle above tray	±	10
Depth below tray	±	5
Length at bottom	±	10
Width at bottom	±	5
Seal pan depth/clearance	+	5
	-	0

The following tolerances in percentages of the area indicated are allowed:

Slot area	+	10
	-	0
Calming section area	+	10
	-	0

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 maximum.

In principle, the calming section discharges liquid only through the slots or seal pan provided for that purpose. The total area of openings elsewhere in the calming section which may lead to leakage of liquid or vapour shall not exceed 1.0% of the open area in the downcomer bottom. Any gap in a seam shall not be wider than 1.0 mm.

3.6.2 HiFi calming section trays

HiFi calming section downcomers should be manufactured as one piece, as shown in Appendix 2. Tolerances on the main dimensions and the requirements for leaktightness are as mentioned under (3.6.1). No parts shall have a material thickness of less than 2 mm.

Baffles are fitted to all except the corner downcomers. The baffles shall be supported by vertical plates extending to 100 mm above the downcomer bottom. Baffle supports should be spaced at approximately 500 mm intervals.

The space for fastening the downcomer to those supports, between the ends of the downcomer and the ring or beam, shall be:

- 50 mm maximum to the centre of the beam,
- 20 mm maximum to the edge of the support ring (see also Appendix 2).

Slots in the downcomer bottom shall be distributed as specified in the requisition and/or drawing. These slots shall be equal in length to the width of the downcomer bottom, unless otherwise specified. Slot width shall be 15 mm unless specified otherwise.

3.6.3 Conventional downcomer trays

No parts shall have a material thickness of less than 2 mm. Tolerances on the main dimensions and the requirements for leaktightness are as mentioned under (3.6.1).

4. DRAW-OFF TRAYS, LIQUID COLLECTORS AND GRAVITY LIQUID DISTRIBUTORS

Three types of draw-off trays can be distinguished:

I. Single deck draw-off trays, both partial and total draw-off

II. Double deck draw-off trays

III. Chimney tray draw-off tray

Two types of liquid collectors can be distinguished:

I. Gutter arrangement above a reboiler compartment

II. Vane collector below a packed bed

Two types of gravity liquid distributors can be distinguished:

I. Gravity distributor with trough(s) and gutters

II. Pan-type gravity distributor

4.1 PROCESS REQUIREMENTS

Minimum free area for vapour passage should be 25% of the column cross section. The minimum free area comprises the riser area, the riser cap clearance and the area between the riser caps (and the downcomers, if applicable).

The liquid outlets (nozzles) in the sump or trough(s) shall be equipped with vortex breakers (Standard Drawing S 10.010).

If so specified on the data requisition sheet, a drip ring shall be welded to the column wall 100 mm above the gutters of the draw-off tray/liquid collector/gravity distributor, see also (2.3). This shall make an angle of 60° with the wall, and shall normally have a width of 100 mm.

The column Manufacturer shall ascertain that the width and length of the drip ring is sufficient to deflect liquid flowing down the wall of the column into the gutters, troughs or sump of the draw-off tray/liquid collector/gravity distributor.

If thermal insulation of gutters and troughs is specified, such insulation shall be by means of double walls.

4.2 MECHANICAL REQUIREMENTS

4.2.1 Loads

Unless otherwise stated on the data requisition sheet or in the order, liquid gravity distributors, single/double deck draw-off trays and their supports shall be designed to withstand the following forces:

I The weight of the full liquid contents of the internal (normally the process liquid is taken for this purpose. However, water is taken if water is used at some time during the operating cycle of the column (e.g. during steaming out) and water is the heavier liquid).

II A maximum operating load in an upward and downward direction of 2 000 N/m^2 at maximum working temperature evenly distributed over the entire surface of the internal.

Apart from the requirements above, the trough(s), sump(s) and gutters shall be capable of absorbing the loads resulting from installation and maintenance activity. These loads shall be taken as 1 000 N downward, equivalent to the weight of one man working on the assembly.

Each draw-off tray/liquid collector/gravity distributor shall be a unit capable of withstanding the weight of liquid hold-up (as defined in 4.3.2) at its operating temperature or of water, whichever is the greater and the loads mentioned above.

In some cases, a draw-off tray may also be required to support other internals, for example a packed bed above, or a liquid distribution spider below. In these cases the extra load shall be added.

4.2.2 Deflections

For a liquid gravity distributor the maximum downward and upward deflection under operating load shall not be more than 1/800 of the internal column diameter with a maximum of 6 mm.

4.2.3 Levelness

The maximum allowable tilt of gravity liquid distributors shall be 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 nominal level.

Each gutter (side-channel) of a gravity distributor shall be capable of being levelled independently of the other gutters. A pan-type gravity distributor shall also have a levelling facility.

All gutters of draw-off trays, gutter arrangements and liquid collector trays shall have a slope of 1:200 towards the trough or sump they drain into.

4.2.4 Support

A draw-off tray, liquid collector or gravity distributor shall be supported on lugs or a supporting ring attached to the column wall, which shall be supplied by the column Manufacturer, see (2.3).

A gravity distributor should never be supported from the packed bed below.

4.2.5 Construction

Material thickness of riser caps and supports shall be 2 mm minimum, of side gutters 3 mm minimum (except for the gutters of a vane collector, see 4.5) and of side sump or transverse trough(s) 6 mm minimum.

Side gutters and trough(s) shall be interconnected by flanged gasketed joints with a material wall thickness of the flanges of minimum 6 mm. The minimum thickness of the gasket shall be 3 mm.

In general, side sumps and troughs shall be of fully welded construction.

Gasketed joints below normal liquid level shall be avoided wherever possible, and metal-to-metal flanged connections should be used instead. For side-sumps and troughs, long straight joints below normal liquid level, if unavoidable, shall be seal or strength welded. Facing or circular joints to pipe connections shall be machined (stock-finished).

If certain parts have to be welded during installation in the column by other parties, the tray Supplier shall state the total weld length and stipulate the required welding procedure.

The bolts connecting the gutters to the sump or trough shall have a maximum pitch of 100 mm. Bolts shall straddle the bottom corners of the gutters.

The ends of the gutters shall be connected in such a way that the gaskets can be readily fitted and thermal expansion of the troughs is possible. The column Manufacturer shall determine whether thermal expansion requires the use of bellows on the draw-off nozzle. Bellows will normally only be required if there are two nozzles on the trough or sump on opposite sides of the column.

All other connections between parts of the draw-off tray, liquid collector or gravity distributor, e.g. baffles, shall be bolted or clamped.

If double wall gutter is prescribed, (see 4.1), the minimum material thickness for the inner gutter shall be 1.5 mm, for the outer gutter 2 mm.

The use of ring channels, welded against the column wall, for draw-off trays and/or liquid collectors instead of troughs or sumps is not allowed.

4.3 DRAINING AND LEAKAGE

4.3.1 Drainage

Except for total draw-off trays at least two drain holes with a diameter of 10 mm shall be provided in the base of each draw-off tray, liquid collector or gravity distributor to permit draining of the liquid hold-up. Total draw-off trays shall be self draining and therefore do not require drain holes.

4.3.2 Leadtightness

The following column internals or parts thereof are designed to hold liquid for sealing, distribution or draw-off purposes and shall pass the leakage test (Appendix 11):

- Total draw-off trays over the full height. With the exception of double-deck draw-off trays, up to the top of the lower gutters. Of vane collectors only the trough shall be tested.
- Partial draw-off trays over their full height, up to the overflow off boxes.
- Gravity liquid distributor up to the height of the perforations in the drip tube or distributor wall.

A gutter arrangement above a reboiler compartment is normally not designed to be liquid tight and hence does not require a leak test.

4.4 INSTALLATION, REMOVAL AND ASSEMBLY

4.4.1 Provisions for installation and removal

To facilitate installation and maintenance, each draw-off tray, liquid collector or gravity distributor shall be made in sections which shall pass through the manholes or the top dome/flange of the column.

Unless otherwise specified, all draw-off trays, liquid collectors or gravity distributors shall be designed to permit installation and removal from the top.

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

A gravity distributor must never rest on the packed bed.

4.4.2 Draw-off tray, liquid collector and gravity distributor assembly

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

Welding of draw-off tray, liquid collector or gravity distributor parts to each other during site erection is not allowed unless it is strictly required in view of manhole dimension constraints. Welding of draw-off tray, liquid collector and gravity distributor parts to column supports or the column shell is not allowed.

Connections to beams or cleats which are 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.

Internal distribution pipes shall have flanged connections; refer to Standard Drawing S 10.016.

4.5 PROVISIONS FOR ACCESS

Manholes in draw-off trays, liquid collectors or gravity distributors are normally not required, since access to this type of tray shall be provided by means of manholes in the column and manholes in the tray above. The support beams of the tray above shall be located so as to allow ready access via the manholes to all parts of the draw-off tray, liquid collector or gravity distributor. If appropriate (e.g. in the case of a draw-off tray close below a packed bed), the tray should be removable from below.

Only in the case of single-deck draw-off trays may access be provided through a removable section of the riser cap. Minimum width of such a removable section shall be 270 mm. If the minimum width of 270 mm cannot be achieved on a riser-cap, provisions shall be made to enable the removal of a complete gutter. Double-deck draw-off trays, chimney tray draw-off trays, gutter arrangements, vane collectors and gravity liquid distributors should have no manholes.

4.6 SPECIFIC TYPES OF DRAW-OFF TRAYS, LIQUID COLLECTORS AND GRAVITY DISTRIBUTORS

4.6.1 Total and partial single-deck draw-off trays

Total and partial single-deck draw-off trays shall comprise a number of parallel gutters alternating with vapour risers, covered with flat strips having sloping rims (bent edges) for reinforcement. Riser caps above the risers shall have upturned vertical ends close to the column wall (minimum height 50 mm). Rims on top of gutters shall be bent downwards 45°, the minimum overlap of the vapour riser and (vertical) gutter wall shall be 10 mm.

The parallel gutters shall drain into a side sump or transverse trough(s), as shown in Appendices 5 through 9.

For large diameters a single-deck draw-off tray with 2 troughs shall be fitted (see Appendix 7). For single-deck draw-off trays with 2 troughs below a normal calming section trays, the column Manufacturer shall ensure that the number of calming section boxes draining to each trough is the same. This can be realised by e.g. alternating the drainage direction of the gutters inbetween the two troughs.

For calming section trays the troughs shall coincide with the support beams of the tray above.

The centre line of the calming section of the tray above a draw-off tray shall coincide with the centre line of the gutter into which it drains.

If riser caps are fitted the following is required:

- Support plates for the riser caps are shown in Figure 4.1 and should not be more than 500 mm apart.
- Side walls of gutters are should be bent at the upper end for stiffness. See Figure 4.2.
- A riser cap has a sloping rim at 30°, and is bent upwards, close to the column wall, in such a way that it ends below the drip ring (if present).

