Gas/Liquid Separation Technology
Introduction

Although perhaps best known in the fields of mass transfer, mixing and reaction technologies, Sulzer Chemtech are now established as a major player in the field of gas/liquid and liquid/liquid separation technology, offering a full range of innovative products and related services. Our commitment to development of technology, combined with application know-how and exacting fabrication standards, ensures that a well-engineered solution is available for most separation problems.

A specialist technical team uses the experience gained from hundreds of successful installations in a broad spectrum of applications to ensure that the best possible product is recommended for each individual duty.

Our strategic alliance agreement with Shell Global Solutions International B.V. provides access to state of the art separation technology, including the Shell Swirftube™ and Schoepentoefer™, and acquisition of the KnitMesh Separation Business has added KnitMesh™ Mist Eliminators and Coalescers as a natural extension to our existing product range.
Service and Supply

Sulzer Chemtech offers a flexible and comprehensive service which can be tailored to suit your project requirements, including:

- process design
- feasibility studies
- detailed engineering
- equipment manufacture and supply
- installation

If installation services are required, our technicians are available on your worksite to make sure your equipment meets specifications and your project goes smoothly from start to finish. A Sulzer Chemtech technician inspects your equipment before it leaves our plant. At your worksite, you can count on our technicians, who are specialists in separation and mass transfer systems, to monitor each phase of your installation to ensure you are up and running on time.

Emergency Delivery

Sulzer Chemtech can react to the most challenging deadlines and can assist with urgent replacement or repair of separator internals. For emergencies, contact your nearest Sulzer Chemtech office - details of which can be found at www.sulzerchemtech.com

Research and Development

We recognize that investment in research and development is an essential component for long term success. We have laboratories where separation internals and design techniques can be tested and developed in fully instrumented pilot scale columns.

Increasingly, computer models are being used to aid the design of new products. Sulzer uses computational fluid dynamics (CFD) models to simulate product performance. This work not only eliminates the requirement for expensive prototypes to be constructed, but provides a much greater understanding of the products operation in advance of any laboratory or operational trials. CFD simulations have also been used to great effect in solving flow distribution problems in a variety of systems.

Specialists in Retro-Fit and Performance Enhancement

Our engineering team relishes the challenges associated with existing installations. Professional advice and tailor-made equipment designs, founded on decades of experience, can overcome a host of separation problems related to:

- changes in process conditions
- de-bottlenecking
- aging plant
- sub-optimal equipment layout
### Product Summary

<table>
<thead>
<tr>
<th>Type of Separator</th>
<th>Materials</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>KnitMesh™ Mist Eliminator</td>
<td>Stainless steels, Alloy C22, C276, 400, 625, 825 and 20, Copper, PP, FEP, ETFE, PTFE, Glass fibers</td>
<td>Broad range of gas/liquid separation problems. Scrubbing systems and absorbers, Evaporators, Steam drums, Knock-out pots, Glycol dehydration, Inert gas scrubbers, MSF/MED desalination, Sulfuric acid absorbers and dryers.</td>
</tr>
<tr>
<td>KnitMesh VKR Mist Eliminator™</td>
<td>Stainless steels, Alloy C22, C276, 400, 625, 825 and 20, Copper, PP, FEP, ETFE, PTFE, Glass fibers</td>
<td>Broad range of gas/liquid separation problems. Scrubbing systems and absorbers, Evaporators, Steam drums, Knock-out pots, Glycol dehydration, Inert gas scrubbers, MSF/MED desalination, Sulfuric acid absorbers and dryers.</td>
</tr>
<tr>
<td>Mellachevron™ Mist Eliminator</td>
<td>Stainless steels, Alloy C22, C276, 400, 625, 825 and 20, Plastics</td>
<td>Broad range of gas/liquid separation problems. Scrubbing systems and absorbers, Evaporators, Steam drums, Knock-out pots, Glycol dehydration, Inert gas scrubbers, MSF/MED desalination, Sulfur condenser</td>
</tr>
<tr>
<td>Shell Swirtube™</td>
<td>Stainless steels, Alloy 625, 825</td>
<td>Gas processing applications; inlet separators, turbo-expander suction drums, dew-point separators, compressor suction drums, glycol dehydration.</td>
</tr>
<tr>
<td>Shell Swirtube Light™</td>
<td>Stainless steels, Alloy 625, 825</td>
<td>Gas processing applications; inlet separators, turbo-expander suction drums, compressor suction drums. Scrubbing systems and Absorbers, Glycol dehydration, PEB neutralization column.</td>
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</table>
## Typical operational Range

