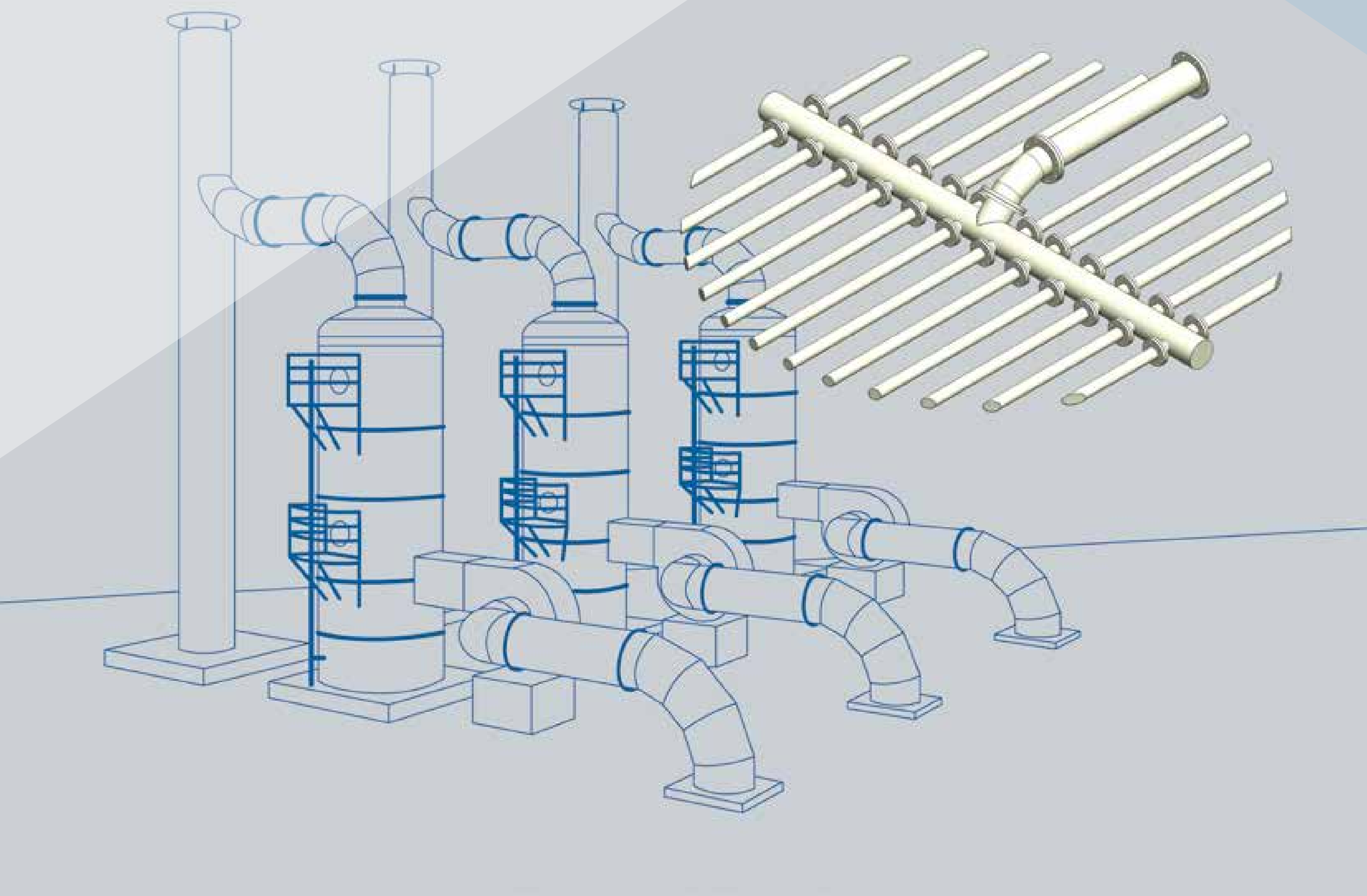
2H COMPONENTS & SOLUTIONS

ENERGY.
ENGINEERING.
EXCELLENCE.

The ENEXIO Selection Guide for Structured Packings and Liquid Distributors



Column design
Our experts will support you in providing the right solution for your separation tasks and the dimensioning and selection of the correct packing and installations. We apply our knowledge, experience and enthusiasm for engineering to provide you with the best possible advice and on an individual basis. Our engineers use modern 3D-CAD software to create their designs and have developed a layout program that you are welcome to use too.

Skills in plastics

ENEXIO is a reflection of what we do and what we have accomplished as a pioneer in the field of mass transfer, water treatment and power cooling over decades. It represents a promise to our customers and business partners at the same time – we as a global provider for mass transfer, water treatment and power cooling solutions stand for **Energy. Engineering. Excellence.**

In Wettringen we develop and produce structured plastic packings for various areas of application, including mass transfer. Our 2H MASSdek® packings are used for air pollution control, absorption and desorption and biological exhaust air treatment.

Engineering and support from ENEXIO

Structured packings can only make full use of their technical benefits compared with a random packing when all installations and components have been precisely coordinated with each other and adjusted to the appropriate process at the planning and basic engineering stage. The aim must be to successfully and profitably solve the required separation task.

At the beginning, it is only known which task is to be performed. The details required for the process design and implementation are often only partially available. This is where our experts are able to provide helpful support in the basic design and configuration of a packing column. In addition to our support in the process engineering of the basic design, we are also happy to review the overall concept which has already been drawn up. We can offer tips and information regarding points at which the process could be optimised and what special types of packing and installation can be used most effectively. For this the mechanical, hydraulic and separation process aspects in particular are taken into account. Our experts will be happy to assist you with any questions you may have. Many years of extensive experience in the engineering of structured plastic packings and both plastic and metal installations make it possible for us to provide individual and optimal advice to our customers in the dimensioning of the packing beds.

We calculate the main dimensions based on the data for ideal material systems and give a guarantee for the column hydraulics based on these values. Our advice also includes recommendations for the additional column installations, which are optimally coordinated with the packings. Upon request, we will also take on the static inspection of constructional interfaces, such as on site support rings or supports.

We design and construct using the most up-to-date 3D CAD software. This enables smooth communication with our customers right from the draft design stage. We are also happy to provide you with our 2H MASSdek® Pro design software.

This brochure
is intended to assist you in the pre-selection of structured packings and liquid distributors and to give you an initial overview. It is continuously expanded to include additional components and types.

Contents

First steps
When designing a column, the material for the components to be used has to be defined first. Then the type of fill is determined and liquid and gas distributors, the droplet separators, the support grids and the retention system are adjusted to this choice.

1. General information

1.1 Material selection

When designing a process, the materials to be used must be selected or pre-selected at a very early stage. The main criteria for this are the temperature resistance and the chemical resistance of the material.

As a rule, the orderer or planner must determine the desired material. Only the process licenser is able to evaluate the suitability of the material based on its chemical resistance. We are only able to draw on the statements from the base material producers and pass them on to the customers.

Thermoplastics are not feasible in most cases for operating or design temperatures greater than 120°C. Some fluorinated plastics may then be considered, however their use is generally not economically advisable due to high costs and their comparable low strength.

In the following it is assumed that the design temperature permits the use of thermoplastics.

Optimal and efficient system solutions come about through

- individual design
- the latest production methods
- a wide product range
- constant quality control
- a highly motivated team
- many years of experience
- continuous development

BACK TO CONTENS

The most frequently used plastic for scrubber packings and installations in this temperature range is polypropylene (PP). This material is highly resistant against acids, alkaline solutions, saline solutions and a number of organic liquids. Critical are halogenated hydrocarbons and some natural oils, such as palm oil.

Like all thermoplastics, PP ages with time due to the adverse influence of high temperatures, strongly oxidizing substances (such as free chlorine) and UV radiation. All these factors can, in the long run, cause splitting of the polymer molecule chains and cause the material to become brittle.

The influence on the material as a result of the demands of temperature and time can be easily recorded and taken into account using recognised rules, such as the DVS guideline [1]. In individual cases chemical stresses can also be determined. The effect of UV-radiation and thermal ageing can be reduced through the use of special additives. If not otherwise expressly agreed, we anticipate a service life of 10 years and a sustained temperature at the level of the operating temperature. The calculation has been made based on the DVS guideline 2205. This determines both long-term strength parameters and deformation criteria over time. These data are applicable for semi-finished pipes and plates with suitably standardised material compositions and also inherently apply to our structured packings as a result of comparative studies by RWTÜV. Installations and packings can be designed from PP, PVC and PVDF using this method.

In those cases in which load-bearing plastic internals are not practical due to high breakdown temperatures, but where thermoplastic packings still provide an economical solution, installations made from metallic materials may be put to use. The choice of materials is only restricted by the necessity to be able to be cold-formed and the suitability for welding. The range of possible materials stretches from simple, rust-free stainless steels through nickel-based alloys to titanium.

1.2 Types of packing

Structured packings are a consistent enhancement and optimisation of the well-known random packings. They represent the state of the art in this area of application. Until now the use of structured packings has been primarily restricted to distillation and rectification. Metallic structured and wire gauze packings have been mainly used there due to the application materials and temperatures.

Plastic random packings have principally been used in the areas of exhaust air treatment, absorption and desorption. In these areas of application, structured packings lead to improved performance in terms of construction and operation in almost all cases.

BACK TO CONTENS

We offer various types of 2H MASSdek® thermoplastic packings for the applications mentioned above.

2H MASSdek® 150 HTC

2H MASSdek® 250 HTE

2H MASSdek® 80 Grid

The improved performance of 2H MASSdek® packings leads to a down-sizing of equipment for new systems. Retrofitting of existing systems from random packings to 2H MASSdek® packings can be amortised within a short time due to a reduction in the gas pressure drop.

Properties of 2H MASSdek® packings

2H MASSdek® packings consist of profile-shaped sheets which are extruded from special plastic compounds and welded together. We currently offer 2H MASSdek® packings made of PE, PP, electrically conductive PP, PVC and PVDF with specific surface areas between 80 and 240 m^2/m^3 . Other plastics are available on request. Most packings are suitable for gas capacities of up to approx. 4.0 $Pa^{0.5}$ for a typical irrigation density of 25 m^3/m^2h.

On customer request we can supply circular shapes and other forms, as the packings can be cut to size individually and are easy to handle.

Due to the high load-bearing resistance of 2H MASSdek® packings almost no settlement occurs of potential deposits or at high temperatures. Thus even bed heights of more than 10 metres can be achieved.

The regular construction of 2H MASSdek® packings ensures a uniform distribution of gases and liquids across the entire cross-section. The gas and liquid flows are separated at the intersection points of the channels running in opposite directions and are then re-mixed. Additionally, the gas and liquid division is supported by the offset, mostly right-angled alignment of the layer levels to each other. In comparison to random packings, this provides better results in terms of throughput capacity and pressure loss for the same separation performance. Compared with a random packing bed with the same surface area, pressure losses may be reduced by almost 90 %, depending on the operating situation and type of packing.

We offer structured packings with continuous vertical channels for special applications in the exhaust air treatment sector. The summary on page 9 enables pre-selection of the most suitable types of packing. Our experts will be happy to assist you in the final selection.

Applications of 2H MASSdek® packings

- Exhaust air scrubbing
- Absorption and desorption
- Biotrickling filters for the elimination of volatile organic compounds (VOCs), hydrogen sulphide and ammonia
- Scrubbing systems with a high level of separation performance

Advantages of 2H MASSdek® packings

- improved throughput capacity
- lower pressure drop
- higher effective mass transfer area
- reduced tendency to blockages
- bed heights significantly higher than 10 m possible
- extremely high mechanical stability
- less susceptible to fouling
- more efficient operation
- can be used for revamps and retrofits
- can be fitted at the container manufacturer

BACK TO CONTENS

2H MASSdek® – At a glance							
Type	**Struc-ture**	**Specific surface**	**Hydraulic capacity / specific pressure**	**Separation perfor-mance**	**Resistance to scaling and fouling**	**Specific pressure loss / separation**	**Typical applications**
2H MASSdek® 250 HTE	Cross	240 m^2/m^3	+	+++	+	++	Scrubbing systems with the highest levels of demand on separation power
2H MASSdek® 250 HTC	Cross	240 m^2/m^3	++	++(+)	+	++	Standard use for the elimination of volatile organic compounds (VOCs), hydrogen sulphide and ammonia
2H MASSdek® 150 HTC	Cross	150 m^2/m^3	+++	++	++	+++	Standard uses for absorption and desorption
2H MASSdek® 125 HTC	Cross	125 m^2/m^3	+++	+	+++	++	Stripper Exhaust air scrubber Biotrickling filter
2H MASSdek® 80 Grid	Grid	80 m^2/m^3	+++	+	+++	+++	Exhaust air scrubber and biotrickling filter, desulphurisation columns

BACK TO CONTENS

Adjustment of column internals to 2H MASSdek® packings

1.2.1 Adjustment of the liquid distributors to the packings

Many influencing factors must be taken into consideration in the selection of the liquid distributors and their adjustment to the types of packing, which are dealt with in greater detail below. The essential aim is to adapt the position and number of feeding points to the packing geometry, dependent on the spread factor of the packing. If the drip point density is too low, there is a risk that the separation performance or the expected effective surface area will not be reached until after a number of packing layers. If the drip point density is too high, particularly where there is a low irrigation density, problems may occur with the uniformity of distribution which then have a negative effect on the separation performance. In all such cases we recommend obtaining the advice of our experts.

1.2.2 Adjustment of the support systems to the packings

We recommend an even grid or a grid-like construction as a support for structured packings. The free gas flow areas must be selected in such a way that the ratio of percent of flood velocity and the product of the free cross-section and the free volume of the packing always remains < 0.9. A design with 60 % flood requires a grid with at least 70 % free cross-section. A system made up of parallel profiles may also be used as a support. In this case it should be ensured that the support contact surface is at least 50 mm wide. The requirements for the free gas cross-section must be maintained as given above.

