SULZER

Sulzer Chemtech

Gas/Liquid Separation Technology

Introduction

Sulzer is 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 knowhow and consistent fabrication standards ensures that a well-engineered solution is available for most separation problems.

Our expertise gained from hundreds of successful installations in a broad spectrum of applications ensures that the best possible product is recommended foe 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 Swirltube™ and Schoepentoeter™. The acquisition of the KnitMesh Separation Business has added KnitMesh™ Mist Eliminators and Coalescers to our existing product range.

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Service and Supply

Sulzer offers a flexible and comprehensive range of 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 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.

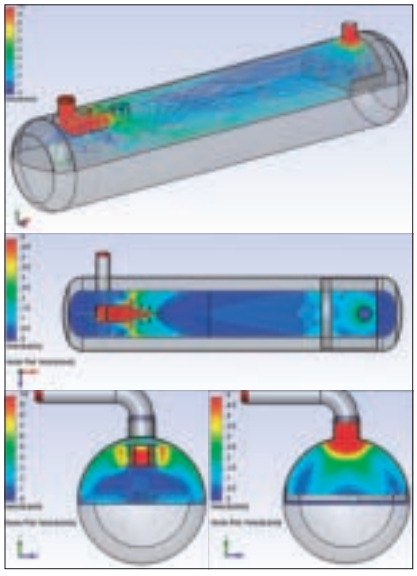
Emergency Delivery

Sulzer 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.sulzer.com

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

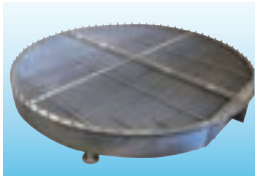
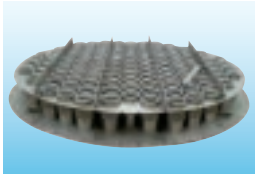


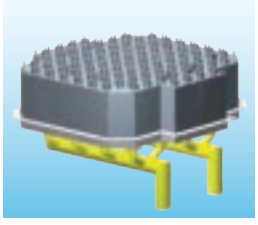
Research and Development

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.

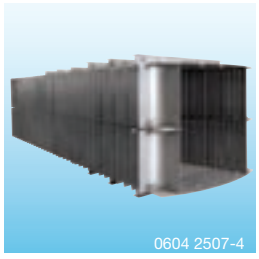
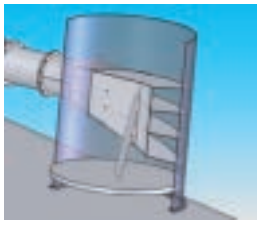
Increasingly, computer models are being used to aid the design of new products. Sulzer uses computational fluid dynamics (CFD) models to simulate product performance. This technique not only eliminates the requirement for expensive prototypes to be constructed, but provides a much greater understanding 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.

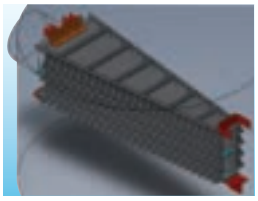
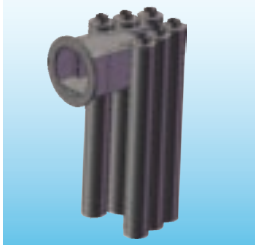
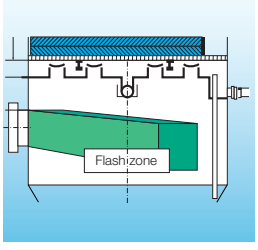
Product Summary

