KLM Technology Group #033, Jalan Bayu 8/1, Taman Nusa Bayu, 79200 Iskandar Puteri, Johor, Malaysia	Kolmetz Handbook of Process Equipment Design DEMISTER PAD / MIST ELIMINATOR SELECTION, SIZING AND TROUBLESHOOTIN (ENGINEERING DESIGN GUIDELINES)	Co Author Rev 01 Utami Ledyana Daulay Rev 02 – Apriliana Dwijayanti Rev 03 – Apriliana Dwijayanti Editor / Author Karl Kolmetz

KLM Technology Group has developed; 1) Process Engineering Equipment Design Guidelines with examples of sizing, 2) Project Engineering Standards and Specifications, 3) Best Practices and 4) Unit Operations Manuals. Each has many hours of engineering development.

KLM can assist your team in providing Senior Engineering and Operations Staff to provide support for your local team in many areas.

Process Equipment Design, Commissioning, Distillation Tower Inspections, HAZOP Facilitation, Facility Siting, Process Engineering Consulting and Specialty Training.

KLM provides specialty equipment in Distillation Columns, Demister Pads, Heat Exchangers and Pumps.

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General Demister Pad / Mist Eliminator Design Flaws

Demister Pads and Mist Eliminators are one of the groups of process equipment that will follow the “Kolmetz Law of Project Stupidity”.

Kolmetz Law of Project Stupidity: a law strictly followed by most engineering projects.

“Save money and poorly design the process equipment by awarding it to the low-cost bidder. Loose money for the next twenty years on plant capacity, maintenance reliability, and excess energy.”

According to this law, awarding a process equipment contract to the lowest bidder may save you money in the short term, but it can cost you heavily in the long run. You may end up losing money for the next twenty years on plant capacity, maintenance reliability, and excess energy. So, next time you are tempted to cut corners, remember the Kolmetz Law of Project Stupidity.

Typically, demister pads are awarded to the lowest bidder with very low standards of guarantees. Typical guarantees by the manufacturers are hydraulic capacity only, and this test must be carried out within three to six months, while the demister pad is still clean and new. Typical process guarantees are by the process engineering company which includes capacity and mist removal, again the performance test must be carried out within three to six months.

Imagine buying a car and receiving a three-to-six-month warranty and only good gas milage for the first six months. You would think the car manufacturer was taking advantage of you, yet this is what we do for heat exchangers, and cars are much more complex than heat exchangers.

These design guidelines are believed to be as accurate as possible, but are very general and not for specific design cases. They were designed for engineers to do preliminary designs and process specification sheets. The final design must always be guaranteed for the service selected by the manufacturing vendor, but these guidelines will greatly reduce the amount of up front engineering hours that are required to develop the final design. The guidelines are a training tool for young engineers or a resource for engineers with experience.

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What are things that should be included in demister pad design that are not being utilized because of the sweetheart guarantees and low-cost bidders.

1. KLM is a recognized expert in Process Equipment Design, only utilize groups with technical expertise. This guideline has five sizing examples in the document and then in an excel spreadsheet.

2. KLM only partners with high quality suppliers, often from the same factories as the Original Equipment Manufacturers (OEM) and has senior inspectors to ensure your equipment is installed correctly

3. Anti Fouling Designs to improve the demister pad over the life of the run length, consider a two-stage demister pad with larger mesh on the bottom where the fouling occurs and smaller mesh on the top for increased removal.

4. Ensure correct metallurgy. Do not use Stainless Steel in Acid or Caustic Solution Servies as some Stainless Steel is not resistant to attack. Many vendors only supply stainless steel demister pads even though they know that this might be the wrong metallurgy for your application.

5. Review Galvanic Corrosion Potential for extended life. If you have polar liquids (water, acids, caustics) and a carbon steel vessel, stainless steel demister pads will experience bi-metallic corrosion with reduced life. Demister Pads can also be manufactured using plastics for highly corrosive environments.

6. Review the failures of the non-technical suppliers.

KLM can assist your team in providing Senior Engineering and Operations Staff to provide support for your local team in many areas including demister pads, distillation towers, heat exchanger and pump design.

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Table of Contents

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LIST OF FIGURES

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LIST OF TABLES

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INTRODUCTION

Scope

Mist elimination, or the removal of entrained liquid droplets from a vapor stream, is one of the most commonly encountered processes regardless of unit operation. Unfortunately, mist eliminators are often considered commodity items and are specified without attention to available technologies and design approaches. The engineered mist eliminator may reduce liquid carryover by a factor of one hundred or more relative to a standard unit, drop head losses by 50% or more, or increase capacity by factors of three or four. This manual summarizes cost effective approaches to reducing solvent losses or emissions, extending equipment life and maintenance cycles using proven and cost-effective technologies and techniques.

In the chemical process industry, there are a number of processes where gases and liquids come into contact with each other and whenever this happens the gas will entrain some number of liquid particles. This liquid phase which gets carried away into the gaseous phase can lead to a number of problems like loss of product, equipment damage, process inefficiency etc. and needs to be eliminated.