<table>
<thead>
<tr>
<th>Characteristics</th>
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<tbody>
<tr>
<td>Relatively low capacity with K-values typically up to 0.107 m/s (0.35 ft/s). High efficiency separation down to droplet sizes of 2 to 3 μm. Pressure drop typically less than 2.5 mbar. Designs available for installation in either horizontal or vertical gas flow.</td>
</tr>
<tr>
<td>Enhanced capacity with K-values typically up to 0.15 m/s (0.49 ft/s). Limited to horizontal installation with vertical gas flow. High efficiency separation down to droplet sizes of 2 to 3 μm. Pressure drop typically less than 2.5 mbar. Very effective for heavy liquid loadings/irrigated systems.</td>
</tr>
<tr>
<td>High capacity systems available with K-values up to 0.45 m/s (1.47 ft/s) at the vane face inlet. Effective droplet separation down to ~20 μm. Efficiency can be enhanced by combination with wire mesh pre-conditioners. Generally for use at: - surface tension &gt; 10 dynes/cm. - operating pressure &lt; 60 bar in hydrocarbon systems. Pressure drop is typically in the range 1 to 10 mbar. Designs available for installation in either horizontal or vertical gas flow.</td>
</tr>
<tr>
<td>High capacity systems with K-values up to typically 0.25 m/s (0.82 ft/s) in the vessel. Effective droplet separation down to ~10 μm. Efficiency can be enhanced by combination with wire mesh pre-conditioners. Pressure drop is typically in region of 30 mbar.</td>
</tr>
<tr>
<td>High capacity systems with K-values up to typically 0.25 m/s (0.82 ft/s) in the vessel. The Shell Swirltube Light is suitable for higher operating pressures, offers higher capacities than vane packs installed for vertical gas flow and is therefore a useful complement to our Mellachevron mist eliminators.</td>
</tr>
<tr>
<td>Array of axial cyclones originated from the Shell ConSep™ Swirltube design. The device can be combined with a Sulzer Mellachevron or KnitMesh pre-conditioner. The separation efficiency of the Shell Swirltube Light is lower than the Shell Swirltube and is in the range of vane packs.</td>
</tr>
<tr>
<td>Type of Separator</td>
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<tr>
<td>----------------------------------------</td>
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<tr>
<td>MKS Multi Cassette™ Mist Eliminator</td>
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<tr>
<td>Shell Schoepentoeter™ Inlet Device</td>
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<tr>
<td>Treelnlet™ Device</td>
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<tr>
<td>GIRZ Cyclone Gas Inlet Device</td>
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<tr>
<td>GITV Vapor Horn</td>
</tr>
<tr>
<td>Vanta™ Inlet Device GITD</td>
</tr>
<tr>
<td>Typical operational Range</td>
</tr>
<tr>
<td>------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Ideal for use in glycol contactors operated with high capacity structured packing MellapakPlus. Meets the glycol loss requirement of 0.1 USgal/MMSCF (~ 14 lt/MMNm³) or less.</td>
</tr>
<tr>
<td>Generally designed at dynamic pressure of &lt; 8000 Pa, but can perform well at higher values. Suitable for installation in horizontal inlets on vertical separators. Can be fitted to horizontal three phase separators.</td>
</tr>
<tr>
<td>The Treelnlet provides a superior liquid pre-separation and gas distribution and is normally effective up to dynamic pressures of about 10000 Pa.</td>
</tr>
<tr>
<td>In the cyclone the gas/liquid mixture is forced to rotate and the liquid droplets are separated centrifugally and collected on the inner wall of the cyclone. Mixing elements on top of the cyclone outlet section provide a proper distribution of the cleaned gas to downstream devices. The device has a high pressure drop associated with it.</td>
</tr>
<tr>
<td>The tangential vane gas inlet device GITV and GITD can be used for very high vapor velocities in the feed pipe of F-Factors up to 120 VPa. The feed flows radially around the vessel projecting and collecting the liquid droplets on the inner wall of the vessel.</td>
</tr>
<tr>
<td>The new Sulzer Vanta™ inlet device combines high liquid separation efficiency with high gas distribution quality.</td>
</tr>
</tbody>
</table>
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.

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. This type of condensation mist can occur during heat exchange processes, the sudden release of pressure or by mixing hot and cold gas streams. Similar mists can result from gas phase reactions which yield a liquid product. Typical applications suffering from mist contamination include sulfuric, phosphoric and nitric acid plants.

If the gas is travelling too fast to allow the liquid droplets to settle out under gravity, they become suspended (or entrained) in the gas or vapor. In most cases, the entrainment must be removed to purify the gas and prevent potential process or environmental contamination.

Sulzer mist eliminators provide an effective solution to liquid entrainment problems in many types of equipment including:

- scrubbing, absorption, stripping or distillation columns
- evaporators
- falling film condensers
- knock-out vessels
- 3 phase separators
- desalination plants
- refrigeration plants
- gas dehydration plants
- compression systems
Several types of mist eliminators are available for the separation of entrained liquid. To choose the appropriate equipment, the four basic mechanisms of droplet capture should be considered.

- **Diffusional Deposition** is only effective in the separation of very finely dispersed aerosols with droplets typically smaller than 1µm - that are small enough to be affected by Brownian Motion.
- **Direct Interception** assumes that a droplet of a given diameter and negligible mass follows the stream line around the "target" wire or fiber and is separated as it touches the target or collection fiber.
- **Inertial Interception** considers the droplet mass and predicts how momentum will make it deviate from the gas stream.
- **Gravitational Deposition** works on the principle that large, slow moving droplets may separate from a gas stream under gravity. This is restricted to large droplet sizes and low superficial gas velocities – making separator dimensions both prohibitively large and uneconomical.