We can be of assistance in determining the minimum required support area in terms of pressure, temperature, time, type and hydraulic loading. If the above aspects are complied with, continuous beds with a height of up to 14 metres may be achieved.

When changing from random packing to structured packing it may be possible to reuse the existing support system. Particularly suitable in such cases are the commonly used, trapezoidal multi-beam support systems with a flat upper profile surface. Please contact our specialists for more demanding hydraulic or mechanical requirements.

Surface and structure

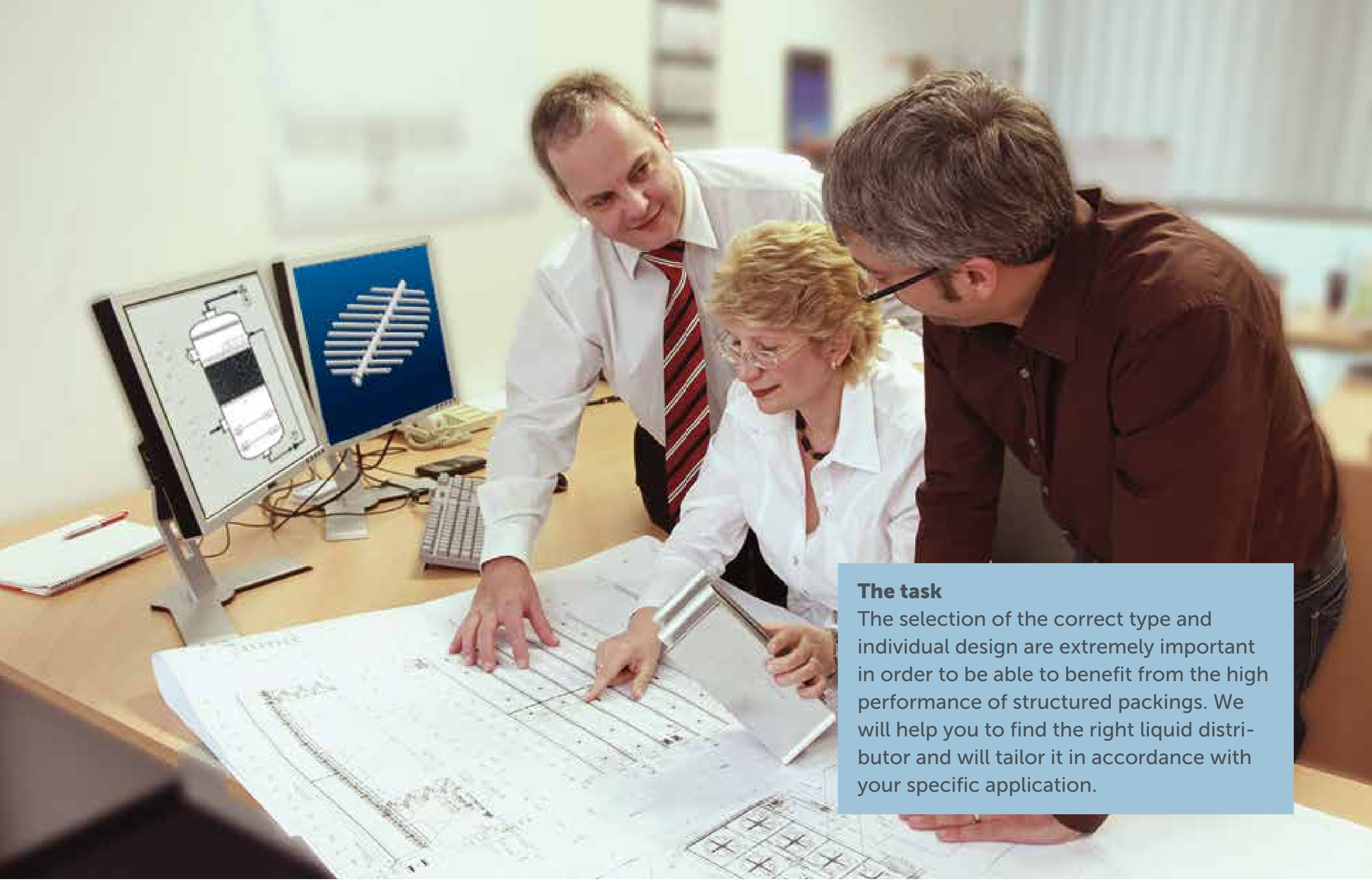
- the structure of the 2H MASSdek® packings guarantees that the liquids have to take a complex path through the separation column
- energy-efficient mass transfer is enabled as a result of the large contact surface

1.2.3 Adjustment of the retention systems to the packings

At high gas capacities some of the pieces of random media may be discharged from the top of the bed. In order to prevent this, a complex retention system is unavoidable. Particularly where there are small fill sizes and a high gas capacity, the retention system becomes the hydraulic bottleneck in the column.

On the other hand, structured packings are significantly less susceptible to this effect. This is due to the large packing elements and the low gas pressure drop. The rising and falling of individual blocks can be reliably prevented by the use of a flat bar running across the top of the block. As this method is independent of the specific surface area, the retention system never forms a bottleneck in a column with structured packings and guarantees a large, free gas cross-section, little interference with the liquid distributor and reduces costs.

BACK TO CONTENS



The task
The selection of the correct type and individual design are extremely important in order to be able to benefit from the high performance of structured packings. We will help you to find the right liquid distributor and will tailor it in accordance with your specific application.

2. Liquid distributors

The main task of a liquid distributor is the even distribution of liquid throughout the cross-section of the bed. At all heights there must be a roughly constant, gradient-free concentration and/or temperature profile. In addition to the packing bed, the liquid distributor is the second most important component for the separation process in an installation assembly in a counter-flow column. Poor initial distribution can only be compensated to a limited degree by a larger bed height.

Column installations
- individual design
- the latest production methods
- a wide product range
- constant quality control
- a highly motivated team
- many years of experience
- continuous development

2.1 Criteria for the selection of liquid distributors

The requirement for even liquid distribution and the material selection are not the only criteria to be taken into consideration in the selection and design of a liquid distributor.

Further factors, such as the packing geometry dependent spread factor, the speed profile of the gas flow and the geometric restrictions resulting from the on site supports and support rings, influence the performance and must be additionally taken into account when dimensioning the bed.

BACK TO CONTENS

The main process parameters are defined by the following factors
- Diameter
- Load range (turn down)
- Dealing with dirt
- Specific liquid load
- Drip point density

Additional process parameters exert an influence on the selection and design of a distributor
- Number of transfer units
- Gas capacity and influence on the gas distribution
- Feed composition (flashing feed)
- Limitations due to site construction requirements

Economic aspects also have to be taken into consideration
- Distributor costs vs. bed height costs
- Distributor costs vs. operating costs

The selection and design of a distribution system for a specific separation task is an iterative process. We recommend determining the material first. If a plastic packing was selected for cost reasons and not for reasons of corrosion, a metallic distributor should always be taken into consideration as an additional option.

2.2 Distinguishing features of liquid distributors

2.2.1 Final distributor arrangement

In the table *Distributor selection aids* a number of the aspects have been summarised which lead to a recommendation for the final distributor arrangement.

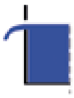
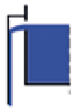
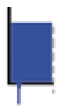
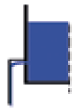
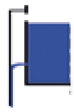
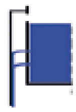
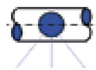
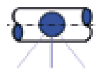
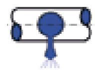
The main distinguishing criteria here are the driving force of the liquid flow either by
- gravity or
- pressure

For gravity a differentiaton is necessary. The final distribution can take place as a free overflow
- across a weir or as
- an outflow via one or more submerged holes

There are significant differences in the distribution quality between the two solutions. A few millimetres in the sloping of the free surface due to the inflow and deviations from the horizontal in a weir distributor can cause significant differences in the flow rate at individual feed points. This influence is much lower for submerged holes.

Pressure force distributors are divided into distributors which generate a liquid jet or a liquid spray.

BACK TO CONTENS

Distributor selection aids									
Physical driving force	Gravity							Pressure	
Principle of distribution	Distributor with free overflow		Distributor with liquid level using discharge holes						
Schematic description of the distributor output stage	Overflow distributor	Overflow distributor with liquid guidance system	Base hole	Side hole	Side hole with liquid guidance system and emergency overflow	Multiple side holes with liquid guidance system and emergency overflow	Pipe distributor, open	Pipe distributor, closed	Nozzle distributor
Example/type	TDP 410	TDP 410 So	TDP 400	TDP 420	TDP 420 So	TDP 420 So	LDP 210	LDP 200	NDP 310
Schematic diagram									
Assessment criterion	suitable in terms of "" : ++ = very well suited or recommended in terms of | + = suited or good in terms of 0 = partially or moderately suited in terms of | — = unsuited in terms of								
Distribution quality	–	–	+	++	++	+	+	+	–
Load range	++	++	+	+	+	++	0	+	–
Susceptibility to blockages	++	++	–	+	++	++	0	0	–
Low irrigation density	–	–	+	++	++	+	0	+	++
High irrigation density	+	+	+	+	++	++	+	++	+
High drip point density	0	0	++	+	+	+	0	0	–
High transfer unit number	–	–	+	++	++	++	+	0	–
High gas capacity	–	+	0	++	++	++	+	+	–
Levelling sensitivity	–	–	+	+	+	+	+	++	++
Height	+	0	0	0	0	+	+	++	++
Procurement costs in PP	++	+	+	0	–	–	+	++	++
Procurement costs CrNi-St.	+	–	+	–	–	–	0	0	++
Operating costs	++	++	+	+	+	+	0	0	–

2.2.2 Flow pad

The selection of a suitable distributor is not based simply on the arrangement of the final distribution but is also determined by the internal flow pad and feed within the distributor. A differentiation is made between

- single-stage or
- multi-stage distributors

The extent of the cost savings for a lower column height may, in individual cases, justify the additional costs of a distributor with a lower constructed height and which is generally then single-stage. A normal distributor consists of a pipe inlet system, a pre-distribution level and a final distribution level. For small column cross-sections or where complex pipe inlet systems are used the pre-distribution level can also be eliminated.

2.2.3 Final distributor level

A further differentiating design feature is the layout of the final distributor level in the form of a

- pan
- deck (tray)
- system consisting of individual channels or pipes

The decision in this case is essentially determined by the diameter of the column and the gas capacity. Pan distributors are common only for diameters of up to approx. 1000 mm due to their feasibility of fitting, preferably using flanges. The deck-type distributors have about 25 % to 30 % free gas cross-section and can be used only for low to moderate gas

BACK TO CONTENS

capacities. For the most part pipe or trough type distributors are used. A modular construction allows installation through manholes DN500 or DN600.

2.2.4 Function

A significant criterion, particularly for larger column cross-sections, is the differentiation based on the function as a

- feed distributor or
- as a re-distributor between two beds

Re-distributors have to mix a liquid passed from the upper bed before it is re-distributed in order to compensate for any possible local differences in concentration. For larger cross-sections and sophisticated separations an additional collecting device is arranged upstream.

2.2.5 Liquid feed

A further differentiation criterion can be seen in the type of the liquid feed. The feed can be made via

- an inlet pipe from the outside
- an inlet pipe from the inside (collector/re-distributor)
- directly from the bed located above or
- for liquids with a gas proportion greater than 1-vol% from a flash gallery or other special equipment

2.3 Distributor type table

	Type	Link
2.6.1	Overflow weir distributor	2H liquid distributor TDP 410
2.6.2	Trough distributor, 2-stage	2H liquid distributor TDP 400
2.6.3	Trough distributor, 2-stage with guide pipes	2H liquid distributor TDP 420
2.6.4	Trough distributor, 2-stage with splash plate	2H liquid distributor TDP 430
2.6.5	Closed pipe distributor with a central inflow	2H liquid distributor LDP 200
2.6.6	Closed pipe distributor with a central inflow	2H liquid distributor LDP 220
2.6.7	Spray nozzle distributor	2H liquid distributor NDP 310
2.6.8	Pan distributor, single-stage with guide pipes	2H liquid distributor PDP 350

2.4 Impact of distribution quality on separation performance

The quality of the liquid distribution is crucially determined by

- a sufficient drip point density
- the drip point pattern on the packing bed
- the uniform flow rates of individual points

Additional influential factors are

- the distance to the top of the bed
- the orientation to the packing
- the free gas cross-section
- design aspects, such as mountability and levelling capability

BACK TO CONTENS

2.4.1 Drip point density

The drip point density quantifies the specific number of final distribution points per m^2 of cross-section area on the top of the packing bed. The unit is [$1/m^2$]. The highest possible drip point density value should be sought. However, practical and commercial considerations often result in limitations on this. For small to average amounts of liquid, minimum hole diameters and minimum liquid levels give rise to a maximum achievable drip point density. It is possible to raise this for average to large irrigation densities, but above 200 drip points practically no noticeable increase in the separation performance can be achieved.

We recommend the drip point densities shown in the adjoining table for applications with sufficient irrigation density and clean liquids.

Drip point density	
Packing type	
2H MASSdek® 250	>90 $1/m^2$
2H MASSdek® 150	>80 $1/m^2$
2H MASSdek® 125	>70 $1/m^2$
2H MASSdek® 80 GRID	>65 $1/m^2$

The observance of the drip point density alone does not provide any conclusions on the quality of distribution. The geometric distribution of the impact points on the packing, the uniform nature of the individual flows to each other, the orientation of the distributor to the packing and the gas flow also influence the result.

