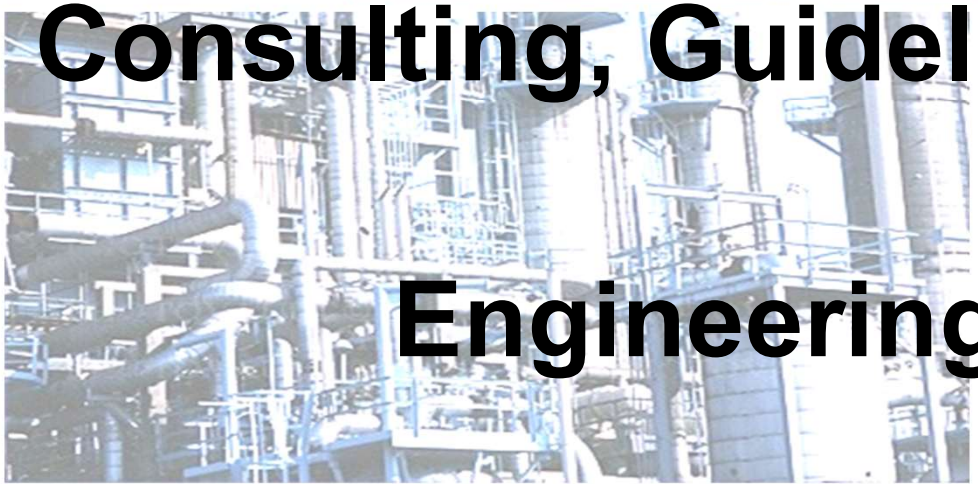
# KLM Technology Group

## Consulting, Guidelines, and Training



## Engineering Solutions

KLM Technology Group
Engineering Solutions

## Based in USA since 1995,

**KLM is a technical consultancy group, providing specialized services and equipment to improve process plant operational efficiency, profitability and safety.**

KLM Technology Group

# KLM Core Business

- Training (75+ Training Classes)
- Engineering Design Guidelines
- Process Optimization Studies
- Process Energy Studies
- Process Safety Management
  - HAZOP Facilitation
  - Facility Siting Studies
- Engineering Support
  - Basic Design Packages
  - Detailed Design Packages
- Process Equipment
  - Random Packing
  - Structured Packing
- Marketing
  - Engineering Practice Magazine
- Unit Commissioning
- Distillation Equipment Inspecting and Correct Instillation
- Unit Benchmarking
- Evaluation of Process Units

## KLM Provides

1. Process Simulation
2. Distillation Hydraulics – KLM and third party
3. Tower Installation Supervision and Inspection
4. Unit Troubleshooting
5. Unit Commissioning
6. Training for your team
7. Thirty Plus Years Process Engineering Experience

# KLM Core Business

# Process Equipment

**KLM as an EPC Company can purchase from many of the major equipment suppliers.**

- **Distillation Equipment**
  - **Towers Shells**
  - **Random Packing**
  - **Structured Packing**
  - **Trays**
- **Heat Exchange Equipment**
- **Pumps and Compressors**

# KLM Core Business

## Process Equipment

**Distillation Equipment**

**Can be ordered with normal lead times or can be sources for immediate replacement**

**Random Packing**

- **KLM has a stock of random packing in key Countries for Immediate replacement**

**Structured Packing**

- **KLM has a stock of Structured Packing in key countries for immediate replacement**

# KLM Core Business

## Process Equipment

**KLM buys a large volume of process equipment each year, because we buy heat exchangers, pumps and distillation equipment for many end users.**

**Many times, our cost to the end user is lower than they can negotiate themselves because the end user may only be buying a few items per year and the vendor adds a large profit margin.**

**Be sure and let KLM bid on your projects.**

# Choice of Distillation Device



There are rules for which Distillation Device should be utilized based on Pressure, Flow and Fouling Tendencies

Pressure

For high pressure applications trays should be utilized, above 150 PSIG (10 Bar). Tray efficiency increases with pressure where packing efficiency decreases.

There is a back mixing effect for packing at high pressures, so it is difficult to guarantee the efficiency at high pressures. Tray efficiency can be guaranteed at high pressures.

For lower pressure application, 1 bar and Vacuum systems, packing has much higher efficiency which can be guaranteed.