Each mechanism is critically dependent on the droplet size distribution for a given application. For example, in gas drying applications using glycol contactors, droplet size distributions are often in the range of 5-25 µm and high separation efficiency is critical. In these circumstances, direct and inertial interception are the most appropriate mechanisms and separation is best achieved by impingement of droplets on the wires and fibers of high performance mesh mist eliminators.

Diffusional deposition is an important mechanism in the design of fiber bed mist eliminators (candle filters) used for removal of sub-micron droplet dispersions found in applications such as acid mists.

Assuming that gravity separation can be disregarded as an effective option, the remaining mechanisms provide the design basis for Sulzer mist elimination equipment:

- **Sulzer Mellachevron™** – inertial interception
- **Shell Swirltube™** – inertial interception
- **Sulzer KnitMesh™** – inertial/direct interception
- **Sulzer MKS Multi Cassette™** – inertial/direct interception
**Mist Elimination**

**Design Advice**

Comprehensive performance information is available on a wide range of standard designs, enabling Sulzer engineering staff to tailor the mist eliminator design to suit most applications.

For best performance, it is important to achieve uniform gas flow distribution and maximum effective area, and recommendation can be given on the most appropriate positioning, in terms of disengagement distances from vessel inlet, outlet and other vessel internals.

**Sizing**

For equipment based on direct and/or inertial interception, gas stream velocity affects all three principles involved in separation (impingement, coalescence and drainage). Flooding, or re-entrainment of liquid, can occur if the flow of gas prevents drainage, and the effective area of the mist eliminator is therefore established by determining an appropriate superficial velocity for the equipment. The overall performance of the mist eliminator is then a balance between efficiency and pressure drop.

\[
 v = \frac{K \cdot \sqrt{\rho_l - \rho_g}}{\rho_g}
\]

\( v \) = maximum superficial gas velocity  
\( \rho_l \) = liquid density  
\( \rho_g \) = gas density  
\( K \) = a constant which is specific to the separation equipment and is a function of process parameters such as:  
- Liquid loading  
- Gas and liquid viscosity  
- Gas pressure  
- Surface tension

Tracting factors are often applied to allow a safety margin for exceptional conditions such as liquid slugs and gas surges, and the K-value can be optimized to suit specific process conditions, and challenging physical properties such as low surface tension systems. The selection of K-value is therefore critical and we recommend that designs should be checked by our engineering team.

**Table A: Summary of relative performance characteristics for mist elimination**

<table>
<thead>
<tr>
<th>Separation mechanism</th>
<th>Gas handling capacity</th>
<th>Turndown capacity</th>
<th>Efficiency</th>
<th>Liquid load capacity</th>
<th>Solids handling capability</th>
<th>Liquid viscosity</th>
<th>Pressure drop</th>
<th>Equipment Type</th>
<th>K-Value</th>
<th>Gas handling capacity</th>
<th>Turndown capacity</th>
<th>Efficiency</th>
<th>Liquid load capacity</th>
<th>Solids handling capability</th>
<th>Liquid viscosity</th>
<th>Pressure drop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravity separators/knockout drums</td>
<td>Low</td>
<td>Very high</td>
<td>Low except for large droplet sizes</td>
<td>Very high</td>
<td>Very high</td>
<td>Suitable for high viscosity</td>
<td>Very low</td>
<td>Gravity Baffles/louvers</td>
<td>0.07</td>
<td>Low</td>
<td>30 %</td>
<td>Low</td>
<td></td>
<td></td>
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<tr>
<td>Baffles/louvers</td>
<td>Low</td>
<td>Very high</td>
<td>Low except for large droplet sizes</td>
<td>Very high</td>
<td>Very high</td>
<td>Suitable for high viscosity</td>
<td>Very low</td>
<td>Baffles/louvers</td>
<td>0.13 – 0.17</td>
<td>High</td>
<td>30 % -50 %</td>
<td>Moderate</td>
<td></td>
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<tr>
<td>Vane packs – simple vanes</td>
<td>Low</td>
<td>Very high</td>
<td>Low except for large droplet sizes</td>
<td>Very high</td>
<td>Very high</td>
<td>Suitable for high viscosity</td>
<td>Very low</td>
<td>Vane packs – simple vanes</td>
<td>0.15 – 0.45</td>
<td>Moderate</td>
<td>30 % -50 %</td>
<td>Moderate</td>
<td></td>
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<tr>
<td>Vane packs – with drainage channels</td>
<td>Low</td>
<td>Very high</td>
<td>Low except for large droplet sizes</td>
<td>Very high</td>
<td>Very high</td>
<td>Suitable for high viscosity</td>
<td>Very low</td>
<td>Vane packs – with drainage channels</td>
<td>0.08 – 0.15</td>
<td>Moderate</td>
<td>Very high down to 3-5 µm</td>
<td>Very high</td>
<td></td>
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<tr>
<td>Axial Cyclone separators</td>
<td>Low</td>
<td>Very high</td>
<td>Low</td>
<td>Very high</td>
<td>Very high</td>
<td>Suitable for high viscosity</td>
<td>Very low</td>
<td>Axial Cyclone separators</td>
<td>0.08 – 0.107</td>
<td>Moderate</td>
<td>Very high down to 3-5 µm</td>
<td>Very high</td>
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<tr>
<td>Knitted mesh mist eliminators</td>
<td>Low</td>
<td>Very high</td>
<td>Low except for large droplet sizes</td>
<td>Very high</td>
<td>Very high</td>
<td>Suitable for high viscosity</td>
<td>Very low</td>
<td>Knitted mesh mist eliminators</td>
<td>0.08 – 0.15</td>
<td>Moderate</td>
<td>Very high down to 3-5 µm</td>
<td>Very high</td>
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<tr>
<td>Candles/fiber beds</td>
<td>Low</td>
<td>Very high</td>
<td>Low except for large droplet sizes</td>
<td>Very high</td>
<td>Very high</td>
<td>Suitable for high viscosity</td>
<td>Very low</td>
<td>Candles/fiber beds</td>
<td>0.08 – 0.15</td>
<td>Moderate</td>
<td>Very high down to 3-5 µm</td>
<td>Very high</td>
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<tr>
<td>Shell SMS, SMSM</td>
<td>Low</td>
<td>Very high</td>
<td>Low except for large droplet sizes</td>
<td>Very high</td>
<td>Very high</td>
<td>Suitable for high viscosity</td>
<td>Very low</td>
<td>Shell SMS, SMSM</td>
<td>0.25</td>
<td>Moderate</td>
<td>Very high down to 3-5 µm</td>
<td>Very high</td>
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</tbody>
</table>

