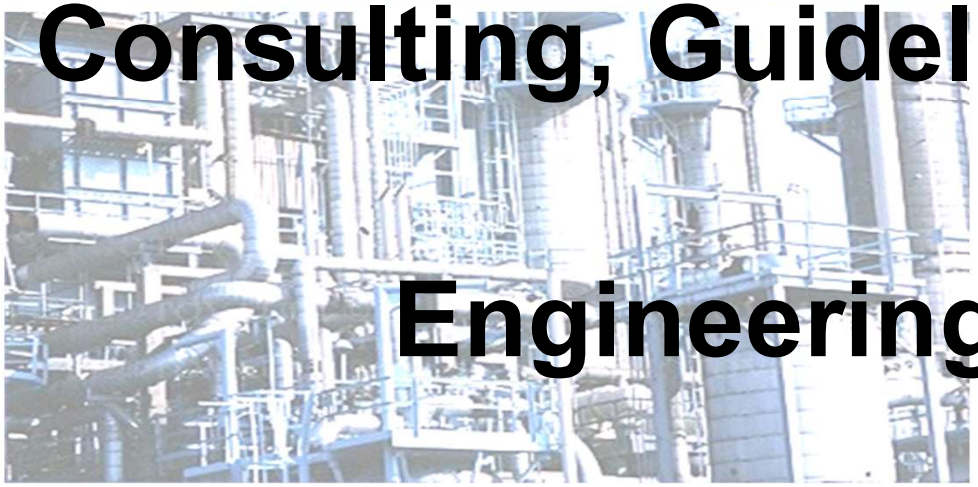
KLM Technology Group

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 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.

Tray Fundamentals

Trayed Columns utilize a pressure and temperature differential to separate the products. For most trayed columns, the weir holds a liquid level of each tray.

The vapor must over come this liquid head to move up the column. On the tray the vapor and liquid are contacted and then above the tray they are separated.

Types of Trays

There are many styles of trays and each style has its best application. There is not a one size fits all tray.

Dual Flow Trays – Early Trays

Bubble Cap Trays – 1920s

Sieve Deck Tray – 1950

Valve Tray – 1955

Fixed Valve Trays -1970s

Flow Advancement on the Tray – 1980s

Advanced Valves – 2000s

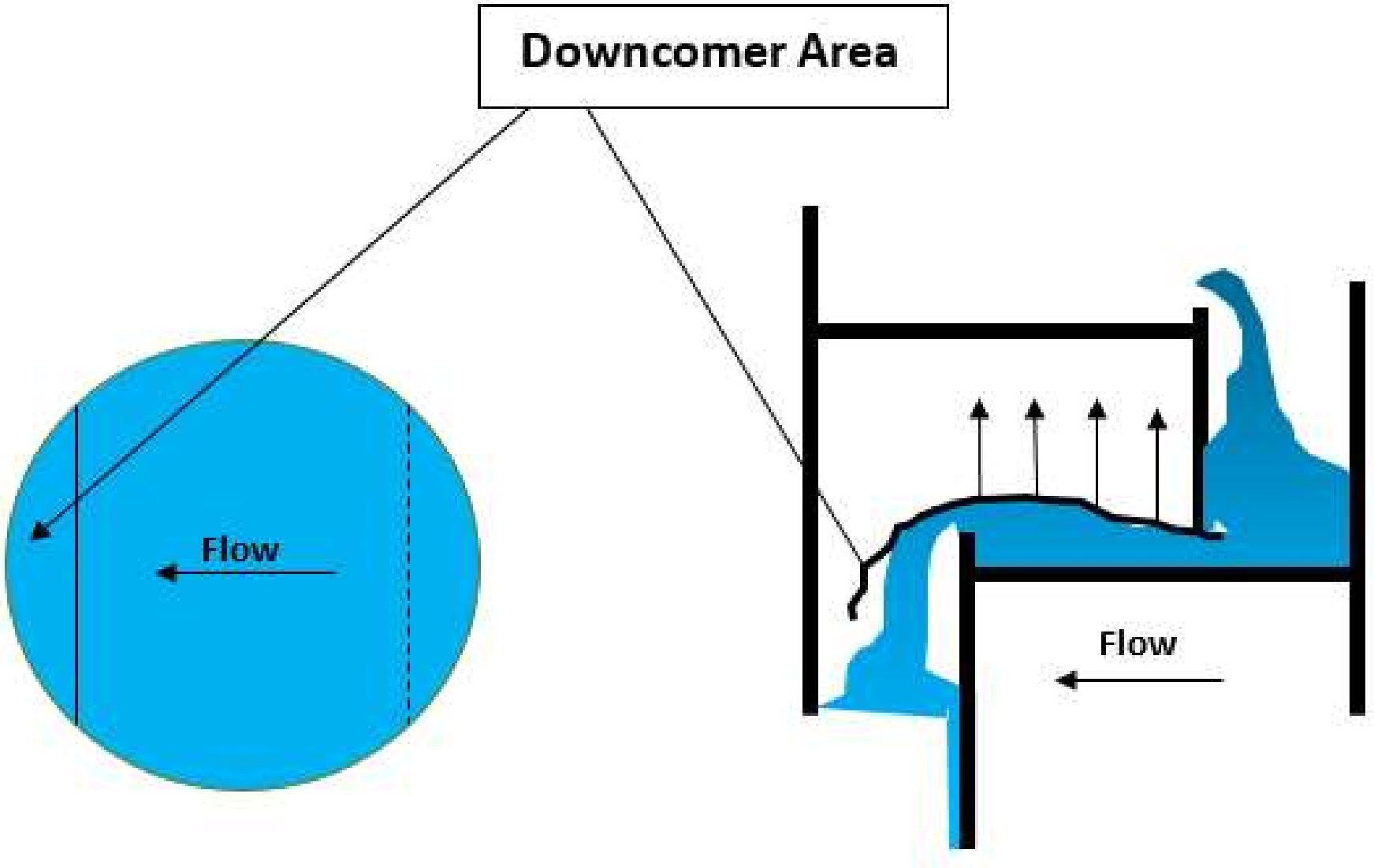
What is a Tray?

Different types of Liquid handling devices are used on a Tray.

Straight Downcomer
Sloped Downcomer
Truncated Downcomer

They all simply keep the liquid segregated from the vapor to enable good capacity.