Figure 4.1 Support of the riser cap

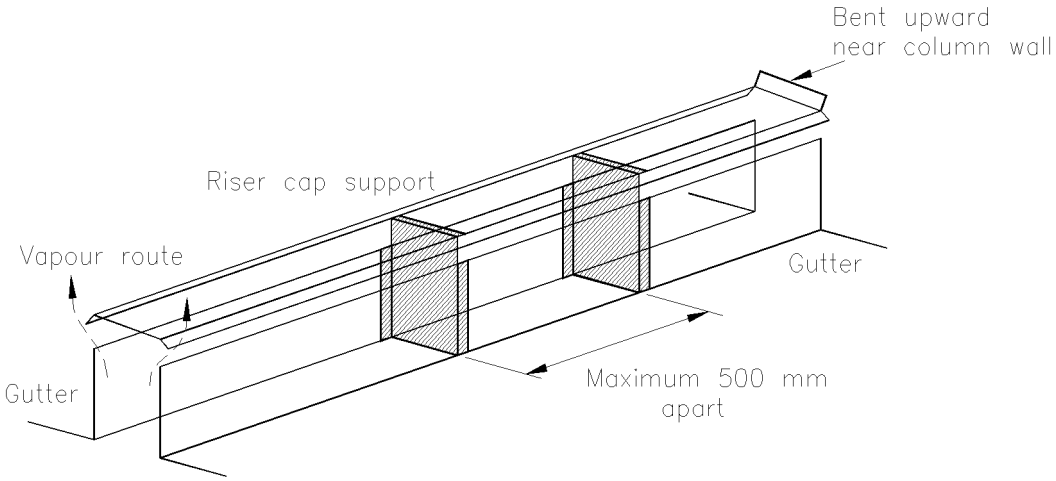


Figure 4.2 Riser detail

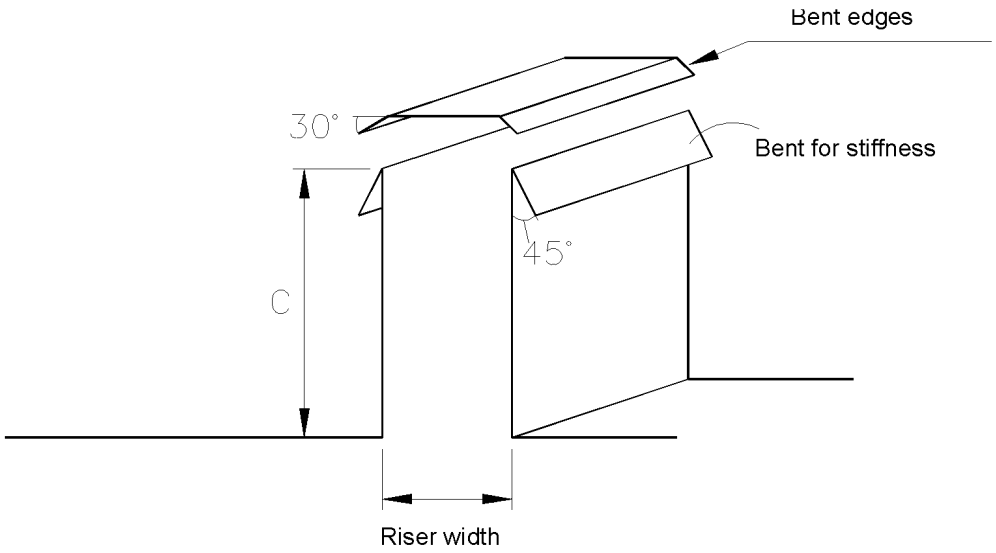
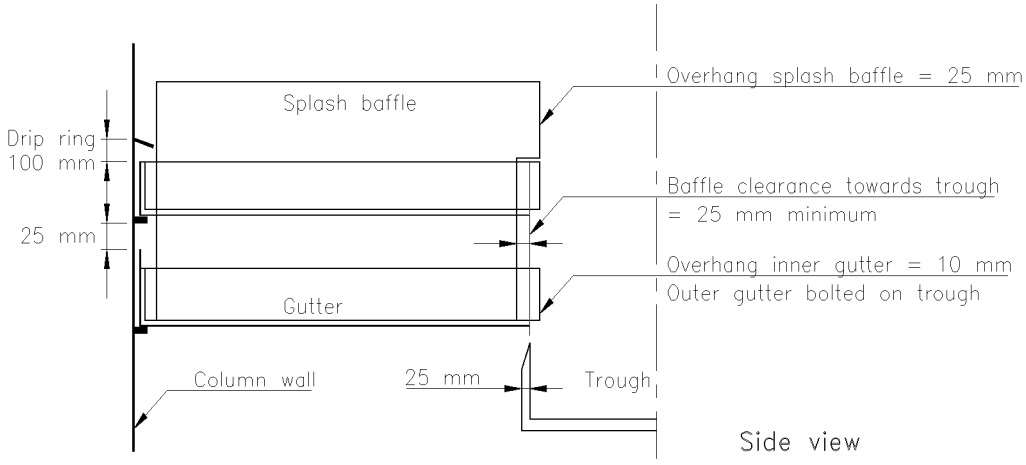


Figure 4.3 Design of insulated gutters and trough for a double-deck DOT



- The lower edges of the gutters shall have a 50 mm bevel, with rounded corners. The upper gutters are equipped with drip strips (see Appendix 7).
- The ends of the gutters underneath the drip ring are closed by means of a seal welded end plate. If fitted underneath spray sections, this end plate shall be extended until 25 mm below the support ring of the upper gutters.
- The splash baffle, if specified, shall have sufficient height to prevent direct splashing in the lower riser. Baffles shall be fitted in the lower gutters only.
- The clearance between splash baffle and trough wall shall be less than 25 mm. The overhang of the baffle over the trough wall shall be at least 25 mm.
- The edge gutters in the upper layer, i.e. close to the column wall, shall be provided with sloped riser caps draining into this edge gutter. The riser caps have an upturned rim underneath the drip ring. The edge risers shall have a width less than 400 mm.
- For a lay-out with two troughs, the gutters between the troughs shall drain alternately into either trough.
- If thermal insulation is specified, it is achieved by fitting inner gutters in both layers of gutters. The clearance between the inner and outer gutters, typically 25 mm, shall be open at the trough side. The trough is insulated by an external double wall, covering the bottom and the side wall up to the underside of the lower gutters. The bottom of the outer wall should be provided with 50 mm drain holes at both sides of the gutter.

4.6.2 Double-deck draw-off trays

The double-deck draw-off tray shall consist of two layers of parallel gutters, alternating with vapour risers and installed in such a way that a vapour riser of the lower layer of gutters is covered by a gutter of the upper layer. Baffles will be in the lower gutters only, see Appendix 7.

The following requirements for double-deck draw-off trays are applicable:

4.6.3 Chimney type draw-off trays and gravity liquid distributors

If a chimney type of draw-off tray or gravity liquid (re) distributor is specified the following riser details are applicable:

- The lay-out of the riser should be as in Figure 4.4 (a). The overlapping part of the discs makes an angle of 90° with the horizontal plane, and extends to the top of the riser.
- Figure 4.4 (b) shows an older riser cap lay-out. This may be used only below a trayed section, with downcomers, extending below the risers.

Figure 4.4 Types of riser cap

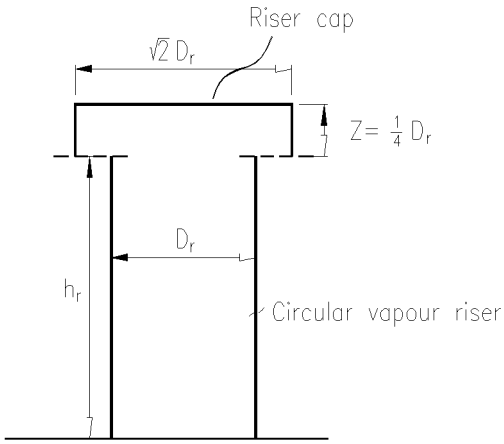


Figure 4.4 (a)

Type of riser cap below packing, sprays, dual flow or fractionation trays or for chimney tray gravity distributor.

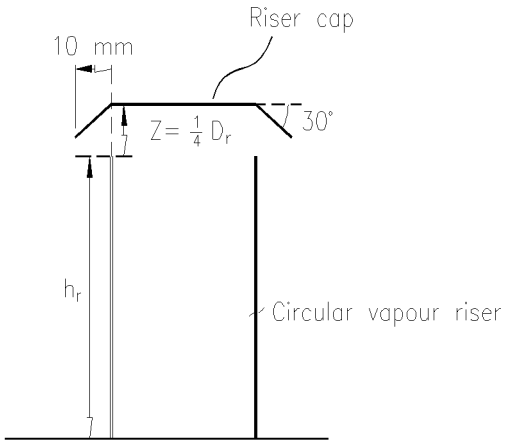


Figure 4.4 (b)

Type of riser cap below fractionation trays.

The dimensions of the preferred riser cap (Figure 4.4 (a)) have been standardised as follows:

Table 2 Standard dimensions for riser caps with 90° angled cap

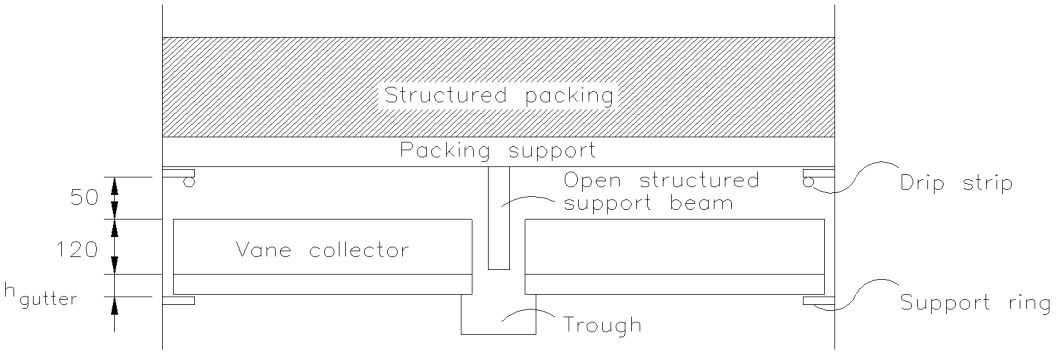
Diameter D_r	200	300	400
Height $Z = ¼D_r$	50	75	100
Diameter of riser cap	290	430	570

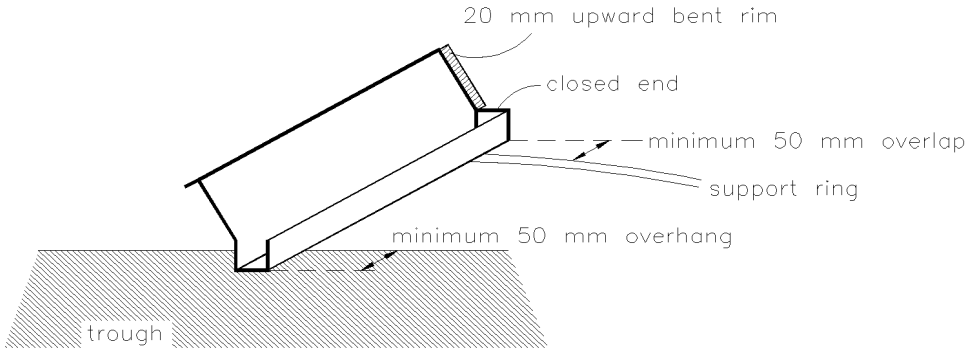
4.6.4 Vane-collector draw-off trays

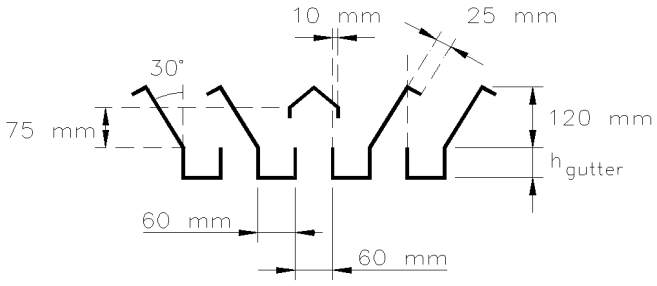
Vane collectors, often fitted below packed beds, shall comprise a number of parallel gutters alternating with vapour risers. The vapour risers are covered by the vane of the neighbouring gutter. All gutters drain into one or two troughs. The minimum overlap of the vapour riser and (vertical) gutter wall shall be 10 mm.