# Choice of Distillation Device



**There are rules for which Distillation Device should be utilized based on Pressure, Flow and Fouling Tendencies**

**Flow**

**For high flow parameters trays are preferred.**

**For low flow parameters packing may be utilized.**

# Choice of Distillation Device



There are rules for which Distillation Device should be utilized based on Pressure, Flow and Fouling Tendencies

Fouling Tendencies

For high fouling system a well-designed anti fouling tray is the best option

With the proper distributors structured packing has worked well in Refinery Vacuum Tower which is a highly fouling service.

For fouling systems random packing may be the last choice. Random packing has horizonal components which enhance fouling.

## Distributor Quality

For Packing systems, every designer will mention that the packing only works a well as the distributor, and then they normally provide a not optimized distributor.

Normal industry standard distributors average about 92% distribution quality. Below 90% is consider poor and 94% is achievable. Some distributors are well below 90% due to poor design and poor installation.

## Distributor Quality

For structured packing, the top two layers distribute the liquid.

If each layer is 300mm and you have a 3-meter bed, you have lost efficiency in the top two layers (600mm) which is 20% of the bed height.

Remember, higher efficiency will save energy and reduce energy cost.

## Distributor Quality

For random packing, the packing will mix the liquid some, but not like the structured packing. It is more important to have an optimized distributor for random packing to increase efficiency and reduce energy.

KLM optimizes distributor design to gain as much distribution as possible, to improve the packing efficiency, reduce energy cost and saves money.

With energy in USA at USD $4.00 MMBtu and in Asia at 15.00 MMBtu, it does not take much energy saving to be real money.

# Distributor Quality – Ideal Distributor

- Uniform liquid distribution
- Proper operation through it turn down range
- Low vapor phase pressure drop
- Resistance to plugging or fouling
- Optimal use of vessel height
- Minimal liquid residence time
- Mixing capability for redistribution to the next bed

## Reasons to Split a Bed and Redistribute the liquid

- Feed Introduction
- Product Side Draw
- High theoretical stage count
- Desire to cross mix the liquid phase
- Liquid maldistribution
- Physical weight of the bed

# Distributors



**The introduction of vapor and liquid to the packing is very important. Trays will normally eventually equalize whatever mal-distribution is developed by the vapor and liquid feeds.**

**Packing will enhance whatever mal-distribution is developed by the introduction of the vapor and liquid feeds.**

# Distributors



As the liquid rate on a distributor is increased, the cross-flow capability of the distributor and its pre-distribution system become more critical.

Since gravity fed distributors are dependent on liquid level to determine flow, the liquid must be carefully balanced in order to provide point-to-point flow uniformity.

# Distributors



It is important that the pre-distribution system properly meters liquid flow to the distributor without inducing excessive horizontal flow velocities, gradients in liquid head or turbulence.

Pre-distribution is achieved by use of feed pipes, pre-distribution channels and/or parting boxes.

The design of the pre-distribution systems becomes increasingly complex as the specific liquid rate and/or the column diameter increases.

# Distributors



**Typically, the higher efficiency the packings, the more uniform the liquid distribution is needed.**

**Examples of the services which require high performance distributors when structured packings or the high-performance random rings where HETP of less than 600 mm / 2 ft are used:**

- **Distillation**
- **Mass-transfer processes approaching equilibrium**
- **Heat-transfer applications with close approach temperature**

