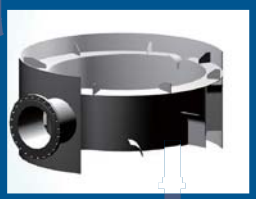
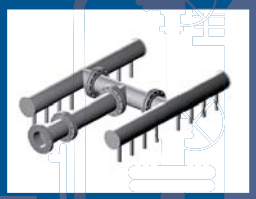
GTI SOLUTIONS

TOWER INTERNALS TECHNOLOGY





INNOVATIVE SOLUTIONS RELIABLE PERFORMANCE

ISO 9001 & ISO 14001 Certified

CONTENTS

Your Partner in Distillation Technology

GTI SOLUTIONS is a process equipment and technology company committed to providing innovative mass transfer equipment and solutions to the refining, chemical and petrochemical industries.

Customer satisfaction is our top priority. We work to earn each client's trust and loyalty by providing customized solutions to all their process engineering needs with rapid response time and competitive pricing.

Our engineering specialists have extensive experience in a wide range of mass transfer applications and work closely with each client to deliver measurable results that maximize operational performance and unit profitability.

Our portfolio of products and services includes:

- Conventional trays
- High performance trays
- Random packing
- Structured packing
- Grid packing
- Column internals
- Mist eliminators
- Liquid-liquid coalescers
- Reactor internals
- Divided wall column technology
- Process validation
- Performance test runs
- CFD modeling
- Engineering services
- Feasibility and complex revamp studies
- Expedited replacement services
- Troubleshooting services
- Technical training
- Site supervision services

Our mass transfer equipment is designed to operate in a range of applications and can be fabricated in a variety of corrosion resistant materials such as zirconium, titanium, monel, duplex steels, stainless steel, and other exotic alloys.

Liquid Distributors

Liquid distributors are essential for maximizing the performance of packed tower. The type of liquid distributor selected for a tower depends on factors such as the liquid rate, column diameter, type of service, type of packing, foaming tendency, fouling tendency and operating range. GTI SOLUTIONS's liquid distributors feature

- Homogeneous liquid distribution over their entire operating range
- Cross mixing capability
- Adequate turndown capability
- Minimum pressure drop with good vapor distribution
- Easy installation
- Fouling and plugging resistance

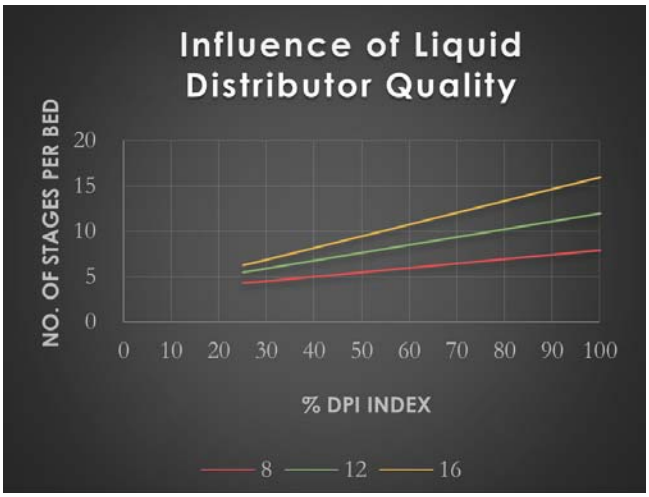


Figure 1a

Liquid Distribution Quality

An ideal liquid distributor is one that provides exactly same amount of liquid to every unit area of packing. The quality of distributor can be determined by the layout of the distribution pattern, referred to as distribution pattern index (DPI), and the actual flow that comes out of each orifice, measured as coefficient of variation (Cv).

The DPI is simply a fractional parameter that represents how far any particular distributor design is away from ideal drip point pattern.

For the majority of applications, a moderate range DPI is sufficient. However, in critical applications a high DPI is required.

Figure-1a & 1b demonstrate how the packing separation performance can be improved by applying a distributor with a higher DPI.

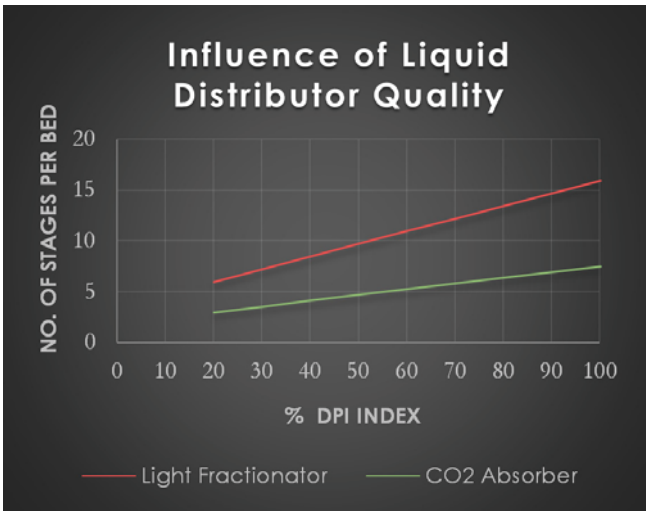


Figure 1b

Cv is the ratio of standard deviation to the mean expressed as a percentage and is one of the most extensively used parameters in the industry to define the quality of liquid distributors. It measures the variance of liquid flow from the individual distribution point compared to the average liquid flow across the cross sectional area of the distributor. Cv varies due to fabrication tolerances, out-of-levelness and liquid cross flow velocities within the individual troughs and pre-distributors. The lower the Cv value, the better the distribution quality.

Cv for any distributor is calculated as

$$CV = 100 \left[\frac{\Sigma \left(\frac{x_i}{\bar{x}} - 1 \right)^2}{N} \right]^{0.5}, \%$$

Where: xi = a flow rate measurement

$\bar{x}$ = average value of all the measurements

N = number of measurements

GTI SOLUTIONS designs most liquid distributors to be within a Cv value of 5% at maximum design rates and 10% at turndown conditions with other values possible.

Drip Point Density

Drip point density is defined as the number of distribution holes per unit area. There is a commonly held belief that the higher the drip point density, the better the distribution quality. However, by increasing drip point density, it reduces the distribution hole size, making the distributor more susceptible to plugging. It also adds to the overall cost and can reduce the open area of the distributor resulting in higher pressure drop.

GTI SOLUTIONS works to establish drip point density after carefully considering the type of service (fractionation, heat transfer or absorption), type of packing and fouling tendency. For low to medium surface area packing (surface area < 200 m2/m3) the incremental increase in packing HETP values with the increase in the drip point density is marginal. However, for high surface packing (surface area ≥ 250 m2/m3), a higher drip point density is recommended in order to maximize the performance of the packed bed.

Table 1. Recommended minimum drip point densities

Drip point density, points/m2	60 – 70	80 – 90	100	125 +
Structured Packing, m2/m3	< 200	200 - 250	250 - 350	> 350 &Gauze Packing
Random Packing, m2/m3	< 170	170 - 200	> 200	

Operating Range of Liquid Distributor

The operating range of a liquid distributor is defined as the ratio of maximum to minimum liquid rates the distributor must be able to handle.

GTI SOLUTIONS single-stage distributor design (holes at a single elevation) can easily provide an operating range of 2:1 to 2.5:1. When the operating range increases, the liquid head also increases, requiring a taller distributor. To prevent the distributor from becoming too tall, GTI SOLUTIONS offers a two-stage (holes at two elevations) or multi-stage design.

When liquid rates is decreased, the liquid head over the distribution hole reduces. A liquid head that is too low can lead to liquid maldistribution in case of out of levelness of the distributor. To ensure good quality distribution a minimum liquid head of 25 mm – 40 mm (based on column diameter) at the turndown condition is recommended.

Fouling

Fouling results from external sources such as dirt or corrosion from unit piping entering the column or from inherent process issues such as polymerization or coking. Over time, the fouling of a distributor can lead to maldistribution and impact the separation performance.

GTI SOLUTIONS recommends using external strainers to prevent unwanted debris or fouling materials from entering the column. In order to mitigate fouling that may arise due to inherent process issues, GT Solutions distributors are designed with the following features to mitigate:

- Minimized residence time
- Avoidance of dead zones
- Use of elevated and large size holes
- Use of notch weirs if distribution quality is not critical

Pre-Distributor

A well-designed pre-distribution system is critical for optimum performance, especially when column diameters and/or liquid rates are increased. A pre-distribution system that has not been optimized will lead to poor distribution quality that is often too difficult to correct through the main distributor design.