The gutter layout is standardised at gutter widths of 60 mm and riser widths of 60 mm. The height of the vanes above the gutters is 120 mm, and the required free space between the top of the vane collector and the underside of the support grid is 50 mm.

Figure 4.6 Typical details of the Vane-collector







The following precautions against leaking of the vane collectors shall be taken:

- The support ring of the packing support grid serves as drip ring, and has to be provided with a drip strip, consisting of a 10 mm round bar. An overlap of at least 40 mm past the end of the vane collector should be applied.
- The ends of the vane collectors underneath the drip rings and underneath the riser caps in the middle section are bent upwards (typically 20 mm) in order to ensure that liquid drains into the gutters.
- The ends of the gutters underneath the drip ring are closed by means of a seal welded endplate.
- At the top of the vane collector a 25 mm rim is bent at an angle of 90 º in order to provide an overlap over the adjacent gutters of at least 15 mm.
- The saddle of the support beam for the packing support grid should be equipped with drip strips or guiding vanes in order to prevent any liquid bypassing.
- Gutters near the column wall should be constructed so that the opening near the column wall is covered.

The following mechanical specifications apply:

- Minimum material thickness for vane collectors is 2 mm.
- The vanes shall make an angle of approximately 30° with the vertical. The vanes change direction at the centre of the column. The central riser is provided with a riser cap.
- The gutters are supported by and fixed to the support ring and the side wall of the trough. Gutters longer than 1 m are bolted together inside the column.
- The gutters shall be removable from below.
- Both the overhang over the trough and the overlap on the support ring shall be at least 50 mm. The vane-collector supplier shall specify support ring dimensions.
- The clearance between the top of the vane collector and the bottom of the packing support grid shall be at least 50 mm.
- The centre lines of the main support beam of the packed bed above and of the trough coincide.

4.6.5 Gutter arrangement above a bottom compartment

A gutter arrangement is a set of parallel gutters alternating with vapour risers. Unless specified otherwise a gutter arrangement does not require a drip-ring or riser-caps.

The parallel gutters shall drain into the reboiler bottom compartment of the column, either directly or via a middle trough.

For calming section trays the troughs shall coincide with the support beams of the tray immediately above.

The centre line of the calming section of the tray above a draw-off tray shall coincide with the centre line of the gutter into which it drains.

4.6.6 Gravity liquid distributors

Unless specified otherwise in the data requisition, the following requirements for gravity liquid distributors should be adhered to:

- The gravity liquid distributor should be self-supporting and fixed to a support ring or support lugs. Supporting the distributor on the packing or on the hold-down grid of the packing is not acceptable. In no case shall the distributor be welded on to the support ring.
- Attachments welded to the column wall (support rings, lugs and brackets) should not hamper the installation/removal of the packing elements. This is especially important for column diameters smaller than 800 mm.

- Slots or holes should be used to divide the liquid over the liquid distribution points. They are preferably located in drip-tubes or in the gutter wall, minimum 40 mm above the bottom of the gutter or pan. A rectangular top slot in the drip tubes is recommended to handle the liquid flow in case the normal distribution holes are plugged.
- The diameter of the drip tubes will be such that the liquid's superficial velocity is less than 0.5m/s. Diameter of the drip tube should at least be twice as large as the slot width or distribution-hole diameter.
- The distance between the bottom of the drip tubes and the top of the packing should be within 10 to 50 mm for standard designs. For high quality distributors (MR<5%, see Appendix 12) 5 to 20 mm should be achieved. In any case, the drip tubes shall not touch the packing.
- Gravity distributors shall not have local liquid velocities above 0.25 m/s in the trough/gutter or pan under any operating conditions. Minimum liquid level (= at turndown conditions) in the gutters or pan shall be at least 30 mm above the distribution perforation.
- If holes in the gutter wall are used they should be shielded from the gas flow. The liquid should be guided to the packing (pipe, splash-baffle) to protect the liquid from being entrained by the vapour. The cover may be a splash-plate or a drip tube. If a drip tube connected to the gutter wall is used, it should have a degassing hole for breaking the syphon effect.

Note: Neither troughs with weirs over which the liquid is projected sideways to fall onto the packing, nor notched troughs shall be used.

- For liquid flows up to 120% of the maximum flow, the liquid level should be below the top of the tube or below the bottom of the top slot (if applied).
- The vapour risers (chimneys or gutters) should be tall enough to accommodate 120% of the maximum liquid flow plus 20 mm for holes in the tray floor or extend to the height of the drip tube above the plate plus 20 mm. Minimum riser height is 150 mm.
- The minimum distance between the packing and a gutter or trough should be half the trough/gutter width.
- Gravity distributors for column diameters above 4 m or for packed sections containing more than 8 theoretical stages should be subjected to a hydraulic test in the workshop (see Appendix 12).

The following minimum hole or slot sizes apply:

Table 3 Minimum hole sizes

Case:	Size (mm)	Filters needed ?
Holes in distributor floor for high liquid loads	>12	No
Holes/slots in drip tubes or gutter wall	>8	No
Holes/slots in drip tubes or gutter wall in re-distributor or distributor below partial draw-off trays	>6	Not needed for clean service
Holes/slots in drip tubes or gutter wall for low liquid loads	4-8	Yes

For slots/holes with a diameter below 8 mm a double set of filters should be installed or verified as present. Holes smaller than 4 mm shall not be used. Holes in the tray floor shall only be used in services with a low fouling tendency and high liquid loads, so that 12 mm diameter holes or larger can be used.

5. PACKING

Two types of packing are distinguished:

I. Random packing

II. Structured packing

5.1 PROCESS REQUIREMENTS

Unless specified in the data requisition the maximum number of theoretical stages permitted in one packed section is 20. For bed heights above 8m or with more than 15 stages the approval of the Principal is required.

5.2 MECHANICAL REQUIREMENTS

5.2.1 Loads

Unless otherwise stated on the data requisition sheet or in the order, the packing and supports shall be designed to withstand the following operating loads:

- A maximum operating load in upward direction equivalent to 100 mm HPL (Hot Process Liquid) per metre packed height at maximum working temperature evenly distributed over the entire surface of the packing.
- A maximum load in downward direction equivalent to the weight of the packing, a liquid hold-up of 50% for a wash-oil bed and 15% for others, and any other internals such as hold-down grids.

Apart from the requirements above, the packing and support grid shall be capable of absorbing the loads resulting from installation and maintenance activity. These loads shall be taken as 1 000 N downward, equivalent to the weight of one man working on the assembly. During installation and maintenance standing directly on the packed bed should be avoided.

5.2.2 Deflections

For a random and structured packing bed and support grid the maximum downward and upward deflection under operating load shall not be more than 1/800 of the internal column diameter with a maximum of 6 mm.

5.2.3 Levelness

The maximum allowable tilt of each layer of a structured packed bed and support grid shall be 0.3% of the column diameter or 6 mm, whichever is the smaller.

5.2.4 Support

For packed sections in a column with a diameter larger than 800 mm a self supporting structured packing grid (100 to 150 mm high) resting on a ring at the wall is mandatory.

The minimum net free area of the grid is 95%.

For a stuctured packing support grid the maximum distance between grid elements is 100 mm. The grid elements should be bolted together.

If the diameter of the column is over 3.5 m one or more support beams should be used. Minimum open area of the beam is defined by the following:

The beam shall occupy not more than one third of the space below the support grid of the packed bed and the top of the internal below , as defined by:

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

where A_{beam} = area of beam, horizontally projected, m^2

D = internal diameter of column, m

Clearance = clearance below the support grid to the top of the internal below, m

If this criterion cannot be met with a solid beam, an open type of beam shall be used, such as an I-type beam with holes therein or an open work construction as shown in Appendix 3.

If a C-type beam is used with separation segments, 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.

5.2.5 Sheet thickness

Unless specified otherwise in the data requisition, the following minimum sheet thicknesses for stainless steel packing apply:

Table 4 minimum sheet thickness of structured packing

Specific area, A_s (m^2/ m^3)	Minimum Sheet thickness*, t for stainless steel packing (mm)
larger than 200	0.15
equal to or smaller than 200	0.2

* Lower sheet thickness may be used if specified on the data requisition sheet and provided the requirements in 5.6.1 are met

5.2.6 Maximum height for a packed section

For mechanical reasons the maximum packed bed height is 12m.

5.3 DRAINING AND LEAKAGE

Due to its openess, a packed bed has no draining and leakage requirements.

5.4 INSTALLATION, REMOVAL AND ASSEMBLY

5.4.1 Provisions for installation and removal

To facilitate installation and maintenance the packed bed and support grid shall be made in sections which can pass through manholes or the top dome/flange of the column.

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

A gravity distributor must never rest on the packed bed.

5.4.2 Packed bed support assembly

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

Welding of support parts to each other during site erection is not allowed unless it is strictly required in view of manhole dimensions constraints. Welding of support grid parts to column supports or the column shell is not allowed.

5.5 PROVISIONS FOR ACCESS

No manholes in packing or support/hold-down grids are to be made.

For inspection of the column shell at the packed section the complete packed bed should be removed.

5.6 SPECIFIC TYPES OF PACKING

5.6.1 Installation of structured packing

All packing layers should be provided with a wall wiper.

The maximum gap between the packing and the column wall shall be less than 25 mm.

The maximum gap in the length direction between the packing elements should be 10 mm.

If specified on the data requisition, it is permissible to install 0.1 mm packing, to which the following additional installation requirements apply:

1. A packing with a larger sheet thickness (0.15 mm or 0.2 mm) for the top layer should be installed directly below the distributors resting directly on the support grid.
2. The packing should be installed by an experienced contractor.
3. There must be an auditable inspection program with installation criteria.