**Equipment Type**

- Gravity
- Gravity Baffles/louvers
- Baffles/louvers
- Vane packs – simple vanes
- Vane packs – with drainage channels
- Axial Cyclone separators
- Knitted mesh mist eliminators
- Candles/fiber beds
- Shell SMS, SMSM

**K-Value**

- Gravity: 0.07
- Gravity Baffles/louvers: 0.13 – 0.17
- Baffles/louvers: 0.15 – 0.45
- Vane packs – simple vanes: 0.08 – 0.107
- Vane packs – with drainage channels: 0.08 – 0.15
- Axial Cyclone separators: 0.08 – 0.15
- Knitted mesh mist eliminators: 0.08 – 0.15
- Candles/fiber beds: 0.08 – 0.15
- Shell SMS, SMSM: 0.25

**Gas handling capacity**

- Low
- High
- Very high

**Turndown capacity**

- 30 %
- 30 % -50 %
- 30 % -50 % with preconditioner
- 25 %

**Efficiency**

- Low except for large droplet sizes
- High down to approx. 25 µm
- High down to approx. 10 µm
- Very high down to 3-5 µm

**Liquid load capacity**

- Very high
- Moderate
- Low

**Solids handling capability**

- Very high
- Moderate
- Low

**Liquid viscosity**

- Suitable for high viscosity
- Suitable for high viscosities/waxes
- Suitable for high viscosities/waxes
- Suitable for high viscosities/waxes
- Unsuitable for high liquid viscosities

**Pressure drop**

- Very low
- Low
- Moderate
- Low
- High
Sulzer KnitMesh™
Wire Mesh Mist Eliminators

Sulzer KnitMesh mist eliminators have an excellent track record as a low cost, highly versatile and efficient method of removing liquid entrainment from gas streams. They are produced as a bed of knitted mesh which presents a tortuous path and large surface area to the droplets entrained in the gas stream. Separation is achieved by impingement on, and capture by, the filaments of the mesh where the droplets coalesce and drain.

Installation can be made in a variety of ways but gas flow is usually either vertically upwards, with the liquid draining counter-current to gas flow, or horizontal, with the liquid draining in a direction perpendicular to the gas flow.

Each mist eliminator is tailor-made to suit the dimensions of the vessel or housing into which it will be installed. Most KnitMesh wire mesh mist eliminators are supplied complete with rigid support grids, which allow direct installation onto appropriate supports such as beams and rings within the vessel. Sectional installation allows ease of handling and access through vessel manways.

Accessories such as tie wire, bolting, clamps and support beams can be supplied where necessary.

<table>
<thead>
<tr>
<th>Metal Designs</th>
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<tbody>
<tr>
<td><strong>Material</strong></td>
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<tr>
<td><strong>Metal</strong></td>
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<tr>
<th>Plastic and Other Materials</th>
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<tr>
<td><strong>Material</strong></td>
</tr>
<tr>
<td><strong>Glass Wool</strong></td>
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<tr>
<td><strong>Polypropylene</strong></td>
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</tr>
<tr>
<td><strong>Multifilament</strong> (glass wool/stainless steel)</td>
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Table B: Standard Sulzer KnitMesh Mist Eliminator Types
The Sulzer KnitMesh VKR Mist Eliminators provide high performance wherever liquid entrainment must be removed from a vertically flowing gas stream. Mist eliminators with Sulzer KnitMesh VKR technology employ the mechanism of a Von Karman Roll (VKR) around a bluff body (See Figure 1a) to obtain high vapor and liquid handling capacity. A vortex develops in a low pressure zone downstream of the channel that has been attached to the bottom of the mesh pad. Collected droplets deposit in the trough and form a flowing liquid stream there. Contrast this with the standard mesh pad (See Figure 1b) where a two phase ‘fluidized’ zone of gas and liquid develops in the bottom third to half of the pad and from which large coalesced droplets must ultimately drain countercurrent to the ascending stream. The high capacity channels of the VKR Mist Eliminators shield the collected liquid and then drain it in steady streams from two sides of the mist eliminator at the column wall, where gas velocity is so low that re-entrainment is limited (See Figure 2).