GTI SOLUTIONS achieves feed pre-distribution by using a feed pipe with metering orifices to feed a specific area of the distributor. We can also achieve pre-distribution by using a combination of feed pipe and pre-distributor box (parting box). To ensure uniform liquid distribution, GTI SOLUTIONS's pre-distribution system is equipped with a calming device to reduce the momentum of liquid being fed and prevent excessive liquid velocities and turbulences.

Redistributor and Cross Mixing Capabilities

Redistributors are required when columns are equipped with multiple packed beds because of:

- Intermediate feed locations or product draws
- Mechanical reasons due to packing load
- A High theoretical stage count
- Cross mixing requirements to eliminate heat or mass transfer gradients

Redistributors are similar in construction to distributors but include gas riser caps eliminating the need for a separate liquid collection system. Redistributors are also equipped with cross mixing capability to unify the composition of the external feed with that of the internal reflux. Cross mixing stabilizes the composition gradient that may develop before being fed to the packed bed below. Cross mixing can also be done through a separate liquid collection and feed forwarding system in order to achieve the most optimum design.

In order to ensures optimum vapor and liquid distribution quality across the column height, we recommend that each packed bed be limited to 20 theoretical stages.

Distributor Hole Diameter

The hole diameter for gravity distributors can vary from 3 mm to 25 mm and is a function of liquid flow rate, operating range, drip point density and distributor height.

When the distributor hole diameter is less than 6 mm, GTI SOLUTIONS recommends elevating holes from the deck to avoid plugging. For a higher operating range, greater than 3:1, a two-stage hole design is recommended.

Figure 2 shows approximate holes sizes with different drip point densities ranging from 60 to 120 points/m^2 when using gravity distributors with a standard operating range of 2:1.

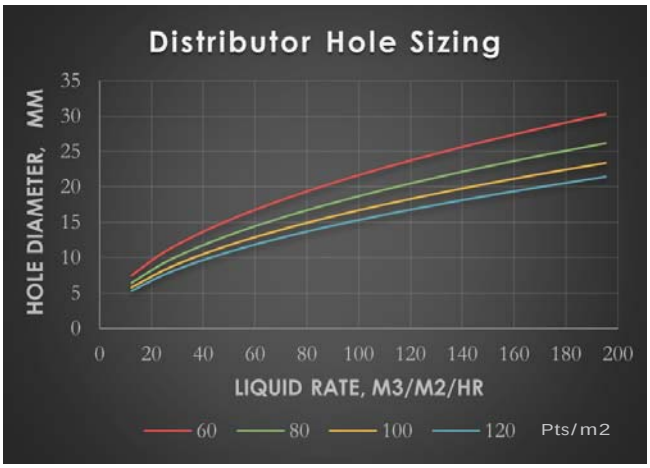


Figure 2. Distributor hole sizing

Distributor Location from Packed Bed

The main body of trough and deck liquid distributors are typically located 150-200 mm above packed beds. This provides sufficient disengagement space for vapor to leave the packed bed without causing excessive liquid entrainment.

When baffles are utilized, they are located directly on the packed bed.

The above arrangement ensures controlled distribution of liquid onto the packed bed while preventing rising vapor from influencing any liquid flow pattern.

Types of Liquid Distributors

GTI SOLUTIONS's liquid distributors are broadly classified as gravity and pressure distributors.

1) Gravity deck and trough distributors utilize gravity (liquid head) to achieve liquid distribution. Gravity distributors are more widely used than pressure distributors, because they can be designed for a wider variety of applications. They can also easily be used as Redistributors with or without liquid collection systems.

   i) Deck distributors consist of a tray deck equipped with circular or rectangular risers for gas passage. The distribution holes are generally located on the tray deck but can include drip tubes for fouling applications. Deck distributors are best suited for towers less than two meters in diameter or for high liquid loads especially above 40 $m^3/m^2/h$ (16 gpm/ft^2).

   Deck distributors are often installed in columns using tray support rings. However for smaller column diameters, deck distributors are installed using clips or can be located between vessel body flanges. A typical operating range of 2.5:1 can be achieved with holes on the tray deck. For a higher operating range, a two-stage design can be used with drip tubes.

   ii) Trough distributors consist of a series of troughs supported from independent beams across the tower. In some applications it is possible to support the distributor from the packed bed itself using an integrated bed hold down grid.

   The distributor holes are typically located on the walls of the troughs while the area between the troughs provides space for vapor passage. In non-fouling applications, the distributor holes can be located on the trough floors.

   A typical operating range of 2.5:1 can be achieved using a single-stage hole design. For a higher operating range, a two stage design can be used.

The trough distributors differ from deck distributors because they can provide a significantly higher open area for vapor passage. Trough distributors are also easier to level in the field and feature a seal welded design that greatly reduces the leakage at low liquid rates.

To ensure uniform distribution, trough distributors are fed through a pre-distribution system (parting box).

For redistribution, trough distributors often require a separate collector above. However, in revamp situations where space is limited, collector trays can be avoided by using a central channel along with riser caps on the troughs.

For gravity distributors a feed pipe is required to introduce the feed into the distributor. In additions, the distributor can be designed to handle two phase feeds when used with a flash feed box or flash feed gallery.

2) GTI SOLUTIONS offers two types of pressure distributors, pipe orifice distributors and spray nozzle distributors

i) Pipe orifice distributors are generally ladder type distributors consisting of a central header with several laterals to cover the column cross-sectional area.

The distribution holes are typically located on the bottom wall of the pipes. Drip point density can be limited and the DPI can be lower compared to other distributor types.

ii) Spray nozzle distributors are similar in construction to pipe orifice distributors but are equipped with spray nozzles instead of holes for liquid distribution. They are typically used in heat transfer applications where distribution quality is not critical.

The distribution quality is a function of the number of spray nozzles, nozzle's height from the packed bed and spray patterns.

A good rule of thumbs is to maintain a pressure drop across the spray nozzles between 0.4 ~ 1.5 bar.

A low pressure drop can cause the spray pattern to collapse leading to a loss of distribution quality.

A pressure drop that is too high will lead to the atomization of liquid causing excessive entrainment.

The advantage of a spray distributor is its resistance to fouling due to the high velocity across the nozzles and a large free passage area.

Spray nozzle distributors often require additional back pressure for operation, and pump capacity should be checked for adequacy.

The operating range of spray nozzle distributors are typically limited to 2:1 and cannot be used with two-phase feed or as redistributors. These distributors are more economical and easier to install and maintain compared to gravity distributors.

Distributor Types

Model TTD-146 Trough Liquid Distributor with Drip Tubes

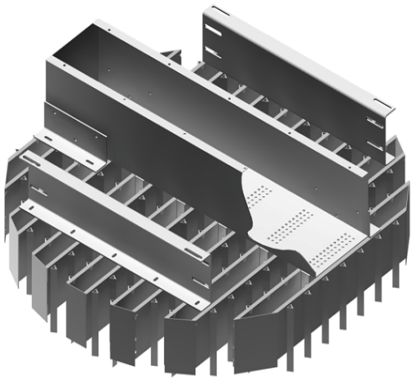
Model TTD-146 is best suited for packed beds in fractionation service that requires high distribution quality and comes with a series of troughs and a pre-distribution parting box mounted above the troughs.

For external feed, liquid is fed into the parting box through a feed pipe.

For a redistributor, liquid is fed into the parting box from a collector.

The parting box reduces momentum of the incoming liquid and feeds into individual troughs in a metered way.

The troughs are equipped with elevated distribution holes that are covered with drip tubes to conduct liquid to the packed bed below. This design ensures minimum entrainment by up-flowing vapor and ensures even distribution quality. In addition overflows holes/ notches are provided to ensure controlled liquid flow even when rates are exceeded.



Column Diameter :
- > 800 mm

Operating Range :
- 2.5:1 achievable with a single-stage design
- 10:1 achievable with a multi-stage design

Liquid Rates :
- 2.5 ~ 40 $m^3/m^2/hr$
- Higher rates can be accommodated by using a special tube design
- Lower rates can be accommodated by using Model TTD-147

Construction Features :
- Beam supports and leveling features are included for easy installation

Model TTD-110 Trough Liquid Distributor with Bottom Orifices

Model TTD-110 is similar to Model TTD-146 except that no drip tubes are present and the distribution holes are located on the trough floors.

The holes are arranged in a predetermined pattern to provide optimum distribution quality while the troughs are arranged to maximize the vapor passage area.

Model TTD-110 is more economical compared to Model TTD-146 and can be applied in moderate to high liquid loads where hole sizes are large enough to prevent fouling.

In addition, the trough construction of Model TTD-110 provides lower pressure drop with the ability for leveling compared to Model DRD-116.