5.6.2 Installation of random packing

1) Different types of random packing should be separated by a bed limiter (= hold down grid)
2) For large beds of random packing (i.e. beds with a volume of more than 10 m^3) the packing elements should not be dumped directly onto the support grid but given the opportunity to settle out by filling the packed section with a liquid lower in density than the random packing material (which is often water).

6. FEED INLET DEVICES

In this section the requirements for the following feed internal types are discussed:

- Liquid elbows
- Spray nozzles
- HiFi schoepentoeters

For the requirements for half-open pipes and schoepentoeters (with the exception of the HiFi schoepentoeter) reference is made to the DEP 31.22.05.11-Gen.

6.1 PROCESS REQUIREMENTS

Unless specified otherwise in the data requisition or order, spray nozzles*, and liquid elbows are designed to relieve the liquid vertically downwards, and hence their orientation angle* is vertically downward.

For spray-nozzle distributors, the maximum deviation from the specified orientation angle* shall be not more than 1 degree.

* For the orientation angle of a spray nozzle, the angle of the nozzle here is meant and not the angle of the liquid emerging from the spray-nozzle.

The ends of main-headers and side-branches of liquid spiders and spray-nozzle distributors should be closed.

6.2 MECHANICAL REQUIREMENTS

6.2.1 Loads

Unless stated otherwise on the data requisition sheet or in the order, the feed inlet shall be designed to withstand the following loads:

- a maximum operating load over the column nozzle of 15 000 Pa;
- liquid spiders and spray nozzle distributors shall be designed to withstand a pressure drop over the liquid outlet of 5 bar.

The inlet device must be strong enough to bear its own weight and the weight of its contents, filled with water or process liquid (whichever is the heavier).

6.2.2 Deflections

For a feed inlet the maximum downward and upward deflection under operating load shall not be more than 1/800 of the length of the feed inlet device with a maximum of 6 mm.

6.2.3 Levelness

The maximum allowable tilt for spiders and spray nozzle distributors shall not be more than 0.3% of the column diameter or 6 mm, whichever is smaller.

6.3 DRAINING AND LEAKAGE

6.3.1 Draining

Drain holes are not required in feed inlet devices, with the exception of drain-holes in main headers of liquid spiders. The main header of a liquid spider should have at least one drain hole with a diameter of 10 mm to permit draining of the liquid hold-up from the base of the main header.

6.3.2 Leaktightness

Except for spray-nozzle distributors and liquid spiders, there are no liquid tightness criteria for feed inlet devices. For liquid spiders and spray-nozzle distributors the amount of liquid by-passing the holes/spray nozzles (e.g. leaking through flanges etc.) should be less than 1% of the distributed liquid.

6.4 INSTALLATION, REMOVAL AND ASSEMBLY

6.4.1 Feed inlet device installation and removal

To facilitate installation and maintenance the feed inlet device shall be made in sections which can pass through manholes of the column.

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

6.4.2 Feed inlet device assembly

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

Connections to beams or cleats which are 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.

Internal distribution pipes shall have flanged connections: refer to Standard Drawing S 10.016.

6.5 PROVISIONS FOR ACCESS

In shut-downs there should be direct access to feed inlets via a column manway.

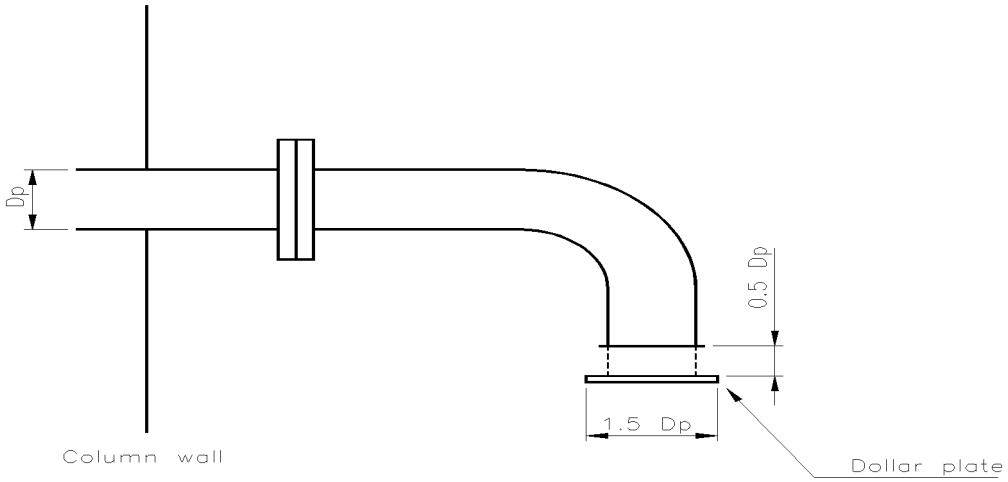
6.6 SPECIFIC TYPES OF FEED INLETS

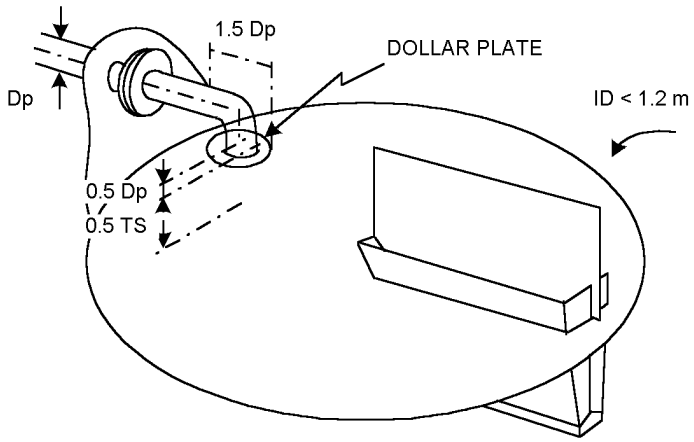
6.6.1 Liquid elbow

A liquid elbow is a liquid inlet, mainly used for normal calming section and single-pass conventional downcomer trays.

The liquid elbow on a calming section tray should be provided with a dollar plate, which diameter is to be taken equal to 1.5 times the diameter of the elbow pipe. The distance between the dollar plate and the pipe should be 0.5 times the pipe diameter.

Figure 6.1 Elbow type liquid inlet device with dollar plate for columns with normal calming sections and a diameter smaller than 1.2 m and for single-pass conventional downcomer





Note Liquid Elbows for a single-pass conventional downcomer tray do not require a dollar plate, but should be sealed with a positive seal of at least 25 mm by an inlet weir of 100 to 150 mm.

6.6.2 HiFi schoepentoeter

A HiFi schoepentoeter is a vane-type inlet device for HiFi calming section trays. The HiFi schoepentoeter has one vane for each tray panel, in which the vanes point back to the inlet nozzle.

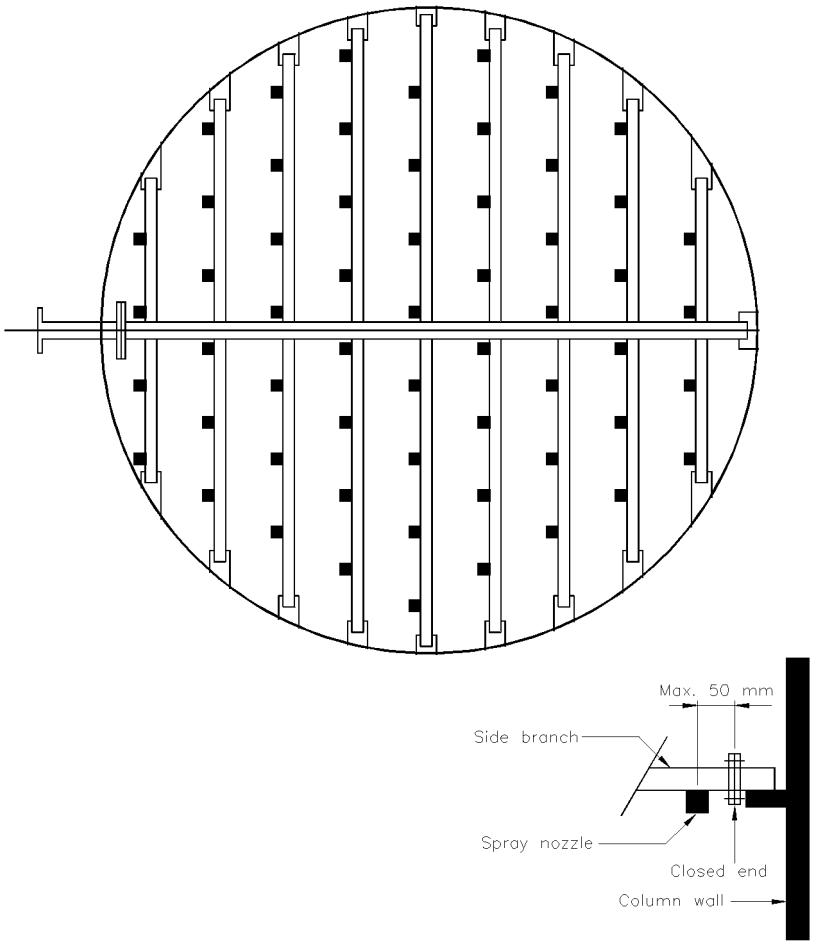
The distance from the bottom of the HiFi schoepentoeter to the tray below should be equal to the tray spacing. The minimum distance allowed from the top of the HiFi schoepentoeter to the tray above is normally 300 mm or, if calming sections are located above the HiFi schoepentoeter, 50 mm to the bottom of the calming sections. If other restrictions are present (e.g. draw-off tray trough, draw-off tray outlet pipe), the clearance above the HiFi schoepentoeter must be increased.

The HiFi schoepentoeter has standard dimensions which are specified in Standard Drawing S 20.025 (see below)

6.6.3 Spray-nozzle distributor

A spray nozzle distributor is a liquid inlet device consisting of a main header and some side branches. The liquid is distributed downwards via spray nozzles, see Figure 6.2 below.

Figure 6.2 A spray nozzle liquid distributor



The following requirements are applicable to liquid spray distributors:

- The nozzles should be of hardened steel.
- The spray nozzles should be of the full-cone type. Type, number of and pitch between the nozzles should be specified to the internals Supplier, who should verify independently that the nozzles can be installed as specified.

- Tangential nozzles should be installed on the main-header and/or side branches via a coupling piece.
- The spray distributor should be tested in situ with water after installation

7. REFERENCES

In this DEP, reference is made to the following publications:

NOTE: Unless specifically designated by date, the latest edition of each publication shall be used, together with any amendments/supplements/revisions thereto.

SHELL STANDARDS

Index to DEP publications and standard specifications	DEP 00.00.05.05-Gen.
Requisitioning binder	DEP 30.10.01.10-Gen.
Data requisition sheet for trays *	DEP 31.20.20.93-Gen.
Data requisition sheet for draw-off trays *	DEP 31.20.20.94-Gen.
Gas/liquid separators - Type selection and design rules	DEP 31.22.05.11-Gen
Field inspection prior to commissioning of mechanical equipment	DEP 61.10.08.11-Gen.