	Type of Separator	*Materials*	*Applications*
 0607 2504-10	KnitMesh™ Mist Eliminator	Stainless steels Alloy C22, C276, 400, 625, 825 and 20, Copper PP, FEP, ETFE, PTFE, Glass fibers	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.
 0607 2512-1	KnitMesh V-MISTER™	Stainless steels Alloy C22, C276, 400, 625, 825 and 20, Copper PP, FEP, ETFE, PTFE, Glass fibers	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.
	Mellachevron™ Mist Eliminator	Stainless steels Alloy C22, C276, 400, 625, 825 and 20, PP, PVC, PVDF, FRP	Broad range of gas/ liquid separation problems. Scrubbing systems and absorbers Evaporators Steam drums Knock-out pots Glycol contactors Inert gas scrubbers MSF/MED desalination Sulfur condenser Flue-gas desulfurization (FGD)
 0607 2507-12	Shell Swirltube™	Stainless steels, Alloy 625, 825	Gas processing applications; inlet separators, turbo-expander suction drums, dew-point separators, compressor suction drums, glycol contactors.
	Shell Swirltube Light™	Stainless steels, Alloy 625, 825	Gas processing applications; inlet separators, turbo-expander suction drums, compressor suction drums. Scrubbing systems and absorbers, PEB neutralization column.

Typical operational Range	*Characteristics*	
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 2.5mbar. Designs available for installation in either horizontal or vertical gas flow.	Manufactured as a knitted wire mesh packing. Can be easily tailor-made to suit most vessel shapes and sizes. Cost effective and versatile solution for most mist elimination applications.	 0607 2504-18
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.	Manufactured as a knitted wire mesh packing. Support grids fitted with special V-MISTER drainage channels to enhance drainage characteristics. Can be easily tailor-made to suit most vessel shapes and sizes. Cost effective and versatile solution for most mist elimination applications.	 0607 2512-3
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 KnitMesh pre-conditioners. Generally for use at: - surface tension > 10 dynes/cm. - operating pressure < 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.	Constructed from banks of parallel corrugated, chevron profiles. High capacity designs provide compact separators - ideal for gas processing applications. Lower capacity designs available for fouling service and heavy liquid loadings.	 0608 2502-6
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.	High performance Swirltubes (HPST) arrayed in boxes or banks provide compact separators designed as Shell SMS, SVS, SMSM and SMMSM units, and are ideal for gas processing at all pressures. Suitable for use in fouling or waxy services.	
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.	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.	 0604 2512

Product Summary

	Type of Separator	*Materials*	*Applications*
	MKS Multi Cassette™ Mist Eliminator	Stainless steels, Alloy 625, 825	Gas processing applications; inlet separators, turbo-expander suction drums, compressor suction drums, glycol contactors.
	Shell Schoepentoeter™ and Schoepentoeter Plus™ Inlet Device	Stainless steels, Alloy 625, 825	The Schoepentoeter is the most commonly used vane inlet device for introducing gas/liquid mixtures into columns. The Schoepentoeter Plus is an advanced feed inlet vane device with considerably increased de-entrainment efficiency and first choice for all demanding tasks such as in vacuum towers, crude distillation and hydrocracker main fractionators and high pressure separators.
	TreeInlet™ Device	Stainless steels, Alloy 625, 825	The Sulzer TreeInlet is an axial flow vane gas inlet device for vertical feed nozzles. Ideal for bulk liquid disengagement in a wide range of services and applications.
	GIRZ Cyclone Inlet Device	Stainless steels, Alloy 625, 825	The GIRZ is used as defoaming cyclonic inlet device to suppress and break many types of process foams. Some typical applications include FWKO drums, flash drums, test separators, 2 and 3-phase production separators.
	GITV Vapor Horn	Stainless steels, Alloy 625, 825	The Sulzer Vapor Horn GITV as well as the new Sulzer Vanta™ inlet device GITD are primarily used in fractionators where flashing feeds require high pre-separation of any free liquids.
	Vanta™ Inlet Device GITD	Stainless steels, Alloy 625, 825	