Downcomer Area

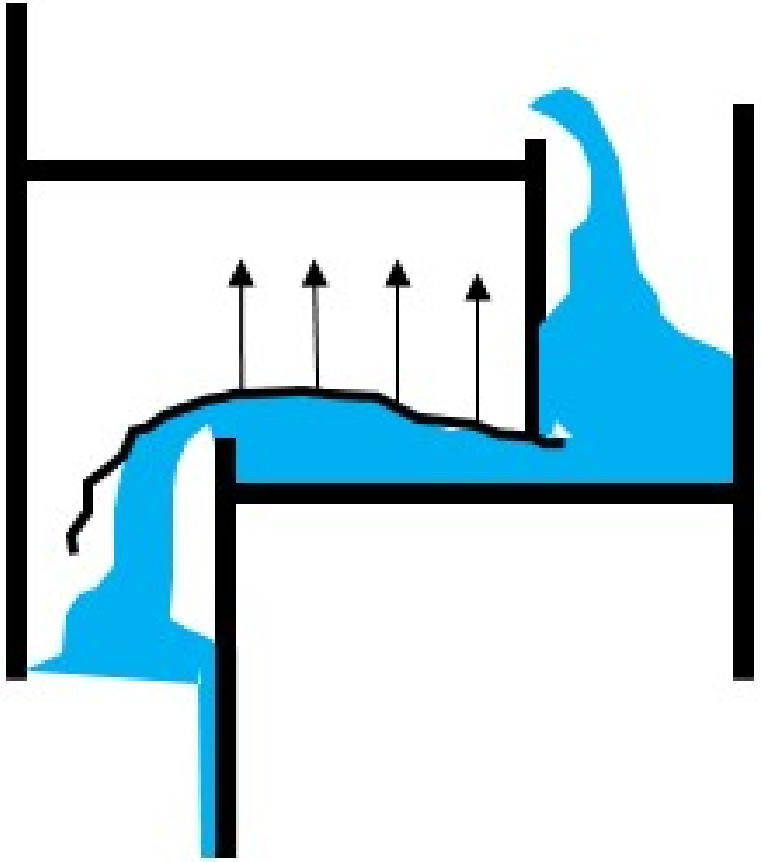


Straight Downcomer

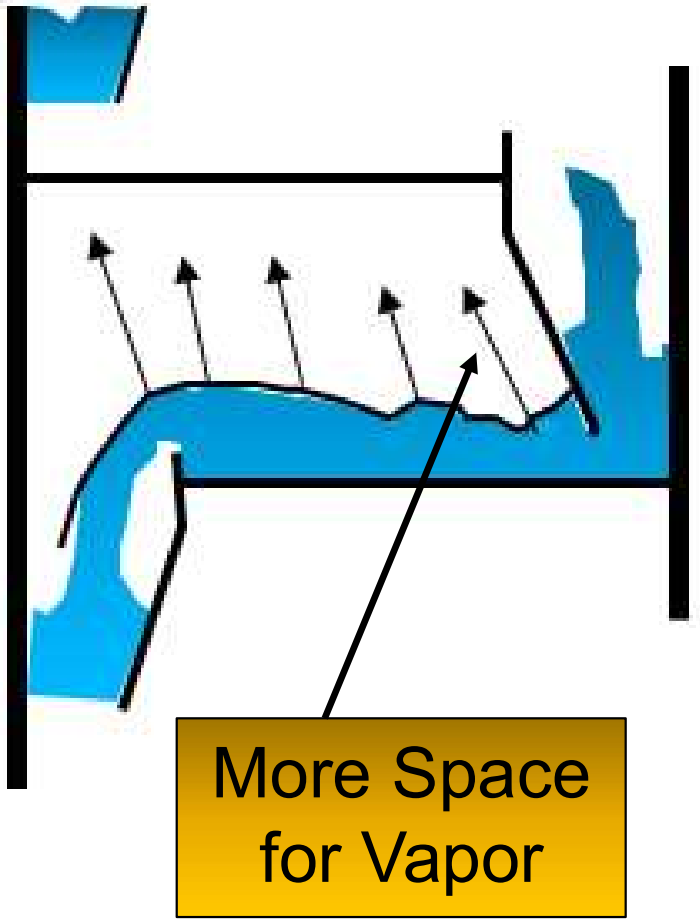
KLM Technology Group
Engineering Solutions