This simple enhancement to a standard mesh pad improves mist elimination because the higher velocities increase the droplets’ inertial impaction with the wires or filaments. Meanwhile, the strategically placed collecting channels provide higher operational gas and liquid flow capacity.
High Performance Sulzer KnitMesh™ 9797 Mist Eliminators

The Sulzer KnitMesh 9797 Mist Eliminator technology provides a means of optimizing designs to meet the challenges of specific applications.

Unlike ‘industry standard’ mist eliminator design methods, which predict performance using bulk density and filament diameter of the separation media, the 9797 modeling techniques consider the characteristics of individual mesh layers as a mathematical model so that the entire process within the separator (capture, coalescence and drainage) can be predicted on a layer by layer basis. This enables Sulzer to produce unique structures where the free volume and mesh free area can be varied through the depth of the pad, giving the best balance of mist eliminator characteristics, such as liquid hold-up and efficiency, from inlet to outlet. Additionally, separation efficiency can be predicted in terms of liquid entrainment concentration providing meaningful, measurable information on separator performance; a considerable improvement on droplet size efficiency predictions which are extremely difficult to verify in practice.

Fig. 3 illustrates one layer of mesh within the mist eliminator and stages of separation considered by the performance model:

- D1 avoids capture and moves in to the next layer of mesh.
- D2 is captured by the mesh.
- D3 and D4 coalesce to form a bigger droplet or film.
- D5 drains from the mesh surface.

An extensive range of mesh styles have been analyzed for a variety of process systems ranging from air/water to more challenging hydrocarbon conditions. The performance of the mist eliminator is established by calculating the cumulative effect of combined mesh layers and their characteristics. The model allows a high degree of optimization so that layer specifications can be varied to meet specific process challenges. For example, high free volume/low liquid hold-up may be an important feature of the inlet region of the mist eliminator with a gradual increase in separation efficiency towards the outlet.

Fig. 4: The stages of droplet separation on a wire mesh.

By assuming that:

- $V_0$ is the volume of droplets entering Layer 1
- $V_n$ is the volume of droplets leaving layer N
- $E_i$ is the individual layer efficiency,

then the overall efficiency of the mist eliminator can be expressed as:

$$V_N = V_0 \prod_{i=1}^{N} (1 - E_i)$$

Existing applications for Sulzer KnitMesh 9797 Mist Eliminators include:

- glycol contactors – minimization of TEG entrainment from natural gas dehydration columns (see p 20).
- gas sweetening – installation in amine absorbers.
- dew-point separators – 9797 designs have helped reduce water and hydrocarbon dew-points in natural gas processing (see p 22).
- rotary screw compressors – reduction of entrainment of synthetic oil from compressor system knock-out drums.
- steam drums – guaranteed steam dryness can be achieved using Sulzer KnitMesh 9797 mist eliminators.
**Sulzer Mellachevron™ Mist Eliminators**

Sulzer Mellachevron vane mist eliminators are high capacity inertial separators constructed as banks of parallel, chevron profiles which cause the gas to change direction several times from inlet to outlet. Momentum forces entrained liquid droplets to impinge on the vane surfaces where they form a liquid film and drain.

The Sulzer Mellachevron range is divided into a number of categories depending on direction of gas flow and the complexity of the vane profile.

Simple Sulzer Mellachevron profiles separate liquid by impingement, coalescence and drainage on the vane surface with no disengagement of the liquid from the gas stream. They are particularly suitable for applications with a significant risk of fouling due to solid particles or high viscosity liquids in the feed but have relatively low gas handling capacity.

More sophisticated designs provide special separation channels to allow disengagement of liquid and drainage from the vane surface. This increases the capacity of the separator and gas load factors of up to 0.45 m/s are possible. This makes them an excellent choice when equipment size is critical, for example, in offshore applications or for de-bottlenecking existing equipment.

Complex Mellachevron profiles require housings which ensure that the vanes are assembled accurately and provide a liquid sump for drainage of liquid into the vessel or column.

Simple Mellachevron profiles are ideal for installation in vacuum distillation columns where low pressure drop is of advantage.
Mellachevron designs are available for installation in either vertical or horizontal gas flow. When gas flow is horizontal, the liquid film on the surface of the vane drains vertically downwards into a liquid sump. Complex Mellachevron profiles are used with hooks or drainage channels which help to disengage the liquid from the gas stream and prevent re-entrainment from the downstream face.