Column Diameter:
- > 800 mm

Operating Range:
- 2.5:1

Liquid Rates:
- 5 ~ 60 $m^3/m^2/hr$

Construction Features:
- Beam supports and leveling features are included for easy installation

Model TTD-147 Trough Liquid Distributor with Baffle Plates

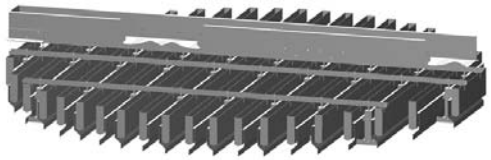
Model TTD-147 is best suited for fractionation service that require high distribution quality. Model TTD-147 is similar to Model TTD-146 distributor except that the distribution holes feed onto a special liquid spreading baffle that is attached to the trough wall.

The baffle spreads the liquid from each distribution hole into multiple streams feeding them in a controlled way onto the top of the packed bed.

This drip point multiplier effect allows us to use larger holes within individual troughs, providing greater fouling resistance while achieving optimum distribution quality even at very low liquid rates.

Model TTD-147 works particularly well with structured packing, due to the linear drip point pattern.

In addition, Model TTD-147 provides good fouling resistance and a high vapor passage area leading to lower pressure drop, even distribution, and minimum entrainment.



Column Diameter:
- > 800 mm

Operating Range:
- 2.5:1 achievable with a single-stage design
- Higher operating range achievable with multi-stage design

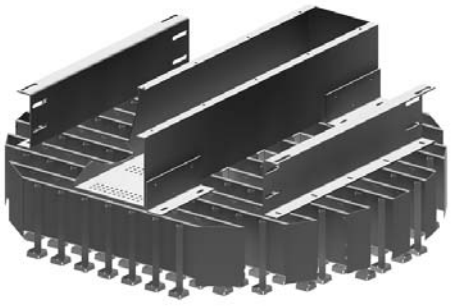
Liquid Rates:
- 0.25 ~ 20 $m^3/m^2/hr$
- Lower rates can be accommodated with a custom design

Construction Features:
- Integrated hold down grids are included and supported from packed beds
- Can be designed for independent beam support

Model TTD-148 Trough Liquid Distributor with Drip Point Multiplier Box

Model TTD-148 is similar to Model TTD-146, except that each of the drip tubes on the troughs are equipped with a special drip point multiplier (DPM) box.

Each DPM box includes several distribution holes which creates multiple drip points for each of the holes in the troughs ensuring complete coverage of the packing at low to very low liquid loads. This special design feature allows us to use larger holes in the troughs and as a result, greater fouling resistance is achieved.



Column Diameter:
- > 800 mm

Operating Range:
- 2.5:1 achievable with single-stage design
- Higher operating range achievable with multi-stage design

Liquid Rates:
- 0.05 ~ 5 $m^3/m^2/hr$

Construction Features:
- Beam supports and leveling features are included for easy installation

Model TTD-246 Channel Trough Liquid Distributor with Drip Tubes

Model TTD-246 includes a series of troughs with a central channel (or off-center channels for large column diameters).

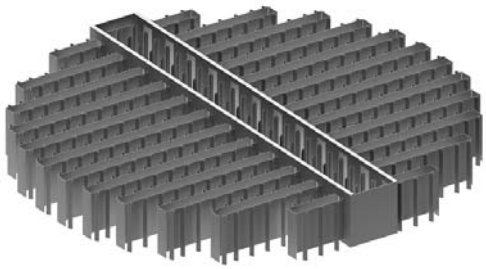
The troughs are equipped with elevated distribution holes that are covered with drip tubes to guide the liquid onto the packed bed below.

The central channel provides liquid equalization and cross mixing capability. The central channel is also equipped with drip tubes and elevated holes to ensure complete cross sectional coverage of the packed bed.

Overflow holes are included and are similar to those in Model TTD-146.

The design provides greater fouling resistance and a higher vapor passage area leading to lower pressure drop, even distribution, and minimum entrainment.

We recommend channel liquid distributors over our deck distributors when pressure drop is critical.



Column Diameter:
- > 800 mm

Operating Range:
- 2.5:1 achievable with single-stage design
- Higher operating range achievable with multi-stage design

Liquid Rates:
- 2.5 ~ 40 $m^3/m^2/hr$
- Higher rates can be accommodated by using a special tube design

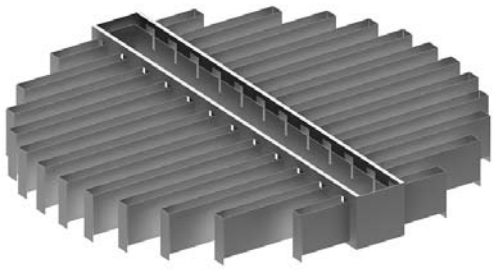
Construction Features:
- Beam supports and leveling features are included for easy installation
- Requires less height when compared to other trough distributors and can be used as a redistributor in revamp situations where height is constrained
- For use as a liquid redistributor, hats can be added over the gas risers with a wall wiper welded onto the column

Model TTD-210 Channel Trough Liquid Distributor with Bottom Orifices

Model TTD-210 is similar to Model TTD-246 except that the distribution holes are located on the trough floors.

The holes are arranged in a predetermined pattern to provide optimum distribution while the troughs are arranged to maximize the vapor passage area.

Model TTD-210 is more economical compared to Model TTD-246 and can be applied in moderate to high liquid loads where hole size will be large enough to avoid fouling.



Column Diameter:
- > 800 mm

Operating Range:
- 2.5:1

Liquid Rates:
- 5 ~ 60 $m^3/m^2/hr$

Construction Features:
- Beam supports and leveling features are included for easy installation

Model TTD-139 Trough Liquid Distributor with V-Notch Slots

Model TTD-139 are best suited for FCC slurry pump-around beds and for applications where solid ingress is a concern and distribution is not critical.

Model TTD-139 features a series of closed end troughs with a parting box above it.

The liquid is distributed through a uniform pattern of elevated triangular notches and slots located on the trough walls.

The vertical slots provide the primary distribution but if plugging occurs, the liquid can still flow in a controlled manner through triangular notches to ensure the packed bed continues to be irrigated. In addition, each notch is protected by a cover plate to ensure minimum entrainment and distribution quality.

Due to V-notch design, Model TTD-139 ensures high fouling resistance with the ability to handle fluids containing high solid contents or catalyst fines while handling moderate to high liquid flow rates.

Column Diameter :
- > 800 mm

Operating range:
- Higher operating range is available due to v-notch slots design

Liquid Rates:
- 5 ~ 100 $m^3/m^2/hr$

Construction Features:
- Beam supports and leveling features are included for easy installation
- If used as a redistributor, a separate collector is used to feed in

General Note: Trough Distributor Selection and Features

Model TTD-146 and Model TTD-147 trough distributors are best suited for packed beds in fractionation services that require high distribution quality.

Standard design can cover operating liquid rates of 0.25 ~ 40 m3/m2/hr in any fractionation service.
Liquid rates higher than 40 m3/m2/hr can be accommodated by using special drip tubes in Model TTD-146.
Model TTD-148 can be used for liquid rates lower than 0.25 m3/m2/hr.

All trough distributors are equipped with leveling features to ensure trouble-free installation with minimum out-of-levelness.

When the troughs are built with elevated holes, it allows for a larger vapor passage leading to a lower pressure drop and higher fouling resistance.

A multi-stage design can easily be employed to maximize the operating range while maintaining adequate distribution quality without excessive distributor height.

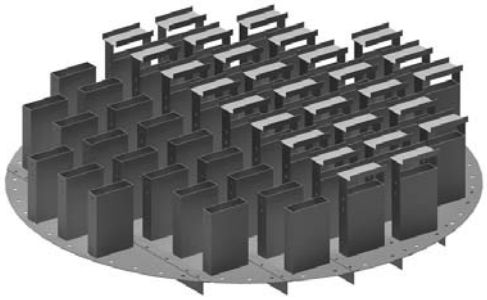
Model DRD-116/117 Deck Orifice Liquid Distributor/Redistributor

Deck orifice liquid distributors/redistributors are recommended for moderate to high liquid rates where hole sizes are large enough to provide adequate fouling protection.

Model DRD-116 deck orifice liquid distributor is equipped with small rectangular risers and holes between and around the risers to ensure uniform distribution quality and maximum cross-mixing capability.

Model DRD-117 is similar in construction to Model DRD-116 except that it includes riser hats to act as a liquid redistributor. This design feature saves on column height by eliminating the need for a separate liquid collector for redistribution.

For liquid only feed, we recommend using feed pipes to ensure even liquid distribution. For two-phase feed, Model FG-605 flash feed gallery is recommended as a feeding device.