Sloped Downcomers

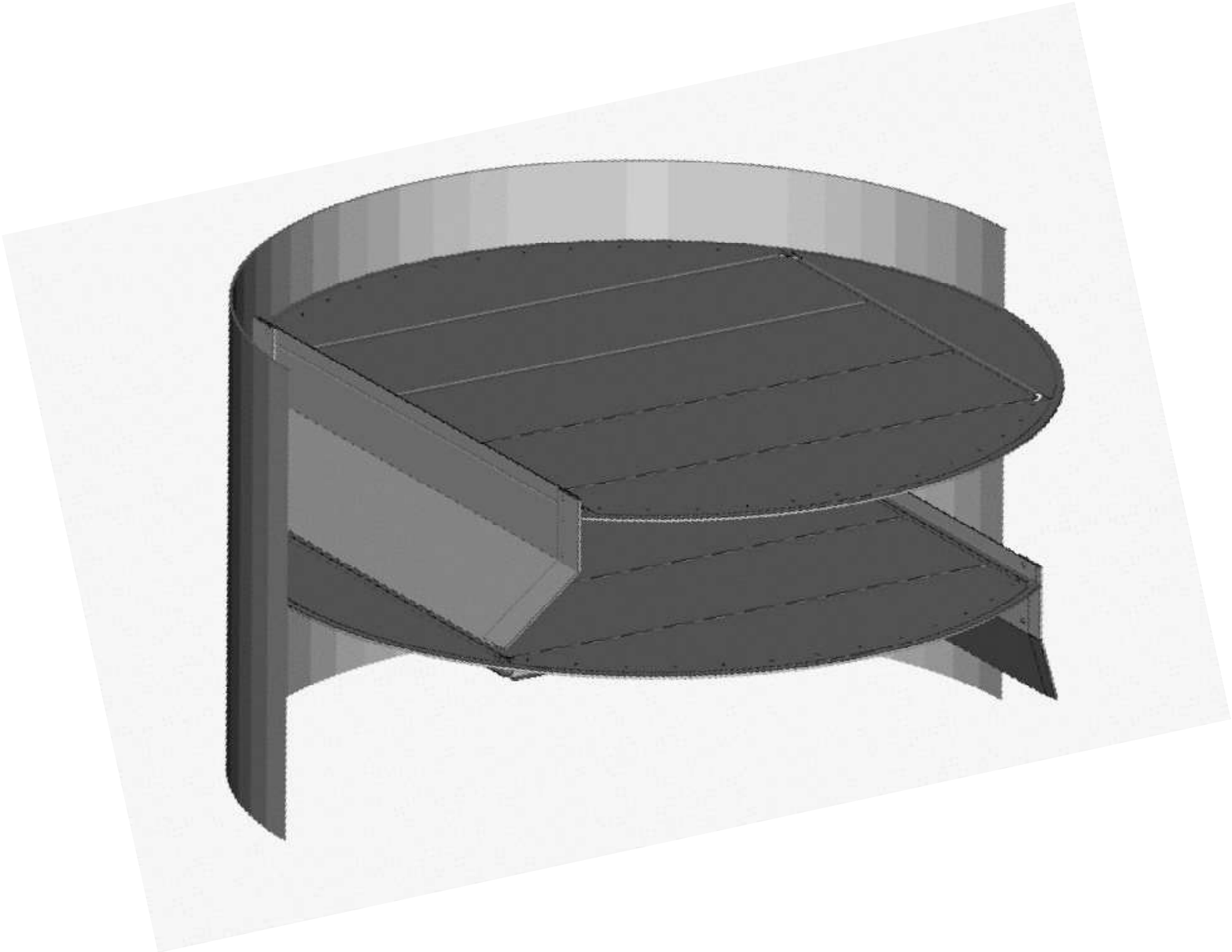
Straight Downcomer



Slopped Downcomer

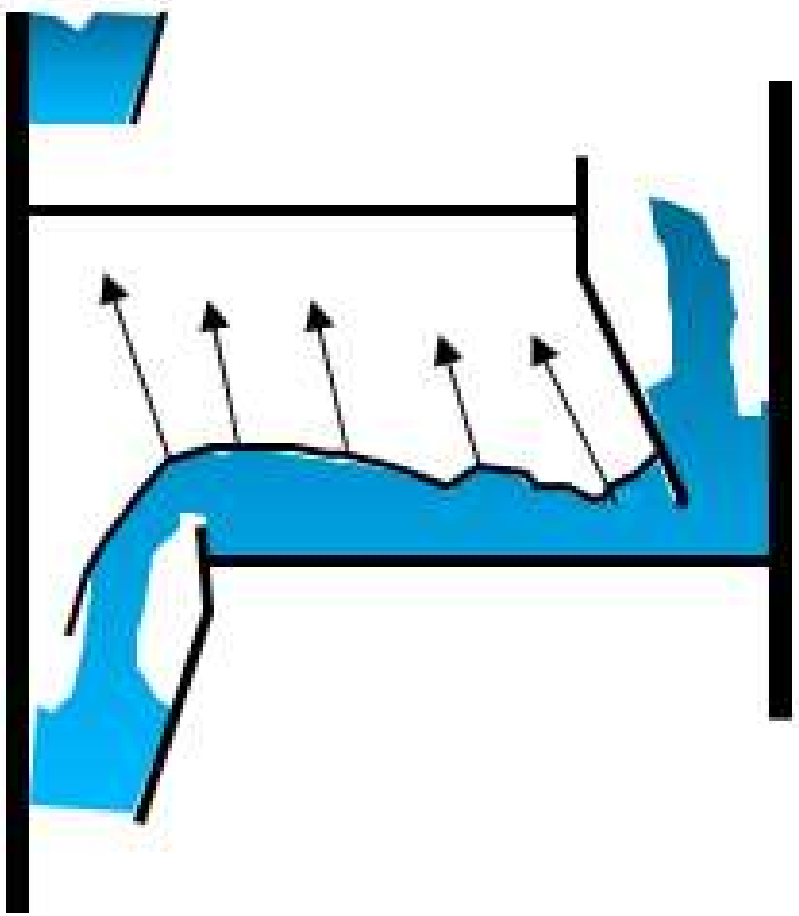


Sloped Downcomer

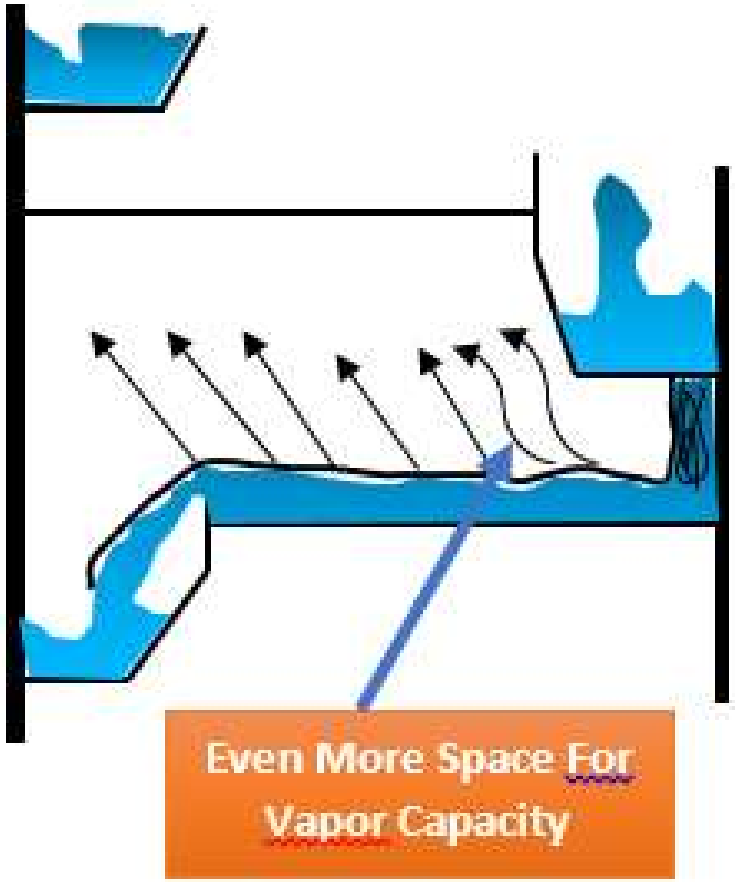


Truncated Downcomers

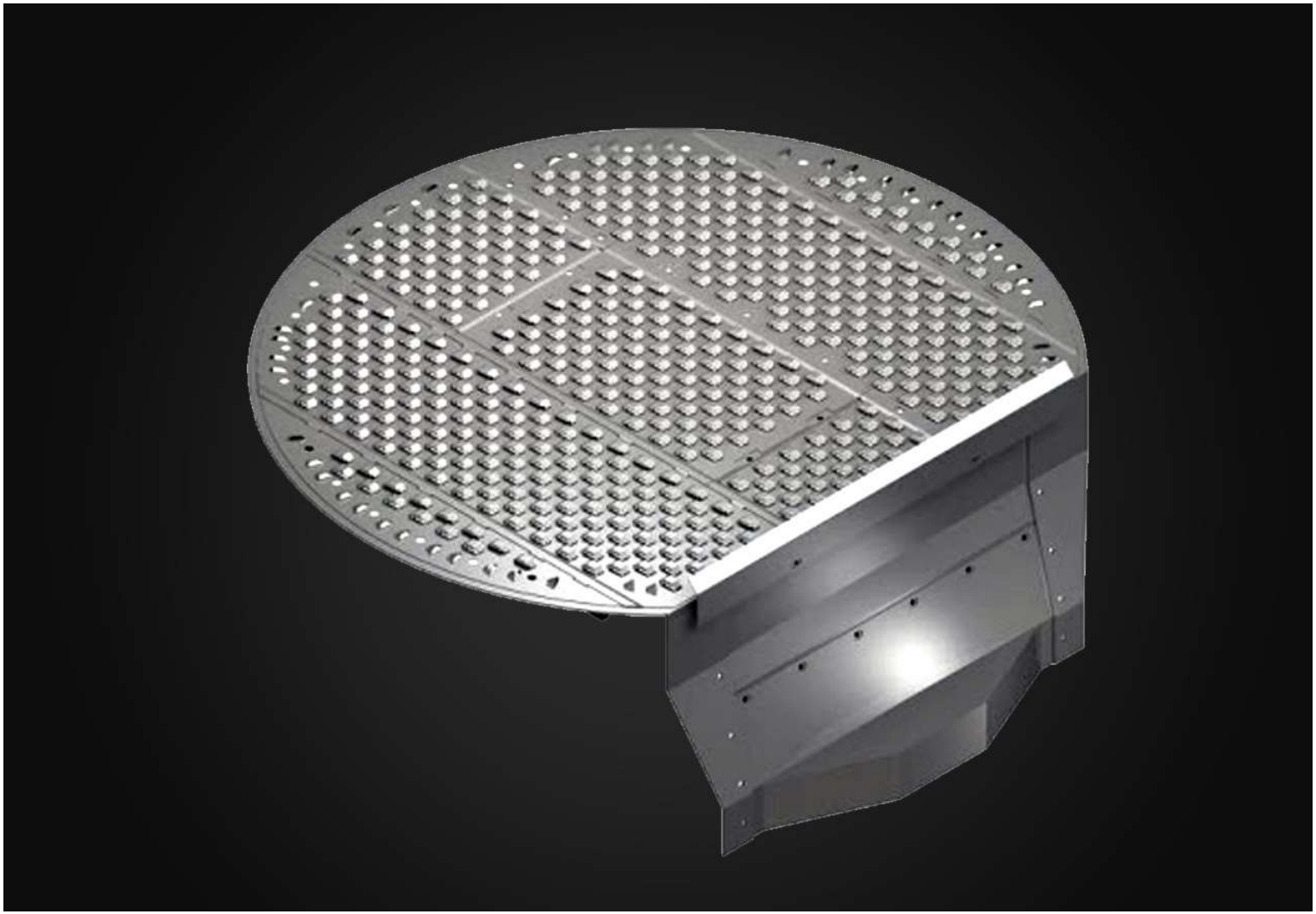
Slopped Downcomer



Truncated Downcomer



Truncated Downcomer



Design of Trays to Improve Efficiencies and Capacities

Improvement	Capacity	Efficiency
Base Straight Down commers and sieve decks	100	70
Slopped Down commers	103	70
Truncated Down Commers	107	70

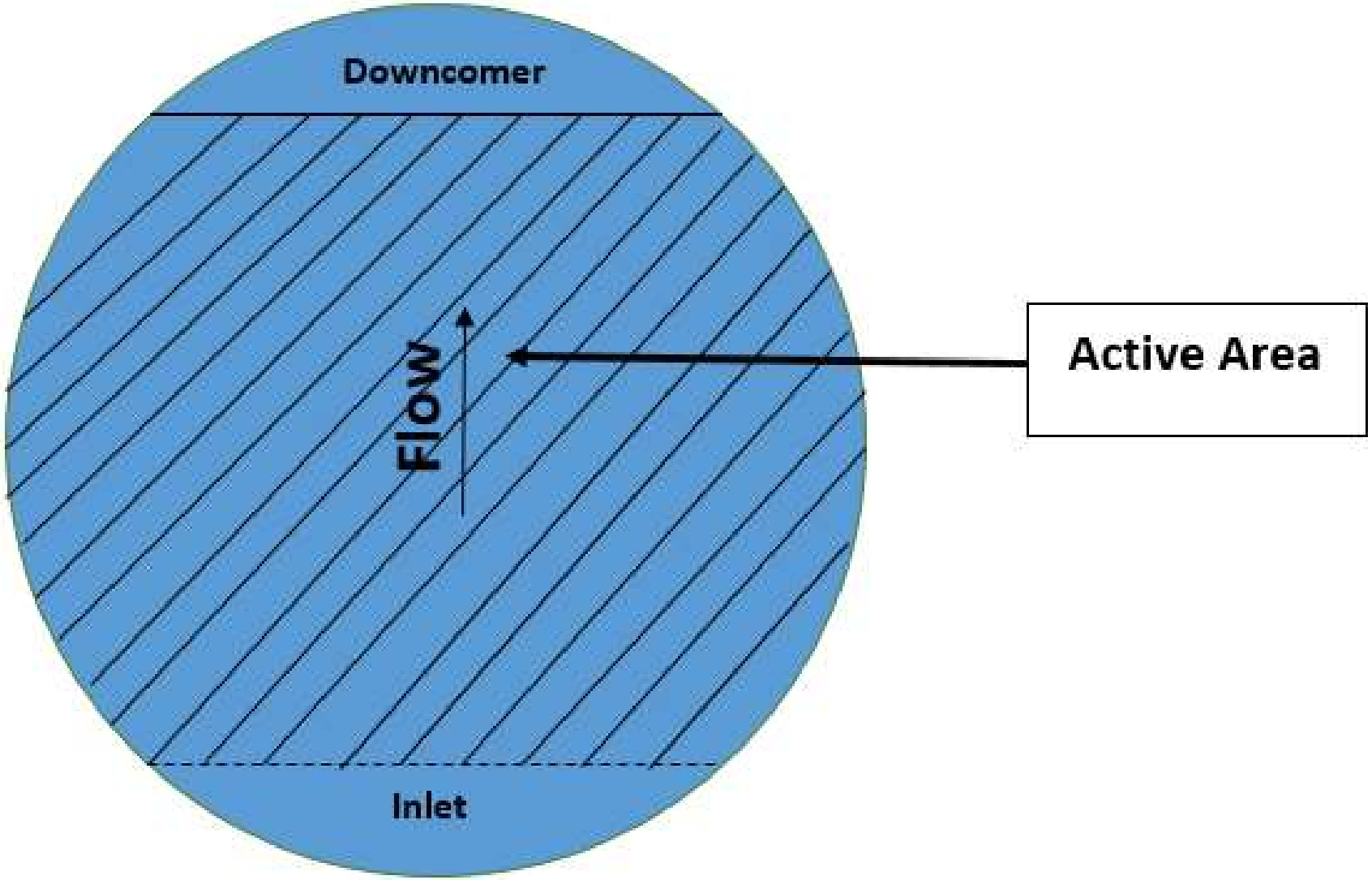
Items that lead to improvements in efficiency include;

1. Path flow length
2. Deck opening size
3. Optimized Valve type
4. Elimination of stagnant zones
5. Down comer outlet devices / froth promoters
6. Weir Heights
7. Hydraulic Rates
8. Feed Inlet Devices

Path Flow Length – For a conventional tray recommendation would be maintain above 500 mm. For a multiple downcomer recommendation would be to maintain above 300 mm

This is an indication of resident time on the tray. The higher the resident time the higher the efficiency. Because multiple downcomers have less resident time their efficiency is typically 10% lower.

Active Area



Design of Trays to Improve Efficiencies and Capacities

Improvement	Capacity	Efficiency
Base Straight Down commers and sieve decks	100	70
Slopped Down commers	103	70
Truncated Down Commers	107	70
Optimize Path Flow Length	107	- 10% to + 2%

Design of Trays to Improve Efficiencies and Capacities

Opening Size – There is an optimum bubble size, therefore an optimum opening size.

Too small or too large can effect the size of the bubble, leading to loss of efficiency.

Here is the normal trade off between capacity and efficiency.