Typical operational Range	*Characteristics*	
High capacity device with K-values up to 0.3 m/s (1 ft/s) in the column. High efficiency separation down to droplet sizes of 8 to 10 µm. Efficiency can be enhanced by combination with KnitMesh pre-conditioner. No limitation in operating pressure. Very suitable for glycol contactors. Meets glycol loss requirement of 0.1 USgal/MMSCF (~ 14 lt./MMNm3) or less	The patented MKS Multi Cassette device combines axial cyclonic and cross flow separation technology to create an efficient and attractive mist eliminator. One or more MKS Multi Cassette candles are assembled on a support plate acting as liquid collector with drain pipes.	
Generally designed at dynamic pressures < 8000 Pa, but can perform well at higher values. Is typically used for feeds having a gas volume fraction of > 70 vol%. Suitable for installation in horizontal or vertical separators. Suitable for liquid slugs.	Constructed from banks of swept vanes. Designs available for operation in most gas/liquid flow regimes. The Schoepentoeter Plus is equipped with sophisticated catching rims to minimize entrainment.	
The TreeInlet provides a superior liquid pre-separation and gas distribution and is normally effective up to dynamic pressures of about 10000 Pa.	By installing a TreeInlet and a high efficiency KnitMesh mist eliminator, liquid carryover losses are reduced to virtually zero.	
The GIRZ cyclonic inlet device utilizes the momentum of the feed stream inlet in order to generate high g-forces. Defoaming is achieved as gas bubbles are separated from the liquid phase by the centripetal forces in the cyclone tubes. Gas is released from the top of the device and the bottom opening of the cyclones is submerged below the liquid in the separator in order to avoid a gas 'blowout'.	The GIRZ consists of an arrangement of two or more cyclones symmetrically arranged off a common, centrally located header. The device can be installed in vertical or horizontal vessels. If required, mixing elements at the cyclone gas outlet will improve the distribution to the downstream device.	
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 $\sqrt{Pa}$. The feed flows radially around the vessel projecting and collecting the liquid droplets on the inner wall of the vessel.	The gas distribution is performed by baffles according to a vane gas inlet device. The device is suitable for vessel inner diameters larger than 4 m. The new Sulzer Vanta™ inlet device combines high liquid separation efficiency with high gas distribution quality.	

Mist Elimination

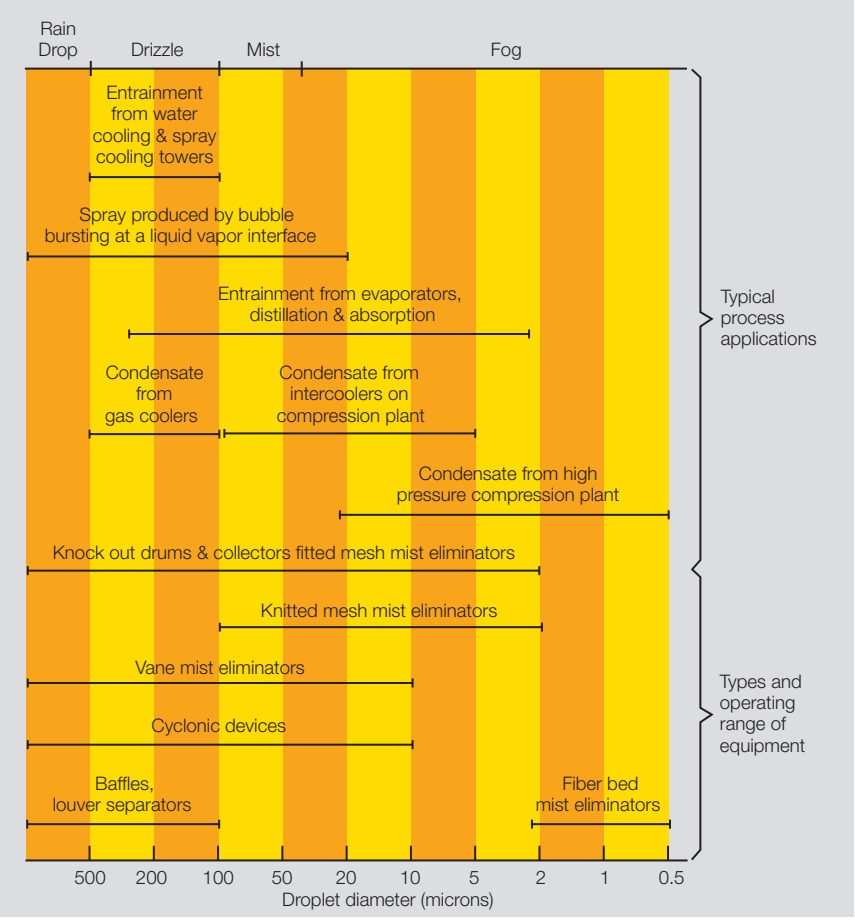
Liquid entrainment in a process gas stream can be formed by either dynamic processes, such as contact between gas and liquid phases in a mass transfer operation, or thermal processes such as condensation. For example, droplets can result from bubbles bursting or jetting at a gas/liquid interface - typically 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.