* data/requisition sheets are contained in the requisitioning binder, DEP 30.10.01.10-Gen.

STANDARD DRAWINGS

Flanges for non-pressure pipe connections inside vessels	S 10.016
HiFi schoepentoeter inlet device	S 20.025
Vortex breakers	S 10.010

AMERICAN STANDARDS

ASME Boiler and Pressure Vessel Code:	ASME IX
Qualification standard for welding and brazing procedures, welders, brazers, and welding and brazing operators	

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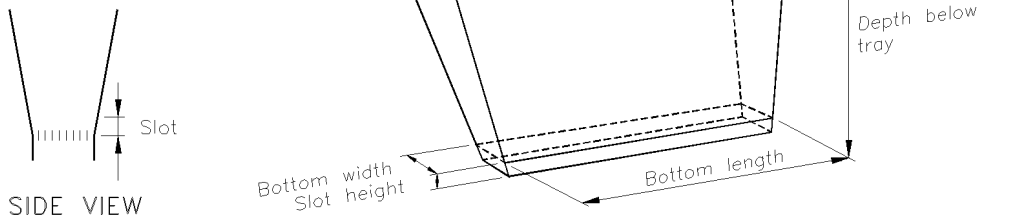
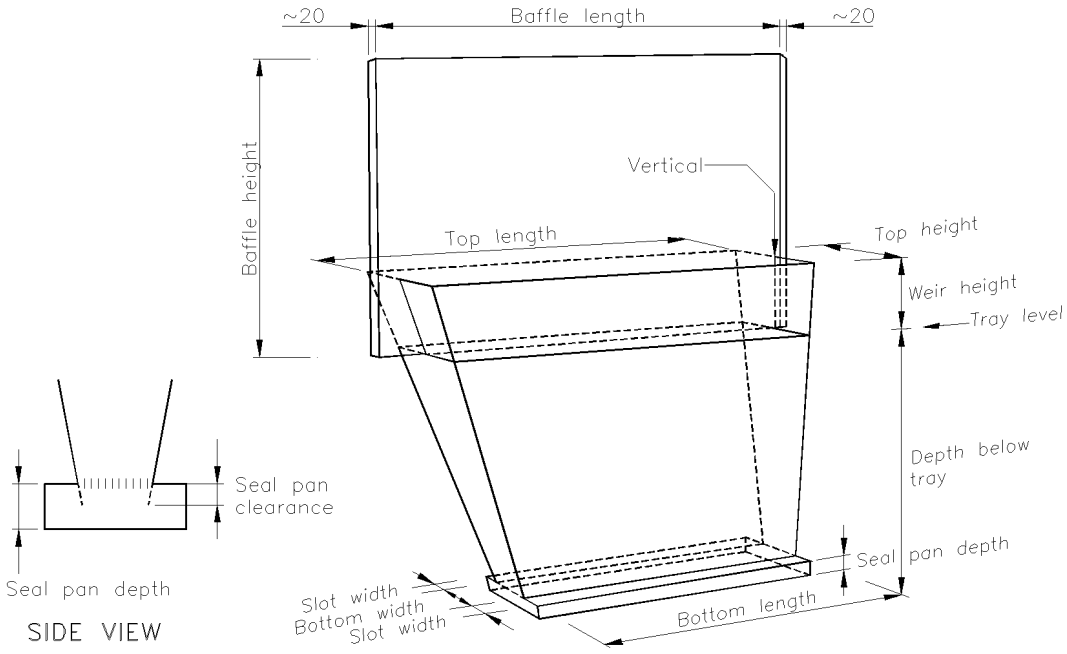
APPENDIX 1 NORMAL CALMING SECTION DOWNCOMERS