Best tested is hole size is 12.5mm

Best open area is 8%

Design of Trays to Improve Efficiencies and Capacities

Improvement	Capacity	Efficiency
Base Straight Down commers and sieve decks	100	70
Slopped Down commers	103	70
Truncated Down Commers	107	70
Optimize Path Flow Length	107	- 10% to + 2%
Optimized Hole Size	107	-10%

Optimized Valve Type – Many types of Valves

1. Movable Valve - + 5% Capacity
2. Fixed Valve - + 10 to 15% Capacity
3. Optimized Valve - + 15% Capacity +10% efficiency

Design of Trays to Improve Efficiencies and Capacities

Improvement	Capacity	Efficiency
Base Straight Down commers and sieve decks	100	70
Slopped Down commers	103	70
Truncated Down Commers	107	70
Optimize Path Flow Length	107	- 10% to + 2%
Optimized Hole Size	107	-10%
Optimized Valves	117	75

Elimination of stagnant zones – parallel flow across a cordial surface can lead to stagnant areas.

Liquid directional valves can help eliminated the stagnant zones.

Two to Four Percent capacity and efficiency gains

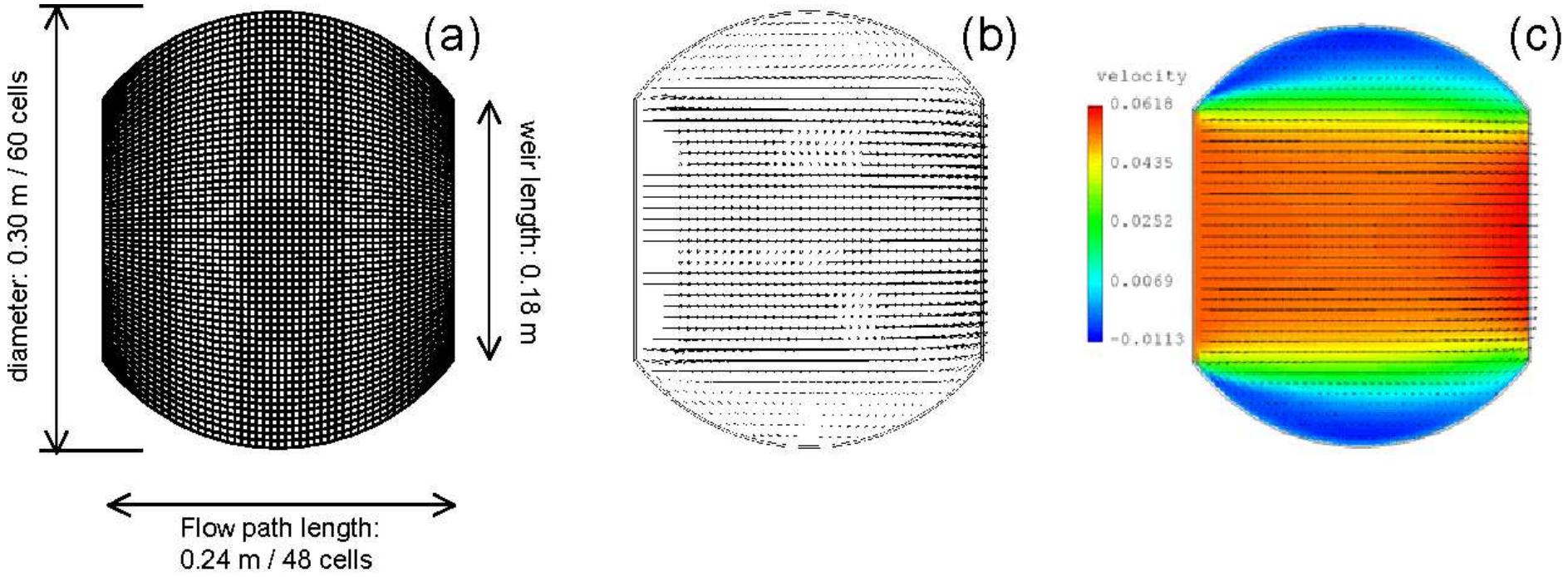
Concept

The devices force the liquid on the tray to go in directions it does not naturally wish to flow.

By strategically designing and placing the devices on the tray deck, plug flow of liquid is achieved and stagnation eliminated.

Design of Trays to Improve Efficiencies and Capacities

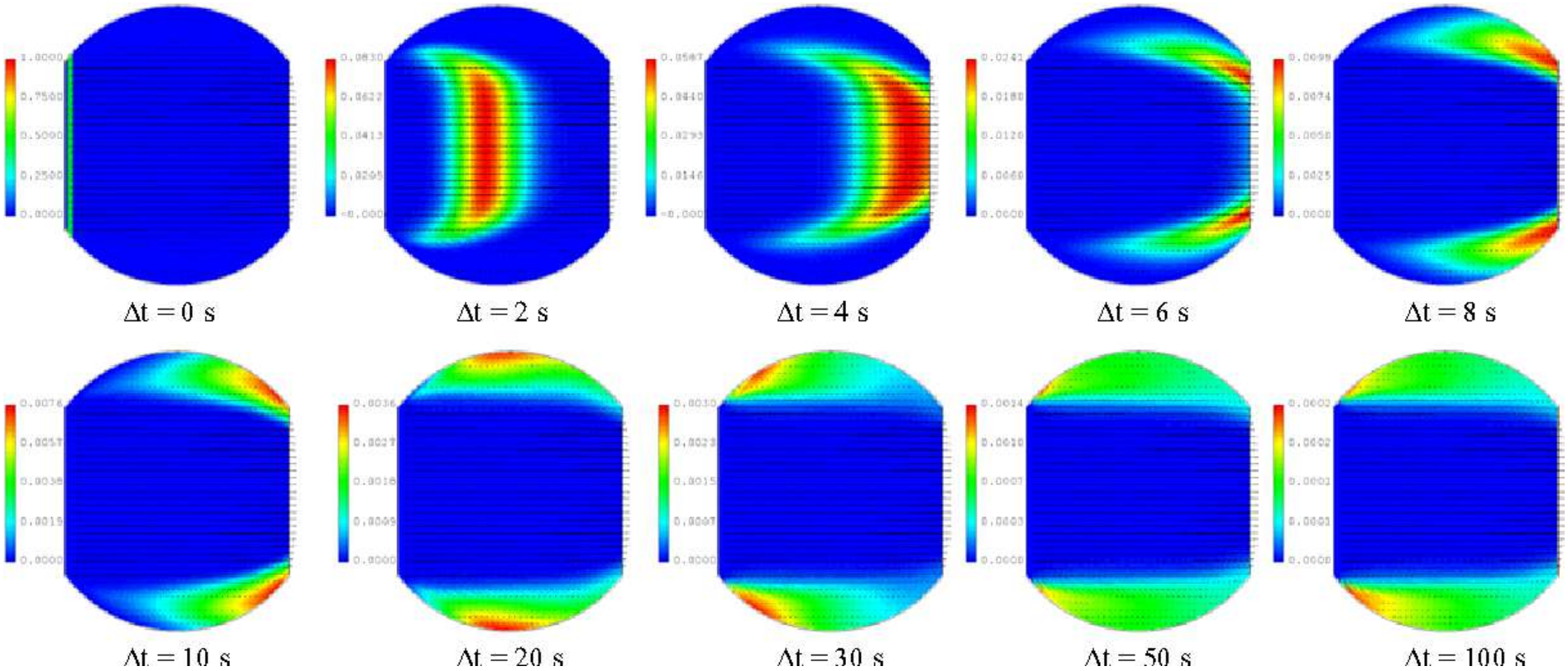
KLM Technology Group
Engineering Solutions