2.4.2 Positioning of the feeding points

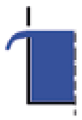
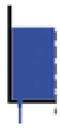
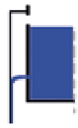
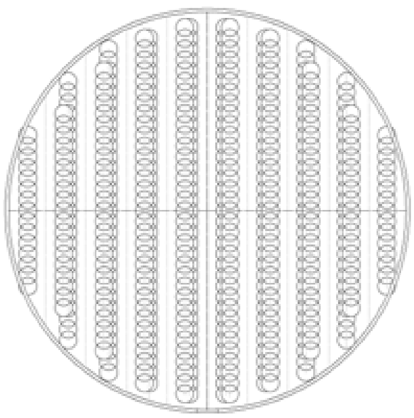
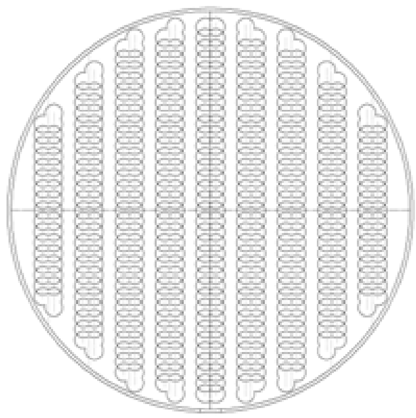
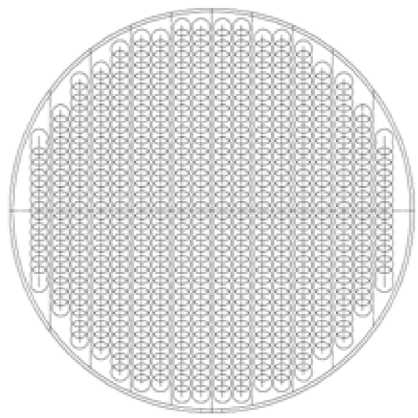
Extensive investigations have been carried out, particularly in distillation, to quantify the influence of the liquid distribution quality on the separation performance. The results derived from these studies confirm the importance of an optimal initial distribution. A consensus exists that a macroscopic unequal distribution has a significantly greater effect than variations among the individual feeding points where these occur spread across the cross-section.

Macroscopic areas are continuous surfaces which take up more than 1/12 of the entire cross-section. The division of the areas may be geometrical, not equal. Concentrical areas, parallel segment areas, pie wedges or other regular geometric shapes, all of which amount to 1/12 of the total cross-section area, are used for comparison.

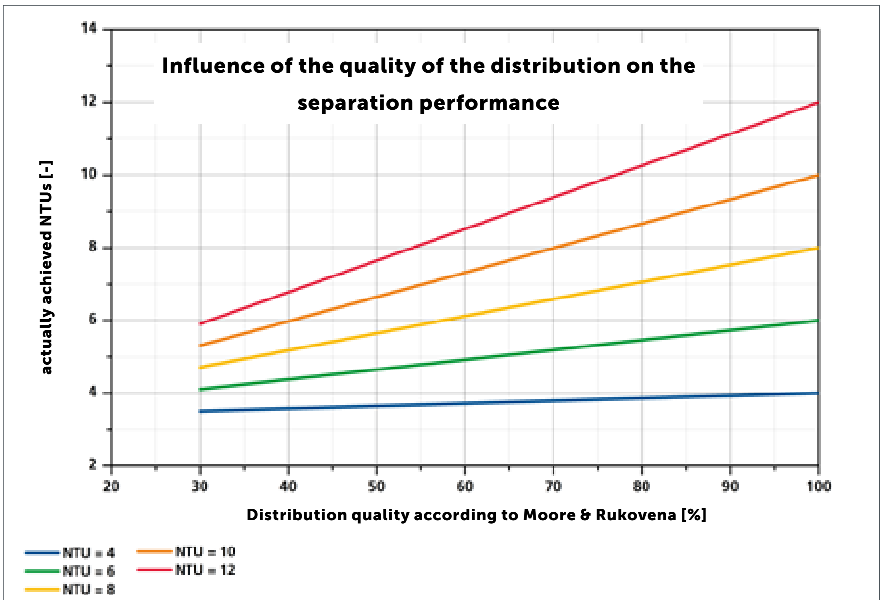
Moor and Rukowena [2] have developed a graphical method which expresses the quality of distribution as a value. This value varies between 30 % and 95 %. In a further investigation the authors have calculated the influence of the distribution quality on the separation performance. The exact method may be found in the literature.

The distributors shown on the following page appear similar at first glance, but there are significant differences in the quality of their distribution. A distributor with a free overflow concentrates the liquid into virtually one line between the troughs. A distributor with a base hole generates a concentrated area below the troughs. A distributor with a side hole and pipe guidance system has the best distribution pattern. For extremely demanding applications a triangular pattern for the hole location and the avoidance of the use of a support ring enable further improvements to be achieved.

BACK TO CONTENS

Distribution quality		
Overflow	**Base hole**	**Side hole with pipe guidance system**
		
Distribution quality = ca. 40 %	Distribution quality = ca. 60 %	Distribution quality = ca. 80 %
		
		

The chart below shows that the quality of the distribution affects the separation result more significantly as the Number of Transfer Units (NTU) increases. Hardly any influence can be determined for 4 transfer units. For 12 transfer units the achievable number of transfer units reduces from 12 to below 9 transfer units with a distribution quality of 60 %. This is equivalent to the quality level of a normal distributor.



BACK TO CONTENS

It should be mentioned at this point that the normal number of transfer units (NTU) for scrubbers is rarely more than 4 transfer units. Poor initial distribution and high hydraulic loads may, however, lead to macroscopic areas with too high and too low irrigation density and these may reach across the whole of the bed. This also reduces separation performance.

2.4.3 Uniformity of flow rates of individual drip points

The observations given above naturally assume an uniformity in the flow rates from the individual drip points. The geometric uniformity of the individual outflow holes or overflow slots is of particular importance here. The distribution hydraulics system described below is a further criterion.

2.4.4 Internal distribution hydraulics

The aim of a good liquid distribution system is to prevent turbulence. The lower the turbulence of the flow, the more even is the distribution.

Less costly distributors have a small flow cross-section and thus high flow velocities. These, in turn, generate a pressure drop across the length of the individual distributor with effects on the outflow volumes at the feed points.

Depending on the task in question, open trough distributors are designed with maximum flow velocities ranging between 0.25 to 0.4 m/s. In closed systems the maximum flow velocity can be set higher, provided that the inlet cross-sections have been sufficiently dimensioned in comparison with the outlet cross-sections.

Particular attention should be paid to the feed system. The discharge speed of a liquid jet which feeds an open trough should not be more than 1 m/s. For columns with a diameter greater than 1000 mm it is recommended to spread the inlet volumes over several points. Installations which interrupt the momentum, such as inlet baskets, packing elements, grids or perforated plates, are often used.

2.4.5 Distance to the bed

The minimum distance to the bed is determined by the gas flow and the maximum distance by the height which the liquid drops and its impact momentum on the packing. Normal distances range between 80 mm to 250 mm. In most cases, distances ranging from 120 to 160 mm provide trouble-free operation.

If the distance to the bed is too small, a directional flow of gas within the bed may arise. In such cases, the separation performance deteriorates, particularly for distributors with a low free gas cross-section. Generally the lower edge of the trough is taken as a reference level. It is recommended that the distance is selected such that there is an angle of at least 45° or preferably 60° between the upper edge of the bed and the area for gas flow in between the distributor troughs. For a trough distributor with a regular trough pitch of 300 mm and a trough width of 140 mm this results in a distance of at least 70 mm, normally 140 mm. Where there is a high gas capacity and a lower distance the gas flow may deflect the liquid jet from its planned point of impact.

BACK TO CONTENS

As the distance from the bed increases, the speed of the falling liquid jet also increases and the impact momentum on the bed is so high that a significant amount of fine splash droplets is generated. These droplets may be carried away by the gas flow. Avoidable entrainment problems may occur through a pressure increase in the droplet separator or, in the worst case, through its flooding. Signs of erosion on the fills cannot be ruled out in cases of extremely large distances and large amounts of liquid.

2.4.6 Orientation to the packing

The upper section of the bed does not achieve its full efficiency either with random or with structured packings. The liquid must first spread out radially in order to be able to develop an effective area typical for the actual loads and system. As a rule of thumb, a depth of 0.25 m is assumed for random fills and the depth of a layer for structured packings.

For structured packings, as compared with random packings, attention must be paid to the orientation of the distributor to the direction of the packing sheets/foils. To ensure that liquid is applied to as many gaps in between the foils as possible in the first layer, a distributor orientation of 45° to the sheets is recommended. This is particularly important for a splash plate distributor.

A 45° angle along the line of the greatest drip point density should be selected for distributors which vary greatly from the ideal triangular or square drip point pattern.

2.4.7 Free gas cross-section

Liquid distributors always present a resistance which generates a pressure loss for the gas flow. The free gas cross-section should therefore be designed to be as large as possible. This is often in conflict with the stipulated distribution quality. As a reference value we recommend remaining below a gas capacity factor in between the troughs of FV= 4.5 $Pa^{0.5}$ for distributors with a free overflow. The free gas cross-section for other types should be at least 35 % of the superficial cross-section of the column and, where possible, should not exceed a gas capacity factor at the narrowest cross-section of 6.5 $Pa^{0.5}$.

2.4.8 Mountability and levelling capability

Liquid distributors should be aligned as precisely as possible to the horizontal. For some types deviations outside the fixed tolerances lead to a drop in performance, for other types deviations may be acceptable in some cases, as the performance is either little affected or not at all. For this in particular the on-site supports must be taken into consideration.

Pipe and nozzle distributor

For a pipe and nozzle distributor the distance to the bed must be maintained so that the intended pattern of impact is achieved. A low incline in the distributor is of less significance. Both types are hung from clamps or hooked into place. Pipe distributors up to a main pipe nominal width of DN 250 may be brought into the vessel over a DN 600 manhole. Cases must be assessed individually where there are larger nominal widths.

BACK TO CONTENS

Gravity distributor

The maximum permitted deviations from the horizontal during installation must be maintained for gravity distributors. Fitting pieces are used for distributors which are positioned on supports and support rings. Smaller distributors with a higher distribution quality have adjusting devices which enable alignment.

Trough distributors

For large plastic trough distributors, a calculation of deflection over time is additionally required. For reasons of permanent deformation resistance larger trough cross-sections, or alternatively additional supports, are often needed. A deflection of the on site supports must also be considered and is counteracted where necessary by additional fitting pieces at the support points. Trough distributors are not fixed to the constructed base in their standard version. The position of the components is determined by designed features on the upper distributor.

The effective weight of the distributor is, even when empty, many times greater than the force resulting from the gas pressure drop. If a rapid momentum increase in gas pressure drop could occur during operation of the column, we recommend securing the distributor device.

Special versions are available on request. A manhole DN 600 is required for fitting. In most cases DN 500 is also sufficient. Smaller installation openings will be reviewed on an individual basis.

We can provide assistance with the positioning and design of on site supports and support rings and the positioning of the manholes.

2.5 Gravity and pressure distributors

The effective dynamic pressure height and the orifice discharge coefficient primarily determine the outflow speed and thus the outflow volume for gravity distributors with submerged holes and pressure distributors.

$$w_a = \mu \cdot \sqrt{2 \cdot g \cdot h_{eff}}$$

w_a = Outflow velocity [m/s]
h_{eff} = Effective dynamic pressure level [m]
μ = Orifice discharge coefficient [./.]
g = Gravitational acceleration [m/s^2]

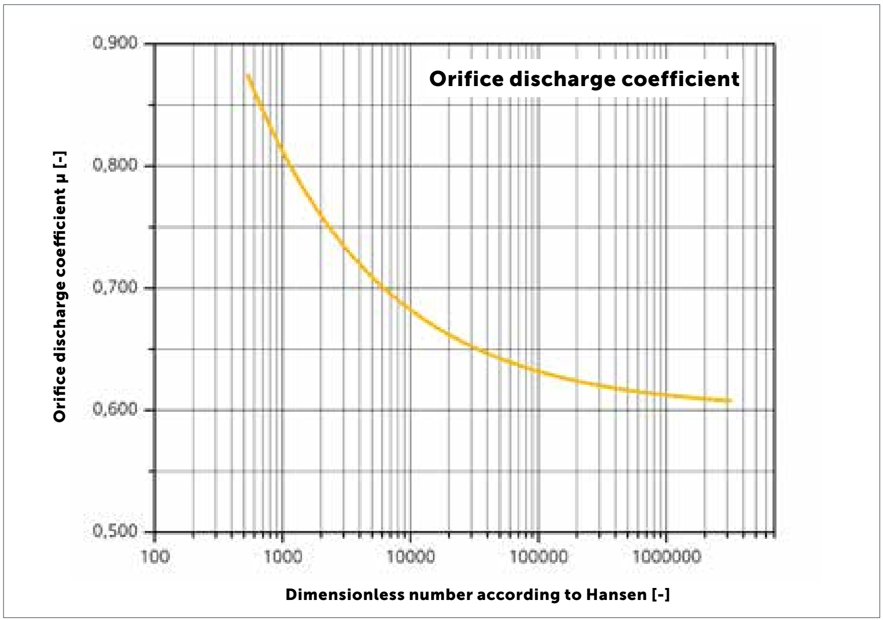
The orifice discharge coefficient is dependent on various parameters:

- The shape size and thickness of the holes
- Liquid properties
- Liquid level
- Cross-flow speed

For sharp-edged holes the value ranges between 0.61 for high liquid levels and 0.83 for low levels. For rounded edged orifices the values are approx. 5 % to 10 % higher.