# Distributors

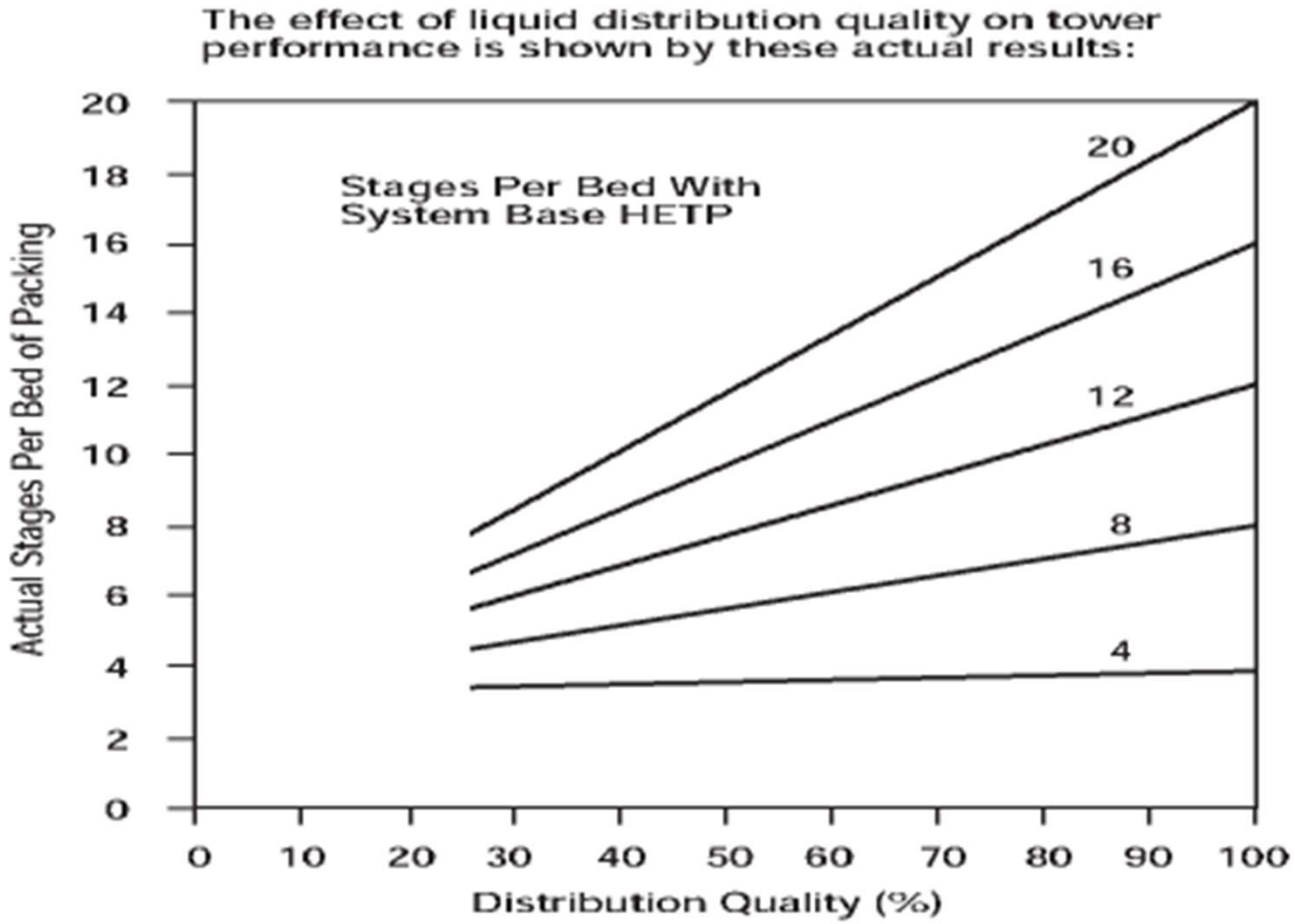


Traditional distributors can work well with the low efficiency packings, like Pall Rings, saddles and grids, in general absorption, stripping and heat transfer applications.

High performance distributors often require more custom designs and careful hydraulic tests than “traditional” distributors.

Traditional distributors take advantage of standardized, pre-engineered design and the optimal use of raw material, although these distributors do not generally provide liquid flow uniformity comparable to the high-performance distributors.

# Distributor Quality



## Feed Introduction

Introduction of a liquid or vapor feed to a tower requires a space in the packing and redistribute the liquid phase.

Normally, unless the feed rate is very small or very large compared to the flow rate the internal column liquid from the bed above, it is desirable to mix the feed with the internal liquid to provide compositional and temperature uniformity before distributing it to the packed bed below.

## Liquid Redistribution

Liquid cross-mixing and maldistribution correction often go hand-in-hand. When a packed tower is designed with a large number of theoretical stages or transfer units, a constant liquid-to-vapor ratio (L/V) is needed to achieve the best overall column performance.

Redistribution of the liquid ensures that the L/V ratio is maintained, while cross-mixing between beds ensures uniform composition.

A single bed should be limited to no more than 20 theoretical stages or 30 ft of packing height.