From - MODELLING SIEVE TRAY HYDRAULICS USING COMPUTATIONAL FLUID DYNAMICS
R Krishna J Baten

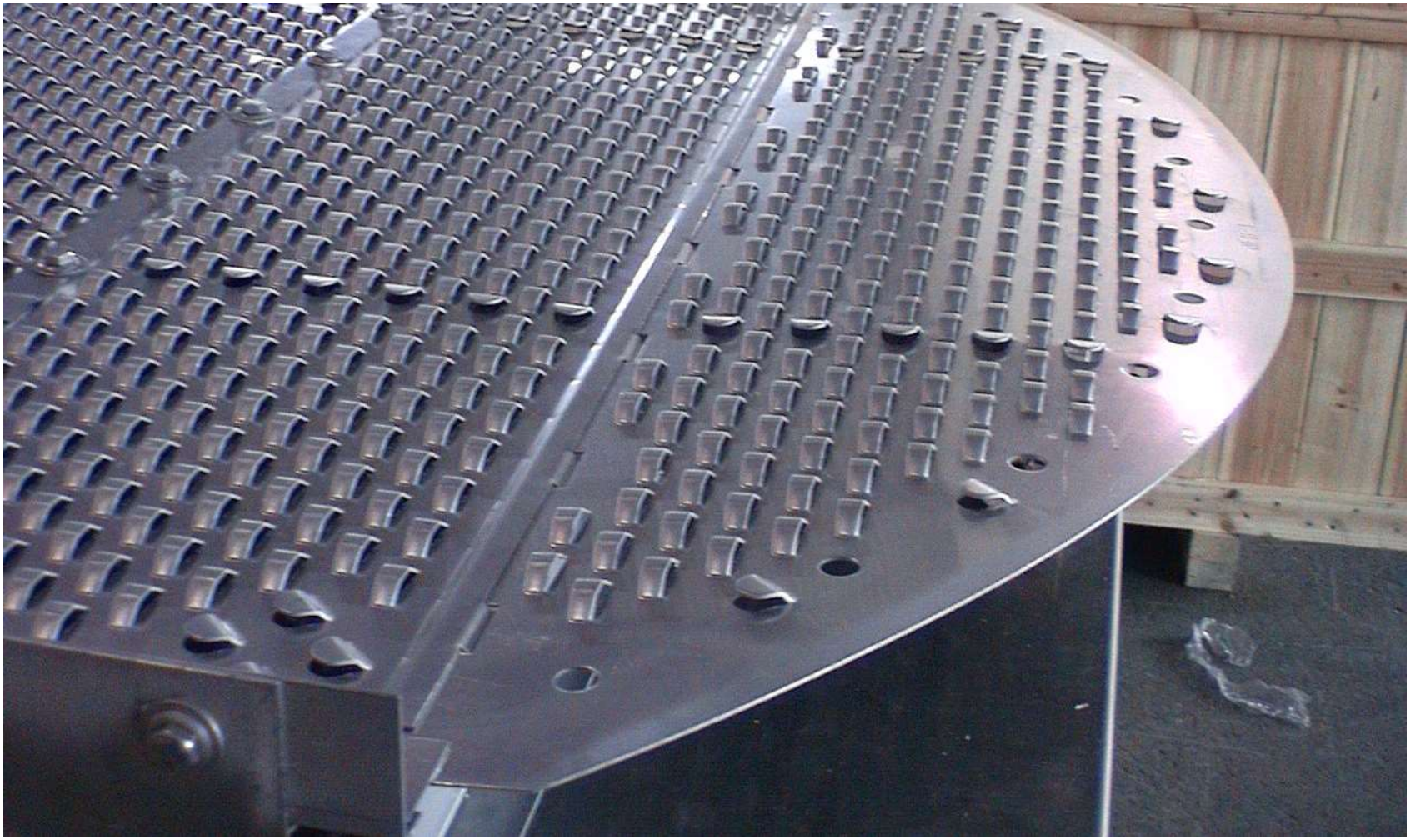
Design of Trays to Improve Efficiencies and Capacities

KLM Technology Group
Engineering Solutions



From - MODELLING SIEVE TRAY HYDRAULICS USING COMPUTATIONAL FLUID DYNAMICS
R Krishna J Baten

Efficiency Enhancing Devices



Design of Trays to Improve Efficiencies and Capacities

Improvement	Capacity	Efficiency
Base Straight Down commers and sieve decks	100	70
Slopped Down commers	103	70
Truncated Down Commers	107	70
Optimize Path Flow Length	107	- 10% to + 2%
Optimized Hole Size	107	-10%
Optimized Valves	117	75
Eliminate Stagnant Zones	121	79

Down comer outlet devices / froth promoters – the clear liquid exiting the down comer becomes a froth on the tray.

Items that assist this froth generation improve efficiency. A small inlet weir will help efficiency, but should not be utilized in fouling service.

Design of Trays to Improve Efficiencies and Capacities

Here is a picture of an air / water tray test device.

At low vapor flow, the clear liquid is shown.

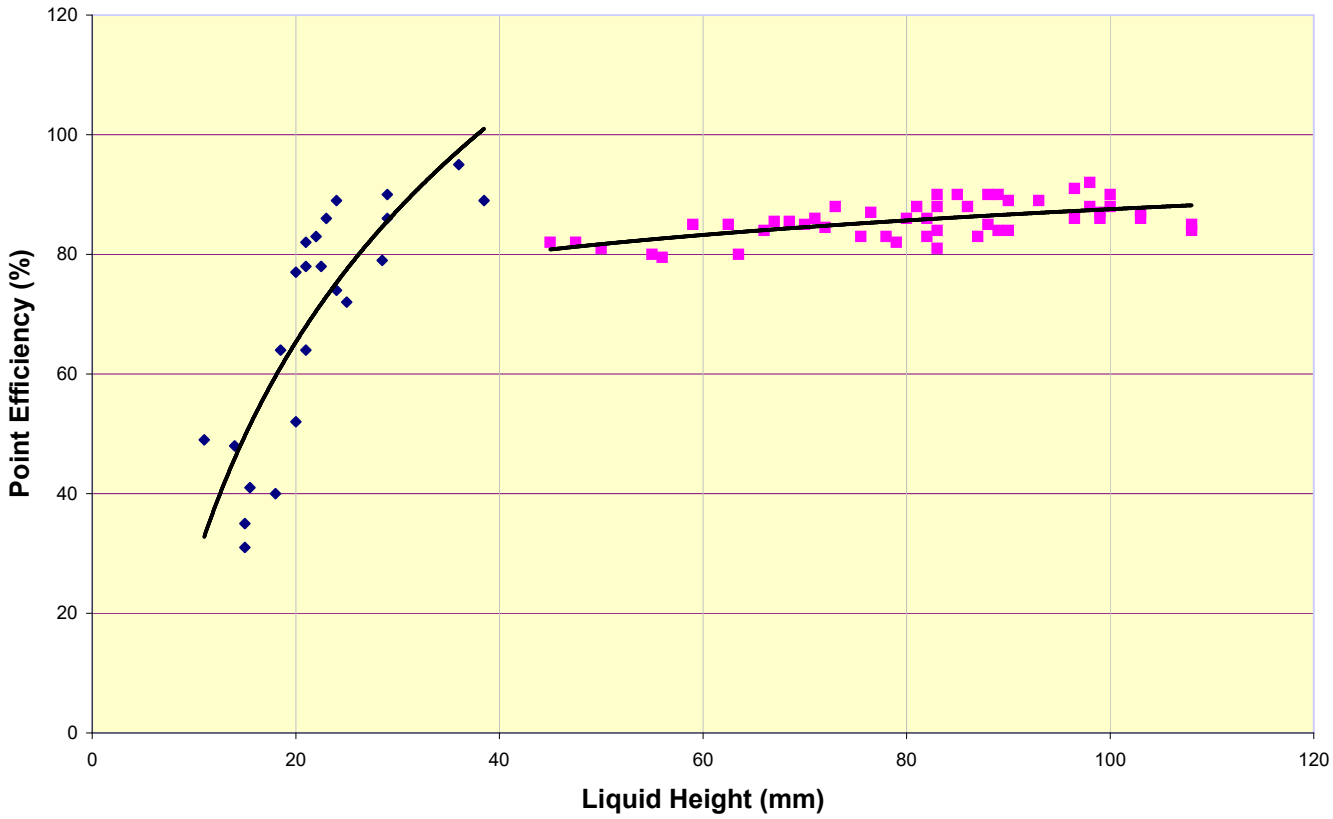
Design of Trays to Improve Efficiencies and Capacities