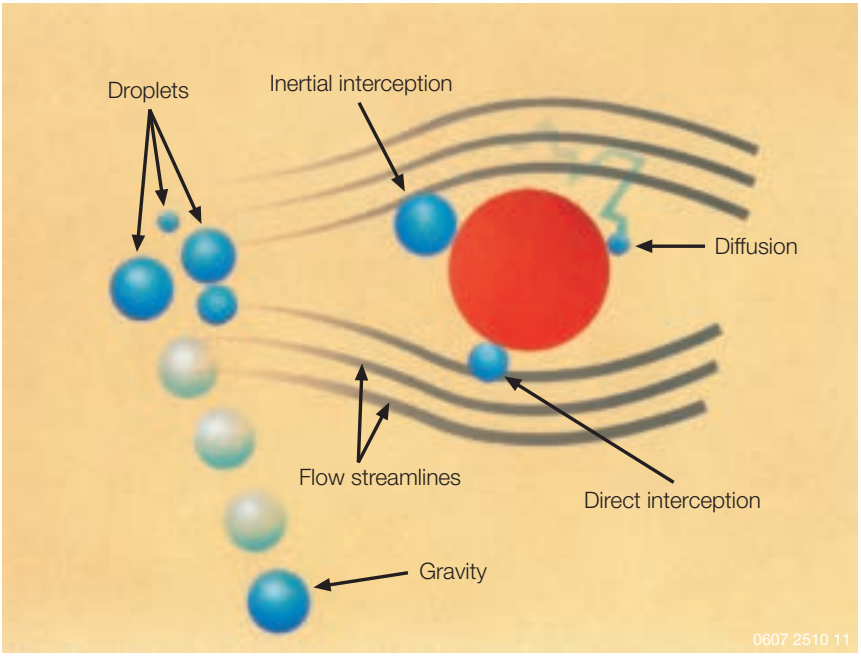
Sulzer mist eliminators provide an effective solution to liquid entrainment problems in many types of equipment including:

- 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.



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

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.

	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
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

Table A: Summary of relative performance characteristics for 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.

$$v = K \cdot \sqrt{\frac{\rho_l - \rho_v}{\rho_v}}$$

- v = maximum superficial gas velocity
- ρ_l = liquid density
- ρ_v = 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

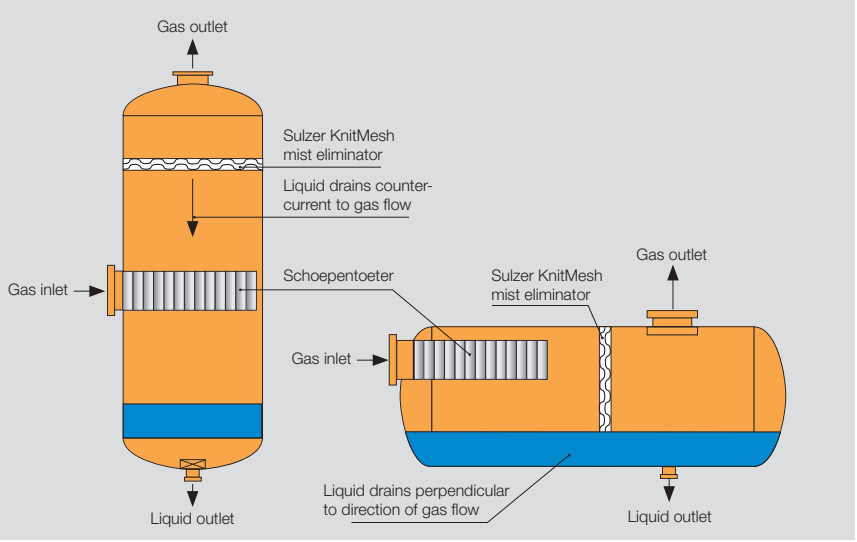
Derating factors are often applied to allow a safety margin for exceptional conditions such as liquid slugs and gas surges, and the K-value can be optimized to suit specific process conditions, and challenging physical properties such as low surface tension systems. The selection of K-value is therefore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