Mist elimination can be defined as the mechanical separation of liquids from gases. The equipment used for the removal of this entrainment is referred to as a mist eliminator or demister.

KLM Technology Group would be happy to assist in your needs for demister pads. We can engineer, supply or troubleshoot your application. Please contact us at info@klmtechgroup.com.

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General Design Consideration

In the chemical processing industry, there are many processes in which gases and liquids come into contact with each other, and whenever this occurs, the gas will entrain some number of liquid particles. Liquid entrainment in a process gas stream can be formed by either dynamic processes, such as contact between gas and liquid phases in a mass transfer operation, or thermal processes such as condensation. For example, droplets can result from bubbles bursting or jetting at a gas/liquid interface - typically in distillation columns, evaporators, bubble columns and flooded packed bed scrubbers. Where there is a high relative velocity between gas and liquid, droplets can be sheared from the wet surfaces. This type of problem is likely to occur in venturi scrubbers, two-phase flow in pipes and packings. The liquid that is carried into the gas may cause many problems, such as product loss, equipment damage, low efficiency, etc., so it needs to be eliminated.

Droplets can also be formed by thermodynamic changes in a system. For example, vapor condenses when saturated gases are cooled in condensers and heat exchangers and, although most of the liquid will remain on the heat transfer surfaces, the gas can become supersaturated in places causing droplet formation.

Demister Pads / Mist Eliminators

Mist eliminator can be defined to mechanically separate the gas and liquid. The equipment in the mist eliminator is called demister pads. Demister pads can help to improve the purity and extend equipment service life.

The role of droplet separators, demisters or mist eliminators is to remove a liquid from an air or gas flow using mechanical collection on a surface or on filaments. The liquid may be a pollutant or, like water, be per se benign, but in either case it is contaminating the air or gas.

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Separation of the liquid from the air or gas within a process may :

- prevent contamination of the process
- prevent damage to or corrosion of downstream equipment
- recover a useful product
- prevent bad atmospheric emissions

There are a number of industrial processes where in the liquid and the gas phases come into intimate direct contact with each other as a part of the process. As a result of viscous and aerodynamic forces, liquid droplets of various sizes are entrained and carried along with the moving gas stream. In most instances, it is desirable or even mandatory that these droplets be removed from the gas stream for different reasons.

Examples of such considerations are recovery of valuable products, improving emission control, protection of downstream equipment, and improving product purity. A typical use of mist eliminator takes place in such operations as distillation or fractionation, gas scrubbing, evaporative cooling, evaporation and boiling, trickle equipment for sewage and the like.

There are several devices which are offered to industry for separating the entrained liquid droplets and each of which are effective over their own particular range of mist size. Mist eliminators can be summarized into the following groups settling tanks, fiber filtering candles, electrostatic precipitators, cyclones, impingement van separators, and wire mesh.

In the early days of evaporators, especially in thermal desalination plants, the solid vane type separators were used. However, the system suffers from the following drawbacks:

1. high pressure drop (which could result in the total loss of temperature driving force between stages)
2. excessive brine carry over.

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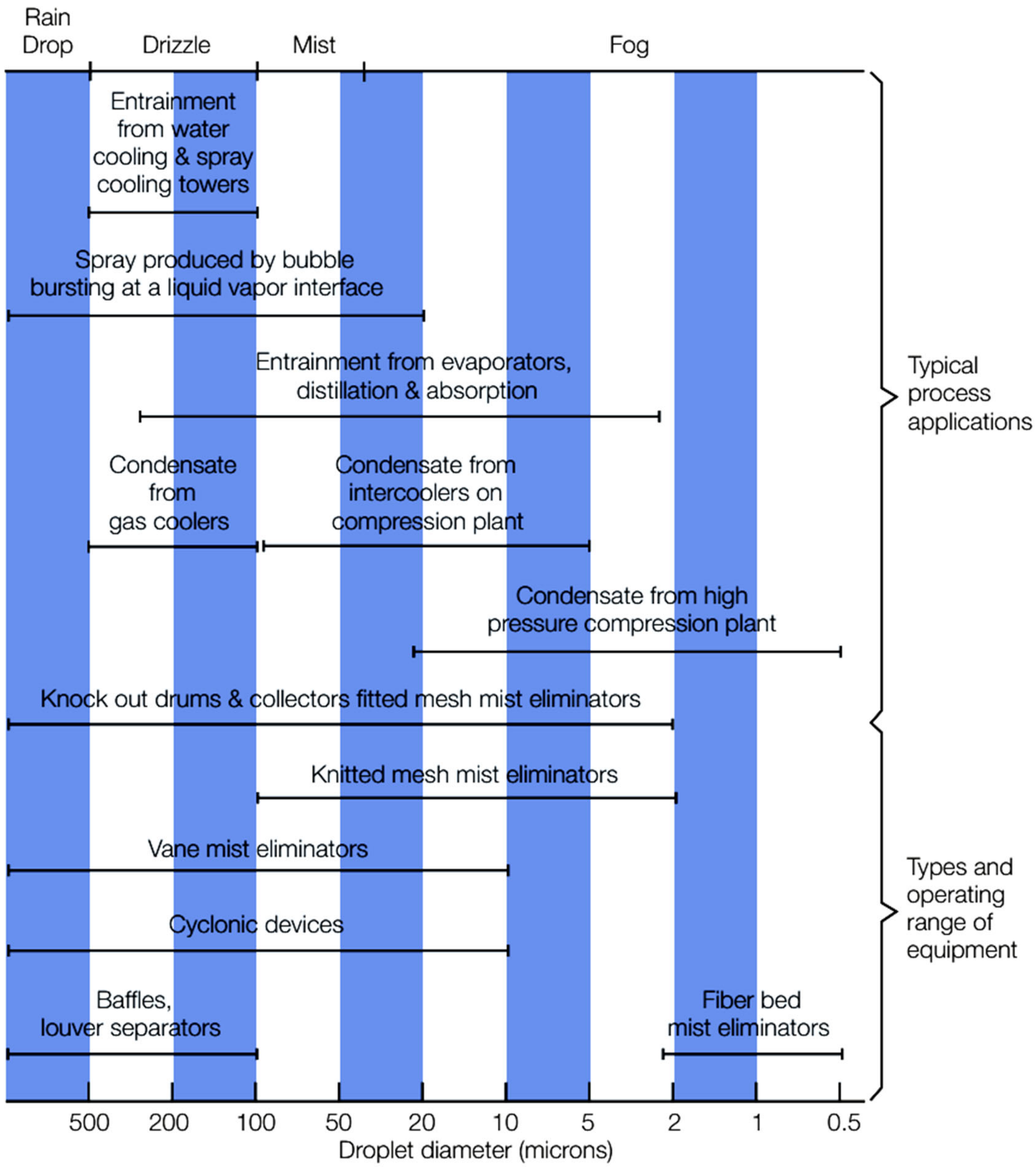