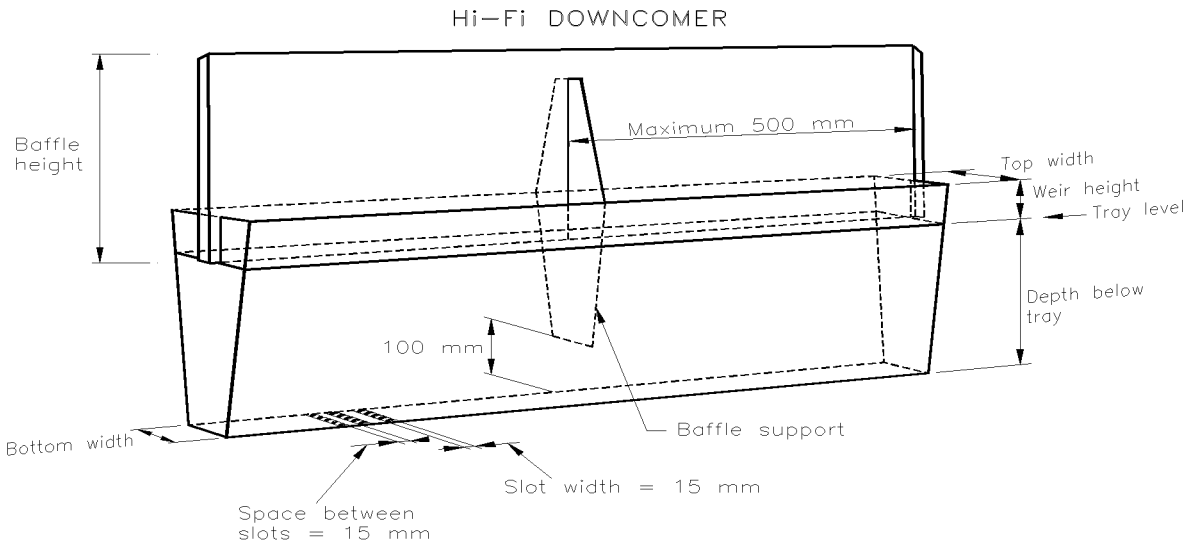
CALMING SECTION WITH OPEN SLOT

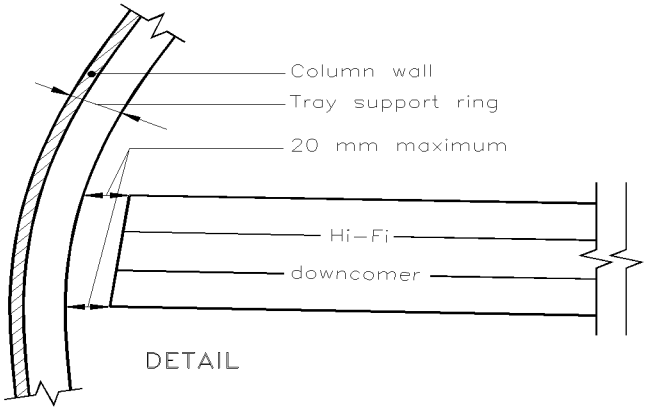


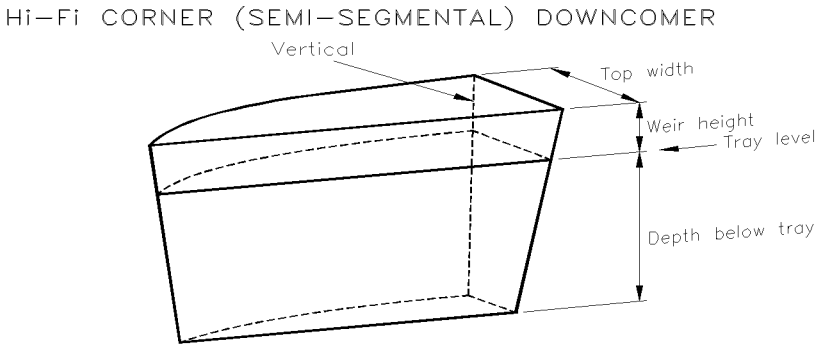
CALMING SECTION WITH SEAL PAN



APPENDIX 2 HiFi CALMING SECTION DOWNCOMER

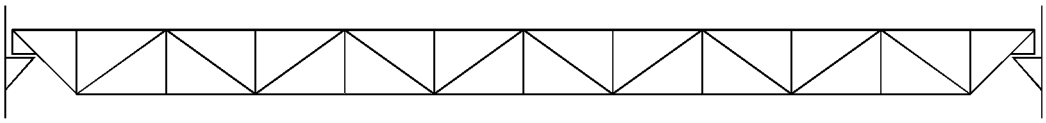




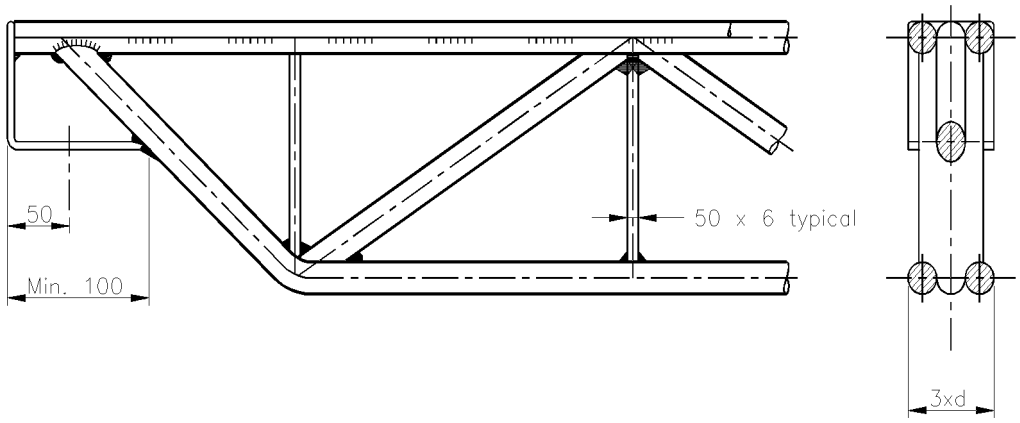


APPENDIX 3 OPEN STRUCTURE SUPPORT BEAM

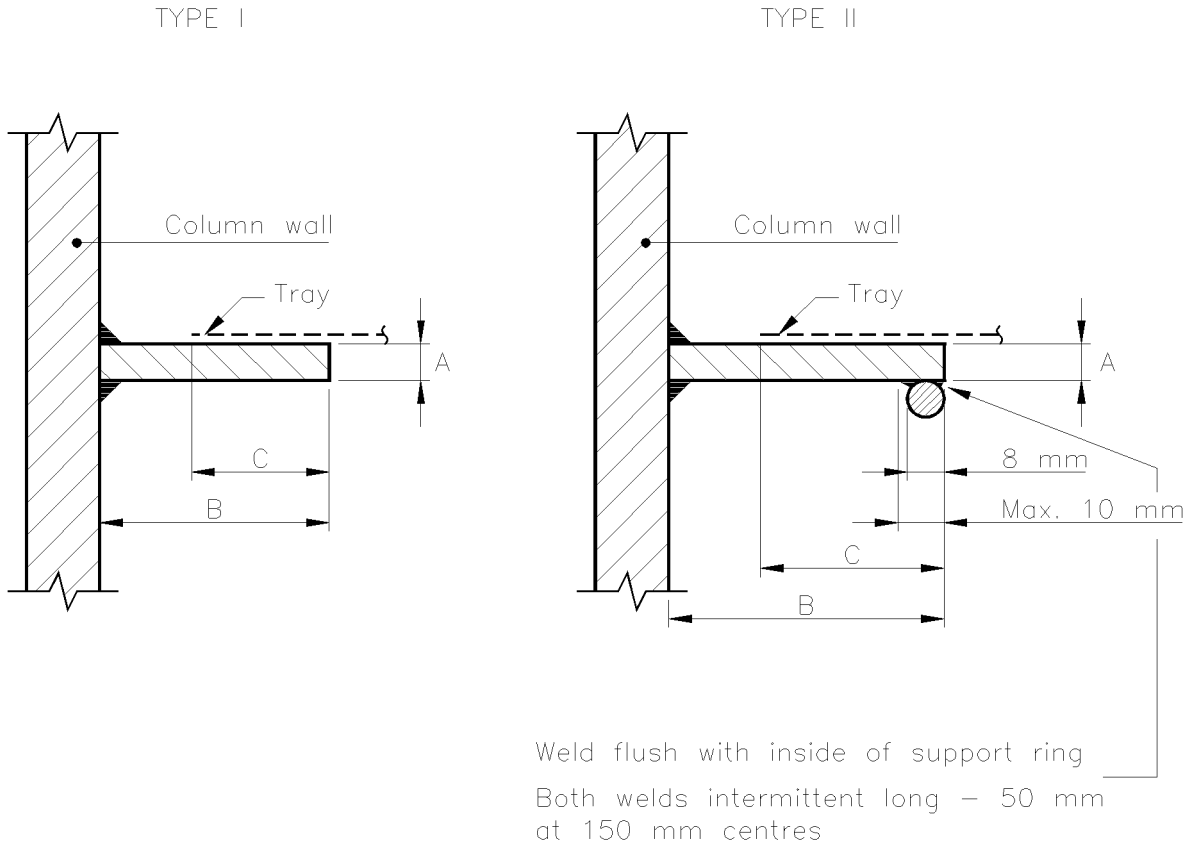
a) Schematic illustration



b) Detail



APPENDIX 4 TRAY SUPPORT RINGS



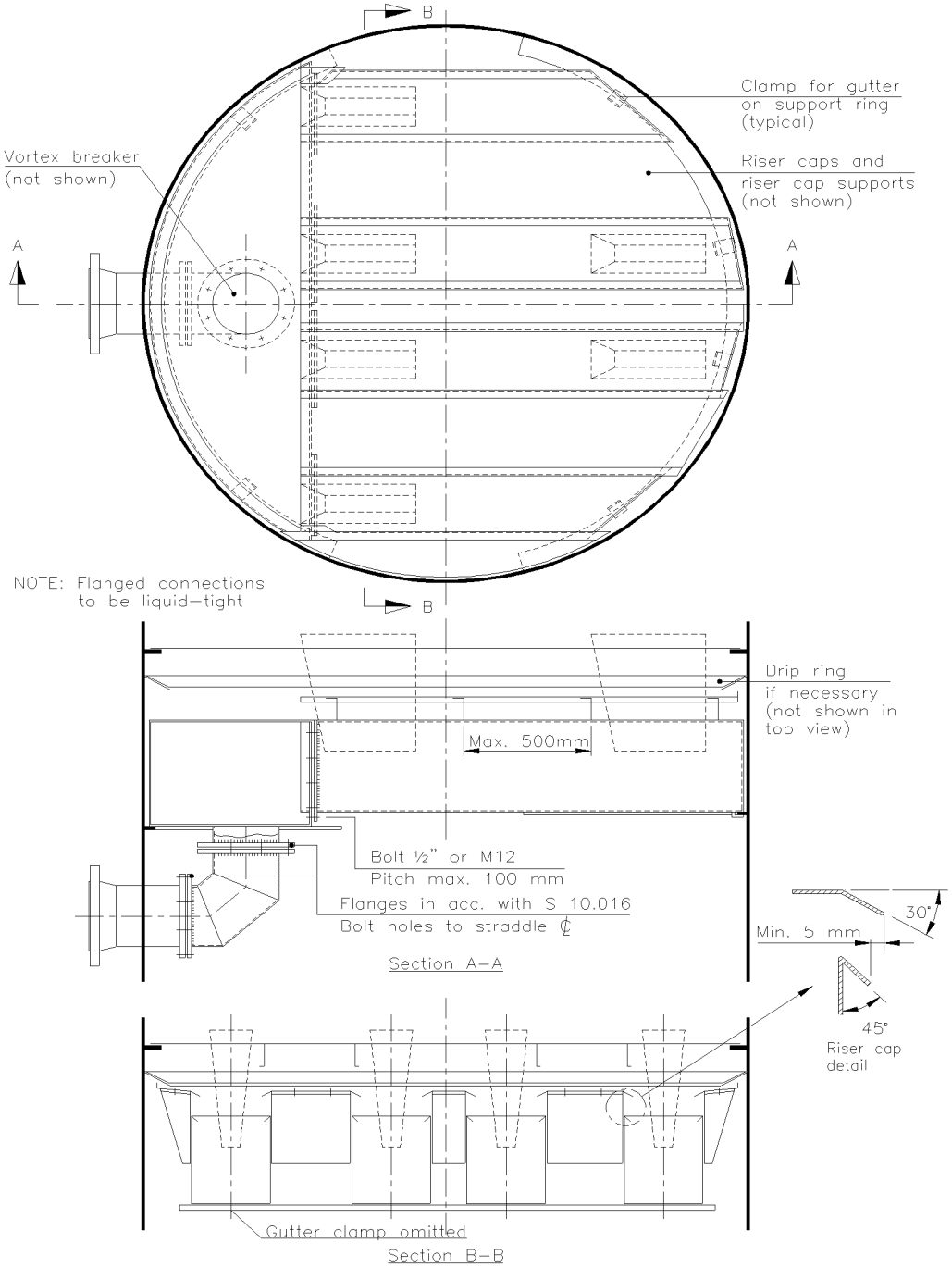
TYPE I For columns in which an instantaneous pressure surge is not expected.

TYPE II For columns in which an instantaneous pressure surge may occur, e.g. vacuum columns, main crude oil columns and strippers or in cases where the bar underneath the support ring also serves as dripring (e.g. for vane collectors).

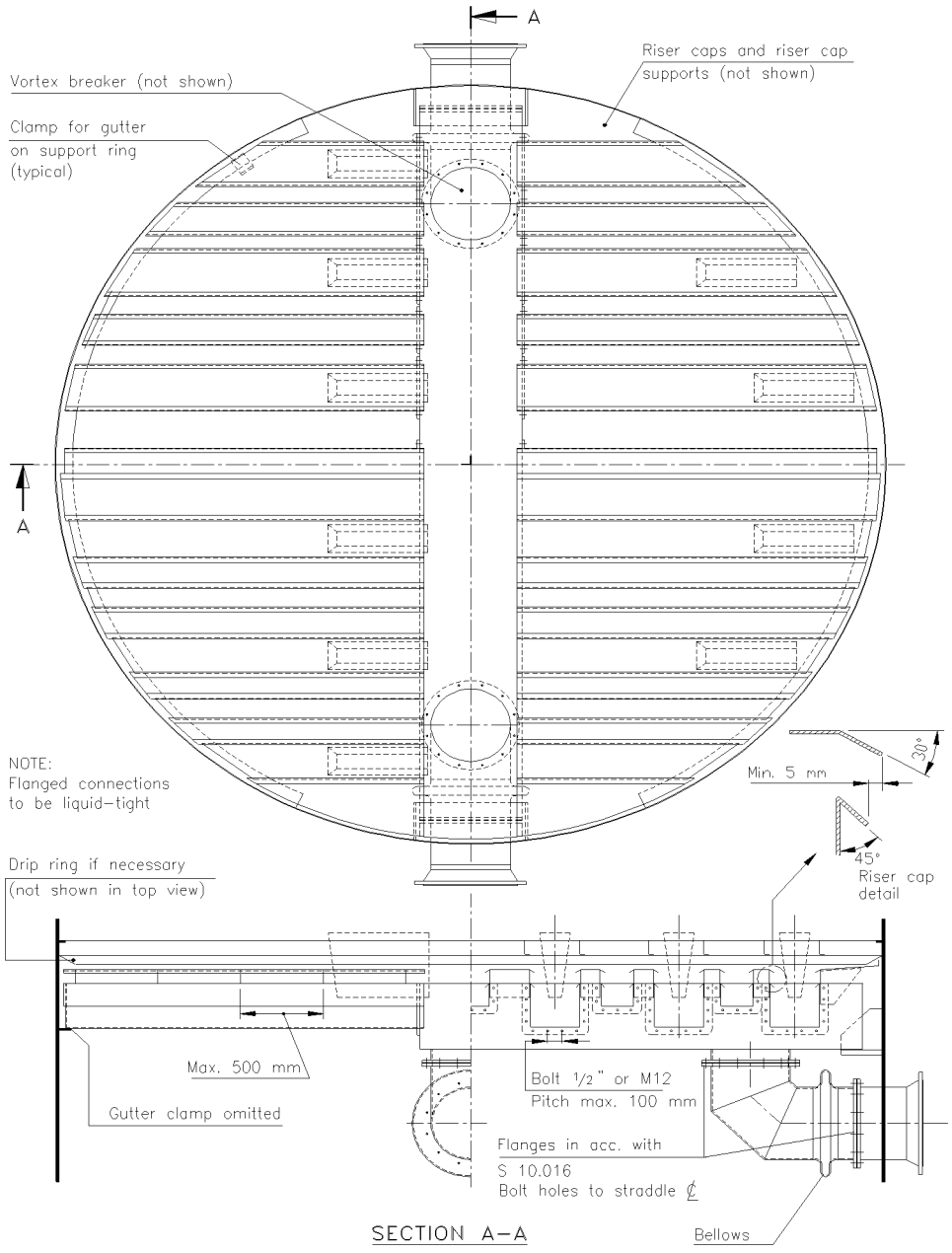
Type of tray	ID of column	Column internal support ring (see note 1) size B x A	Size C (mm)	
	mm	mm	Nom.	Min.
All trays except draw-off trays	up to 800 (see note 2)	40 x 8	25	18
	800 to 2 500	50 x 8	30	25
	2 500 to 3 500	60 x 8	35	25
	3 500 to 5 000	75 x 8	35	25
	5 000 and larger	individual design	40	30
Draw-off trays	800 to 5 000	85 x 8	40	30
	5 000 and larger	individual design	58	48

NOTES:
1. A total of 3 mm corrosion allowance has been included in dimension A. Dimensions given are indicative only; the exact dimensions should be specified by the column Manufacturer.
2. Stacked trays shall normally be used.