In a work by Hansen [3] from the first half of the last century the most significant combinations were determined using dimensionless numbers. It was determined that the orifice discharge coefficient was greatly determined by the Weber Number, the Reynolds Number and by the geometric relationship of the hole diameter to the level.

BACK TO CONTENS



The influence of the wall thickness was also investigated. As expected, holes in thick walls tend to have a greater orifice discharge coefficient than those in thin walls or the ideal sharp-edged holes. Where the ratio of the wall thickness to the hole diameter has a value of 2, the orifice discharge coefficient will tend to 1.

The orifice discharge coefficient value may be significantly greater than 0.61 for very small hole diameters and low liquid levels. The orifice discharge coefficient value over the level reduces significantly quicker for large holes than for small holes. Deviations from the value shown in the graph of approx. 10 % are possible in individual cases but are considerably more for small Reynolds Numbers.

Exact knowledge of the orifice discharge coefficient is especially necessary for applications where a large loading range is demanded so that malfunctions or incorrect component dimensioning can be avoided. A value of 0.7 is sufficient for a rough estimate. The fundamental correlations between pressure distributors and gravity distributors with covered outlet holes are the same and they only differ due to the size of the effective dynamic pressure height.

For nozzle distributors the design data necessary for the determination of the volume-related pressure loss are taken from the type and data sheets of the manufacturers.

There are varying operating costs depending on the pressure heights. The decisive factors here are, on the one hand, the pressure loss through the distributor and also the necessary delivery height over the height of the packing. The following table clarifies the different levels of energy costs for various distributor systems. It can be seen that a nozzle distributor with 7 nozzles creates additional operating costs of approx. 2,000 €/a compared with an open trough distributor with the same volume of liquid.

BACK TO CONTENS

Before deciding on the use of a particular type of distributor we recommend carrying out a profitability analysis.

Operating cost comparison			
	Nozzle distributor	**Pipe distributor**	**Trough distributor**
Distance over bed [m]	0.6	0.5	0.75
Pressure drop [bar]	1	0.2	0
Delivery height [m]	10.41	2.462	0.75
Irrigation density [m^3/m^2h]	15	15	15
Column diameter [m]	3	3	3
Volume flow [m^3/h]	106	106	106
Theoretical pump power [kW]	3.0	0.7	0.2
Motor power [kW]	3.7	0.9	0.3
Annual power consumption [kWh/a]	**29647**	**7012**	**2136**
Annual power costs [EUR/a]	**2668 €**	**631 €**	**192 €**

Net electricity price, industrial customers [EUR/kWh]	0.09
Hydraulic efficiency	0.9
Electrical efficiency	0.9
Annual operating hours [h/a]	8000
Fluid density [kg/m^3]	998

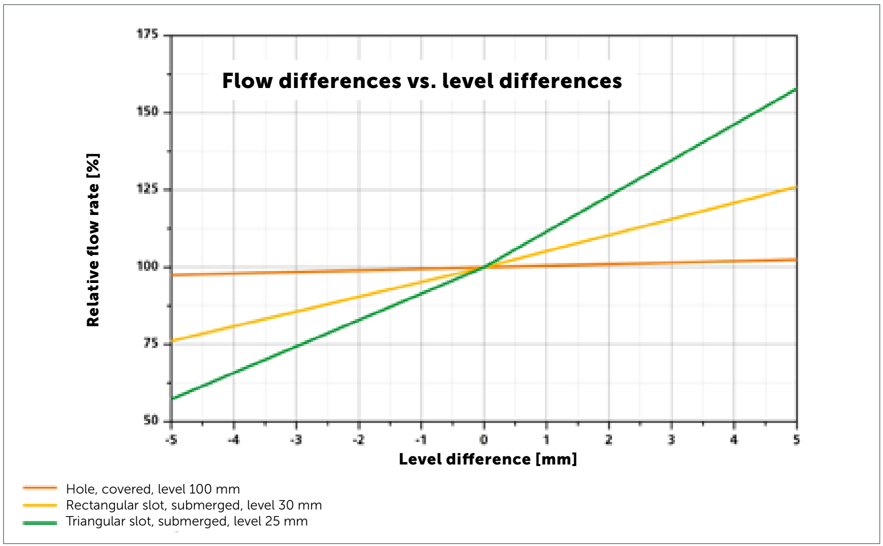
2.5.1 Orifice vs. weir

As described above, weir distributors and distributors with submerged holes vary significantly in their distribution quality. Overflow distributors have two serious disadvantages. On the one hand, the geometric points of impact on the packing bed are dependent on height and are mostly poorly distributed (see Table Distributor selection aids) and, on the other hand, they are extremely sensitive to level offset. The latter will be explained and illustrated by the use of a comparison of various orifices and principles.

We will consider a column with a diameter of 3 m where the permitted tolerances for variance of horizontal of a max. of 0.1 % of the diameter are maintained. A single continuous trough could thus be located on one side 3 mm above and on the other side 3 mm below the nominal height.

If a hole with a nominal 100 mm liquid level is now compared with a rectangular overflow slot with a nominal 30 mm liquid level, for the same flow rate the variation for the hole is +1.5 % / -1.5 % and for the rectangular slot +15.4 % / -14.6 %. For a triangular slot with an opening angle of 45° and a nominal 25 mm level the changes in the values even amount to +32.8 % / -27.4 %.

BACK TO CONTENS



This shows that distributors which only have overflow slots should only be used for separations with low requirements and, at the same time, with a tendency of media to blockages/incrustation. Overflow distributors are a problematic selection in particular for desorbers and plastic distributors which are liable to deflection. In order that you may make a better assessment, whether the use of an overflow distributor is unavoidable, we provide recommendations for the dimensions of the orifices below.

Outlet holes in the base of a distributor with a diameter of greater or equal to 1o mm are not liable to blockages. This diameter reduces to 6 mm for distributors with outlet holes in the side wall. For liquids with a high amount of suspended solids, we advise a strainer filter upstream with a mesh width of 1/5 of the hole diameter. For overflow weir distributors 6 mm is similarly recommended as the smallest width of the orifice. If there is a tendency to incrustation or saline deposits near the orifice, the largest possible orifice size is recom-mended (lowering of the number of drip points, possibly provide emergency overflow slots).

Smaller orifice dimensions are permitted for clean liquids. However, orifice diameters must always be regarded in conjunction with the wall thickness and the minimum required hydrostatic pressure. For a wall thickness of 2 mm we recommend holes larger or equal to 3 mm, for a wall thickness of 10 mm holes larger or equal to 8 mm or holes larger or equal to 5 mm with a special shape.

BACK TO CONTENS

2.5.1.1 Minimum liquid level

To ensure that a submerged hole or an overflow slot comes into operation, minimum forces are required to overcome the interfacial tension. This demands a minimum liquid level which is determined by the system and type. This is increased by the positional tolerances and a safety margin.

Investigations have shown that there is no discharge below a minimum Weber Number. For example, for a round orifice with a diameter of 4 mm and the minimum Weber Number the hole has a coverage of 7.4 mm (water at 20 °C). It can be seen that this effect is only significant for small orifices.

To guarantee that all holes be brought into operation a Weber Number of around 20 is normally selected.

$$We = \frac{\rho_W \cdot d_B \cdot 2 \cdot g \cdot h_{min,s}}{\sigma_W}$$

We = Weber Number [–]

$h_{min,s}$ = Minimum liquid level due to surface tension [m]

d_B = Hole diameter [m]

ρ_W = Water density [kg/m³]

σ_W = Surface tension of water [N/m]

g = Gravitational acceleration [m/s²]

The gas pressure drop has a further effect. Depending on the gas capacity and free cross-section of the distributor, gas pressure drops in the region of 0.2 to 2 mbar may occur. For the liquid in the distributor the minimum liquid level would increase by the equivalent amount of hydrostatic pressure. For water at 20 °C and 2 mbar this equates to an additional liquid level of 20.5 mm.

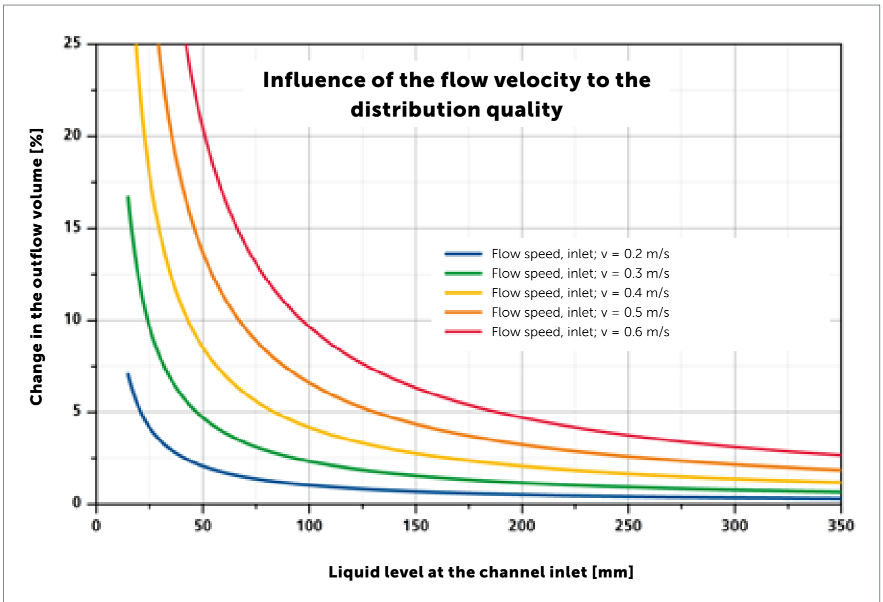
The formation of a closed jet must also be ensured for larger holes. Additionally, vortex formation must be avoided by ensuring that the minimum liquid level in no case falls below 1.5 times the orifice diameter. This point must be taken into consideration in particular for parting boxes with relatively large holes.

The demanded distribution quality similarly affects the minimum liquid level. For a stipulated maximum deviation between the flow of the first and last outlet hole of a channel section the minimum liquid level can be calculated through the conversion of the dynamic pressure into liquid level. An assumed average flow speed of 0.3 m/s at the channel inlet and a stipulated deviation of 10 % between the volumes of the first and last outlet hole gives a minimum liquid level of 24.1 mm.

$$h_{min,Ma} = \left(\frac{v_1}{\sqrt{2 \cdot g \cdot (1-(1-\eta_{Ma})^2)}} \right)^2$$

$h_{min,Ma}$ = Minimum liquid due to hole to hole flow deviation [m]
v_1 = Average flow speed [m/s]
η_{Ma} = Relative deviation of the volumes [%/%]
g = Gravitational acceleration [m/s²]

The following graph illustrates how the flow speed has an effect, in accordance with the Bernoulli equation, at the channel inlet on the expected differences in the outflow volume between the first and last hole in the channel. It is clear to see how the flow speed influences the distribution quality. Particularly high demands on the distribution quality with low minimum loads are then substantial factors in the dimensioning of the trough cross-section.



If no special demands are derived from the customer specification, we select a minimum liquid level for gravity distributors with outlet holes of 25 mm in the fine distributor and a minimum liquid level of 35 mm in the upper distributor.

2.5.1.2 Nominal liquid level

The liquid level at nominal load is determined by the demands on the distribution quality and by the distribution principle used. A nominal liquid level of 100 mm at 100 % load is set for a type of distributor with base or side wall holes and normal demands. Demands for minimum loads may, however, considerably increase this value. For example, at 40 % nominal load this means, allowing for a minimum liquid level of 25 mm, a level of 156 mm, at 30 % a level of 278 mm. Unless there are compelling reasons, the minimum loads should not be specified too low. The maximum load should also not be larger than necessary unless it is absolutely imperative.

Usual requirements for the load range are 50 to 110 %. Significant variations from this require additional efforts or affect the distribution quality. Increased demands on the distribution quality and the maintenance of minimum gas cross-section values may lead here to larger construction heights.

For overflow weir distributors with a rectangular slot the liquid level planned in the standard is 30 mm and for triangular slots 25 mm.

A discharge speed range of 0.9 to 1.5 m/s is planned for pipe pressure distributors. The pressure loss resulting from the effective dynamic pressure height ranges from 100 to 300 mbar.

2.5.1.3 Maximum liquid level

The trough height at maximum load is determined, with a safety margin of 10 %, from the calculated liquid level plus 50 mm.

To ensure correct functioning at maximum load and where there is a tendency to fouling, emergency overflow slots can prevent the distributor from overflowing in an uncontrolled manner. As the component dimensions are greater as the liquid level increases, the size of the installation opening is frequently critical for an economic component design.

BACK TO CONTENS

2.5.2 Design aspects

For all distributors made up from individual pipes or channels the speed slows down toward zero in the direction of flow. As a result, the liquid level increases in the open trough in the direction of flow and the pressure in the pipe increases. These influences can only be limited through appropriately low inlet speeds.

The increase in the delivery height (liquid height, equivalent dynamic pressure height) across the length is calculated using the adjacent formula.

$$h_d = \frac{1}{2 \cdot g} \cdot v_e^2$$

h_d = Increase in the delivery height [m]

v_e = Inlet speed [m/s]

g = Gravitational acceleration [m/s²]

As a result of this effect on standard pipe distributors the flow increases by up to 4 %, on standard trough distributors with submerged holes by up to 2.5 % and on standard trough distributors with rectangular overflow slots by up to 20 %. The maximum design inlet speed varies for each type of distributor and is lowest for overflow distributors. This aspect may be ignored for spray nozzle distributors.

2.5.3 Problems

- **High energy/momentum input**
  Where liquid flow intakes are poorly designed a large momentum may occur locally. This risk is especially significant at high irrigation densities. To remedy this, many small feed outlets instead of fewer larger ones can be used. This affects mainly the upper parting box and therefore a trough-in-trough version or flow breakers in the form of cages, structured packing elements or similar items may be useful.