## Liquid Redistribution

**Redistribution of liquid should be considered when:**

a. **Tower is large in diameter and when beds have high theoretical stage count (>=8).**
b. **Feed is sub cooled over 30 degree F.**
c. **Feed composition does not match with tower internal flow.**

## Drip Point Density

Drip Point Density has an influence on the efficiency of the uppermost part of a packed bed, especially for high surface area and very high efficiency packings.

High drip point densities can affect the cost of high-performance distributor and can also limit the vapor capacity for some distributor types.

In addition, distributors with high drip point densities can be prone to fouling due to small orifice diameters.

## Recommended Drip Point Density

| | 5.5 pts/ft2<br>60 pts/m2 | 8 pts/ft2<br>85 pts/m2 | 12 pt/ft2<br>130 pts/m2 |
|---|---|---|---|
| Wire Gauze Packing | | | Recommended |
| Structured Packing | 250 Y and larger | 350 Y | |
| Random Packing KLM I Style | 25 and larger | 15 and smaller | |
| Random Packing KLM P Style | 25 and larger | 15 and smaller | |

## Distributor Orifice Size

**Distributor Orifice Size is typically in a range of 5-30 mm (0.2-1.2 inches).**

**The smaller the orifice sizes, the higher the drip point density, but the lower the fouling resistance.**

**Therefore the choice of orifice sizes and the distributor type should be dependent on fouling potentials.**

## Operating Range

Operating Range of a distributor with a single level orifice can be 60 to 120% of design flow. A distributor is designed to give its best performance at and around 100% of design liquid flow rate.

As the rate decreases and the liquid head drops, levelness of the distributor as well as gradients in liquid level becomes a large percentage of the operating liquid head.

At some turndown rate, the flow variation from point to point will fall outside of acceptable limits.

## Micro / Macro Maldistribution

Micro maldistribution is characterized by small-scale variations in mass flows across the column area. Generally, a packed column has a reasonable tolerance for micro maldistribution.

In contrast, a packed tower will not be able to perform as expected with the macro maldistribution, as a result of poor design, faulty installation, or compromised mechanical integrity to either the distributor or the packing.

The pre-distribution system like the feed branch pipes and parting boxes must be checked and rated to avoid the large scale bias like flows to walls, center, one side or one quadrant of the tower area.

## Liquid Distributor Selection

**Following factors should be considered when selecting a liquid distributor:**

- **Type and size of packing to be used**
- **Fouling tendency of the service**
- **Fractionation or heat transfer service (required distribution quality)**
- **Operating range required (Turndown)**
- **Tower diameter and space height available**

## Liquid Distributor Selection

Liquid distributors are usually classified into pressure distributors and gravity distributors. In general, pressure distributors provide more open area for vapor flow and tend to be less expensive, lighter, and to require smaller lead-up piping or pre-distribution system than gravity distributors.

Their disadvantages are high operating cost because of high pumping pressure drop, susceptibility to plugging, corrosion or erosion, entrainment, and a relatively low quality of liquid distribution.

The common pressure distributors are the perforated pipe type, the spray type and splash nozzle type

## Spray Nozzles

Spray Nozzles have a limited application window. They can only be utilized in low vapor applications due to the drift of the spray to the next level, reducing the overall efficiency of the column.

Spray Nozzles have an advantage that they have some mass transfer ability as compared to a distributors which has no real mass transfer ability.

The disadvantage is that the distribution quality for a Spray Nozzle is lower than a well-designed distributor.