Figure 1. The appropriate equipment of mist eliminatorbased on droplet size

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Demister Pad / Mist eliminator major market process applications

Oil and Gas Industry

Separating liquids & contaminants from the oil is a fundamental requirement to the oil & gas industry. Mist eliminators are used to remove carry over liquids, removal of condensed liquids and removal of contaminants etc.

Process Industry

Mist elimination plays a vital role in recovering lost product and in protecting downstream equipment’s and processes. They provide predictable operation even under heavy liquid loading. Appropriately designed mist eliminators allow process to run at velocities facilitating small apparatus dimensions.

Flue Gas Desulphurization

Appropriate use of mist eliminators in this application protects the environment by preventing droplets escaping into the atmosphere. It captures the liquid solvent, thus minimizing cost of cleaning gases. It cleans the exhaust gas phase from droplets thus protecting the downstream heat exchangers.

Sulphur Acid Plants

Well-designed mist eliminators play a significant role in cost effective operation of Sulphuric acid plants. If mist eliminators are not designed properly it may lead to corrosion of blowers, heat exchangers and vessels adversely affecting plant efficiency.

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Refineries

Mist eliminators in fractionators increase throughput capacity and allow deeper cuts for greater yields.

- In atmospheric and vacuum pipestills, reduced entrainment from the wash oil zones allows deeper cuts and greater throughput.
- In downstream crackers and reformers, mist eliminators prolong catalyst life by reducing carbon and metals in side draws.

Petrochemical Plants

Mist eliminators are used in the interstage knock-out drums of the compressor trains to extend compressor run length and service life. They are also used in quench towers to prevent contamination and protect downstream equipment

Gas Absorption Systems

Designers and operators of gas absorption systems use glycols, amines, and other proprietary solvents to remove water vapor, H_2S, CO_2, or other contaminants from gas streams. However, they often follow equipment specifications that have not been optimized to minimize losses of these expensive chemicals. Losses can result from several causes, including the following:

- Carryover losses of absorption chemicals with the treated gas.
- Entrainment losses in the overhead gas from the regeneration towers.
- Foaming resulting from liquid hydrocarbon entrainment into the absorber.

Mist Eliminator Benefit

a. Improves throughput capacity
b. Improves product purity
c. Provides equipment protection
d. Low pressure drop
e. Provides environmental protection

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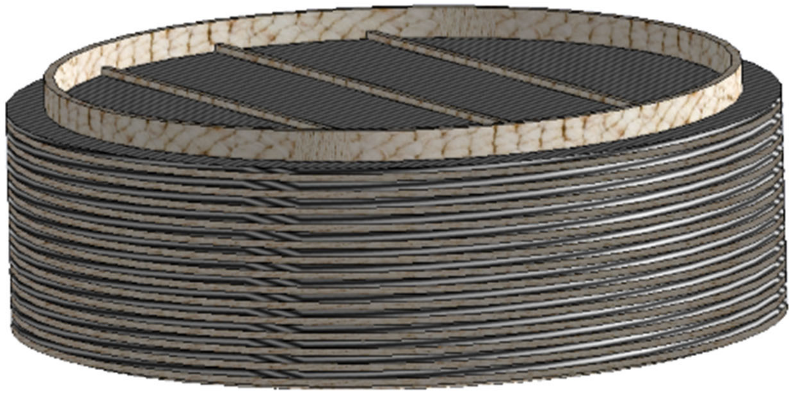