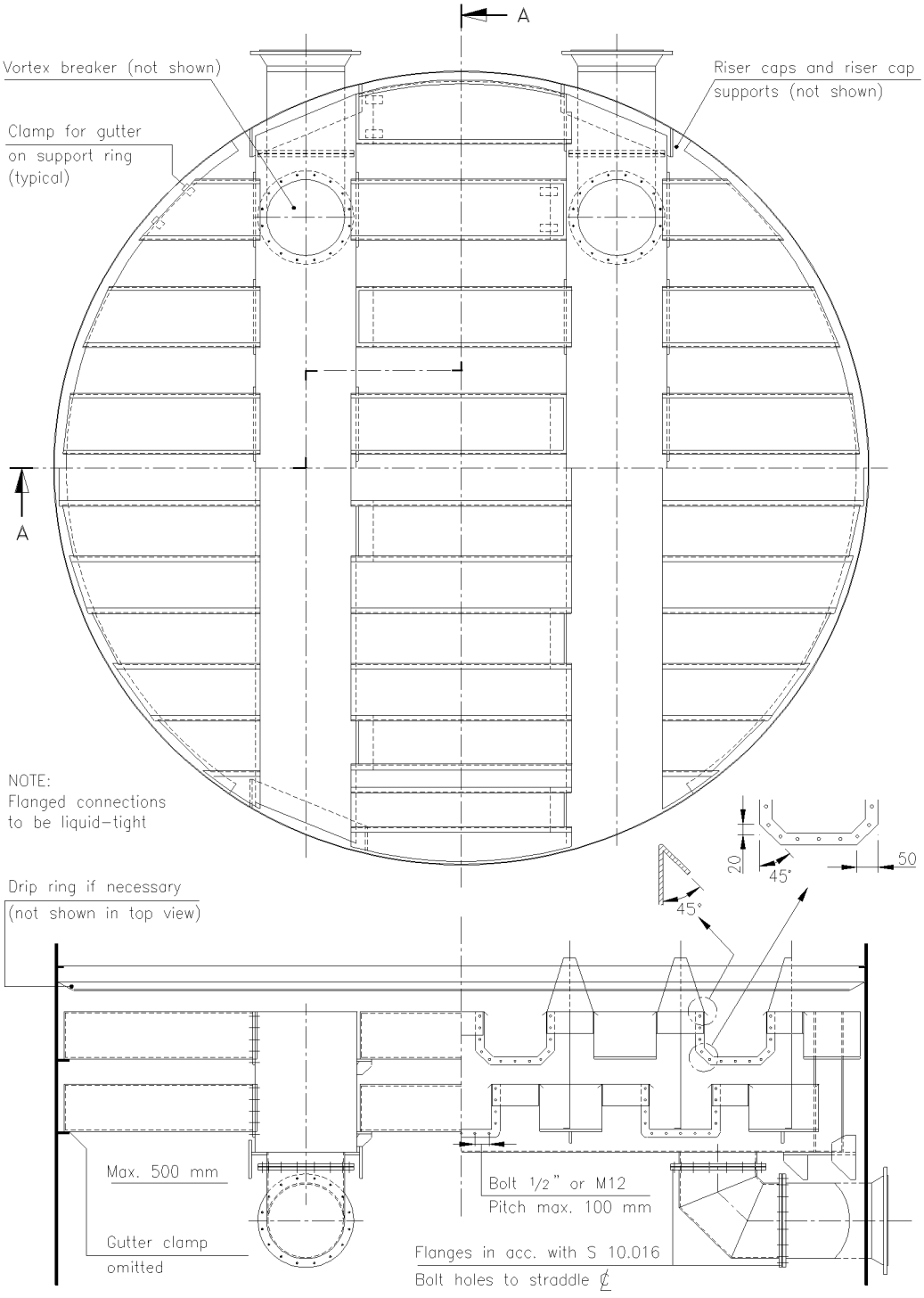
APPENDIX 5 TYPICAL TOTAL DRAW-OFF TRAY WITH SIDE SUMP



APPENDIX 6 TYPICAL TOTAL DRAW-OFF TRAY WITH CENTRAL TROUGH

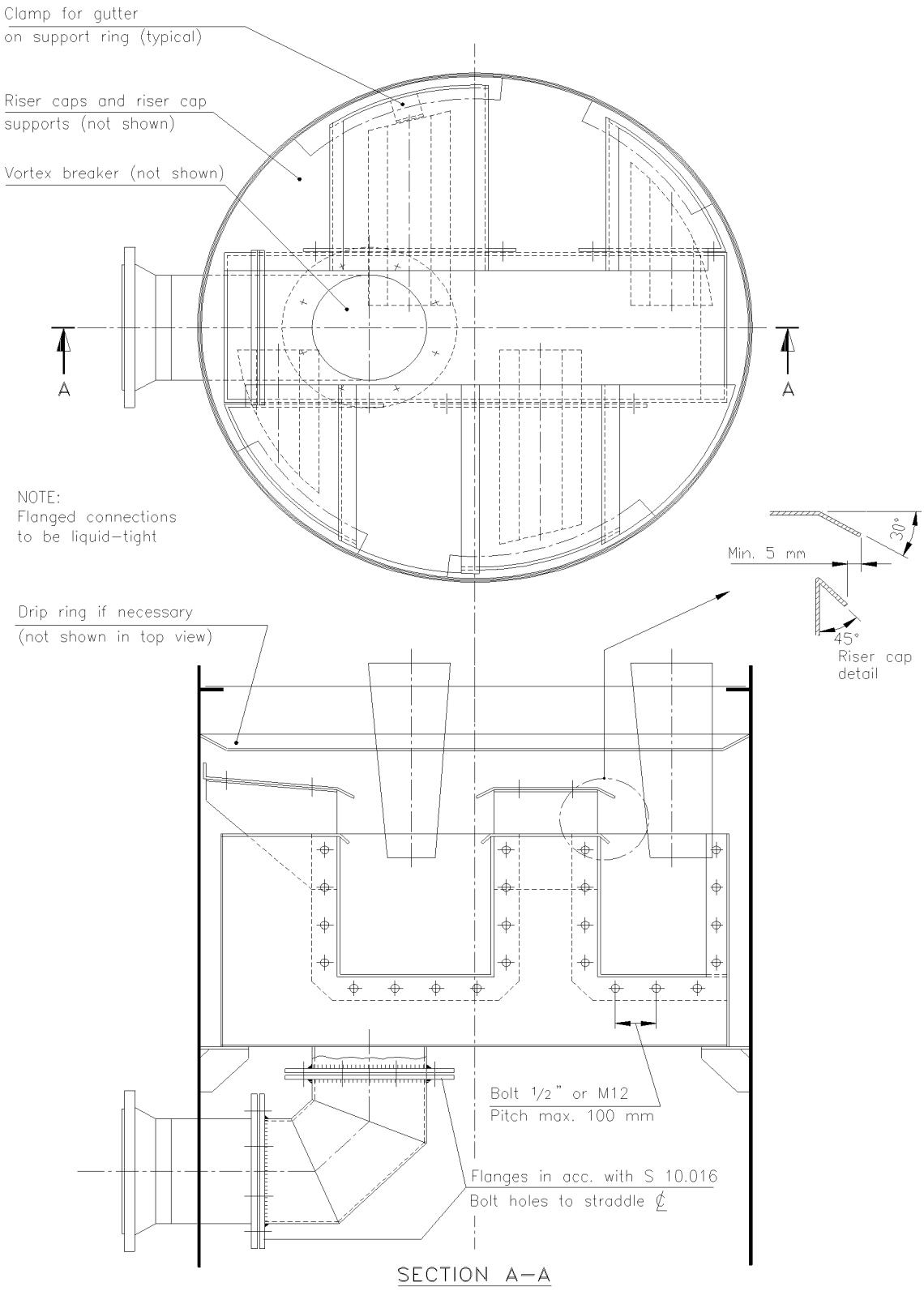


APPENDIX 7 TYPICAL TOTAL DRAW-OFF TRAY WITH TWO TROUGHS

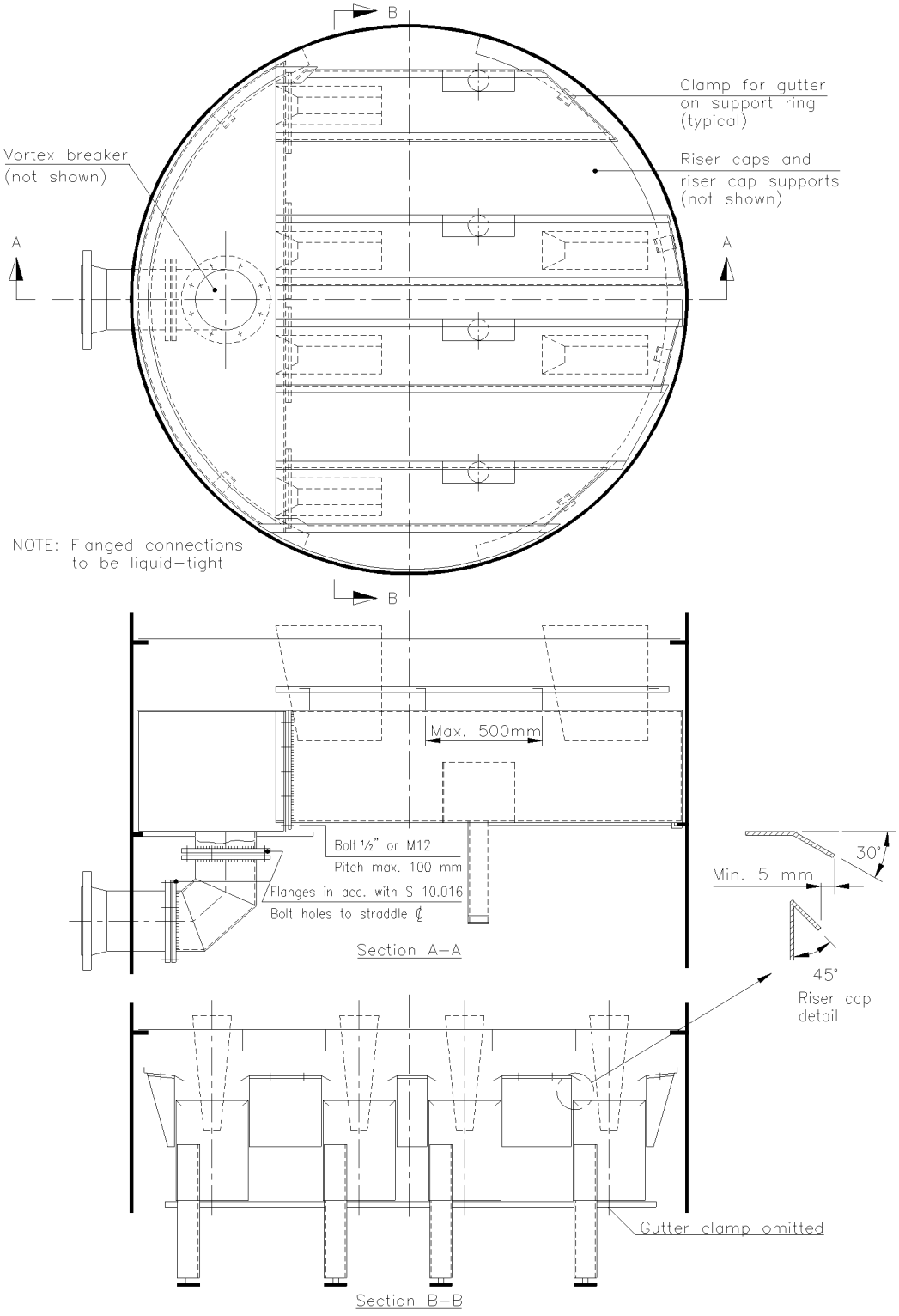


SECTION A–A

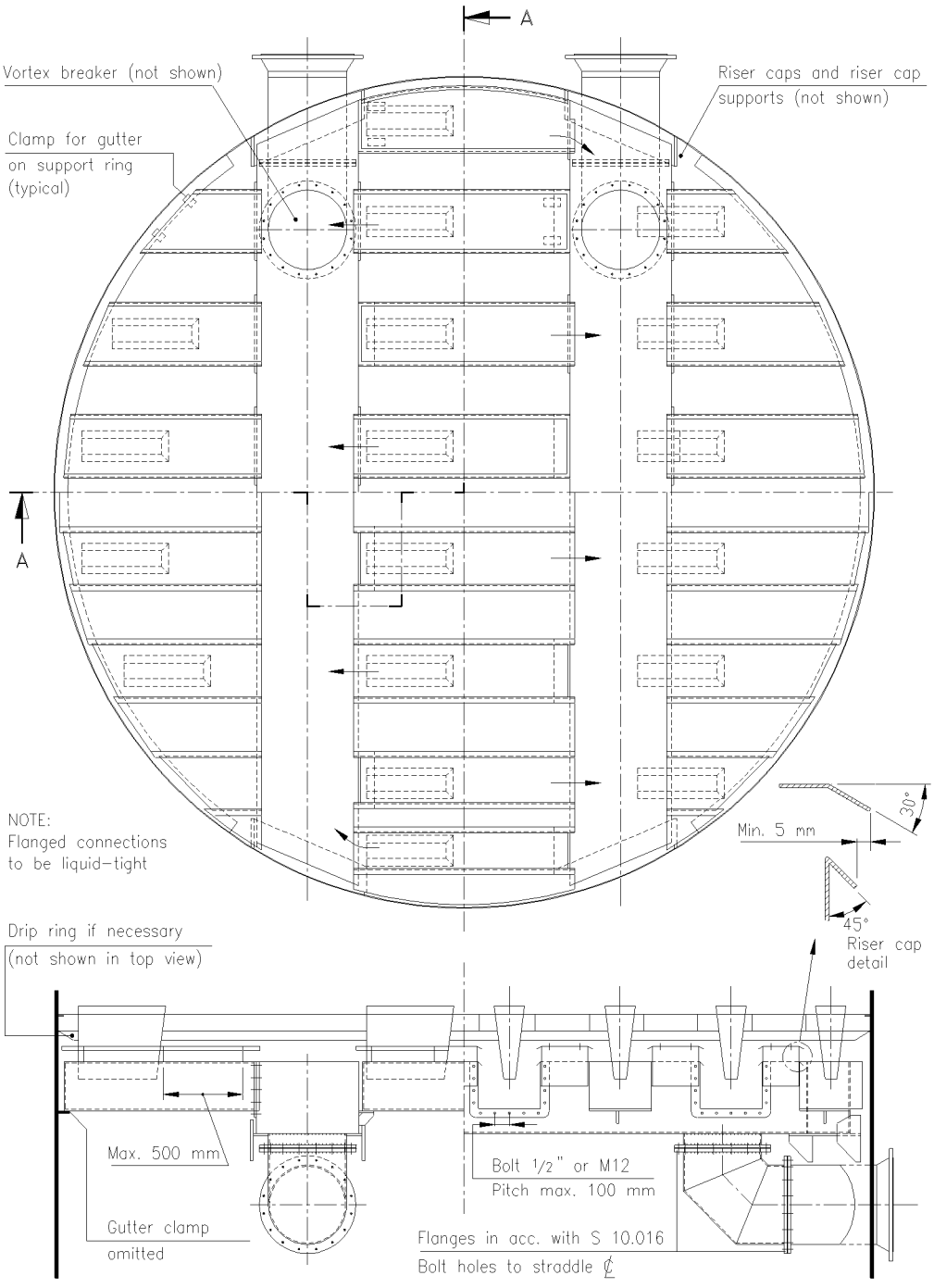
APPENDIX 8 TYPICAL TOTAL DRAW-OFF TRAY FOR HiFi CALMING SECTION TRAY



APPENDIX 9 TYPICAL PARTIAL DRAW-OFF TRAY



APPENDIX 10 TYPICAL SINGLE-DECK DRAW-OFF TRAY WITH TWO TROUGHS



SECTION A–A

APPENDIX 11 LEAKAGE TEST AND TEST CERTIFICATE

Test certificates

The Manufacturer shall certify that the column internals will not exceed the stated leakage rate based upon an actual leakage test stated below. This certification may be based on tests of column internals of identical design but not necessarily of the same size.

The column internals shall satisfy this test as installed in the column.

Leakage test

Column internals or parts of column internals which are designed to hold liquid (see 4.3.2) shall be designed and fabricated so that they are capable of passing the following leakage test:

- With all drain holes plugged and water level at the height indicated in section 4.3.2 the drop in level shall not exceed 5 cm in 30 min, unless otherwise specified.
- It should be verified that leakage through joints of bubble cap trays is uniformly distributed across the tray.

Note: After testing, the plugs shall be removed.

APPENDIX 12 LIQUID MALDISTRIBUTION TEST FOR GRAVITY LIQUID DISTRIBUTORS

A shop test shall be performed on gravity liquid distributors of high quality or for larger diameters *(D > 4m).*

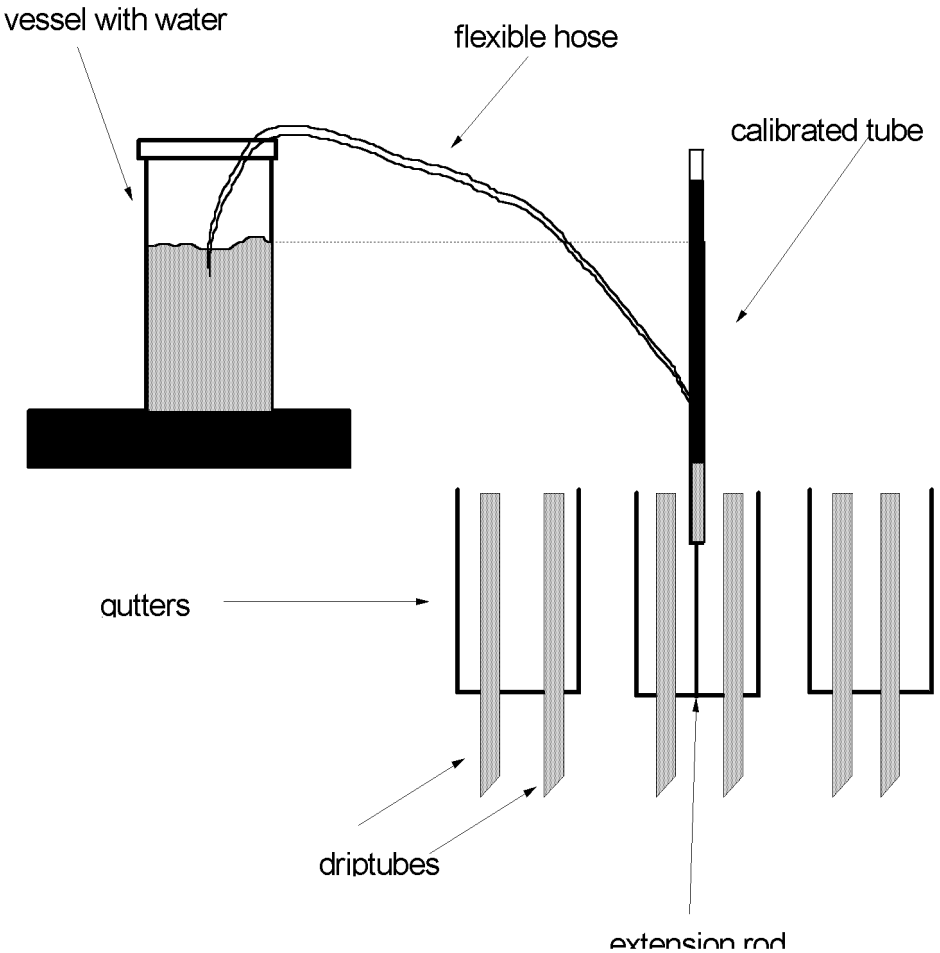
A complete test consists of:

1) **Verification of the levelness of the distributor**

The correct levelness is of the utmost importance for the proper functioning of a gravity distributor.