## Liquid Distributor Selection

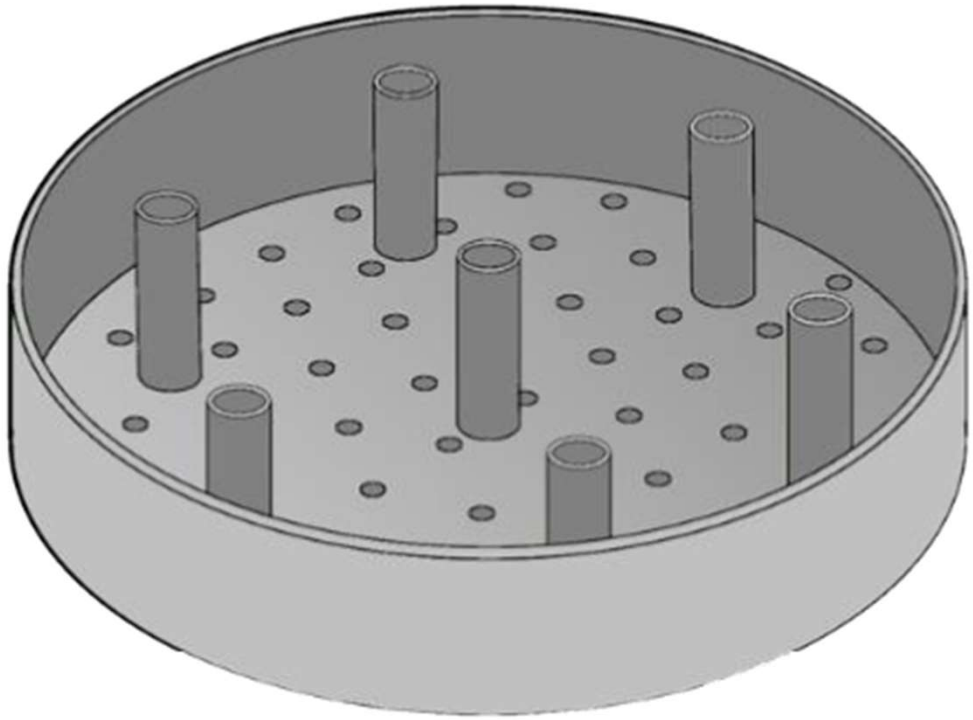
The common gravity distributors are the deck type, pan type, channel type and trough type.

Deck type distributors are clamped on an annular ring that is seal welded to the tower wall.

KLM rarely recommends deck and pan type distributors as they are prone to fouling.