Figure 2. Single unit mist eliminator

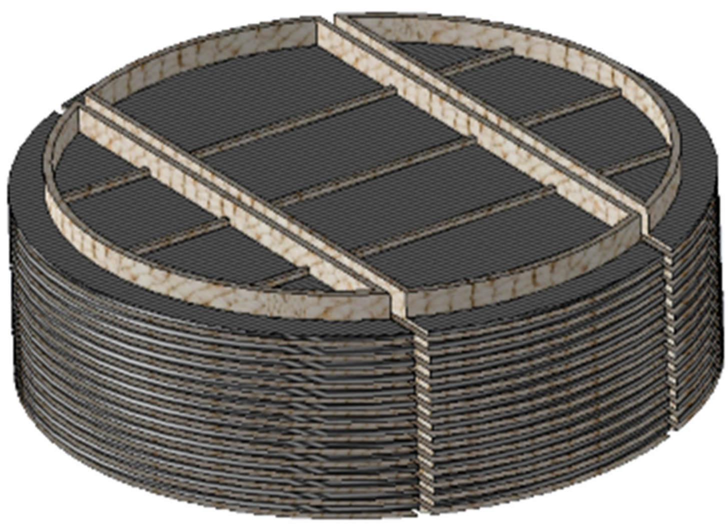

Figure 3. Segment mist eliminator

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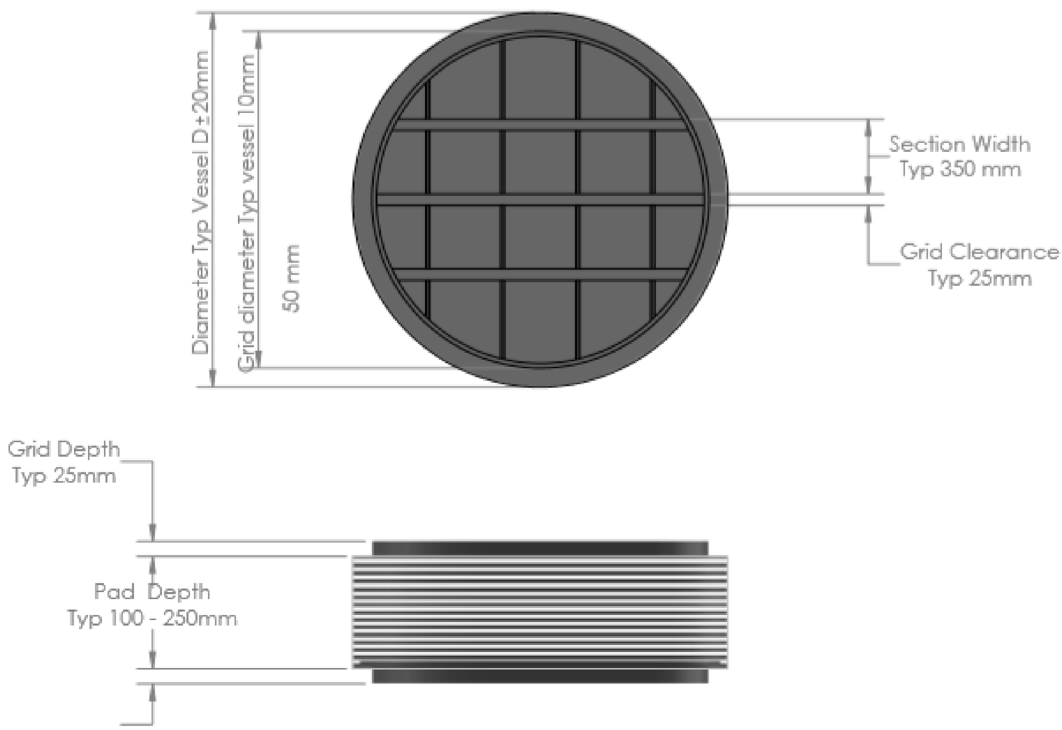

Figure 4. Typical Arrangement mist eliminator

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Demister Pad / Mist eliminator application in unit process

Knockout Drums

Designing knockout drums to include mist eliminators will reduce capital equipment costs and improve efficiency. Knockout drums relying solely on gravity settling typically remove drops larger than 100 microns. Using an efficient mist eliminator will remove entrainment of all drops larger than 5 to 10 microns. This higher efficiency reduces product loss; downstream corrosion; contamination; and damage to equipment such as compressors, molecular sieve driers, and blowers. Vessel weights can easily be reduced to half, and handling of liquid slugs is improved.

Evaporators

Customized mist eliminators reduce carryover of dissolved and undissolved solids to obtain specified steam condensate purity levels below 1 to 50 ppm. This not only prevents product loss, but it also protects compressor internals in vapor recompression systems, provides boiler feed water quality condensate, and prevents potential pollution problems.