Liquid drains down vane surface to a sump.

Horizontal gas flow arrangement.

<table>
<thead>
<tr>
<th>Mellachevron – simple vanes</th>
<th>Mellachevron – Complex profiles with drainage channels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>C – profile</td>
</tr>
<tr>
<td>Profile</td>
<td>Z - profile</td>
</tr>
<tr>
<td>Flow Direction</td>
<td>Vertical</td>
</tr>
<tr>
<td>Installation</td>
<td>No housing</td>
</tr>
<tr>
<td>Gas handing capacity (K-values)</td>
<td>0.17 m/s</td>
</tr>
<tr>
<td>Turndown capability</td>
<td>≈ 30 – 50 %</td>
</tr>
<tr>
<td>Efficiency</td>
<td>Medium down to ≈ 30 – 40 µ</td>
</tr>
<tr>
<td>Liquidity load capacity</td>
<td>Moderate</td>
</tr>
<tr>
<td>Solids handling capability</td>
<td>Moderate to High</td>
</tr>
<tr>
<td>Liquid viscosity</td>
<td>Suitable for high viscosities/waxes</td>
</tr>
<tr>
<td>Typical applications</td>
<td>Vacuum, general use, fouling service</td>
</tr>
<tr>
<td>Pressure drop</td>
<td>Very low</td>
</tr>
</tbody>
</table>

Table C: Sulzer Mellachevron Mist Eliminator Styles

Typical housing arrangement for cross-flow Mellachevron. Sectional installation allows installation and removal through manway and vane profiles can be dismantled individually for cleaning if necessary.

Liquid is collected in the sump and drained through the downcomer pipe connection.
Sulzer Mellachevrons can be installed in a variety of vessel configurations to provide optimum flow and drainage characteristics within the space available. Typical installation arrangements are illustrated below in Fig. 5.

Sulzer Mellachevron cross flow high capacity vane pack for installation in a discharge drum of an ethylene plant.

The customer chooses Sulzer Chemtech for a solution which will increase the capacity of the installed vane pack in the separator.

1. Vertical Flow
2. Cross flow – Horizontal vessel
3. Cross flow – Two-stage separator
4. V-bank
5. Cross flow – In-line separator
Shell Swirltube™

The Shell Swirltube is, in essence, a stainless steel tube with a swirler at the inlet and longitudinal slits in the tube wall. Liquid is separated by impaction of droplets and on the tube wall by the centrifugal forces induced by the swirling gas flow. Re-entrainment of this liquid is prevented by draining the film via the slits to the liquid collection chamber outside the tube. To ensure the proper functioning of the Swirltube it is essential that some gas is also bled through these slits. This gas leaves the liquid collection chamber via the secondary outlets at the top of the Swirdeck assembly. Performance can be improved by using a secondary KnitMesh mist eliminator to separate entrainment from the gas leaving the secondary outlets. The main fraction of the gas leaves the Swirltube via the primary gas outlet at the top. Drain pipes guide the liquid, collected in the space between the tubes and on the upper cover of the Swirdeck, to below the liquid level.

Scaling-up of a separator equipped with a Swirdeck is done simply by increasing the number of Swirltubes proportional to the gas flow in the separator.

Shell Swirltube Light™

The Shell Swirltube Light is available as an attractive alternative to vane packs for high capacity bulk separation. The Swirltube Light is based on the sophisticated de-entrainment device used in the Shell ConSep™ Tray.

Recommended use:

- comparable efficiency but higher capacity compared to vane packs.
- operation possible at higher pressures/lower surface tensions than vane packs.
- compact design makes it suitable for offshore industry or in general for high pressure conditions.
- for debottlenecking of existing separators.
- for high turndowns with pre-conditioner (up to factor 10).
- application for slightly fouling service and may be used where complex vanes or wire mesh mist eliminators may become plugged.
Combined Systems

Increasing gas capacities and higher performance requirements in mass transfer equipment are challenging the capabilities of conventional mist eliminator equipment.

To solve this, Sulzer Chemtech offers combined systems which optimize the benefits of individual types of equipment and improve overall performance.

For example, KnitMesh mist eliminators can be used in combination with Sulzer Mellachevron vane packs or Shell Swirltubes to produce very high separation efficiencies at high gas loadings. By using the KnitMesh mist eliminator as a pre-conditioner for the Mellachevron, it is operated above its normal re-entrainment or flooding point and consequently liquid is stripped away from the downstream surface.

The liquid dispersion re-entrained from the mesh mist eliminator has a larger mean diameter (See Figure 6) and is suitable for subsequent separation by secondary, high capacity equipment.

By analysis of the inlet fluid conditions, Sulzer Chemtech can design optimized mesh structures to provide the best possible outlet conditions for the downstream separator.