- **Uncontrolled overflow**
  Where serious design errors in cross-section dimensioning or in the dimensioning of the discharge points may be ruled out as the cause of an overflow, a number of discharge points is usually blocked. This effect can also occur where there is an extremely large gas pressure drop across the distributor and the recorded heights are too low.

- **Incrustation/saline deposits**
  If a warm saline solution which is near to its solubility limit is fed in, saline deposits or incrustation may occur in the area of the orifices due to evaporation. Chemical reactions between the liquid and the gas flow may also have a similar effect where the product of the reaction falls below its solubility limit.

- **Erosion**
  A high flow speed together with a high proportion of solids may lead to signs of erosion. This particularly occurs in the inlet area and in the orifices. A change in the orifice discharge coefficient may be expected in this case and attention should be paid to this from the beginning. The cross-sections of the inlets should be more generously dimensioned.

- **Aeration**
  If the inflow momentum is too high, the liquid jet may contain gas. The resulting 2-phase mixture then has a lower average density and takes up more space. This can lead to overflows and also to locally and temporally significant variations in the uniformity of distribution. At very high flow speeds and thus low retention time the liquid may, in some cases, not be degassed. This also has a negative influence on the distribution characteristics.

- **Floods in the spaces**
  On overflow weir distributors without guide pipes the liquid is fed horizontally into the gas space between the troughs. A strongly constricted gas flow can fan out the descending flow and pull it upwards to some extent. A spray regime layer of up to 600 mm in height occurs which could then also flood the droplet separator. It is reasonable to assume that the distribution quality will suffer as a result. This type of distributor is only suited for low gas capacities.

- **Strongly directional gas flow**
  If the even distribution of the gas is affected when entering the bed by on site supports or similar constructions or if the gas is improperly fed in, the separation performance may be reduced and an increase in pressure loss occurs.

BACK TO CONTENS

- **Minimum level / use of all drip points**
  Improper mounting and high liquid gradients may lead to some areas having too low a liquid level which does not permit the use of all drip points.

2.6 Distributor data sheets

on the following pages

2.6.1 2H liquid distributor TDP 410

Weir distributor

2.6.2 2H liquid distributor TDP 400

Trough distributor with base holes

2.6.3 2H liquid distributor TDP 420

Trough distributor with side-wall holes and guide pipes, 2-stage

2.6.4 2H liquid distributor TDP 430

Trough distributor with splash plate, 2-stage

2.6.5 2H liquid distributor LDP 200

Closed pipe distributor with a central feed

2.6.6 2H liquid distributor LDP 220

Closed pipe distributor with a side feed

2.6.7 2H liquid distributor NDP 310

Spray nozzle distributor

2.6.8 2H liquid distributor PDP 350

Pan distributor with guide pipes, single-stage
Trough distributor with side-wall holes and guide pipes, 2-stage

2.7 Re-distributors and special designs

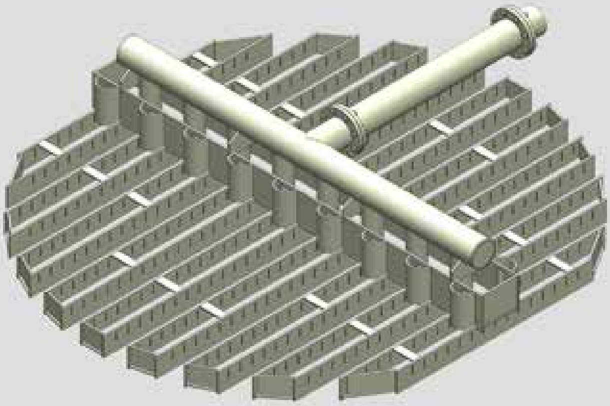
In addition to the distributors shown here, other types, such as re-distributors or special designs are available on request.

If the height in the column is restricted, single-stage gravity distributors may also be used. Here the fine distributors are connected with a central parting distributor on one level as a continuous system. The upper parting box is not required. Some height can also be saved by the use of an inlet pipe connected by a flange to the side of the upper distributor. For special designs it is also recommened to always check whether the reduction in the column costs justifies the additional costs for the distributor.

BACK TO CONTENS

2H LIQUID DISTRIBUTOR TDP 410

Overflow weir distributor



Technical specifications	
Application	
Diameter range	> 1,000 mm
Irrigation density range	15 to 40 (80) m^3/m^2h
Standard turn down	2.5 : 1 (for triangular slots 4 : 1)
Range of the maximum gas capacity	2.25 $Pa^{0.5}$
Susceptibility to fouling	low

Advantages

- relative immunity to fouling and scaling
- low tendency to erosion
- large load range
- low component and operating costs

Standard version

In the standard version a distributor consists of parallel aligned U-troughs in the lower level and, above this, one or more parting boxes. The parting distributors have got overflow slots in their side walls on both sides. The liquid is channelled into the fine distribution level via guiding pipes. The liquid is then fed via regularly arranged overflow slots in the side walls of the lower troughs onto the packing bed.

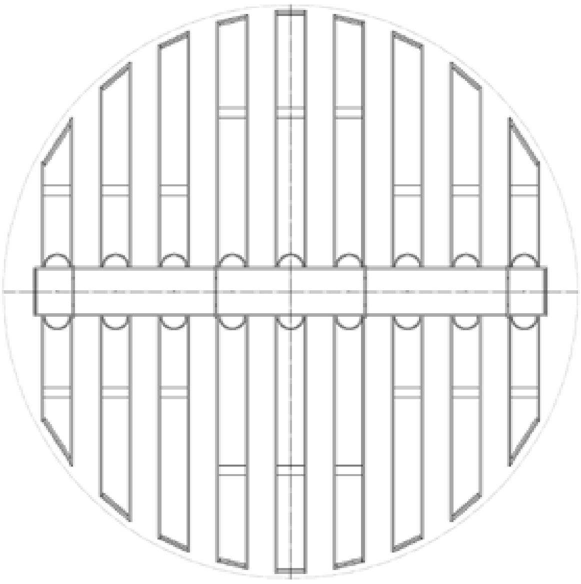
Main areas of application

The main areas of application are processes where liquids with large and very large volumes of suspended solids are to handle and liquids which are handled near to their solubility limit, in such cases also with triangular slots. The use of a weir distributor is preferable for absorption processes with a low gas and liquid capacity and with a low to mid-single digit number of transfer units.

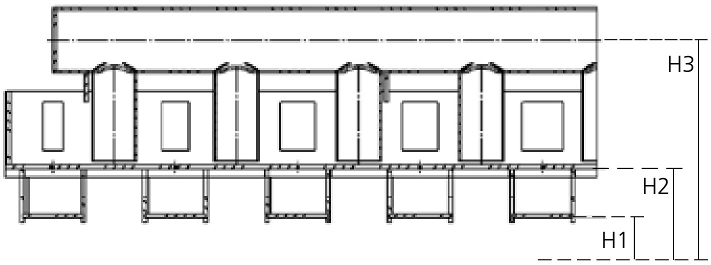
Note

The distribution quality is extremely sensitive where there is a height offset. An overflow weir distributor can only be used for low to average gas capacities.

BACK TO CONTENS



Top view



Vertical section

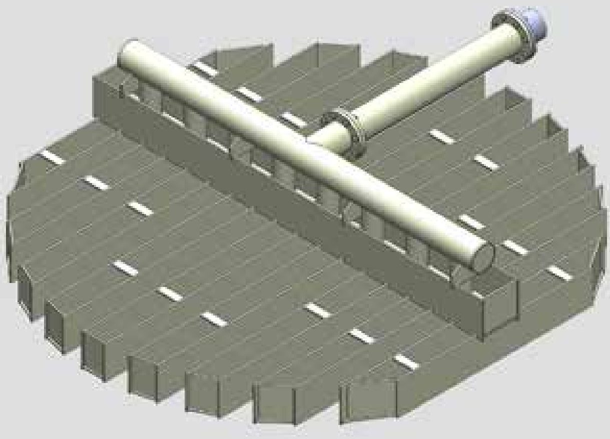
Technical specifications	
Functions	
Distribution principle	2-stage trough distributor with a free overflow
Specific drip point density	65 to 80 drip points/m²
Free gas cross-section	45 to 50 %
Position of the drip points	Discharge points in the side walls of the troughs in the final distribution level and the parting distributor level
Arrangement / division of the drip points	Rectangular
Type of fitting	Loosely mounted, outer troughs mounted to parting distributor
Feed system	Optionally via a central inflow, straight feed pipe with several outlets or a T-shaped feed pipe
Optional	Overflow slot shape with special contours for particular capacity conditions

Technical specifications	
Heights	
H1	150 mm
H2	280 mm
H3	up to 650 mm
Distributor height parting box + distributor troughs	400 mm
Minimum installation opening diameter	480 mm

BACK TO CONTENS

2H LIQUID DISTRIBUTOR TDP 400

Trough distributor with base holes, 2-stage



Technical specifications	
Application	
Diameter range	> 1,000 mm
Irrigation density range	12.5 to 60 (120) m^3/m^2h
Standard turn down	2.1 : 1
Range of the maximum gas capacity	2.75 $Pa^{0,5}$
Susceptibility to fouling	average to high

Advantages

- low susceptibility to height offset
- uncomplicated construction
- low tendency to erosion
- large load range
- low component and operating costs

Standard version

In the standard version a distributor consists of parallel aligned U-troughs in the lower level and, above this, one or more parting boxes. The parting distributors have got outlet holes in the base plates. The liquid is channelled into the fine distribution level from a direct drop. The liquid is then fed onto the packing bed via outlet holes arranged in two rows in the base of the lower troughs.

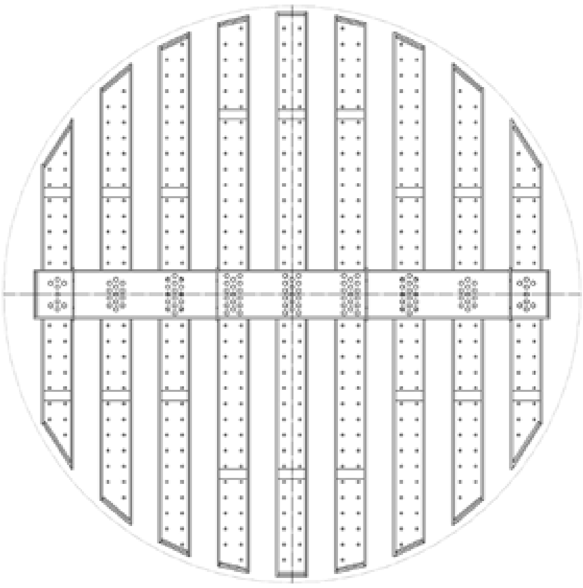
Main areas of application

The main areas of application are processes with clean or less strongly with solids suspended liquids and liquids which are handled near to their solubility limit, in such cases additionally with triangular emergency slots. The preferred use of a trough distributor with base holes is for absorption processes with an average gas and liquid capacity and with a mid-single digit number of transfer units.

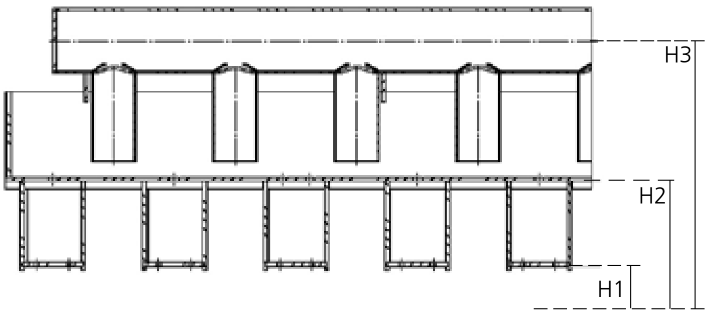
Note

Risk of blockages at low irrigation densities. This form of trough distributor can only be used for up to average gas capacities.

BACK TO CONTENS



Top view



Vertical section

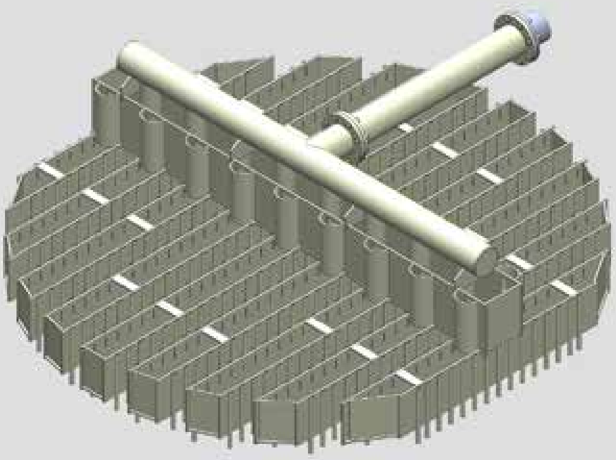
Technical specifications	
Functions	
Distribution principle	2-stage trough distributor with a free outflow
Specific drip point density	90 to 100 drip points/m^2
Free gas cross-section	40 to 45 %
Position of the drip points	Discharge points in the trough base in the final distribution level and the parting distributor level
Arrangement / division of the drip points	Rectangular
Type of fitting	Loosely mounted, outer troughs mounted to parting distributor
Feed system	Optionally via a central inflow, straight feed pipe with several outlets or a T-shaped feed pipe
Optional	With specially contoured turbulence breakers in the inlet feed section

Technical specifications	
Heights	
H1	125 mm
H2	335 mm
H3	up to 725 mm
Distributor height parting box + distributor troughs	560 mm
Minimum installation opening diameter	480 mm

BACK TO CONTENS

2H LIQUID DISTRIBUTOR TDP 420

Trough distributor with side-wall holes and guide pipes, 2-stage



Technical specifications	
Application	
Diameter range	> 1,000 mm
Irrigation density range	12.5 to 50 (100) m^3/m^2h
Standard turn down	2.1 : 1 (with multiple rows of holes: 10 : 1)
Range of the maximum gas capacity	3.60 $Pa^{0,5}$
Susceptibility to fouling	low to average

Advantages

- low susceptibility to height offset
- low fouling tendency
- precisely positionable feed points
- high gas capacity
- low tendency to erosion
- large load range
- low operating costs

Standard version

In the standard version a distributor consists of parallel aligned U-troughs in the lower level and, above this, one or more parting boxes. The parting distributors have got outlet holes in the side walls. The liquid is channelled into the fine distribution level via guiding pipes. The liquid is then fed via submerged orifices arranged at regular intervals on both sides of the side walls of the lower troughs and then via guide pipes.