Industrial installations vary from chemical plants (caustic and inorganic chemical concentrators), to pulp and paper (black liquor and pulping chemical recovery), to the food industry (sugar, salt, and corn syrup production).

Steam Drums

Customized mist eliminators reduce carryover of dissolved solids to obtain specified steam condensate purity levels from 1 ppm down to 5 ppb without the need for external separator vessels. Operating pressures can range from 20 to 2500 psig [1 to 170 bar].

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Distillation Towers

Liquid entrainment can cause performance problems and limit capacity in packed and trayed distillation towers in two ways.

- At intermediate draw-off trays, entrainment from below reduces product purity and can allow non-volatile contaminants into the draw-off liquid.
- The overhead gas product can also be contaminated with liquid entrainment.

In both cases, the problem is often misinterpreted as a problem with the trays or packing. In reality, it is a problem of entrainment, which can be solved by a properly designed mist eliminator

Scrubbers

From clean gas scrubbers and process vents to fouling services, such as flue gas desulfurization (FGD) systems or steel mill blast furnace exhausts, mist eliminators help improve efficiency and capacity. In severe services, high performance wash systems are specially engineered to meet the process requirements and considerably extend service life with minimum wash liquid usage.

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Demister Pad / Mist Eliminators Selection Guide

Mist eliminators find a wide variety of applications such as evaporators, three phase separators, knockout vessels, scrubbers etc. The choice of mist eliminator must be done on the basis of the application requirements. Products are available in a wide array of metals, plastics, thermoplastics to suit a variety of applications.

1. Mesh Pad Mist Eliminator

   The mesh pad mist eliminator removes droplets by impingement on surface of a wire. The liquid collected on the filament is drained off under gravity. These mist eliminators provide almost complete removal of droplets down to 3 to 5 microns.

2. Plain Vane Pack Mist Eliminator

   The plain vane pack mist eliminator is a high efficiency mist eliminator commonly used for removing entrained liquids from vapor flowing vertically upwards. These mist eliminators use corrugated vanes as a mechanism for mist elimination.

3. Pocketed Vane Pack Mist Eliminator

   The high capacity vane pack mist eliminators use a hooked vane mechanism for higher capacity mist elimination. They provide for efficient droplet removal and superior resistance to fouling for high rate horizontal vapor flow.

4. Mist Eliminators for high efficiency mist elimination

   The high efficiency mesh pad mist eliminators remove droplets by impingement on the wire surface. The liquid collected on the filaments drains off under gravity. They provide almost complete removal of droplets down to about 3-5 microns. They provide a turndown range of vapor rate of around 3:1.

At excessively high velocity the liquid droplets that impinge on the wire surface are sheared off by the vapor and entrained before they are able to drain. At very low vapor velocities all but the larger droplets are able to follow the vapor path through the mesh and thus avoid impingement. However, the inherent design of the separator vessel means that in most applications an effective turndown of 10:1 can be achieved.

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High efficiency mesh pad mist eliminators can provide liquid entrainment solutions in a variety of equipment's including

A. Scrubbers & distillation columns
B. 3 phase separators
C. Knock out vessels
D. Evaporators
E. Falling film condensers
F. Desalination plants
G. Steam drums
H. Gas dehydration plants

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Table 1. Characteristics for mist elimination

	Gravity separators/ knockout drums	Baffles/ louvers	Vane packs – simple vanes	Vane packs – with drainage channels	Axial cyclone separators	Knitted mesh mist eliminators	Candles/ fiber beds
Separation mechanism	Gravitational deposition	Inertial interception	Inertial interception	Inertial interception	Inertial interception	Inertial/direct interception	Direct interception/ diffusional deposition
Gas handling capacity	Low	High	High	High	Very high	Moderate	Low
Turndown capacity	Very high	30 %	30 %-50 %	30 %-50 %	30 %Higher with preconditioner	25 %	Very high
Efficiency	Low except for large droplet sizes	Low except for large droplet sizes	High down to approx.25 µm	High down to approx.25 µm	High down to approx.10 µm	Very high down to 2-5 µm	Very high at sub-micron droplet sizes
Liquid load capacity	Very high	Very high	Moderate	High	High	Moderate	Low

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Solids handling capability	Very high	Very high	Moderate	Low	Moderate-high	Low	Very low
Liquid viscosity	Suitable for high viscosity	Suitable for high viscosity	Suitable for high viscosities/ waxes	Prone to fouling with high liquid viscosities/ waxes	Suitable for high viscosities/ waxes	Prone to fouling with high liquid viscosities/ waxes	Unsuitable for high liquid viscosities
Pressure drop	Very low	Very low	Low	Low	Moderate	Low	High

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Advantages of Demister Pad / Mist Eliminator

Demister Pad is a necessity to be used where liquid in gaseous or vapor stream is not acceptable. For example – compressor suction lines. Separation of mist from gaseous or vapor stream can improve the operating condition, optimize process indicators, reduce corrosion of the equipment, extend equipment life, increase the amount of processing and recovery of valuable materials, protect the environment, and decrease air pollution. Demister also produces high quality condensate suitable for use a boiler's feed water.