Equipment Type	K-Value m/s	ft/s
Gravity	0.07	0.23
Sulzer Mellachevron – simple profiles	0.13 – 0.17	0.42 – 0.56
Sulzer Mellachevron – high capacity profiles with drainage channels	0.15 – 0.45	0.49 – 1.46
Sulzer KnitMesh Mist Eliminator	0.08 – 0.107	0.26 – 0.35
Sulzer KnitMesh V-MISTER	0.08 – 0.15	0.26 – 0.49
Sulzer MKS Multi Cassette	0.10 – 0.30	0.33 – 1.00
Shell SMS, SMSM	0.25	0.82

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.

Standard designs are available for routine applications, providing excellent separation efficiency down to droplet sizes as small as 2 µm, and with a pressure drop typically less than 2.5mbar. A selection of standard styles is described in Table B. Alternatively, we can provide optimized designs to suit specific duties using sophisticated design tools.

Metal Designs							
Material	Type number	Free volume	Density (lb/ft^3)	Density (kg/m^3)	Specific Surface Area (ft^2/ft^3)	Specific Surface Area (m^2/m^3)	Application
Metal	9001	97.5%	12	192	196	643	Very high efficiency, very clean service
	9033	97.5%	12	192	110	350	Heavy duty
	9032	97.75%	10.5	170	93	305	For general use
	9030	98%	9	144	79	258	Standard general purpose media
	9030-L2	98%	9	144	147	482	High efficiency for fine entrainment
	9059	98.5%	7	107	109	358	Fine entrainment
	9036	98.75%	6	96	52	172	High velocity, dirty service
	4530	98.75%	6	96	52	172	High velocity, clean service
	4540	99%	5	80	44	145	Minimum pressure drop, dirty service
Plastic and Other Materials							
Glass Wool	9036	93%	12	195	450	1500	Coalescer-very fine mists
	9048	95%	8.25	135	300	1000	Coalescer fine mists
Polypropylene	9008	95%	2.75	45.5	320	1050	High performance-acid mists
	9030	93%	4.5	74	250	820	Acid mists and marine engine intakes with minimum pressure drop
	9036	95%	2.75	44.5	150	495	
	9048	97%	2	41	110	360	
Multifilament (glass wool/ stainless steel)	9033	94%	19	305	340	1115	Fine mist conditions where stainless steel can be allowed and minimum pressure drop is important
	9030	95%	13.5	215	250	820	
	9036	96%	9	145	160	525	
FEP	9048	94%	8	128	250	820	Highly corrosive conditions
ETFE	9048	95%	5.25	85	220	725	Highly corrosive conditions

Table B: Standard Sulzer KnitMesh Mist Eliminator Types

Sulzer KnitMesh V-MISTER™

The patented Sulzer KnitMesh V-MISTER (formerly Sulzer KnitMesh VKR Mist Eliminator™) provides high performance wherever liquid entrainment must be removed from a vertically flowing gas stream. Mist eliminators with Sulzer KnitMesh V-MISTER technology employ the mechanism of a Von Karman Roll 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 counter-current to the ascending stream. The high capacity channels of the Sulzer KnitMesh V-MISTER 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. Summarized the V-MISTER collecting channels provide an increased liquid capacity of up to 300 % and a higher gas throughput of up to 20 %.