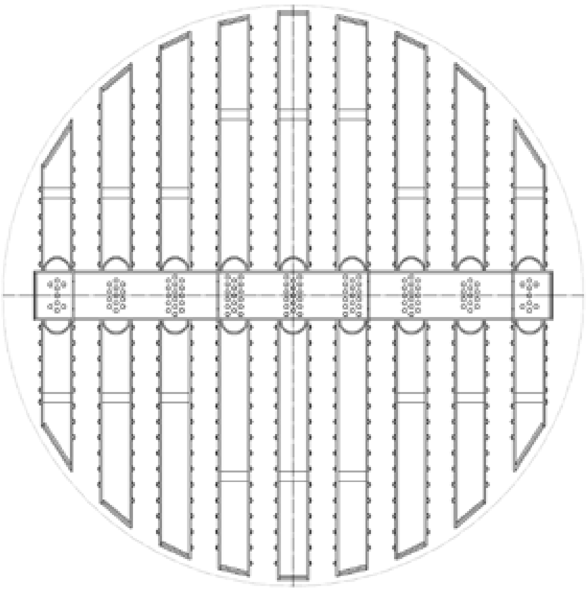
Main areas of application

The main areas of application are processes with moderately with solids suspended liquids. For liquids near to their solubility limit the distributor can optionally be fitted with additional emergency overflow slots. The preferred use of a trough distributor with side-wall holes and guide pipes is for absorption processes with high gas capacities and average liquid loadings and with an average to high number of transfer units.

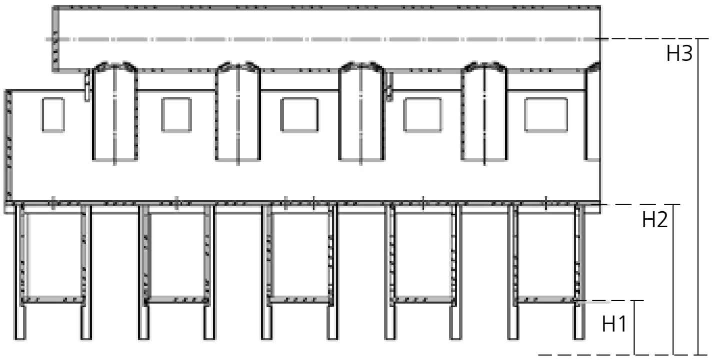
Note

This type of liquid distributor has a more complex design.

BACK TO CONTENS



Top view



Vertical section

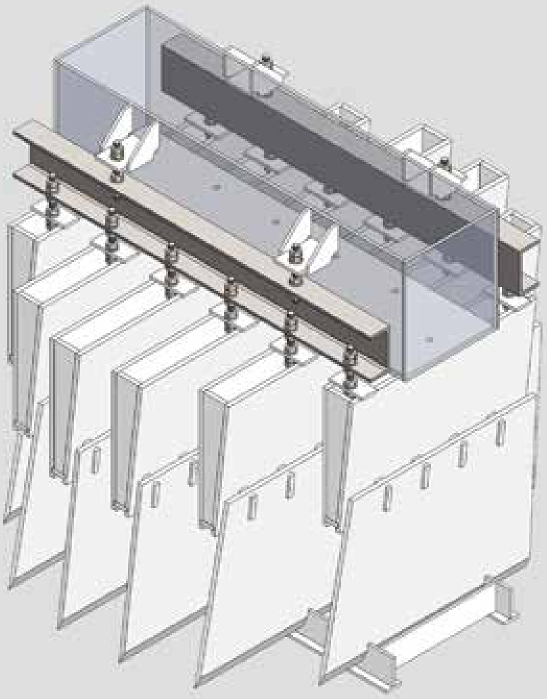
Technical specifications	
Functions	
Distribution principle	2-stage trough distributor with a free side-wall outflow
Specific drip point density	65 to 75 drip points/m^2
Free gas cross-section	50 to 55 %
Position of the drip points	Discharge points in the side walls of the troughs in the final distribution level and the parting distributor level
Arrangement / division of the drip points	Rectangular (triangular)
Type of fitting	Loosely mounted, outer troughs mounted to parting distributor
Feed system	Optionally via a central inflow, straight feed pipe with several outlets or a T-shaped feed pipe
Optional	Overflow slot with special contours for particular capacity conditions

Technical specifications	
Heights	
H1	110 mm
H2	390 mm
H3	770 mm
Distributor height parting box + distributor troughs	560 mm
Minimum installation opening diameter	480 mm

BACK TO CONTENS

2H LIQUID DISTRIBUTOR TDP 430

Trough distributor with splash plate, 2-stage



Technical specifications	
Application	
Diameter range	> 800 mm
Irrigation density range	3 to 30 (60) m^3/m^2h
Standard turn down	2.1 : 1
Range of the maximum gas capacity	3.90 $Pa^{0,5}$
Susceptibility to fouling	average

Advantages

- multiple drip points
  Applications with low drip point densities from 3 m^3/m^2h would exhibit either too low a drip point density or an inadequate liquid level as a result of the minimum hole diameter.
- low trough cross-section
  This allows for a larger free gas cross-section. The free gas cross-section near the drip edge is close to 100 %.
- low gas pressure drop

Standard version

In the standard version a distributor consists of an upper distributor trough or troughs and several fine distributor troughs. The liquid is fed against a splash plate using holes in the side walls of the trough. There it spreads out and arrives as a film on the lower edge of the plate. A number of drip points are then generated.

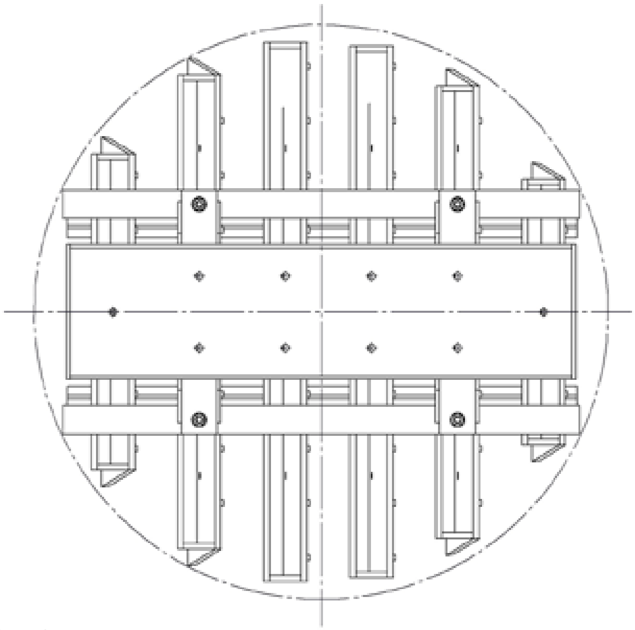
Main areas of application

The main areas of application are processes with an average to high number of transfer units with low irrigation densities at the same time.

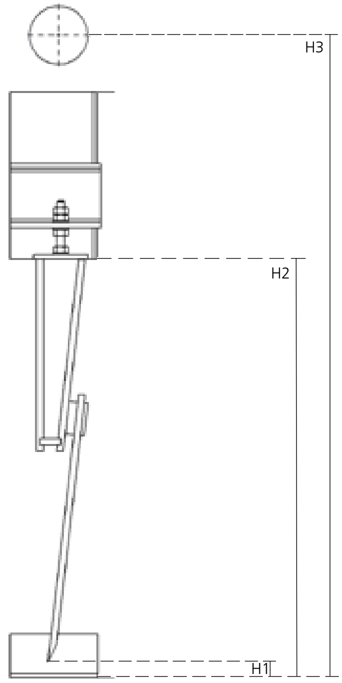
Note

This type of liquid distributor places great demands on the exact alignment within the column and its complex design.

BACK TO CONTENS



Top view



Vertical section

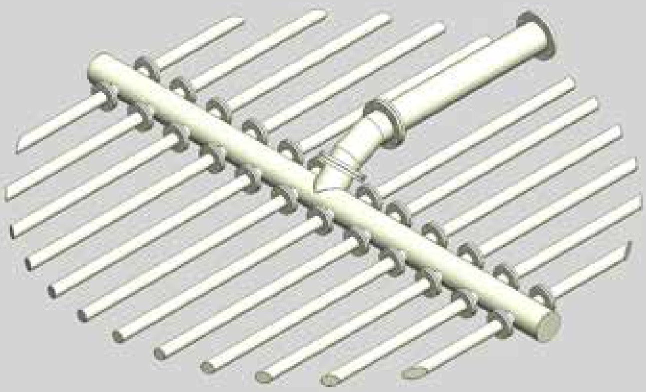
Technical specifications	
Functions	
Distribution principle	2-stage trough distributor with a side-mounted outlet and drip edge behind a splash plate
Specific drip point density	160 drip points/m^2
Free gas cross-section	45 to 50 %
Position of the drip points	Discharge points in the base of the parting distributor level and in the side walls of the troughs in the final distribution level
Arrangement / division of the drip points	In line
Type of fitting	Loosely mounted, end of troughs mounted to parting distributor
Feed system	Optionally via a central inflow, straight feed pipe with several outlets or a T-shaped feed pipe
Optional	–

Technical specifications	
Heights	
H1	15 mm
H2	up to 500 mm
H3	up to 880 mm
Distributor height parting box + distributor troughs	780 mm
Minimum installation opening diameter	580 mm

BACK TO CONTENS

2H LIQUID DISTRIBUTOR LDP 200

Closed pipe distributor with a central feed



Technical specifications	
Application	
Diameter range	> 800 mm
Irrigation density range	8 to 30 (60) m^3/m^2h
Standard turn down	1.7 : 1
Range of the maximum gas capacity	3.90 $Pa^{0.5}$
Susceptibility to fouling	average

Advantages

- low gas pressure drop
- low susceptibility to height offset
- low height of internals
- low tendency to deposits
- low component and fitting costs

Standard version

In the standard version a distributor consists of a main pipe which is fed from one side by an internal flanged nozzle. Flanged side pipes are fitted in a grid of approx. 330 mm on both sides. Underneath the side pipes and the main pipe there are holes which provide an even impact pattern at a fixed distance to the packing bed. In order to increase the distribution quality the inflow is supplied to the distributor centrally and vertically or at an angle of 45° from above.

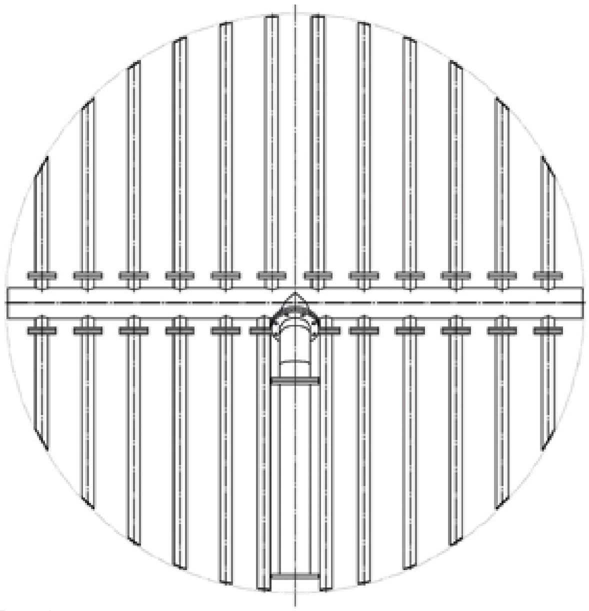
Main areas of application

The main areas of application are in gas humidification, gas cooling, in absorption processes with a low to average transfer unit number and for desorption. The preferred use of a pipe distributor is for absorption processes with an average to high gas capacity.

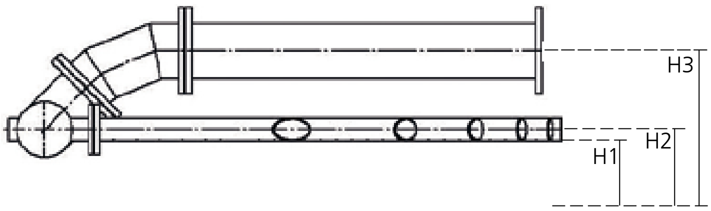
Note

Erosion at the orifices may appear where there are abrasive suspensions and a high loss of liquid pressure. A fixed distance to the packing bed is required.