Must have Features in a Demister

- Simple structure.
- Lightweight.
- High porosity.
- Cause less pressure drops.
- Large surface area.
- High mist separating efficiency.
- Easy to install, operate and maintain.
- Easily tailor made to suit most vessel shapes and sizes.
- Durable and long service life.
- Corrosion resistance.

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DEFINITIONS

Air standard - Air having a temperature of (20°C), a relative humidity of 36 percent, and under a pressure of 14.70 PSIA. The gas industry usually considers (16°C) as the temperature of standard air.

Annular velocity - the actual flow rate divided by the annulus area. Modeled as a linear function with vertical distance, and the annular velocity is zero at the bottom of the cartridge and increases to a maximum value at the top of the cartridge.

Annulus - A ring-like part or, the orifice of a hollow die, through which extruded metal flows from the press.

Coalescence - Liquid particles in suspension that unite to create particles of a greater volume.

Coalescer- A mechanical process vessel with wet table, high-surface area packing on which liquid droplets consolidate for gravity separation from a second phase (for example gas or immiscible liquid).

Control Volume- A certain liquid volume necessary for control purposes and for maintaining the velocity limit requirement for degassing and to counter foam in separators.

Conventional Gas-Liquid Separator- Vertical or horizontal separators in which gas and liquid are separated by means of gravity settling with or without a mist eliminating device.

Critical Diameter- Diameter of particles larger than which will be eliminated in a sedimentation centrifuge.

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Density - The density of a homogeneous substance is the ratio of its mass to its volume. The density varies as the temperature changes and it is usually expressed as the mass per unit volume at a specified temperature.

> **Absolute Density** – The mass of a substance per unit volume at a specified temperature.
>
> **Relative Density** - The ratio of the mass of a given volume of fluid to the mass of an equal volume of pure water at the same temperature and pressure. Relative density replaces the term “specific gravity”.
>
> **Relative Density At 60°** - Fluid relative density measured against water with both materials at 60 degrees F and reference pressure of 14.696 psia (or equilibrium pressure). Equivalent to “RD 60/60”

Demister Mist Extractor- A device installed in the top of scrubbers, separators, tray or packed vessels, etc. to remove liquid droplets entrained in a flowing gas stream.

Design Pressure - The pressure used in the design of a vessel component for the most severe condition of coincident pressure and temperature expected in normal operation

Disengaging Height- The height provided between bottom of the wire-mesh pad and liquid level of a vapor-liquid separator.

Entrainment - A process in which the liquid boils so violently that suspended droplets of liquid are carried in the escaping vapor.

Fabric Filter- Commonly termed "bag filters" or "baghouses", are collectors in which dust is removed from the gas stream by passing the dust-laden gas through a fabric of some type.

Filter- A piece of unit operation equipment by which filtration is performed.

Filter Medium- The "filter medium" or "septum" is the barrier that lets the liquid pass while retaining most of the solids; it may be a screen, cloth, paper, or bed of solids.

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Filtrate- The liquid that passes through the filter medium is called the filtrate.

Gas-Liquid Separator - vertical or horizontal separators in which gas and liquid are separated by means of gravity settling with or without a mist eliminating device

Highspeed mist eliminator – separator removal of very small droplets can be achieved using a two stage mist eliminator by fitting a mesh pad to the upstream face of the unit to coalesce droplets as small as 4 to 5 microns into droplets in the size range which are easily removed by the vane separator

Hold-Up Time- A time period during which the amount of liquid separated in a gas-liquid separator is actually in the vessel for the purpose of control or vapor separation.

Knock-Out- A separator used for a bulk separation of gas and liquid.

Line Drip- A device typically used in pipelines with very high gas-to-liquid ratios to remove only free liquid from a gas stream, and not necessarily all the liquid.

Mesh- The "mesh count" (usually called "mesh"), is effectively the number of openings of a woven wire filter per 25 mm, measured linearly from the center of one wire to another 25 mm from it.

Mist Cyclone Eliminator - separator multi-cyclone elements are designed specifically for the removal of high levels of liquids and solids from gas in a single separation stage.

Nozzle - A short flanged or welded neck connection on a drum or shell for the outlet or inlet of fluids; also, a projecting spout for the outlet or inlet of fluids; also a projecting spout through which is fluid flows.

Operating Pressure - The pressure at the top of the vessel at which it normally operates. It shall be lower than the MAWP, design pressure, or the set pressure of any pressure relieving device.

Operating Temperature - The temperature that will be maintained in the metal of the part of the vessel being considered for the specified operation of the vessel

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Open Area- A percentage of the whole area of a woven wire filter.

Overflow- The stream being discharged out of the top of a hydrocyclone, through a protruding pipe, is called "overflow". This stream consists of bulk of feed liquid together with the very fine solids.