Column Diameter:
- > 500 mm

Operating Range:
- 2.5:1

Liquid Rates:
- > 6 $m^3/m^2/hr$

Construction Features;
- Can be equipped with an anti-migration bar avoiding a separate bed limiter
- Designed for installation on tower tray support rings
- For diameters larger than 3000 mm, a separate beam may be required.

Other Types of Deck Liquid Orifice Distributor/Redistributor

We offer fully customizable deck distributors and redistributors for a wide variety of applications.

For instance, we offer Model DRD-216/217 which are similar in design to Model DRD-116/117 except that they are customized to include circular gas risers for vapor passage.

We also offer Model DRD-126/127 which are customized to accommodate fouling susceptibility and an operating range higher than 2.5:1 by replacing the distribution holes in the deck with drip tubes. The design provides greater fouling protection while a higher operating range can be achieved using a multi-stage design.

For applications susceptible to fouling with high liquid loads, our Model DRD-136/137 deck distributors are customized to include drip tubes and triangular notches with bottom V-notch slots allowing for liquid cross flow while providing high fouling protection.

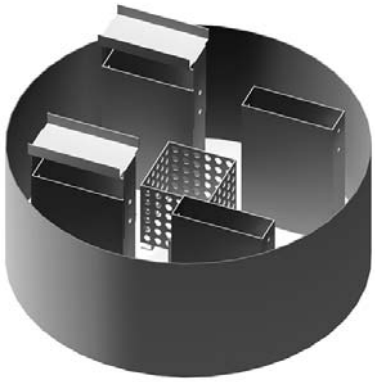
Model DRD-116/117RM Pan Liquid Distributor/Redistributor

Model DRD-116 RM is recommended for small column diameters with high to moderate liquid rates.

The holes are located on the pan floor for liquid distribution, while the vapor passage area is provided by gas risers within the pan and/or by annular spaces between the column and the pan rim.

For fouling applications or higher operating ranges, the orifices on the floor can be replaced by drip tubes.

For liquid redistribution we recommend Model DRD-117 RM which is designed with gas riser covers and a wall wiper (supplied by a vessel fabricator) welded to the column wall.



Column Diameter:
- < 600 mm

Liquid Rates:
- > 6 $m^3/m^2/hr$

Operating range:
- 2.5:1

Construction features
- Supported by using lugs on the column wall (can also be hang from the column flange ring upon request)

Model TDF-210 Trough Distributor for Offshore Applications

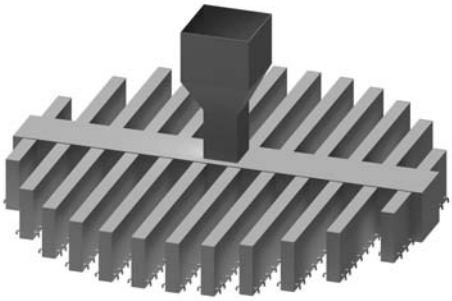
Liquid distributors used in FPSO applications are subjected to harsh offshore conditions and must be able to perform under constant motion and/or tilt.

Model TDF-210 has been specifically designed for such demanding operating conditions and comes with a series of enclosed troughs connected through a central channel.

The troughs are equipped with holes on the bottom to provide the required distribution while the central channel provides the required cross mixing and equalization.

The enclosed construction allows Model TDF-210 to maintain high liquid heads for good quality distribution, minimizing the effect of out-of-levelness and movement.

In addition, good distribution quality is achieved at all operating rates resulting in better separation performance, low pressure drop, and reduced energy consumption



Column Diameter:
- > 700 mm

Liquid Rates:
- > 2.5 $m^3/m^2/hr$

Operating Range:
- 2:1
- Higher operating range achievable by using a custom made design

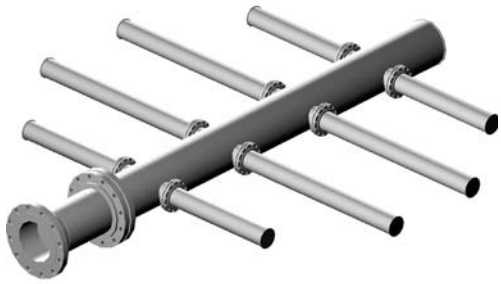
Construction Features:
- Hung from separate beams secured to the column wall
- For top feed, a pipe with downpipes directly feeding into the central channel is used
- When used as a liquid redistributor, a custom designed liquid collector is included

Model POL-929 Pipe Orifice Lateral Distributor

Model POL-929 consists of several laterals connected with a central header using flange construction.

The distribution holes are typically located on the bottom of the pipe. Additional holes, if required, can be provided at an angle to vertical facing the packed bed.

Model POL-929 requires minimum height for installation and provides a high vapor passage area.



Column Diameter:
- > 400 mm

Operating Range:
- 2:1
- Higher operating range achievable by using deck or trough type distributors

Construction features
- For small column diameters, pipe and laterals are supported by clips attached to the vessel wall.
- For large column diameters, the distributor is secured by beams attached to the column wall

Model SND-100 Spray Nozzle Distributor

Spray nozzle distributors are ideal for heat transfer applications, gas scrubbers or wash beds where distribution quality is not critical but complete wetting of packing is required.

SND-100 consists of a central header and several laterals with downpipes and spray nozzles located underneath the pipework to provide uniform liquid distribution.

Model SND-100 can use one to several spray nozzles, depending on the column diameter, liquid flow rate and distributor pattern and coverage required.

The standard design uses a full conical pattern with a 120º spray angle that can be further customized.

This ensures that the spray pattern has a large degree of overlaps to provide complete liquid coverage to the packed bed below in order to prevent dry spots and fouling.

Spray nozzle distributors are less sensitive to out-of-levelness and are easy to install and maintain.

Column Diameter:
- ≥ 150 mm

Liquid Rates:
- > 0.25 $m^3/m^2/hr$

Operating range:
- 2:1
- Higher operating range achievable by using deck or trough type distributors

Construction features
- For small column diameters, pipe and laterals are supported by clips attached to the vessel wall.
- For large column diameters, the distributor is secured by beams attached to the column wall

Liquid Collectors and Draw-off Trays

Liquid collectors are installed in packed columns to collect liquid from the beds above for liquid redistribution, cross-mixing and/or liquid draw-offs from the column. Liquid collectors can also be utilized as vapor distributors or as transition trays in tray columns.

GTI SOLUTIONS offers three types of collector trays:

- Deck riser collectors
- Trough channel collectors
- Vane collectors

The type of collector we recommend is based on the applications, amount of liquid draw, residence time requirement, pressure drop limitation, and space available within the column.

For tray and/ or packed columns, deck riser collector trays are used for product draw-off or as transition trays when the number of passes are changes with or without feed introduction.

For packed columns, any one of our three collectors can be applied depending on the application, pressure drop restriction, and functional requirement.

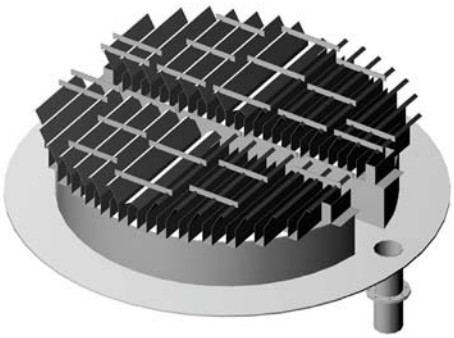
Model VCT-401 Vane Collector

Model VCT-401 is used to collect liquid between the packed beds, cross-mixing it before feeding it forward through down pipes or down boxes to the liquid distributor below.

Model VCT-401 features a series of vanes that are bolted onto an annular sump using channels. The sump is welded onto the column wall and the adjacent vanes are strapped together to provide greater mechanical stability

The vane construction allows for a large open area with minimum resistance to vapor flow resulting in a lower pressure drop.

For large columns, Model VCT-401 is equipped with a central sump that provides greater cross-mixing capability.



Column Diameter:

- ≥700 mm

Construction Features:

- Partial draw-off can be provided through the annular or central sump
- Vane width and height can be customized depending on the specific liquid rate
- Less height required compared to deck collectors
- Requires minimum welding providing leak-free construction

Model DCT-110 Deck Riser Collector

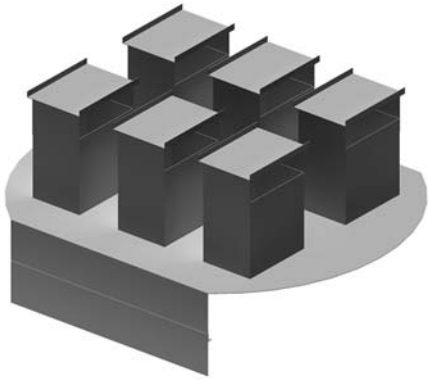
Model DCT-110 consists of a deck with rectangular risers welded onto it and is typically used for partial or complete draw-off and/or as vapor distributor.