# Distributors

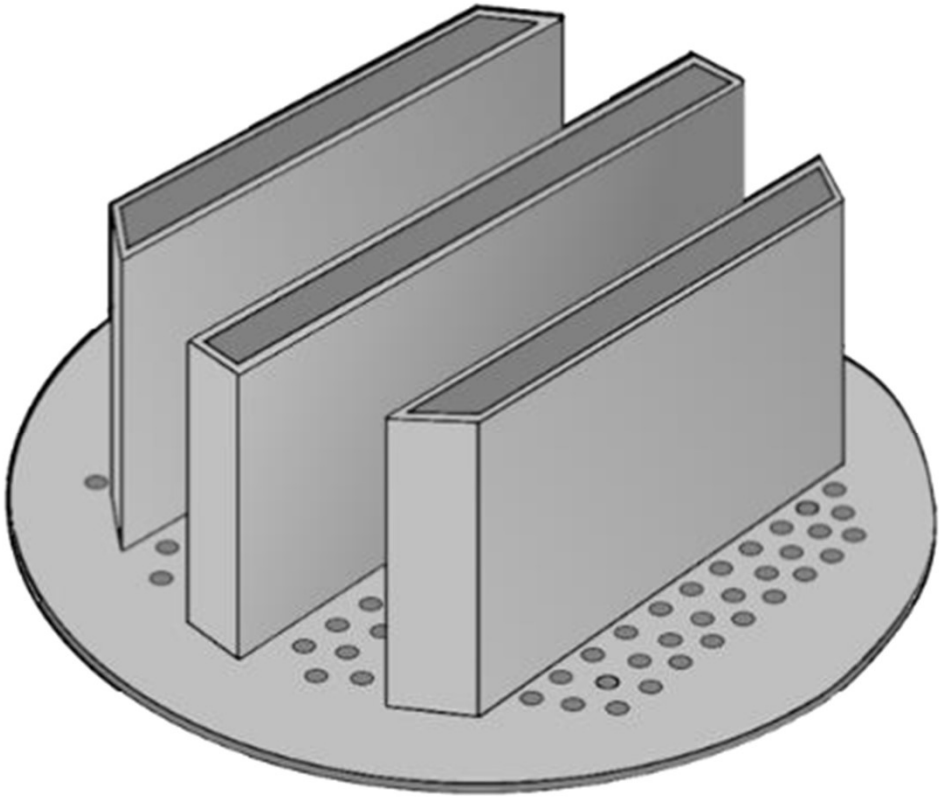




## Pan Type

# Distributors





## Deck Type

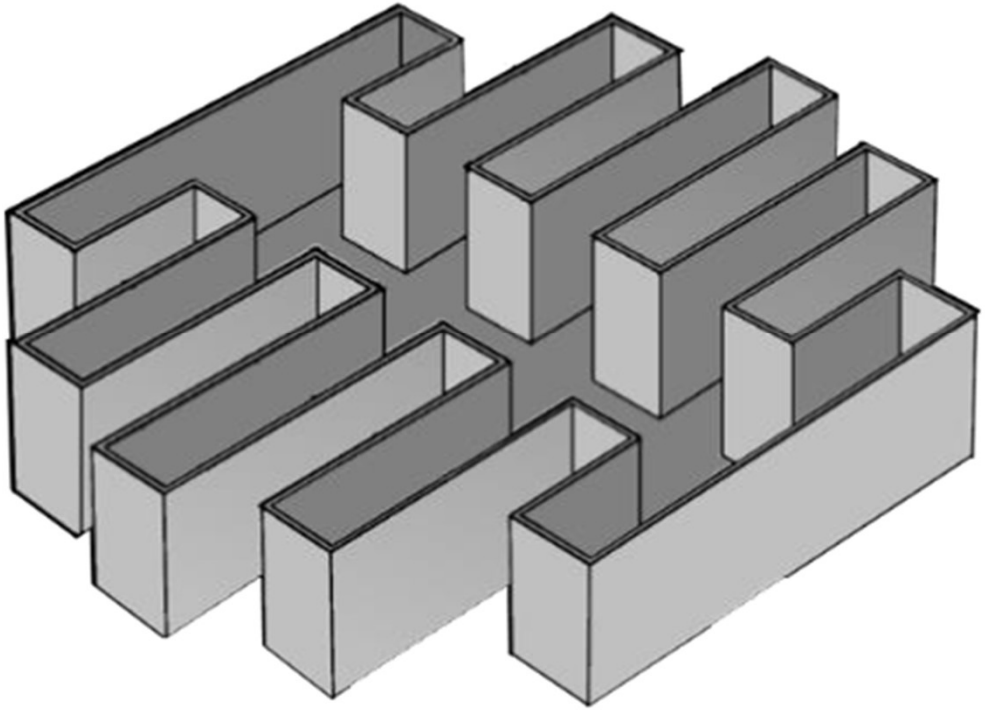
## Liquid Distributor Selection

**Channel type distributor has one center channel which provides cross flow capacity between troughs.**

**The center channel is designed as a structure member allowing the distributors to rest on a support ring and span column up to 20 ft (6m) without the need for additional beam.**

# Distributors





## Channel Type

## Liquid Distributor Selection

Trough type distributors include the troughs and the parting boxes above the troughs.

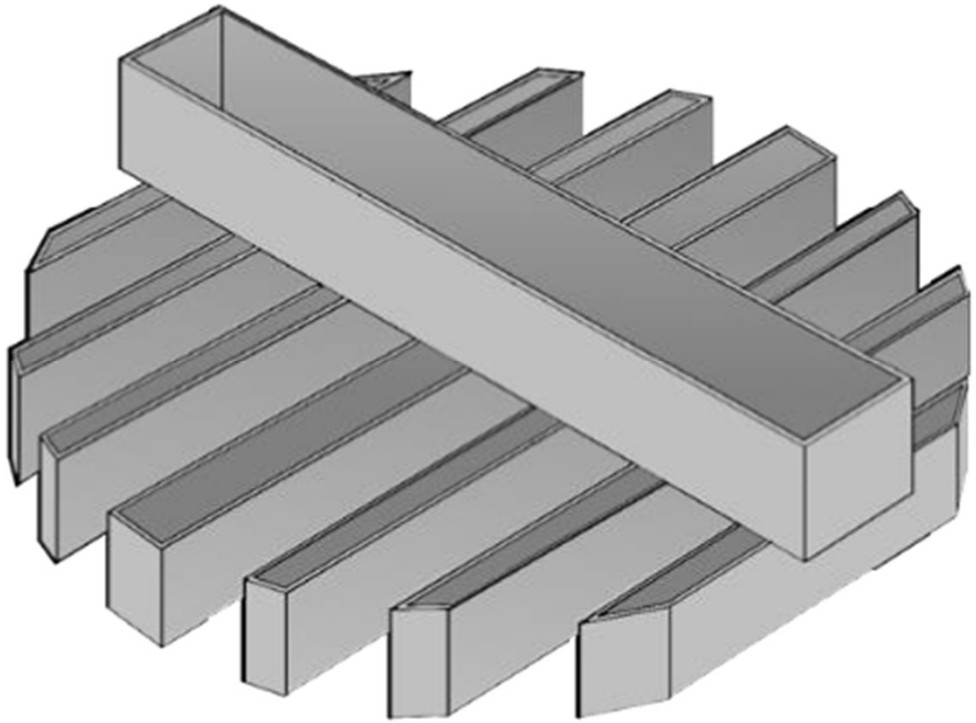
Different from the channel type, there is no flow communication between the troughs in the trough type distributors. The performance of parting box is critical.