Additional benefits of combined systems include:

- The ability to design the equipment to provide very high turndown capabilities
- At low gas velocities, where high capacity separators tend to be ineffective, the mesh pre-conditioners behave as conventional mist eliminators

High Capacity Separators with Sulzer Mellachevrons™

![Diagram of High Capacity Separators with Sulzer Mellachevrons™](image)
**Shell High Capacity Separators**

Shell proprietary high-capacity gas/liquid separators, such as Shell SMS™, SVS™, SMSM™ and SMMSM™ separators, combine the best features of the separation products from Sulzer Chemtech’s portfolio. Shell gas/liquid separators combine Swirldeck, KnitMesh, and Schoepentoeter separation technologies in a single vertical vessel drum. Selection of separation technologies is function of the dispersed liquid phase concentration, droplet size and the required separation efficiency. Their typical application window is for separation of liquid/gas or three-phase liquid/liquid/gas mixtures, when a high capacity and high separation efficiency is required. SMS(M) Technology is the lowest weight and volume solution for phase separation offshore and onshore. It gives up to 2.5 times more capacity compared to a conventional KnitMesh mist eliminator without vessel replacement.

### Description

Shell SMS, SMSM and SMMSM gas/liquid separators are named after the configuration of the different internals used for each type of separator:

- **Schoepentoeter (S)** - used as feed inlet device for vapor distribution with bulk liquid removal
- **KnitMesh (M)** - which acts as coalescer and separator, depending on the gas flow rate
- **Double Primary KnitMesh (MM)** - specially developed for applications with two immiscible liquid phases in the feed to the separators (such as glycol/condensate in Dew-Point Separators)
- **Swirldeck (S)** - comprising multiple swirltubes

A second KnitMesh (M) is used downstream of the Swirldeck in SMSM gas/liquid separators for demisting secondary gas.

In fouling or waxy service the KnitMesh can be replaced by a Sulzer Mellachevron vane pack (SVS systems).
Applications

Natural Gas Dehydration with TEG

Old Fashioned
Bubble Cap trays and KnitMesh™ mist eliminators

State of the Art
Mellapak™ and KnitMesh™ mist eliminators incl. the sophisticated KnitMesh 9797 type

High Capacity
MellapakPlus™ and our high capacity mist eliminators such as MKS Multi Cassette™, Mellachevron™, Shell SMS™ or Swirltube Light™

The Ultimate
Shell Swirl Tube™ Trays and Shell SMS™ (see also the Brochure Trays for any Applications)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Characteristics</th>
<th>Characteristics</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 % capacity</td>
<td>190 % capacity</td>
<td>300 % capacity</td>
<td>400 % capacity</td>
</tr>
<tr>
<td>&gt; 20 % more efficiency</td>
<td>&gt; 20 % more efficiency</td>
<td>20 % more efficiency</td>
<td>6.0 F-Factor</td>
</tr>
<tr>
<td>~ 1.5 F-Factor ((\sqrt{\text{Pa}}))</td>
<td>~ 2.9 F-Factor</td>
<td>~ 4.5 F-Factor</td>
<td>~ 6.0 F-Factor</td>
</tr>
</tbody>
</table>

Using Sulzer’s sophisticated KnitMesh 9797 Technology in Glycol Contactors

The first application for Sulzer KnitMesh 9797 mist eliminators was for installation on an offshore platform in the North Sea. The requirement was to control and reduce the glycol entrainment (as liquid drops) in the gas prior to compression and export. In off-shore facilities the implications of entrainment from the dehydration columns are not only on the value of the glycol lost (and re-supply from shore), but also the consequences of admitting the excess glycol into the gas export pipeline. Notwithstanding possible operational problems for the pipeline, the increased separation load at the shore terminal to separate gas condensate and glycol, and disposal of the glycol phase, are significant costs. The ‘industry standard’ figure defining the maximum entrainment of 0.1 US gallons per MMSCF gas was therefore challenged and had to be improved upon. The mist eliminator supplied with this application was shown to significantly reduce the free glycol loss in the exit to < 0.05 US gallons per MMSCF gas, a figure verified after measurement of total glycol loss from the dehydration unit.
Using Sulzer’s MKS Multi Cassette™ Technology in Glycol Contactors

The first application for Sulzer MKS Multi Cassette mist eliminators was for installation in Glycol Contactors in Russia. The contactors were revamped from trays to Sulzer MellapakPlus and were operated at very high gas loading factors. In order to keep the glycol loss low at this high column gas throughput the MKS Multi Cassette mist eliminators were installed in the contactor top section. The application was shown to meet measured glycol losses of < 0.1US gallons per MMSCF gas.

The patented Sulzer MKS Multi Cassette mist eliminator combines the useful centrifugal forces in cyclones with the high separation efficiency of wire mesh packings to give a new superior demisting device.

Glycol Dehydration Process using Shell SMSM internals in the Feed Inlet Scrubber and Glycol Contactor

Highly efficient liquid scrubbing from the gas feed to glycol contactors is needed in order to avoid bottlenecks in the dehydration system caused by hydrocarbon carry over which can lead to foaming and excessive overall glycol losses. Sulzer’s mist elimination products such as Sulzer KnitMesh and Shell Separators meet for these high process demands.