Improvement	Capacity	Efficiency
Base Straight Down commers and sieve decks	100	70
Slopped Down commers	103	70
Truncated Down Commers	107	70
Optimize Path Flow Length	107	- 10% to + 2%
Optimized Hole Size	107	-10%
Optimized Valves	117	75
Eliminate Stagnant Zones	121	79
Froth Promoters	121	81

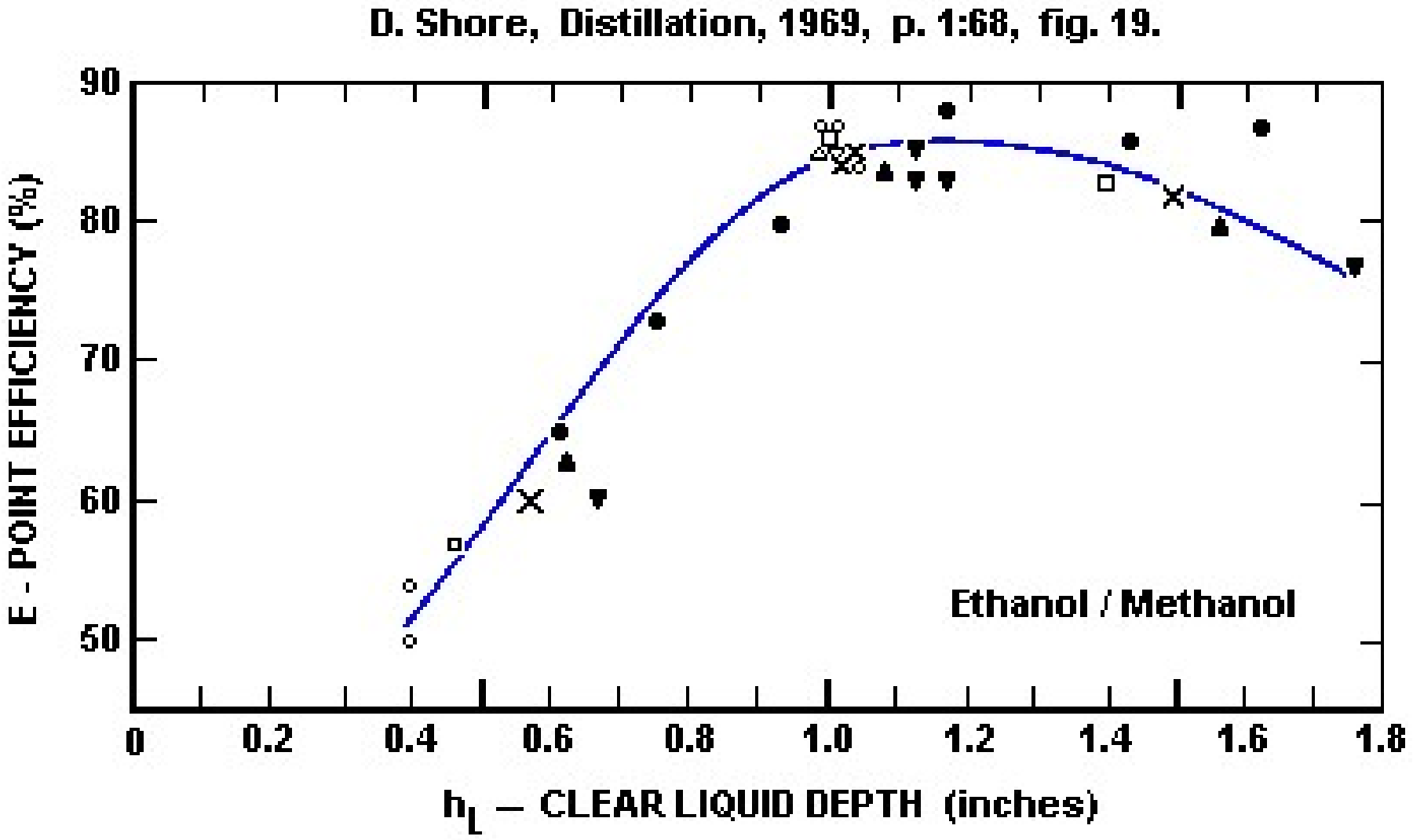
Design of Trays to Improve Efficiencies and Capacities

Weir Heights - The weir height has an effect on the tray efficiency.

Recommendations are not to exceed 100 mm or 1/6 of tray spacing, and 50 to 75 is suggested for all services except vacuum services.