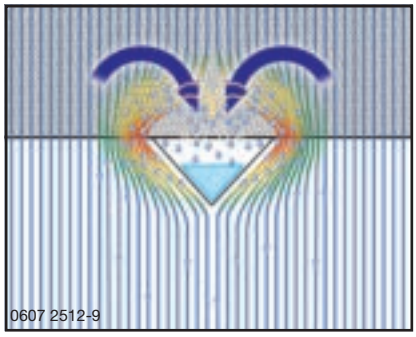


Fig. 1a

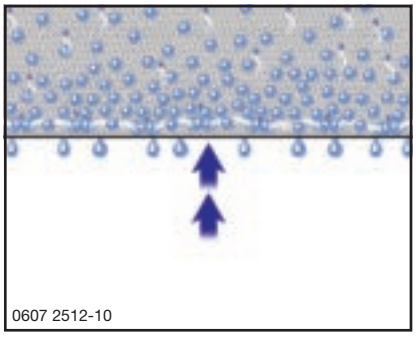
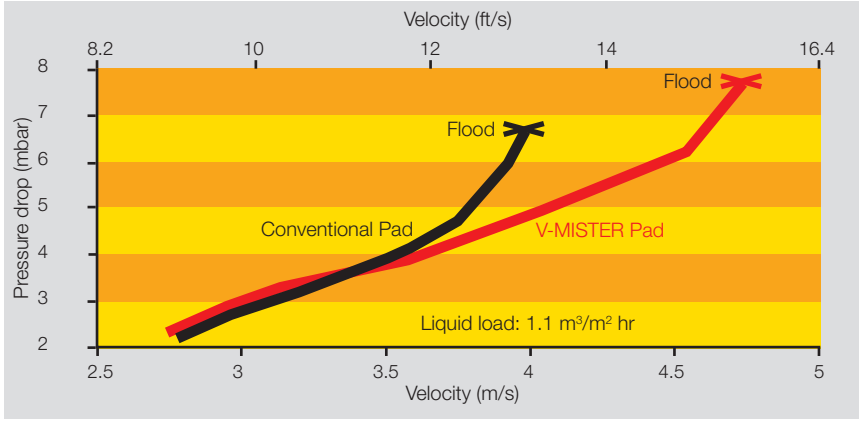


Fig. 1b

Fig. 2

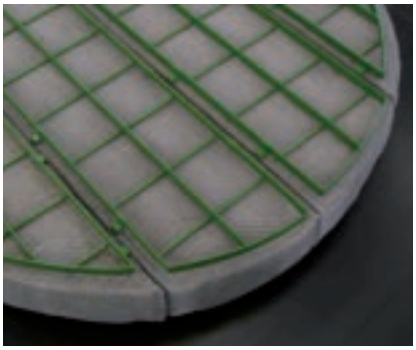


The New and Unique Sulzer KnitMesh XCOAT™ Mist Eliminator: The Perfect Solution for Corrosive Services

Sulzer has developed a completely new KnitMesh mist eliminator for corrosive services. The Sulzer KnitMesh XCOAT is based on a metal wire which is coated with 100% pure PTFE. This new mesh material is unique and available exclusively through Sulzer.

Sulzer KnitMesh XCOAT mist eliminators are characterized by a high deformation, corrosion and temperature resistance, and are therefore ideal for applications which have to deal with acids such as sulfuric, acetic and nitric acid.

The advantage of longer service time of the Sulzer KnitMesh XCOAT mist eliminator compared to common wire mesh pads using Teflon filaments or higher alloyed and acid-resistant steel wires has been demonstrated with first industrial applications.



Sulzer KnitMesh XCOAT mist eliminator for a sulfuric acid drying column

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.

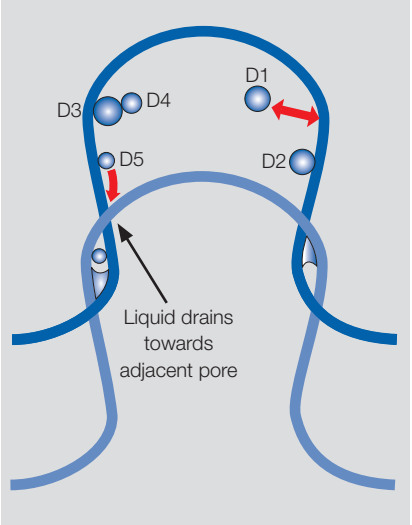


Fig. 3: The stages of droplet separation on a wire mesh.