Condensate Treatment Unit

Application for Sulzer Chemtech’s liquid/liquid separator products such as:
- Sulzer Mellaplate™ plate pack
- Sulzer DC Coalescer™
- Sulzer Dusec™ and Dusec Plus™
- Sulzer Static Mixers

Application for Sulzer Chemtech’s mass transfer products in the glycol regeneration facility.
**Applications**

**Low Temperature Separation (LTS) Process**

The performance of the gas separators in LTS Processes is crucial in order to meet the hydrocarbon and water dew point specifications. The dew point separator is especially essential for the overall performance of the plant. Even small amounts of entrained liquids will rapidly appear as increased dew point in the sales gas. To obtain the best from the LTS Process, our high performance Shell SMMSM separator internals are implemented in the Expander Suction Drum and in the Dew Point Control Separator, and Shell SMS separator internals in the Inlet Separator and in the Export Compressor Suction Drum.

**Molecular Sieve Dehydration Process**

The effect of a high performing Feed Inlet Separator on the deactivation rate of the molecular sieves is substantial. The water absorption capacity deteriorates badly over time as the co-adsorbed hydrocarbons accumulate in the molecular sieve. Sulzer Chemtech recommends the use of a drum with Schoepentoeter and a high efficiency KnitMesh mist eliminator or the Shell SMMSM separator internals when high capacity and efficiency are required.
Mist Eliminators in Desalination Processes

Desalination by multi-stage flash evaporation or multiple effect distillation units is by far the most widely used method of generating fresh water from brine or sea water in the world. It is extremely reliable and can produce high purity water from almost all forms of feed. The process involves evaporating water from a brine solution and condensing the vapor as fresh water.

However, the performance of any flash evaporator can deteriorate if liquid entrainment is carried over from the flash chambers into the condenser tube bundles. This is a very likely occurrence in view of the high velocities and volumetric flowrates experienced in these plants, and can lead to problems such as:

- Reduced water purity
- Scaling of condenser tube bundle and downstream equipment such as boilers
- Corrosion of downstream equipment

Sulzer Mist Eliminators are designed to reduce these problems and are installed in most desalination systems.

Our experience in desalination has helped us develop a range of equipment to meet the specific process needs of our customers, and great care is taken to ensure that the optimum design is offered for any particular duty. The main factors to consider in desalination applications are:

- Efficiency
- Pressure drop
- Fouling characteristics and the tendency to scale
- Materials of construction
- Cost

Sulzer KnitMesh Mist Eliminators
Sulzer KnitMesh mist eliminators are ideally suited to most desalination applications. In multi-stage flash evaporators the mist eliminators are installed directly above the flash chambers. Water vapor rises vertically upwards through the mist eliminator and passes into the condenser tube bundle. Any entrained liquid droplets are captured on the wires where they coalesce and drain, counter-current to the vapor flow, back into the flash chambers. The separation mechanism is similar to this in multiple effect distillation systems.

The combination of high free volume and specific surface area mean that excellent efficiencies can be achieved for droplets as small as 5 µm while presenting minimum pressure drop.

High capacity designs
To achieve the required capacity, the evaporators are often very large and the mist eliminators usually cover a large effective free area above the flash chambers. The total area required is determined by calculation of the mist eliminator capacity and is a very important part of the plant design. Clearly, any opportunity to reduce the capital cost of the evaporators is very attractive and the capacity of the mist elimination equipment is of vital importance in this calculation.

Most installations are designed using a conventional K-value of 0.107 m/s but Sulzer Chemtech has developed the high capacity type 4540NS KnitMesh mist eliminator which can operate at up to 20% higher K-values, providing the opportunity for either reduced equipment size or an increase in capacity. Major projects have been successfully commissioned using the Sulzer KnitMesh 4540NS mist eliminators in Oman, Algeria and the UAE.

Sulzer Mellachevron Mist Eliminators
Precipitation of salts and scale on the wires of KnitMesh mist eliminators can be a problem in some plants, particularly in the first two or three effects of the evaporation. In these circumstances, the Mellachevron Type V20Z has been used to overcome the problem. This simple vane profile provides high separation efficiency performance for droplets larger than 30 µm, and its ability to withstand heavy scaling applications makes it an ideal alternative to the KnitMesh mist eliminators when fouling is of concern. Its robust construction makes it easy to clean, and the Mellachevron V20Z also has a relatively low pressure drop compared to the more complex Mellachevron designs with drainage hooks and channels – an important factor when designing for large volumetric flowrates at low pressure.
Sulzer Chemtech Ltd, a member of the Sulzer Corporation, with headquarters in Winterthur, Switzerland, is active in the field of process engineering and employs some 2500 persons worldwide.

Sulzer Chemtech is represented in all important industrial countries and sets standards in the field of mass transfer and static mixing with its advanced and economical solutions.

The activity program comprises:

- Process components such as trays, structured and random packings, internals for separation columns and reaction technology
- Engineering services for separation and reaction technology such as optimizing energy consumption, plant optimization studies, pre-engineering for governmental approval, basic engineering
- Separation and purification of organic chemicals by means of crystallization and membranes
- Mixing and reaction technology with static mixers
- Mixing and Cartridges Technology
- Tower field services

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