Model DCT-110 can also be used as a transition tray or to collect, re-mix and feed forward liquid to the redistributor below.

If the collector is used as a draw-off tray, side or central sumps are provided for the locating draw-off nozzles. In addition, the height of the riser can be customized to achieve a specific residence time on the deck. Panels can be bolted or seal welded. For complete draw-off trays, seal-welded construction is recommended.

Model DCT-110 can also be equipped with downpipes or downcomers when providing internal reflux within the column.

Riser shapes can be round and can also be designed to act as a manway.



Column Diameter:
- ≥750 mm

Open Area:
- 15% - 35%

Construction Features:
- Able to handle large liquid rates
- Provision for thermal expansion provisions can be provided for certain applications in case of fully welded construction

Model VCT-310 Trough Channel Collectors

Model VCT-310 consists of a series of troughs that drain into a side or central sump.

The troughs are supported from the tray support rings and bolted and gasketed to the sump.

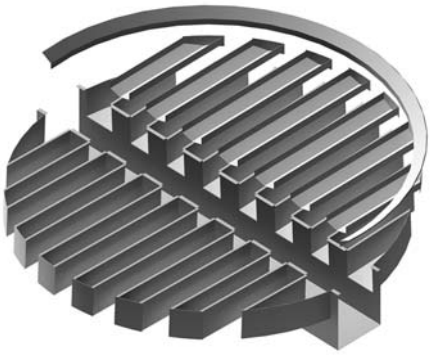
The trough arrangement provides a leak free design and minimizes welding to the column wall.

For construction, a wall wiper is welded to the column wall to collect liquid and directing it to the collector when installed below a packed bed.

The spaces between the troughs provide a vapor passage area and are covered with hats to collect and direct the liquid to the trough area when used below a packed bed.

Model VCT-310 can be used as partial or total draw-off tray and as a liquid collection system in between packed beds.

Trough and sump heights can be customized to meet specific liquid rates.



Column Diameter:
- ≥ 1000 mm

Construction Features:
- Requires less welding compared to deck collectors

Feed Devices

Correct introduction of any feed entering the column is essential to maximizing column performance. Poorly designed feed devices can lead to column malfunctions such as premature flooding, foaming, weeping, and entrainment. There are three basic types of feed:

- Liquid only feed
- Two-phase feed (flashing or suppressed flash)
- Vapor only feed

Feed device selection should be based on the type of feed, amount of feed, location of where the feed is being introduced and type of internals within column.

GTI SOLUTIONS works closely with each client to select the most appropriate feed device to adequately separate phases, address turndown needs and ensure proper fluid feed velocity.

Feed Pipes

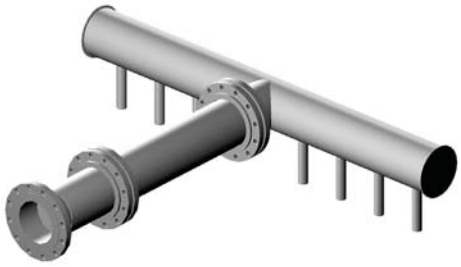
GTI SOLUTIONS offers a wide variety of feed pipes designed to reduce liquid feed velocity and turbulence in order to improve the column performance.

We offer straight, T-shaped, H-shaped, or multi-lateral pipes depending on the column diameter and equipment to which the feed is being introduced.
For liquid or vapor only feed, we utilize simple pipe construction.

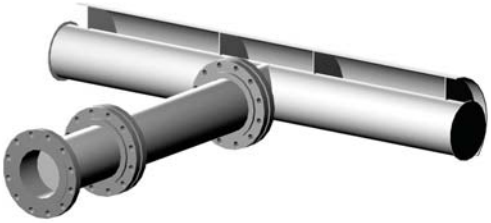
For two-phase feed, pipes can be built with a hood, baffle or flash-feed box to provide the required disengagement between the two phases.

The type of flash device we recommend for clients is based on which internal the pipe is feeding and the section of the column where the feed is located.

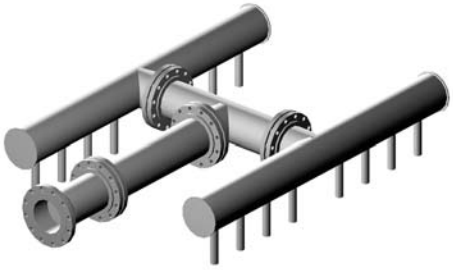
For smaller columns, we offer insert bayonet pipes. For larger columns, the main header is bolted to the flange of the internal stub.



Model FP-204 T-Shaped Feed Pipe



Model FP-202 T-Shaped Flash Feed Pipe with Hood



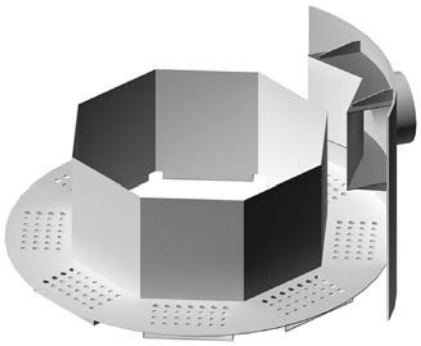
Model FP-304 H-shaped Feed Pipe

Model FG-605 Flashing Feed Gallery

Model FG-605 is used to introduce two-phase feed into a column.

The design consists of an annular channel with a central gallery riser. Feed is introduced through a tangential or radial deflector baffle and the liquid is collected onto the gallery floor to provide time for vapor disengagement before being fed to the liquid distributor below.

The annular channel floor is equipped with holes to feed the liquid in a metered way to the distributor below.



Column Diameter :

- ≥ 800 mm

Construction Features :

- Large open area suited to handle a high ratio of flash feed
- Deflector baffle is of welded construction supplied by a vessel fabricator
- Gallery is clamped to the tray support ring

Model FC-611 Flashing Feed Chamber

Model FC-611 is generally used to introduce two-phase feed into smaller columns.

The feed is introduced through a central cylindrical channel where it is centrifuged resulting in the separation of liquid and vapor.

The vapor leaves the chamber from the top opening while the liquid is fed through downpipes to a distributor below.

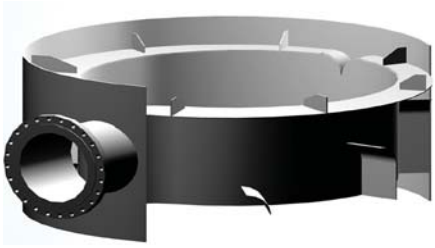
The chamber can be constructed in one or two-pieces based on column diameter and is able to handle high vapor to liquid ratios within the feed.

Model G-FLOW™-611/612 Vapor Horn Technology

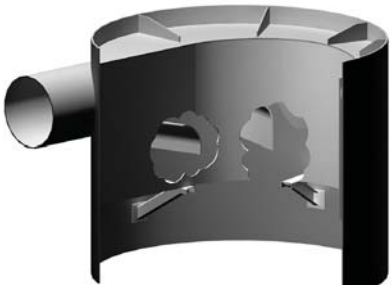
In order to optimize yields from crude units, it is critically important that the flash zone and wash section work together to provide trouble free operation.

G-FLOW Vapor Horn technology not only provides phase separation and initial distribution but also maximizes de-entrainment, leading to a trouble-free wash bed operation and better quality gas oil yield.

Both G-FLOW-611 and G-FLOW-612 are equipped with several propriety features including vane deflectors at key locations to reduces high momentum of incoming fluid and provide even distribution across the entire column.



MODEL G-FLOW™-611 Radial Vapor Horn



MODEL G-FLOW™-612 Tangential Vapor Horn

Column Diameter:

- ≥1500 mm

Construction Features:

- Customizable design for a higher mechanical strength of 1~2 psi
- Multiple feed designs possible

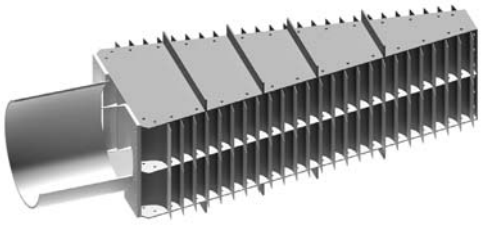
Model G-VANE™-600 Multi-Vane Distributor

Vane distributors are used as feed devices to reduce feed velocity, uniformly distribute vapor, and avoid entrainment of liquid.

Model G-VANE-600 is designed with a radial inlet for initial distribution of vapor or two-phase feed and consists of a series of vanes that taper radially.