BACK TO CONTENS



Top view



Vertical section

Technical specifications	
Functions	
Distribution principle	Pipe pressure distributor with aligned outflow
Specific drip point density	85 to 100 drip points/m^2
Free gas cross-section	50 to 75 %
Position of the drip points	Discharge points in the lower section of the pipes
Arrangement / division of the drip points	Rectangular
Type of fitting	Mounted, end of pipes fixed to constructed base
Feed system	Central pipe, internally flanged (to DN 400)
Optional	Overflow slot shape with special contours for particular capacity conditions

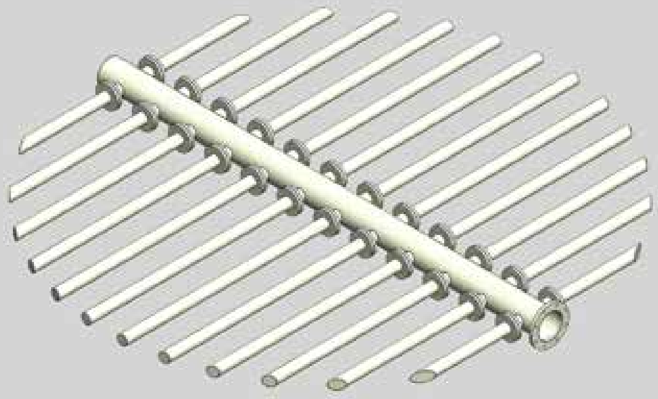
Technical specifications	
Heights	
H1	150 to 250 mm
H2	200 to 340 mm
H3	to 1,200 mm (depending on the liquid loading)
Minimum installation opening diameter*	580 mm

* May be even larger for large nominal widths

BACK TO CONTENS

2H LIQUID DISTRIBUTOR LDP 220

Closed pipe distributor with a side feed



Technical specifications	
Application	
Diameter range	> 800 mm
Irrigation density range	8 to 30 (60) m^3/m^2h
Standard turn down	1.7 : 1
Range of the maximum gas capacity	3.90 $Pa^{0,5}$
Susceptibility to fouling	average

Vorteile

- low gas pressure drop
- low susceptibility to height offset
- low height of internals
- low tendency to deposits
- low component and fitting costs

Main areas of application

The main areas of application are in gas humidification, gas cooling, in absorption processes with a low to average transfer unit number and for desorption. The preferred use of a pipe distributor is for absorption processes with an average to high gas capacity.

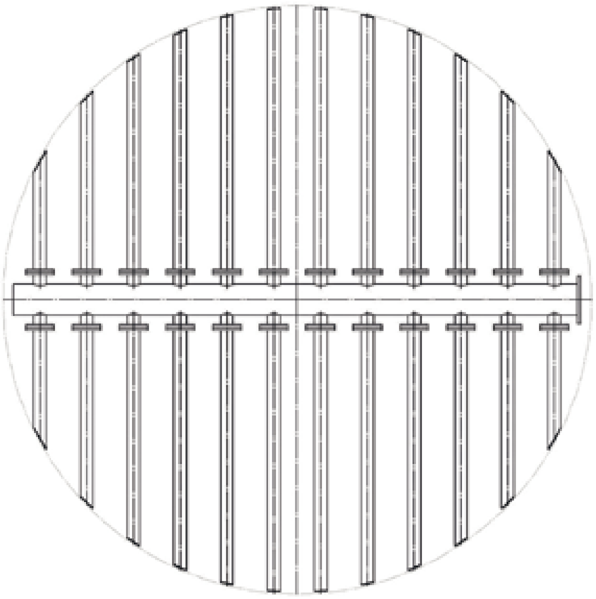
Standard version

In the standard version a distributor consists of a main pipe which is fed from one side by an internal flanged nozzle. Flanged side pipes are fitted in a grid of approx. 330 mm on both sides. Underneath the side pipes and the main pipe there are holes which provide an even impact pattern at a fixed distance to the packing bed.

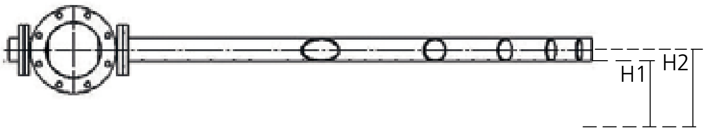
Note

Erosion at the orifices may appear where there are abrasive suspensions and a high loss of liquid pressure. A fixed distance to the packing bed is required.

BACK TO CONTENS



Top view



Vertical section

Technical specifications	
Functions	
Distribution principle	Pipe pressure distributor with aligned outflow
Specific drip point density	85 to 100 drip points/m^2
Free gas cross-section	50 to 75 %
Position of the drip points	Discharge points in the lower section of the pipes
Arrangement / division of the drip points	Rectangular
Type of fitting	Mounted, end of pipes fixed to constructed base
Feed system	Central pipe, internally flanged (to DN 400)
Optional	Overflow slot shape with special contours for particular capacity conditions

Technical specifications	
Heights	
H1	150 to 250 mm
H2	200 to 340 mm
Minimum installation opening diameter*	580 mm

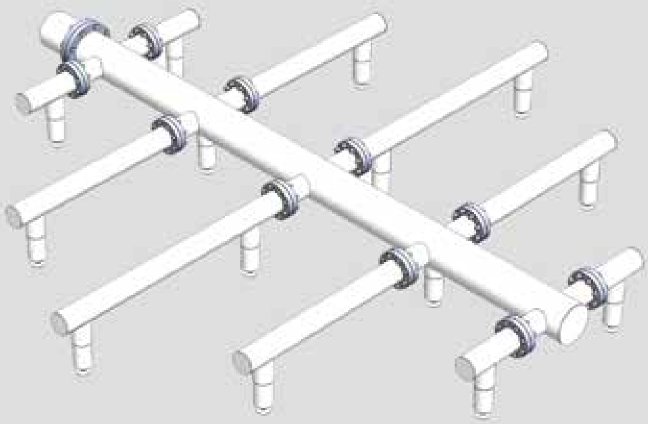
* May be even larger for large nominal widths

This information has been put together with greatest care. However, any performance data given in this leaflet is subject to compliance with certain surrounding conditions and hence may vary from case to case. Further, we reserve the right to make changes at any time without notice. We strongly recommend (i) reconfirmation with us whether this information is still fully valid, before using it for final designs and (ii) to verify performance data taking into account the actual surrounding conditions. We do not take any responsibility for any consequences due to non-compliance with these recommendations.

BACK TO CONTENS

2H LIQUID DISTRIBUTOR NDP 310

Spray nozzle distributor



Technical specifications	
Application	
Diameter range	> 2,100 mm
Irrigation density range	3 to 180 m^3/m^2h
Standard turn down	1.5 : 1
Range of the maximum gas capacity	3.25 $Pa^{0.5}$
Susceptibility to fouling	high for low irrigation densities

Advantages

- low gas pressure drop
- additional effect on the mass and heat transfer process through the generated droplet surface
- low susceptibility to height offset
- low liquid content
- low tendency to deposits
- low component and fitting costs

Standard version

In the standard version a distributor consists of a main pipe which is fed from one side by an internal flanged nozzle. Flanged side pipes are fitted in a grid of approx. 600 mm on both sides. Underneath the side pipes and the main pipe there are collars with screwed on full cone nozzles which provide an overlapping impact pattern at a fixed distance to the packing bed.

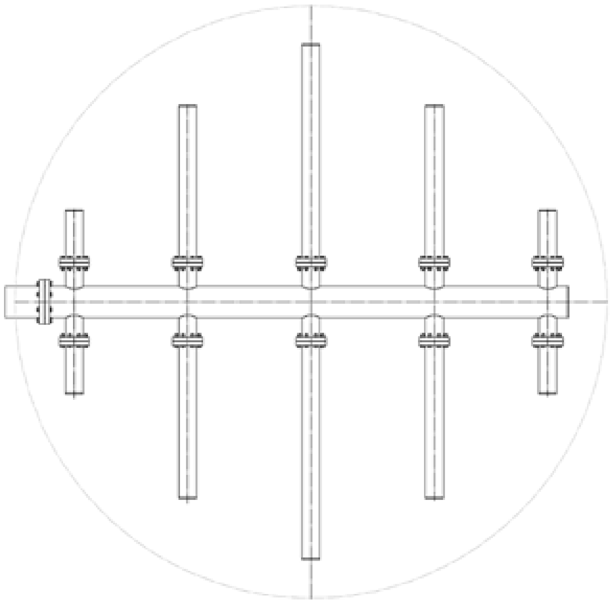
Main areas of application

The main areas of application are in gas humidification, gas cooling, in uncritical absorption processes with a low transfer unit number and/or where particles are simultaneously present. Not recommended for desorbers.

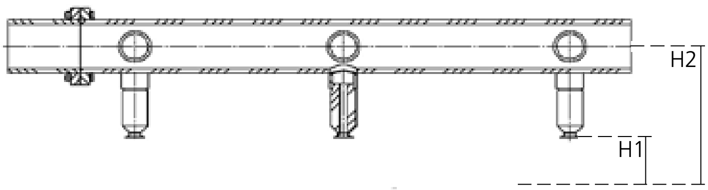
Note

Be aware of the nozzle opening's susceptibility to blockage, high liquid pressure loss, extremely uneven drip point densities, low operational reliability as a result of the uncontrolled clogging of individual nozzles, limited gas capacity due to droplet entrainment, a limited load range, a high entry momentum on the packing bed and high operating costs.

BACK TO CONTENS



Top view



Vertical section

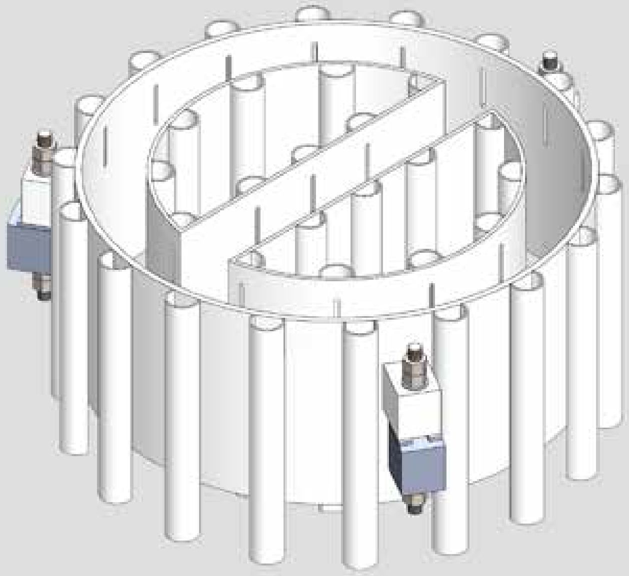
Technical specifications	
Functions	
Distribution principle	Full cone or spiral nozzle with a spraying angle of between 90° and 120°, 0.7 bar to 1.5 bar gauge pre-pressure
Specific drip point density	0.5 to 2 drip points/m²
Free gas cross-section	Greater than 90 %
Arrangement / division of the drip points	Circular or triangular
Type of fitting	Mounted or hung on supports, fixed with clamps
Feed system	Internal radial nozzles
Optional	–

Technical specifications	
Heights	
H1	300 to 600 mm
H2	550 to 850 mm
Minimum installation opening diameter	480 mm

BACK TO CONTENS

2H LIQUID DISTRIBUTOR PDP 350

Pan distributor with guide pipes, single-stage
Trough distributor with side wall holes and guide pipes, 2-stage



Technical specifications	
Application	
Diameter range	> 500 mm
Irrigation density range	12.5 to 80 m^3/m^2h
Standard turn down	2.1 : 1 (with multiple rows of holes: 10 : 1)
Range of the maximum gas capacity	3.25 $Pa^{0.5}$
Susceptibility to fouling	low to average

Advantages

- low susceptibility to height offset
- low fouling tendency
- precisely positionable feed points
- high gas capacity
- low tendency to erosion
- large load range
- low operating costs

Standard version

In the standard version a distributor consists of a round pan which has large gas risers in its central section. Holes are arranged in all side walls. The liquid is fed over the outlet holes and then via guide pipes onto the packing bed. The distributor has a particularly high distribution quality due to the geometric arrangement of the drip points.

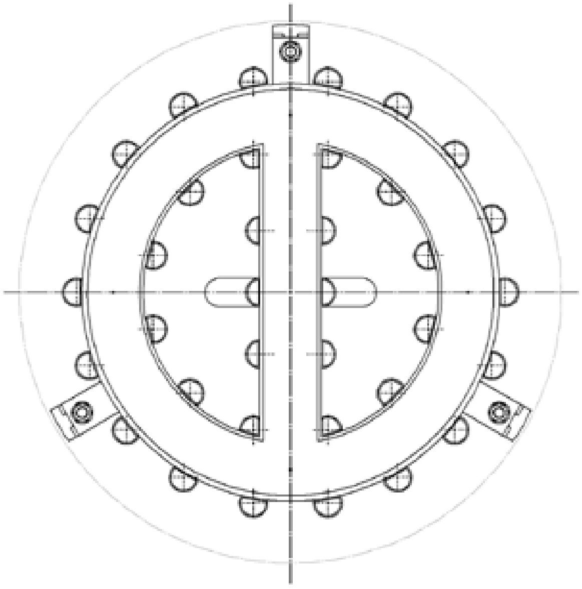
Main areas of application

The main areas of application are processes with mode-rately with solids suspended liquids. For liquids near to their solubility limit the distributor can optionally be fitted with additional emergency overflow slots. The preferred use of a pan distributor with side-wall holes and guide pipes is for absorption processes with high gas capacities and average liquid loads and with an average to high number of transfer units.

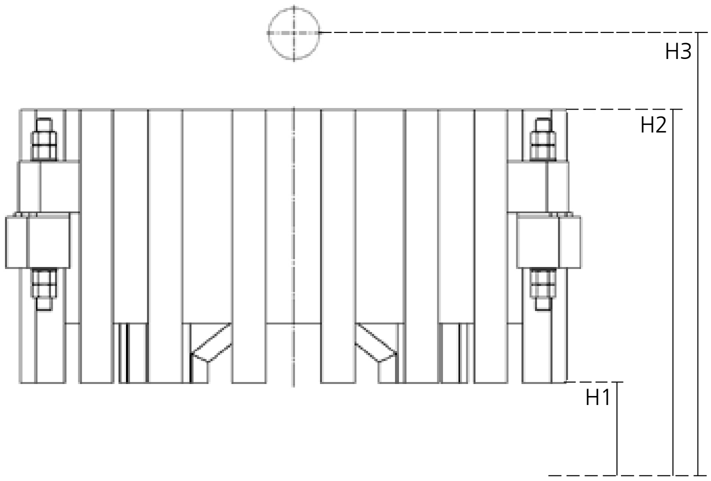
Note

A complex design and fitting using a flange from above are required.