Pressure drop - the difference in total pressure between two points of a fluid carrying network. A pressure drop occurs when frictional forces, caused by the resistance to flow, act on a fluid as it flows through the tube.

Separator - a cylindrical or spherical vessel used to isolate the components in mixed streams of fluids.

Settling velocity - The velocity reached by a particle as it falls through a fluid, dependent on its size and shape, and the difference between its specific gravity and that of the settling medium; used to sort particles by grain size.

Stokes' law - the law that the force that retards a sphere moving through a viscous fluid is directly proportional to the velocity of the sphere, the radius of the sphere, and the viscosity of the fluid

Surge tanks- These are storage tanks between units and can serve a variety of purposes. They can dampen fluctuations in flow rate, composition or temperature. They can allow one unit to be shut down for maintenance without shutting down the entire plant.

Vane Inlet Device s - inlet devices are used in phase separator vessels as well as stripper, absorber, distillation columns etc. mainly for even distribution of the inlet flow across the vessel or column cross sections. Even distribution of the fluids across the cross section geometries becomes important in order to minimize the channeling of these fluids, which can lead to reduced equipment efficiency.

Target Efficiency- The fraction of particles or droplets in the entraining fluid of a separator, moving past an object in the fluid, which impinge on the object.

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Terminal Velocity or Drop-Out Velocity- The velocity at which a particle or droplet will fall under the action of gravity, when drag force just balances gravitational force and the particle (or droplet) continues to fall at constant velocity.

Underflow- The stream containing the remaining liquid and the coarser solids, which is discharged through a circular opening at the apex of the core of a hydrocyclone is referred to as "underflow".

Vessel height - the distance from the bottom of the flange to the inside bottom of the dissolution vessel.

Vapor Space- The volume of a vapor liquid separator above the liquid level.

Vane mist eliminators – vessel consist of a series of plates or vanes spaced to provide passage for vapor flow and profiled with angles to provide sufficient change of direction for liquid droplets to impact, coalesce and drain from the surfaces of the plates

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NOMENCLATURE

A_G,	min Minimum required vessel cross-sectional area for gas flow m²
A_r	Archimedes number
A_v	The vane pack area face, m^2
A_{gmin}	Minimum vessel cross-sectional area for gas flow, m^2
D	Diameter, m
d	Nozzle diameter, m
d_2	Minimum outlet noozle diameter, m
d_4	The drip ring (anti-creep baffle), m
f_η	Derating factor
h	height of vessel required for liquid hold-up, m
h_v	The vane height, m
h_{vb}	The height of the vane pack box, m
H	Vessel height, m
H/D	Height diameter ratio
H_{vfb}	Distance between vortex finder and bottom plate, m
K_v	Friction loss factor
L	Length, m
LZA (HH)	Height of vessel required for liquid hold-up, m
M_G	Flow rate vapor, kg/h
M_L	Flow rate liquid, kg/h
n	Number of perforated plates
NFA	The net free area of the perforated plate, m^2
P	Operating Pressure, atm
Q_G	Gas flow volumetric, m^3/s
Q_L	Liquid flow volumetric, m^3/s
Q_{max}	Volumetric flow rate, m^3/s
s	The gap between the bottom plate and the cyclone wall, m
t_{wm}	Thickness of demister mat, m

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t_{vb}	The depth of the vane box, m
v_G	Gas velocity, m/s
v_m	Mixing velocity, m/s

Greek Letters

ΔP	The pressure differential, Pa
ΔP_{wm}	The pressure drop across the mistmat, Pa
Δp_v	Pressure drop through vane, Pa
Δp_{perfpl}	Pressure drop through perforated plate, Pa
ρ_m	Mixing density, kg/m^3
η_L	Dynamic viscosity, Pa.s
ϕ_{feed}	Feed flow parameter
ϕ_{wm}	Function of the flow parameter of the feed
λ_{max}	Maximum gas load factor, m/s
$\lambda_{V,max}$	Maximum allowable gas load factor based on the face area of the vane pack, m/s
ρ_L	Liquid density, kg/m^3
ρ_G	Vapor density, kg/m^3
σ	Gas/liquid interfacial tension, N/m

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REFERENCES

1. Smith R. Chemical Process Design and Integration. McGraw Hill, 2005.
2. P. Fabian, R. Cusack, P. Hennessey, M. Neuman, Demystifying the selection of mist eliminators, Part I: The basics, Chem. Eng. 11 (1993) 148 ± 156.
3. I.K. Bradie, A.N. Dickson, Removal of entrainment liquid droplets by wire mesh demisters, Proc. Inc. Mech. Eng. 184 (1969) 195 ± 203.
4. M.V. Bhatia, Entrainment separators, process equipment series, VCH, New York, 1989.
5. W. Capps, properly specify wire-mesh mist eliminators, Chem. Eng. Prog. (1994) 49 ± 55.
6. T.L. Holmes, G.K. Chen, Design and selection of spray: mist elimination equipment, Chem. Eng. October (1984) 82 ± 86.
7. HAT international, AlphaMIST Design sheet.
8. Dessouky, Imad M, Ettouney at all. Performance of wire mesh mist eliminator. Chem. Eng Kuwait University. 1999
9. ACS Industries. The Engineered Mist Eliminator. Houston, Texas.
10. Finepac Structures PVT. LTD. Mist Eliminator
11. Sepco Process, INc. Mist Eliminator Design Manual
12. K Kolmetz et al, Kolmetz Handbook of Process Equipment Design, KLM Technology Group, Distillation Column Selection, Sizing, and Troubleshooting, Engineering Design Guideline. June 2013
13. K Kolmetz et al, Kolmetz Handbook of Process Equipment Design, KLM Technology Group, Filter Separator Selection, Sizing and Troubleshooting, Engineering Design Guideline. Jan 2020