The liquid drips from gravity distributors can be generated by passing the liquid through orifices, notches, or tubes on the bottom panels or the side walls of troughs.

The liquid from each drip point can be further conducted and/or dispersed into the lower vapor velocity region below the troughs, by baffles or other devices.

# Distributors





## Trough Type

# Distributors



## Trough Type

# Distributors



## Liquid Distributor Selection

Distributor Selection is based on Specific Liquid Loads and column diameters.

Liquid Loads and below 0.8 meter diameter

Low Liquid Load Distributor
Medium Liquid Load Channel Type Distributor
High Liquid Load Channel Type Distributor

Liquid Loads and above 0.8 meter diameter

Low Liquid Load Splash Plate Distributor
High Liquid Load Splash Plate Distributor

## Quality Suppliers-Buyer Beware

There are hundreds of Tray, Packing and Distributor Suppliers, some at very low cost. KLM only buys from Quality Suppliers that we have vetted.

Suppose you are buying trays and thickness is 0.30 mm. Low-cost vendor provides you thickness of 0.28, which is difficult to measure. His raw material cost is 6.66% percent lower.

This distributor / tray will have lower strength and corrosion resistance.

## Quality Suppliers-Buyer Beware

**Metallurgy is an important consideration in trays. A low-cost vendor buys slightly off spec metal at greatly reduced price from the metal supplier.**

**It is very important to confirm the metal specification. This can be easily done today with a Positive Material Identification Machine (PMI). Ensure your team checks the metal specifications.**

## Quality Suppliers-Buyer Beware

**There may be a good reason someone's trays are lower cost – and it may not actually save you money.**

## Equipment Installation

KLM can design and supply the very best distillation internals, but if they are not installed correctly the capacity and efficiency will be reduced.

Many organizations do not have the experienced tower inspectors because they only enter the towers on 3-to-5-year basis

KLM is happy to provide senior tower inspectors to assist in your turnaround and tower reviews.

## Equipment Installation

**KLM Service Technicians provide a valuable service to our customers by assuring that the distillation column equipment is installed properly, meeting KLM's installation specifications.**

**KLM Service Technicians are available as our customers need them, any time, anywhere, providing the following services;**

- **Inventory of mass transfer equipment at customer's site**
- **Supervision of installation to meet equipment specifications**

## Equipment Installation

**KLM Service Technicians are available as our customers need them, any time, anywhere, providing the following services;**

- **Observation and assessment of new and replacement column equipment**
- **Review and evaluation of existing mass transfer equipment**
- **Installation expediting and troubleshooting**
- **Turnaround and installation consulting**

# Column Hardware

**Column Hardware Can be ordered with normal lead times or can be sourced for immediate replacement**

**KLM has a stock of column hardware packing in key Countries for immediate replacement**

**We can also provide column hardware on a consignment basis for your turnaround**

# KLM Technology Group – Equipment References

1. Over 40 Distillation Projects with multiple columns
2. Over 40 Heat Exchangers
3. Over 25 Pumps
4. Over 20 Pressure Vessels

# KLM Technology Group

1. Solid Track Record of Projects since 2005.
2. Strength in Process Engineering
3. Distillation Equipment Supply
4. Strong Partners in Mechanical Engineering and Fabrication, especially Modular Fabrication.
5. Wide Range of Industries Serviced.
6. Ready to assist in your next project.

# *Thank You*