BACK TO CONTENS



Top view



Vertical section

Technical specifications	
Functions	
Distribution principle	single-stage pan distributor with a guided sideways outlet
Specific drip point density	65 to 100 drip points/m²
Free gas cross-section	40 to 50 %
Position of the drip points	Orifices in the side walls of the curbing, inside and outside. Predominantly symmetrical.
Arrangement / division of the drip points	Individually optimised
Type of fitting	Mounted on foundations
Feed system	Optionally via a central inflow, straight feed pipe with several outlets or a T-shaped feed pipe
Optional	Overflow slot shape with special contours for particular capacity conditions

Technical specifications	
Heights	
H1	100 to 150 mm
H2	380 to 430 mm
H3	up to 475 mm
Minimum installation opening diameter*	Column diameter

This information has been put together with greatest care. However, any performance data given in this leaflet is subject to compliance with certain surrounding conditions and hence may vary from case to case. Further, we reserve the right to make changes at any time without notice. We strongly recommend (i) reconfirmation with us whether this information is still fully valid, before using it for final designs and (ii) to verify performance data taking into account the actual surrounding conditions. We do not take any responsibility for any consequences due to non-compliance with these recommendations.

BACK TO CONTENS

The optimisation
Once type of packing, column diameter and bed height have been fixed for the separation task, the position and size of the main gas and liquid nozzles must be dimensioned. The aim is to generate as near as possible a plug flow pattern. Following this, on-site supports, support rings, fixings and instal-lation openings must be selected.

3. Dimensioning of columns

3.1 Inlet and outlet nozzle

False cross-sections, incorrect orientations and unsuitable vertical distances of the nozzles to the packing bed or to other installations are frequently the cause for reductions in performance or malfunctions in the application. Particularly the gas in-let nozzle must be mentioned here.

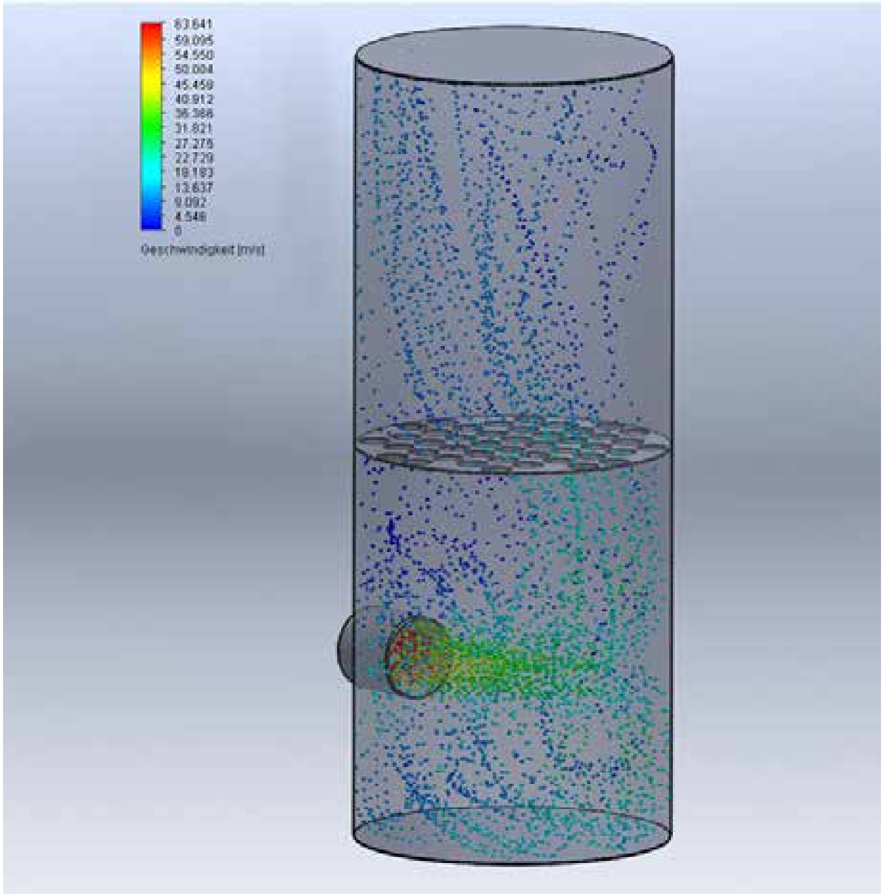
3.1.1 Gas inlet nozzle

Optimal separation assumes a uniform distribution of the gas flow speeds across the cross-section of the column. The position and dimensions of the gas inlet nozzle influence the gas flow significantly and must therefore be determined with care.

If the ratio of the kinetic energy at the inlet to the specific pressure loss of the packing is too large, a gas bypass flow is likely. The gas flow collides against the opposite column wall and then flows after the deflection at a far above-average speed in this local section into the packing bed. This risk exists particularly for small and medium-sized columns with a high inlet impact.

BACK TO CONTENS

For large column cross-sections and a low gas capacity or low kinetic energy in the gas inlet cross-section, particular attention must be paid to the distance of the nozzle to the bed. A short-circuit flow may occur here. The gas then flows mostly in the area of the nozzle at an over-average speed in a local section into the packing bed.



CFD study gas feed

Some design recommendations on this matter were published by Moor and Rukovena [2] for random packings which also apply to structured packings. According to these there is no risk of an inequality of distribution of gas for a column diameter of up to 6.0 m if the specific pressure loss in the bed is larger than 70 Pa/m, the ratio of kinetic energy in the gas inlet to the special pressure loss does not exceed a value of 24.53 and a minimum distance between the nozzle and the bed inlet is not below 300 mm. The use of a gas distributor is recommended for a larger ratio. Up to a column diameter of 2.5 m it can be arranged as a straight pipe with orifices in the lower cross-section area, for a column diameter of over 2.5 m as an H-shaped pipe. Alternatively, gas distributor systems with guide plates may be used. However, their lower pressure loss means higher initial investment costs.

For the benefit of the uniformity of gas distribution it is sometimes helpful, in coordination with the flood load, to install a support grid with a free cross-section which is not too greatly open to lift the pressure loss in the first metre of the packing somewhat.

Further specifications for gas inlet nozzles which ensure an even flow without a gas distributor, limit the inlet momentum, defined as the product of the gas density and the square of the flow speed, to 1400 Pa for a nozzle distance of at least 0.45 times the

BACK TO CONTENS

container cross-section.
Our recommendation for the minimum nozzle distance, calculated from the centre of the nozzle to the packing, is the simple nozzle diameter plus 300 mm. For this a minimum pressure loss in the first metre of the packing of 70 Pa is assumed. Our recommendation for the maximum specific inlet momentum for internally flush inlet nozzles is 1000 Pa.

If the distance is lower, the inlet momentum is exceeded or if the pressure loss in the bed is too low, we recommend the use of a gas distributor. Please contact our specialists on this matter.

3.1.2 Gas outlet nozzle

The dimensioning of the gas outlet nozzle is generally determined by the droplet separator as the last component in a column. A uniform flow must also be ensured here through the distance to the nozzle.

For a centrally located nozzle we recommend a distance of half the column diameter less half of the nozzle diameter plus 100 mm, but at least 300 mm. If the pressure specifications permit, the maximum specific momentum of the gas outlet nozzle may be up to 3400 Pa.

3.1.3 Liquid inlet nozzle

For aqueous media common practice has shown that an inlet velocity of approx. 2.5 m/s should be set for the nozzle. It is normal to use an internally flanged inlet pipe to feed the distributor. The outflow then normally takes place in a downward direction.

If the feed involves free inflow, the aim will be to achieve a supply which is as low in turbulence and as uniform as possible. For distributors with an upper parting box a T-shaped feed pipe with submerged guiding pipes is recommended, for a distribution system with 2 upper parting boxes an H-shaped feed system. Small column diameters mostly have a centrally located feed. However, it must be ensured by the design of the outlet that the discharge speed range is brought to less than 1.25 m/s.

By too large turbulence entry into the parting boxes, strongly fluctuating surfaces are generated, which cause variations in volume, spillages or an overflow in the distributor due to the entering of gas.

Our experts can, on request, design and offer you a complete distribution system including the feed pipe distributors.

BACK TO CONTENS

3.1.4 Liquid outlet nozzle

As a broad guide, a flow speed of 1 m/s should be set and sufficient coverage ensured. It is essentially recommended to plan a vortex breaker. Further parameters, such as degassing time, emergency storage volumes, etc. determine the design of the bottom of the column and are not described in greater detail at this point. We refer you to the relevant literature.

3.2 Height of liquid distributors

The height of a liquid distributor is determined by mechanical and hydrauic demands or limited by the internal diameter of the installation opening.

The standard heights may be found in the relevant data sheets (see 2.6). A distance to the bed and a distance to the following component must be added. The total minimum distances give a value in the range of 600 mm to 1200 mm. Larger distances must be provided for greater column cross-sections. The fitting work and the free space under the supports are critical in this area. Distances of 2000 mm to 2400 mm between the packing bed and the droplet separator or the bed above are common.

3.3 Pressure drop of liquid distributors

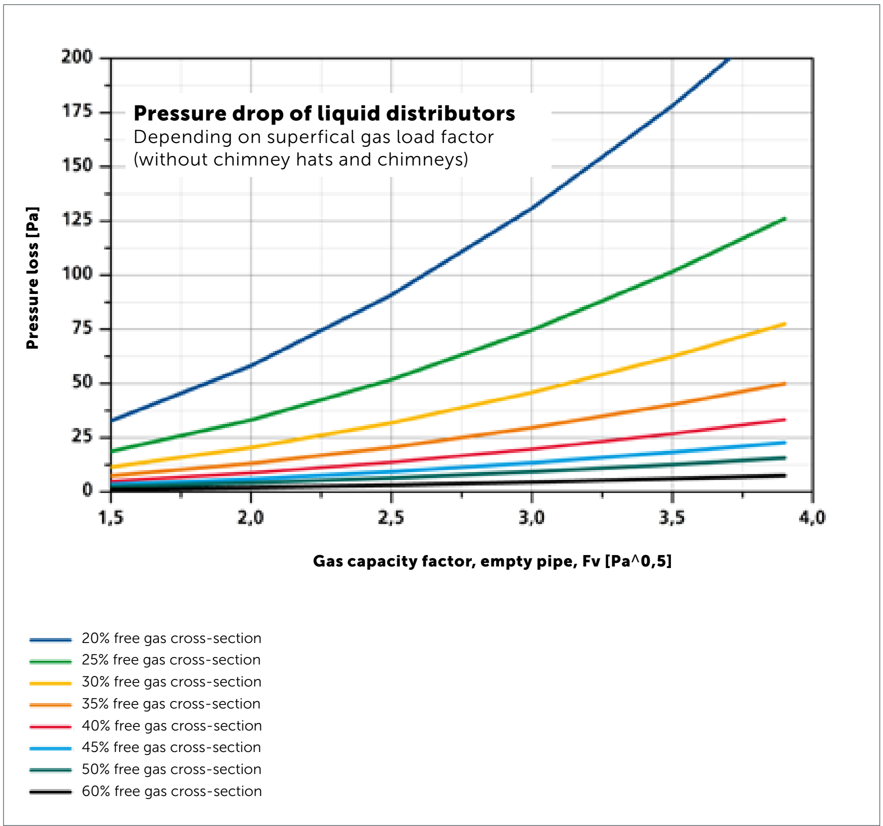
All liquid distributors present an obstacle for the gas flow and generate a pressure loss. Depending on the gas capacity and type, this mostly ranges from 10 to 100 Pa.

The pressure loss is determined by constant or sudden constriction, in some cases by friction and by a constant or sudden expansion behind the distributor.

The lines in the following graph show the expected size of pressure loss in a distributor. For re-distributors with riser covers the pressure loss is larger. For an initial dimensioning we recommend allowing for 1 mbar. If the design and distance recommendations given in the previous chapters are maintained, the distributor does not represent the hydrauic bottleneck of a counter-flow application.

Particular attention, however, must be paid where there are low irrigation densities and high gas capacities. For gravity distributors with outlet holes with a low free gas cross-section the pressure loss across the distributor represents a counter-gravitational force. The driving force of a water level of 25 mm with the lowest possible liquid loading will be reduced by a pressure loss of 100 Pa by approx. 10 mm. This may lead to not all outlet holes coming into operation and good distribution cannot be guaranteed under these circumstances.

BACK TO CONTENS



When designing a distributor the minimum liquid level for this case must be increased by the effective additional liquid level resulting from the gas pressure drop. A liquid distributor does not just represent an obstacle for the gas flow but also leads to a directed gas flow behind the distributor. Downstream components, such as droplet separators, particularly require a uniform onflow velocity. Therefore, a sufficient height must be planned behind a distributor so that a uniform flow can be brought about. For pipe and nozzle distributors we recommend keeping a distance of 2 pipe diameters of the main pipe, but at least 300 mm free.

For gravity distributors the distance between the gas outlet from the lower distribution level and the downstream component should be at least 6 times the largest internal riser width. Here, too, at least 300 mm above the inlet pipe should remain free.

BACK TO CONTENS

3.4 Sources

[1] DVS guideline 2205-1

[2] F.Moore, F.Rukovena, „Liquid and gas distribution in commercial random packing columns“, cav 1987, May, pp 33 – 41

[3] M.Hansen, „On the outflow problem“, VDI research paper 428, 1949/50

BACK TO CONTENS

www.enexio.com