Normally, the levelness of the distributor cannot be measured accurately enough with conventional equipment. Instead a calibrated water tube and a vessel (bucket) filled with water, standing on a fixed surface could be used. The vessel and the calibrated tube are connected via a flexible hose and should be filled with water.

Figure 12 Measuring the levelness of a gravity distributor by using "the Law of communicating vessels"



The diameter of the vessel should be relatively large compared to the diameter of the tube, so that due to the "Law of communicating vessels" the liquid level in the tube stays at the same elevation. The elevation of the tray floor at various points can than be measured relative to the constant liquid level in the tube. Levelness shall be within 6 mm.

2) **Leakage-test of the distributor**

See Appendix 11.

3) **Range performance tests:** The following measurements shall be carried out:

- Measurements of the liquid levels in the channels at minimum and maximum flow

(Delta level (for a flow-rate) to be within 5 mm)

- Area measurements:

  The gravity distributor shall be divided in typically 4-8 areas with typically 6-12 distribution points per area. Liquid flow samples to be taken from each area at normal liquid flow.

Maldistribution criterion:

The maximum allowable maldistribution (*MR*) is defined as the absolute maximum percentage deviation from the average liquid flow.

$$MR = \left[\frac{(U_{mean} - U_{min})}{U_{mean}} \right] * 100\%$$

or

$$MR = \left[\frac{(U_{max} - U_{mean})}{U_{mean}} \right] * 100\%$$

where:

U_{mean} is the average liquid flow through the (groups of) distribution points calculated from e.g. a flow meter;

$U_{min,\ max}$ is the measured minimum, maximum liquid flow through a single (group of) distribution point(s)

The maximum allowable Maldistribution Ratio for high quality distributors is 5%:

Therefore, in that case: $(U_{max}-U_{mean})/U_{mean} < 5\%$

and $(U_{mean}-U_{min})/U_{mean} < 5\%$

In which U is the liquid flow through an area