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.

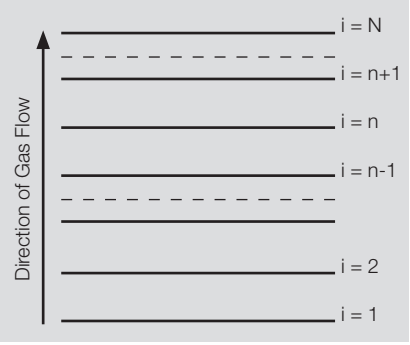


Fig. 4

Fig. 4 represents a bed with N layers of 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:

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

Existing applications for Sulzer KnitMesh 9797 Mist Eliminators include:

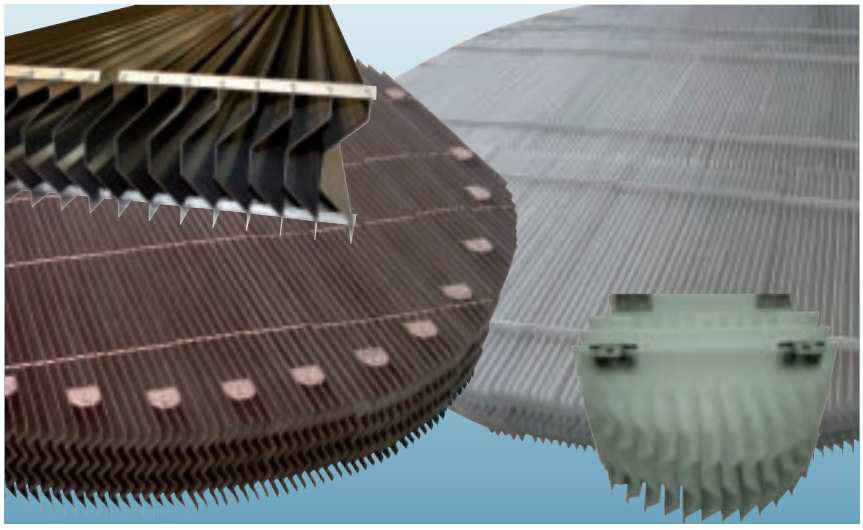
- glycol contactors – minimization of TEG entrainment from natural gas dehydration columns (see p 20).
- gas sweetening – installation in amine absorbers.
- dew-point separators – 9797 designs have helped reduce water and hydrocarbon dew-points in natural gas processing (see p 22).
- rotary screw compressors – 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

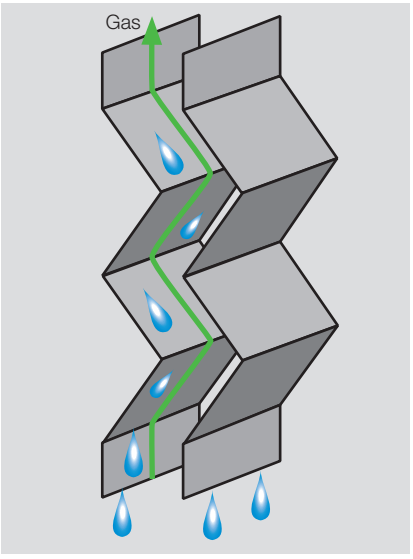
Sulzer Mellachevron vane mist eliminators are high capacity inertial separators constructed as banks of parallel, chevron profiles which cause the gas to change direction several times from inlet to outlet. Momentum forces entrained liquid droplets to impinge on the vane surfaces where they form a liquid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