The design of Model G-VANE-600 reduces the high momentum of incoming feed while also providing even distribution with minimum pressure drop. In addition the vanes uniformly distribute the feed in multiple horizontal streams while reducing the velocity, and improving vapor distribution.

The number of vanes, vane length and vane angle can be customized depending on the column diameter, inlet nozzle size and feed conditions.



Column Diameter:

- ≥1200 mm

Construction Features:

- Requires an inlet attachment for new columns
- Attached to an existing flange for revamp columns
- A mid-span beam and support clips attached to the vessel wall may be required for large columns

Support Plates

Packed beds must be equipped with support plates to physically support the weight of the packed bed load under operating conditions.

GTI SOLUTIONS offers random and structured packing support plates that feature:

- A high open areas to minimize resistance to upward gas flow and downward liquid flow
- A high mechanical stability to support the full weight of packing and liquid hold-up.
- Easy installation

The selection of the packing support plates is often based on several factors including:

- The type of packing and material to be supported
- The liquid hold-up and maximum mechanical load capability
- The packing size and load

For random packing, we typically recommend clients using a gas injection support plate with undulated panel construction to provide two distinct passageways for vapor and liquid. Our design ensures that the vapor and liquid phases flow through different sets of openings while also minimizing pressure drop and preventing excess liquid build up.

For structured packing we recommend a grid construction to maximize the open cross-sectional area of the support plates. This ensures minimum restriction to vapor and liquid flow capacity.

For random packing, the packed bed height is measured from the bottom of the gas injection support, RPS-201.

For structured packing, the packed bed height is measured from the top of the support grid, SPS-201. The plate's thickness depends on column diameter and the packing load being supported.

Model RPS-201 Gas Injection Support Plate

Model RPS-201 is used to support random packing beds for column diameters of 800 mm or larger.

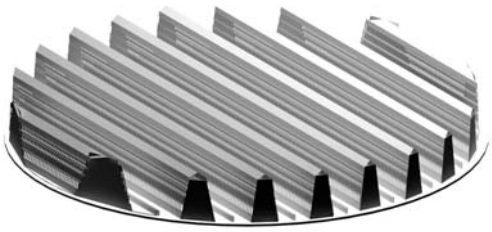
We use undulated construction for the support plate in order to provide a high open area and the required mechanical strength to hold the packing load.

The slots within the panel can be customized to handle various packing sizes and types while the height is based on process requirements.

The thickness of the support plate depends on column diameter and the packing load being supported.

Model RPS-201 can be designed with an open area of 85% ~100%.

For columns smaller than 800 mm, Model RPS-202 Gas Injection Support Plate is recommended.



Column Diameter:
- ≥800 mm

Pressure Drop:
- Negligible due to high open area

Construction Features:
- Support plate sections are bolted together and clamped onto the column support ring
- Mid-span beams may be required for column diameters larger than 3000 mm based on packed bed height

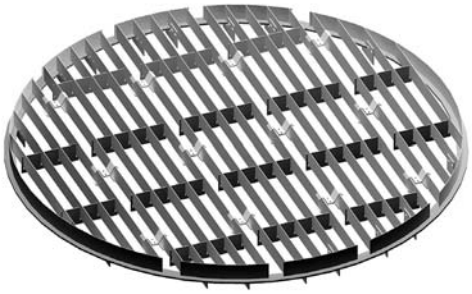
Model SPS-201 Structured Packing Support Grid

Model SPS-201 is designed with a high open area to reduce resistance to gas and liquid flow. This maximize packing capacity and minimize pressure drop while still providing the required mechanical strength to support the weight of the structured packing bed.

The thickness and height of the support plate depends on the column diameter and packing load being supported.

In addition the proprietary clamped construction allows for vessel out of roundness and quick installation.

The typical open area for Model SPS-201 is 85~95%.



Column Diameter:
- Suitable for all size ranges

Pressure Drop:
- Negligible due to high open area

Construction Features:
- Support plate sections are clamped together and the grid rests on the support rings of the column
- Mid-span beams may be required for column diameters larger than 3000 mm based on he packed bed height

Bed Limiters

A sudden increase in gas velocity or an intermittent pressure surge can result in the expansion of packed beds.

GTI SOLUTIONS offers bed limiters which are hold down grids designed to retain random and structured packing beds within their position and ensure good distribution quality.

For random packing, Model RHG-101 is designed to retain packing levelness, especially during high vapor loads when the packed beds are susceptible to becoming fluidized.

For structured packing, Model SHG-101 is designed to prevent packing displacement especially during upsets or flooding conditions.

Both of our random and structured bed limiters feature high open areas to minimize pressure drop and interference with the liquid distribution pattern.

Bed limiters are typically installed with bolting clips or support rings fastened onto the column wall.

For structured packing, in certain applications, Model SHG-101 can be integrated with the liquid distributor that sits on the packed bed or supported from the beam of the liquid distributor above.

For a random packed bed, our distributor's gas risers can include an anti-migration device, eliminating the need for a separate bed limiter. Although the anti-migration device ensures the packing are not swept away through the gas risers, it does not offer the same protection as a bed limiter for retaining the packing surface level and avoiding fluidization.

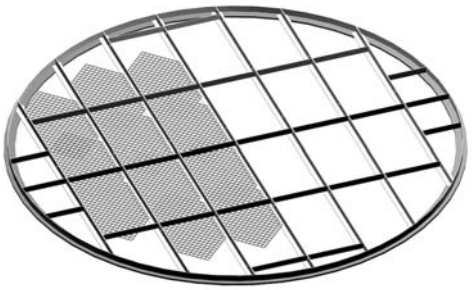
Model RHG-101 Random Packing Bed Limiter

Model RHG-101 is used to prevent the expansion of plastic or metal packing by maintaining the surface level at the top of the bed.

The bed limiter consists of an expanded metal plate supported by a frame of metal grid bars. This allows a maximum open area while providing enough mechanical strength to retain the packed bed.

The design of the expanded metal screen can be customized to suit individual packing being retained. Each bed limiter is built to pass through a column manhole. The bed limiter is installed inside the column by clamping it to brackets, which are then welded onto the vessel wall or tray support ring.

Alternatively, an expandable design with jackscrews can be used to tighten the bed limiter against the column wall.



Column Diameter:
- Suitable for all size ranges

Open Area:
- 85% to 95%

Pressure Drop:
- Negligible due to high open area

Approximate Weight:
- Standard uplift design is 250 kg/m2 with higher uplift design options available

Construction Features:
- For large column diameters, a center-span beam may be required

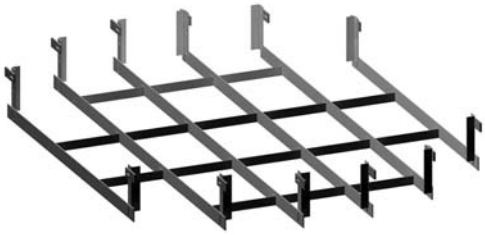
Model SHG-101 Structured Packing Hold Down Grid/Bar

Model SHG-101 is used at the top of a packed bed to retain sheet metal or wire gauge structured packing.

The grid bar is designed in sections in order to pass through manholes and can be attached to the vessel wall using bolting clips.

Model SHG-101 can also be hung from the beams of the distributor above.

For certain design hold down bar/grid can be made integral to the liquid distributor with the distributor resting on the packed providing the required strength.



Column Diameter:
- Suitable for all size ranges

Open Area
- 85% to 95%

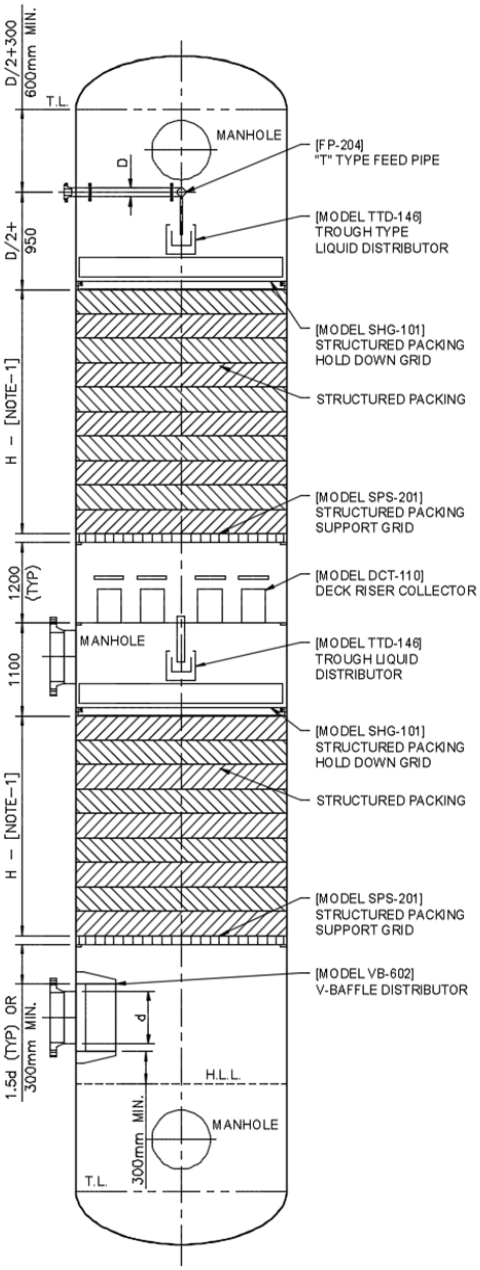
Pressure Drop:
- Negligible due to high open area

Construction Features:
- For large column diameters, a center-span beam may be required.
- Standard uplift design is 250 kg/m2 with higher uplift design options available

Packed Bed Arrangement Liquid-Vapor Columns

The sketches below provide example layouts of internals in columns with liquid feed only. The space shown between various internals are typical and can be fully customized to suite a wide variety of columns.