Types of Stages



Design of Trays to Improve Efficiencies and Capacities

KLM Technology Group
Engineering Solutions

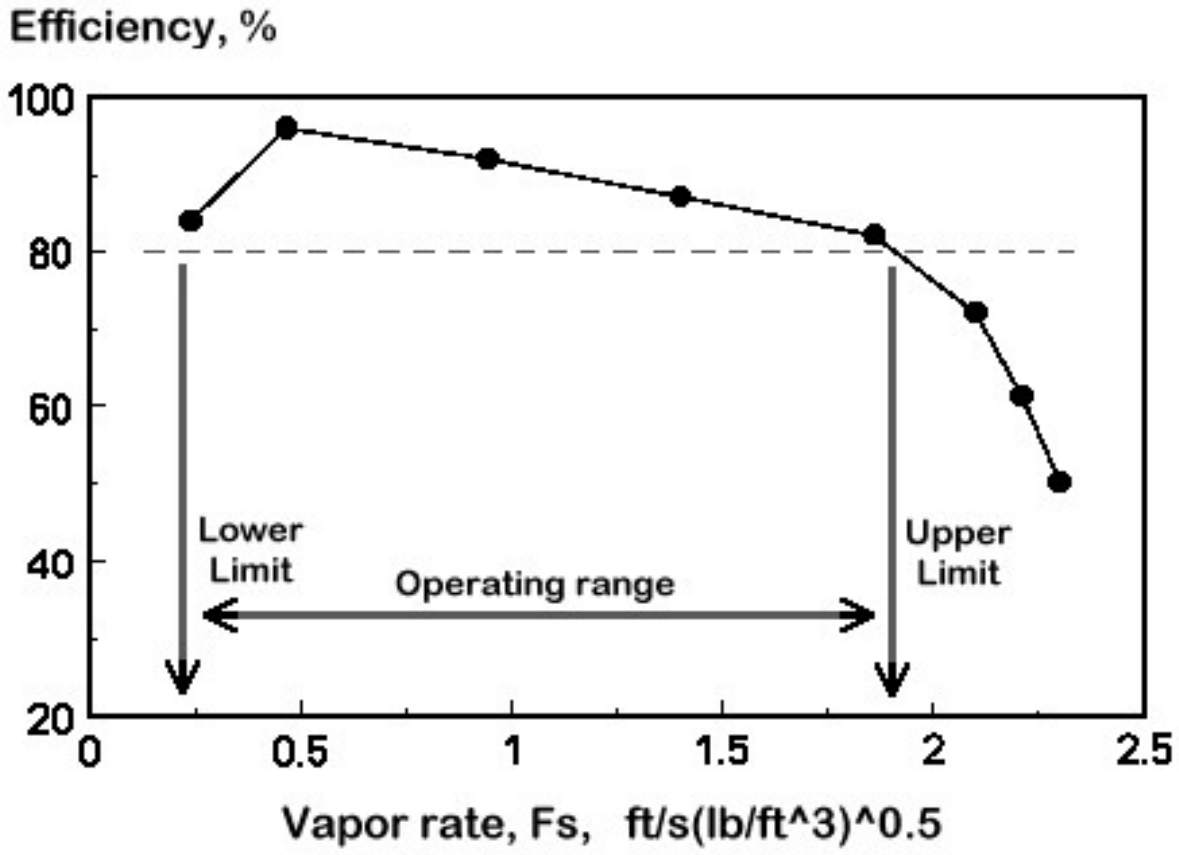
Improvement	Capacity	Efficiency
Base Straight Down commers and sieve decks	100	70
Slopped Down commers	103	70
Truncated Down Commers	107	70
Optimize Path Flow Length	107	- 10% to + 2%
Optimized Hole Size	107	-10%
Optimized Valves	117	75
Eliminate Stagnant Zones	121	79
Froth Promoters	121	81
Weir Heights	121	-10

Design of Trays to Improve Efficiencies and Capacities

Hydraulic Rates - The hydraulic rate has an effect on the tray efficiency.

At low rate trays will weep, at high rates froth touches the next tray.

When the V:L ratios are not equal molar, efficiency will decrease.



Design of Trays to Improve Efficiencies and Capacities

Improvement	Capacity	Efficiency
Base Straight Down commers and sieve decks	100	70
Slopped Down commers	103	70
Truncated Down Commers	107	70
Optimize Path Flow Length	107	- 10% to + 2%
Optimized Hole Size	107	-10%
Optimized Valves	117	75
Eliminate Stagnant Zones	121	79
Froth Promoters	121	81
Weir Heights	121	-10
Hydraulic Rate	121	-10

Feed Inlet Device – The Feed Inlet Device can disrupt the flow on the tray leading to lower efficiencies.

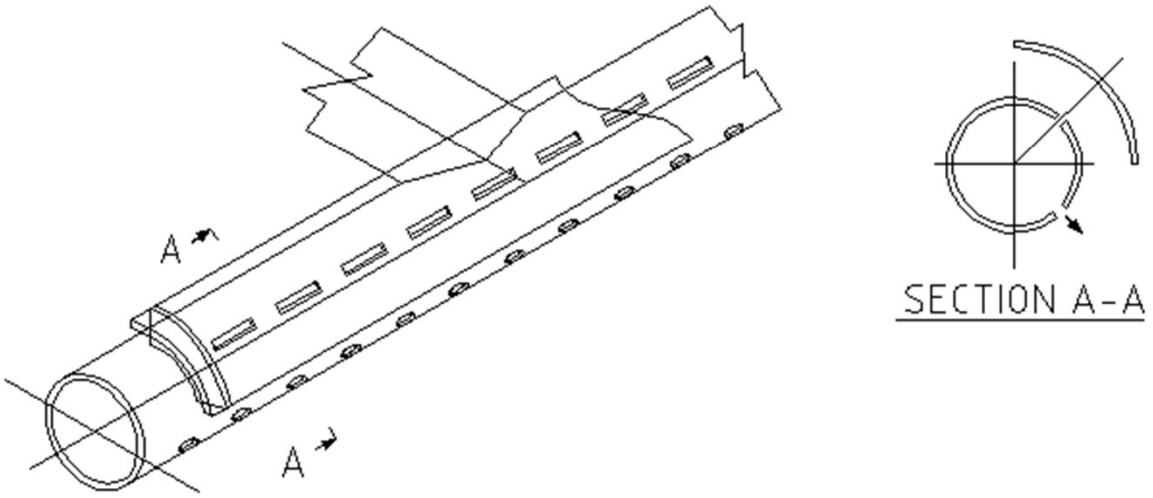
Reflux piping installed correctly

Feed Inlet Device – The Feed Inlet Device can disrupt the flow on the tray leading to lower efficiencies.

If you have a 30 tray column, each tray is 3.33% of tower efficiency – and you introduce the reflux poorly- you disrupt the flow on the top two trays at least – loss of about 5% of tower efficiency.

For a feed in the middle of the tower you can disrupt the flow for 3 trays – potential 6 to 9% of tower efficiency

Design of Trays to Improve Efficiencies and Capacities



Design of Trays to Improve Efficiencies and Capacities

KLM Technology Group
Engineering Solutions

Design of Trays to Improve Efficiencies and Capacities

Improvement	Capacity	Efficiency
Base Straight Down commers and sieve decks	100	70
Slopped Down commers	103	70
Truncated Down Commers	107	70
Optimize Path Flow Length	107	- 10% to + 2%
Optimized Hole Size	107	-10%
Optimized Valves	117	75
Eliminate Stagnant Zones	121	79
Froth Promoters	121	81
Weir Heights	121	-10
Hydraulic Rate	121	-10
Feed Inlet	121	-5

Internals Options - Trays

Tray Efficiency

Typical Tray Efficiencies are:

Demethanizer	**65%**	**Air Separation**	**90%**
Deethanizer	**70%**	**C_2 & C_3 Splitter**	**85%**
Depropanizer	**75%**	**Stabilizer**	**80%**
Debutanizer	**80%**	**Hydrocarbon/Water**	**15%**
Depentanizer	**85%**	**EB/Styrene**	**90%**
Low α Aromatics	**80%**		
High α Aromatics	**70%**		
Amine Contactor	**33%**		
Alcohol - Water	**75%**		

Quality Suppliers-Buyer Beware

There are hundreds of Tray 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 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