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14. K Kolmetz et al, Kolmetz Handbook of Process Equipment Design, KLM Technology Group, Fluid Flow Piping Hydraulics Fluid Flow Line Sizing and Material Selection Engineering Design Guideline, 2018

15. K Kolmetz et al, Kolmetz Handbook of Process Equipment Design, KLM Technology Group, Pressure Vessel Selection, Sizing and Troubleshooting, Engineering Design Guidelines, June 2020

16. K Kolmetz et al, Kolmetz Handbook of Process Equipment Design, KLM Technology Group, Separator Vessel Selection, Sizing and Troubleshooting, Engineering Design Guideline, Jan 2015

17. AMISTCO. “Mesh & Vane Mist Eliminators for Optimal Removal of a Wide Range of Liquid Droplets from Gas Streams”. 2004

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THEORY

Mixtures of two immiscible liquids occur throughout the process industries. Often this is an unavoidable result of the process. In other cases, the mixing of two liquids is necessary to obtain mass transfer between the phases or to promote a chemical reaction. Almost always, a full separation of the liquids will be important for efficient and cost-effective performance of the downstream process.

The method of droplet creation will often give a good indication about the difficulty of separation. Physical properties of each phase and other data need to be collected:

1. Density differences and viscosity determine how fast the droplets will disengage,
2. Flow rates will determine the ultimate size of the required separation equipment,
3. Desired separation performance must be defined,
4. Interfacial tension, which is a measure of the ease of droplet coalescing and how it is affected by pH and temperature, is very helpful when available,
5. presence of impurities and solids will often create a more difficult separation, since they can collect at the interface between the liquids, making coalescing difficult and also limiting equipment choices,
6. Relative solubility at operating temperature will help the designer understand whether the desired separation is being prevented by solubility limits.

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PRINCIPALS OF MIST REMOVAL

Demister pad, also called mist pad, wire mesh demister, mesh mist eliminator, catching mist, mist eliminator, is used in gas entrained mist separation column to guarantee the filtering efficiency. Demister pad is commonly placed at the top of the packing tower, which can not only ensure the mass transfer efficiency, but also reduce the board spacing. Demister pad is widely used in chemical, petroleum, pharmaceutical, light industry, metallurgy and other industrial production in the vertical cylindrical equipment vapor-liquid separation device. It can also be used in the desulfurization and other productions to remove oil mist, toxic and poisonous gas.

When the gas with mist rises at a constant speed and passes through the wire mesh, the rising mist will collided with the mesh filament and attached to the surface filament due to the inertia effect. The mist will be diffuse on the filament surface and the droplet will follow along the filaments of the two wire intersection. The droplet will grow bigger and isolate from the filament until the droplets gravity exceeding gas rising force and liquid surface tension force while there is little gas passing through the demister pad.

Separate the gas in the droplets can improve the operating condition, optimize process indicators, reduce corrosion of the equipment, extend equipment life, increase the amount of processing and recovery of valuable materials, protect the environment, and decrease air pollution.

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The factors governing the removal of particles or mist from vapor flows are:

1. Diffusion
2. Inertial impaction
3. Interception

1. Diffusion is the predominant removal method for particles with diameter, less than 0.5m but is only important when fine entrainment is considered. Diffusion occurs for fine droplets because they not only follow vapour streamlines around a collection body but also move across them in an irregular way. This erratic ‘zigzag’ movement of the particles across the streamlines, caused by their continued and irregular bombardment of gas molecules, is known as ‘Brownian Motion’. In moving vapour flows, the time for diffusion to a collecting fibre is limited, therefore, only the particles near the fibres will be collected.

2. Inertial impaction occurs when a particle does not have enough inertia to follow the vapour streamlines around an obstacle such as a wire filament. The vapour then deviates from the streamline and impacts on the obstacle. The factors governing inertial impaction efficiency are particle mass and vapour velocity. As both the particle mass and vapour velocity are increased the inertial impaction efficiency is also increased. Inertial impaction is characterized by a half of ‘Stokes Number’ or the stopping distance.

3. Interception occurs when a particle or mist droplet passes within half of its diameter of the collection obstacle and thus impacts on the obstacle. Interception is characterised by the ratio of the particle diameter over obstacle diameter. As most of the mists encountered in the process operations have diameters greater than 2mm, the primary removal processes are inertial impaction and interception

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