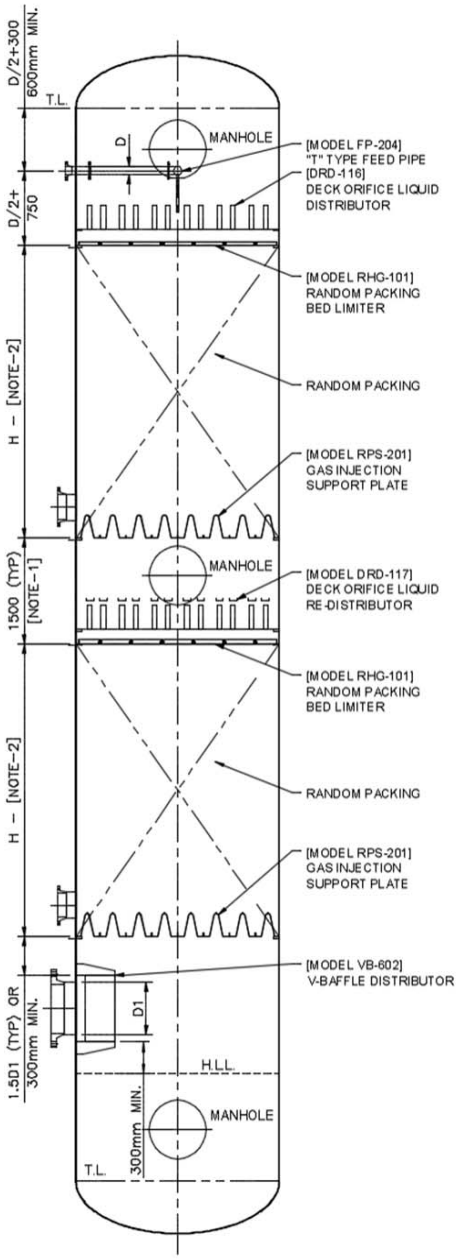
Structured Packing Column



NOTE :

1. For structured packing bed, bed height is measured from the top of support plate

Random Packing Column



NOTES :

1. If there is an intermediate feed then use spacing of 1500mm + D2, where D2 is the diameter of intermediate feed pipe
2. For random packing bed height is measured from the bottom of the support plate.

Liquid-Liquid Extraction Tower Internals

Liquid-liquid extraction is an important process that is used when separation by conventional distillation technology is uneconomical or impractical. GTI SOLUTIONS's liquid-liquid extraction technology is often used in situations where there is:

- Separation of close boiling components or those forming azeotropes
- Separation of small amounts of high boiling impurities from bulk mixtures
- Separation of thermally sensitive components

In packed columns, the wetting of the packing is achieved by the continuous phase while the mass transfer happens across the surface area of individual droplets in the disperse phase. The function of packing is to provide increased residence time to improve the mass transfer while providing sufficient turbulence to avoid the disperse phase droplets from coalescing.

From an operational point of view, either the light or heavy phase can be dispersed. However, as a general rule the liquid with the larger flow rate is dispersed to achieve the highest droplet surface area possible in order to maximize the interfacial contact. Some exceptions include situations where a higher flow rate liquid preferentially wets the packing or has a lower viscosity.

For liquid-liquid contacting towers, the selection of the column internals and their arrangement within the column depend on whether the light or heavy phase is dispersed. The dispersed phase distributor provides the optimum disperse phase droplet size and also leads to uniform velocities across the entire cross sectional area of the column, minimizing entrainment.

Model LPD-621 disperser support plate is located at the bottom of the packed bed when the light phase is dispersed. It provides the required dispersed phase distribution while also acting as the packing support plate. Model HPD-610 dispersed phase distributor is located above the packed bed when the heavy phase is dispersed. In this scenario a separate support grid is required to support the packed bed.

The introduction of the two liquid phases within the column is important to ensure trouble free operation without excessive entrainment.

The Model CFP-703 feed pipe can introduce the continuous phase inside the column without excessive velocity to minimize any disturbance to the light/heavy phase interface level.

We highly recommended using Model DFP-704 dispersed phase feed pipe to introduce the feed on to Model LPD-621 / HPD-610 dispersed phase distributor. This allows the dispersed phase into the column with controlled velocity and provides the required pre-distribution to the dispersed phase distributor plate.

Model LPD-621 Disperser Support Plate

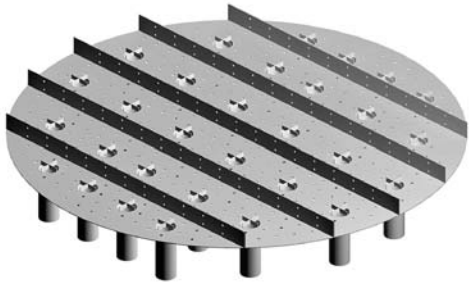
Model LPD-621 is used to disperse the light phase into the heavy phase while simultaneously acting as a packing support plate.

The design consists of downriser tubes welded onto the bottom of the deck with holes located on the deck floor.

As the downriser tubes distribute the heavy phase into the section below, the light disperse phase flows up the column, forming a coalesced layer below the disperser plate, dispersing into droplets through the holes on the deck.

The hole size and pattern are optimized to generate the required droplet size with uniform velocity, maximizing the interfacial area while minimizing entrainment.

In addition, the downriser tubes are equipped with anti-migration device to prevent the packing from falling through.



Construction Features:

- Clamped to a tray support ring that is welded onto the vessel wall
- For small columns, a ledge may be used instead of full 360º rings
- For intermediate beds, the plate can act as a re-disperser packing support plate

Model HPD-610 Dispersed Phase Distributor

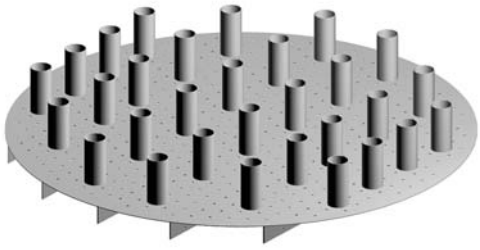
Model HPD-610 is used to disperse the heavy phase into the light phase.

The design consists of upriser tubes welded onto the deck with distribution holes located on the deck floor.

As the light phase flows upward through the upriser tubes, the heavy dispersed phase flows down the column forming a coalesced layer above the disperser plate, dispersing into droplets through the holes on the deck.

The hole size and pattern are optimized to generate the required droplet with a uniform velocity to maximize interfacial area while minimizing entrainment.

In certain cases, Model HPD-610 can be designed as disperser support plate for intermediate beds.



Construction Features:

- Located just above the top of the packed bed and is clamped to a support ring that is welded to the vessel wall
- For small columns, a ledge may be used instead of full 360º rings

Model CFP-703 Continuous Phase Feed Pipe Distributor

Model CFP-703 is used to introduce continuous phase feed into the column.

The design consists of a central header with several laterals to cover the column cross sectional area.

The holes are located on the bottom of the laterals when the heavy phase is continuous or on top of the laterals when the light phase is continuous.

The hole size and layout are optimized to ensure uniform distribution of the continuous phase without excessive velocity. As a result, the light and heavy phase interface level is not influenced thereby minimizing entrainment.

Construction Features:

- The central header is bolted to the internal nozzle stub while the laterals are supported by vessel clips

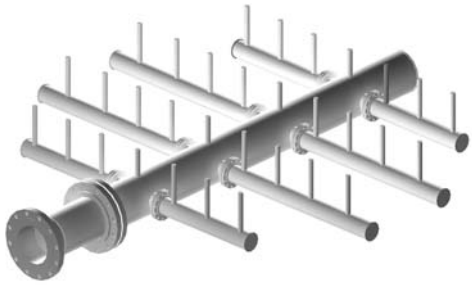
Model DFP-704 Dispersed Phase Feed Pipe

Model DFP-704 is used to introduce dispersed phase feed into the column.

The design consists of a central header with several up-pipes when the light phase is dispersed or downpipes when the heavy phase is dispersed.

In addition, our design ensures metered feeding of the dispersed phase feed to Model LPD-621/HPD-610 by providing the initial pre-distribution. This allows us to control the feed velocity and avoid excessive turbulence, leaving the coalesced layer undisturbed.

The above ensures that the back-mixing of phases are avoided while maximizing the packing performance.



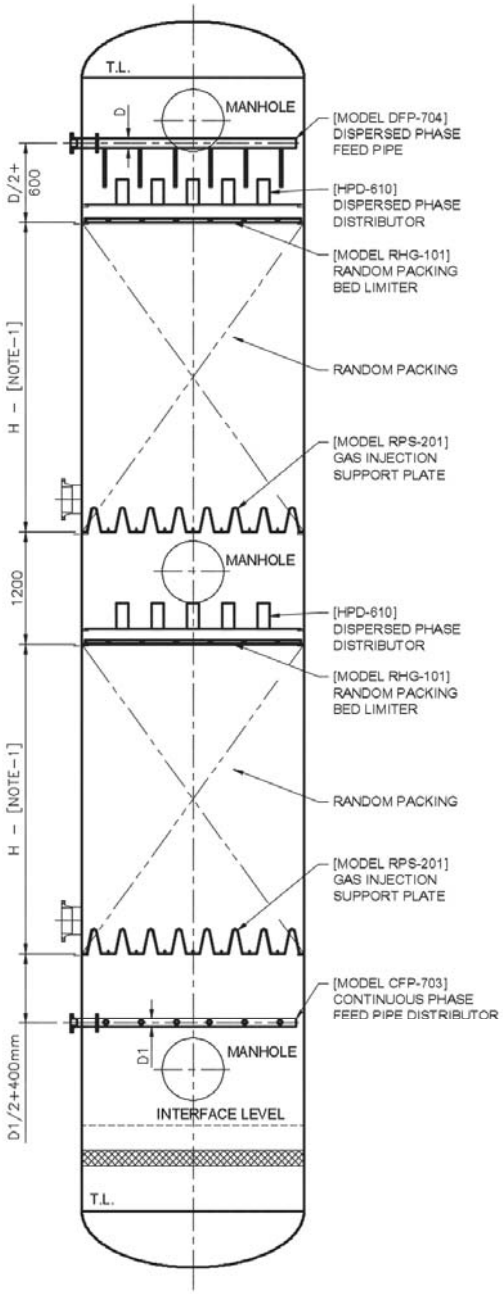
Construction Features:

- Central header is bolted to the nozzle stub on the column wall and supported by wall clips on the opposite side
- For smaller columns, bayonet feed pipes can be used

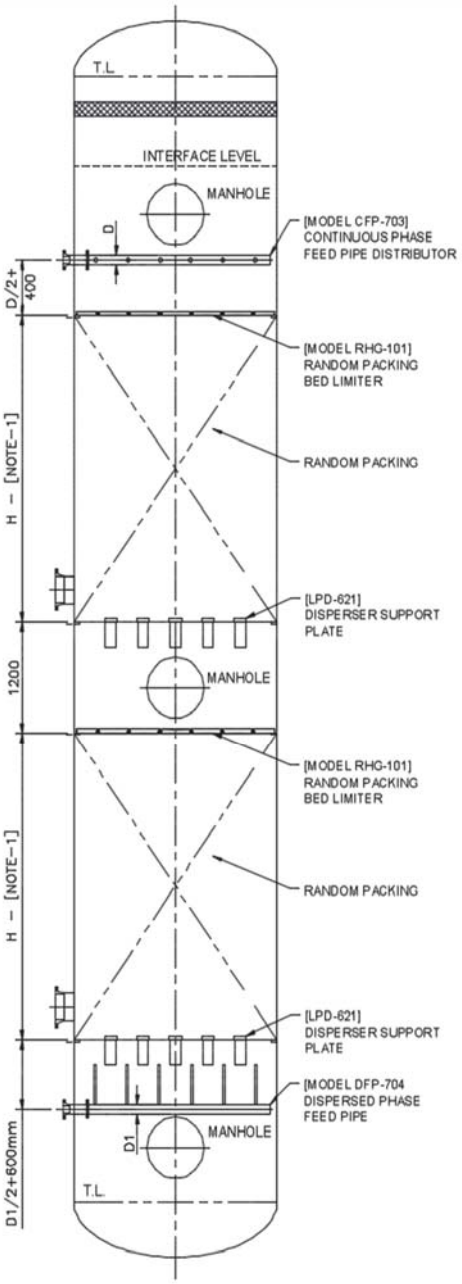
Packed Bed Arrangement for Liquid-Liquid Contactors

The sketches below provide example layouts of internals in columns with liquid feed only.
The space shown between various internals are typical and can be fully customized to suite a wide variety of columns.

Heavy Phase Disperse



Light Phase Disperse



NOTES :

1. For random packing bed height is measured from the bottom of the support plate.

Other Internals

G-MxFlow™ Support Ring

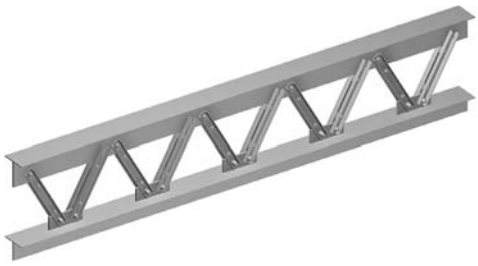
Model G-MxFlow is ideal for maximizing the open area at the bottom of a packed bed when using structured packing.

The support rings ensure unrestricted drainage of liquid around the column wall and can help in improving distribution while further reducing the risk of fouling.

Model VB-600 V-Baffle Distributor

Model VB-600 is a V-baffle distributor that is used to introduce vapor or two-phase feed into tray and packed columns. The baffle splits the incoming fluid into two, directing it tangentially across the column wall.

This helps to reduce excessive momentum of incoming feed and also provides initial distribution. In addition, the V-baffle can be combined with an anti-swirl baffle on the column wall to enhance the distribution effect.



Lattice Beams

For large columns, the use of conventional beams is not possible because they occupy a large area, limiting column capacity. Instead, GTI SOLUTIONS recommends lattice beams, which have a higher strength to weight ratio providing better support while maximizing the column open area.

Lattice beams generally support internals/trays in pairs and can be bolted or welded to the column wall.

Model EF-606 Feed Device

FCC main fractionators are subjected to harsh operating conditions that can lead to coking, corrosion and frequent upsets resulting in significant production losses and unit shutdowns.

Model EF-606 is designed specifically for FCC Main fractionators columns and can withstand extreme operating conditions and handle high velocity feed, catalyst fines and high temperatures.

The feed device is designed without horizontal surfaces and is particularly useful when there is limited distance between the feed nozzle and slurry pump-around the bed.

It features ensure uniform vapor distribution across the entire cross section of the bed avoiding any hot spots or dry sections that could otherwise increase the potential for coking.

As a result, fouling can be reduced and performance and unit profitability can be improved.

Global Locations

Korea: GTI Solutions Korea Co., Ltd.

Technical & Sales Office

Mapo-gu, Seoul
Phone: +82-2-6246-7400
Fax: +82-2-6246-7409
Email: gtis-korea@gtisoln.com

Manufacturing Facility

Wonju-si, Gangwon-do
Phone: +82-33-901-9241
Fax: +82-33-901-9295
Email: gtis-korea@gtisoln.com

USA: GTI Solutions International LLC.

Technical & Sales Office

Dallas, Texas
Phone: +1-707-400-0214
Fax: +1-707-202-1916
Email: usa@gtisoln.com

Houston, Texas
Phone: +1-346-219-3418
Fax: +1-707-202-1916
Email: usa@gtisoln.com

Japan: GTI Solutions Japan Co., Ltd.

Technical & Sales Office

Shinbashi, Minatoku, Tokyo
Phone: +81-3-6452-9555
Fax: +81-3-6452-9557
Email: japan@gtisoln.com

Singapore: GTI Solutions Pte Ltd.

Technical & Sales Office

Selegie Road, Singapore
Phone: +65-3138-1769
Email: singapore@gtisoln.com

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www.gtisoln.com