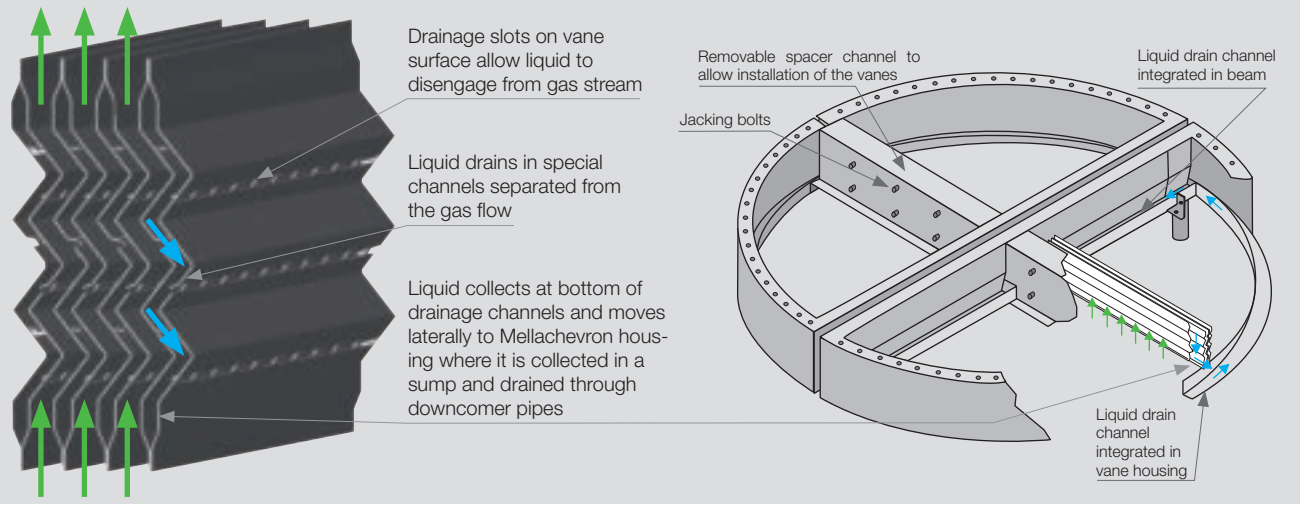
Sulzer Mellachevrons are available in various profiles and materials such as stainless steels, alloys or plastics.



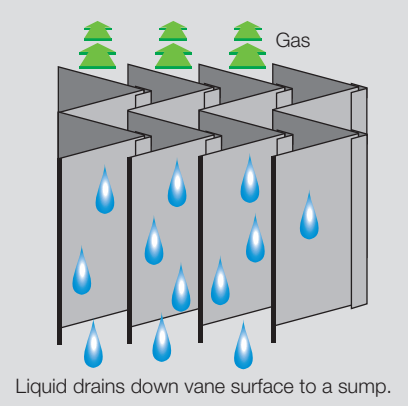
Simple Mellachevron profile with countercurrent drainage of liquid from vane surface.

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.

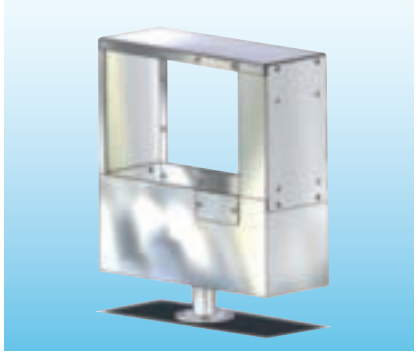
Complex Mellachevron profiles require housings which ensure that the vanes are assembled accurately and provide a liquid sump for drainage of liquid into the vessel or column.

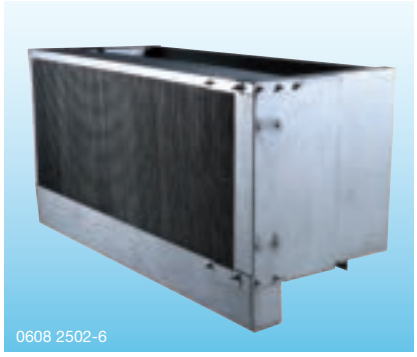


Mellachevron designs are available for installation in either vertical or horizontal gas flow. When gas flow is horizontal, the liquid film on the surface of the vane drains vertically downwards into a liquid sump. Complex Mellachevron profiles are used with hooks or drainage channels which help to disengage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



Horizontal gas flow arrangement.





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.

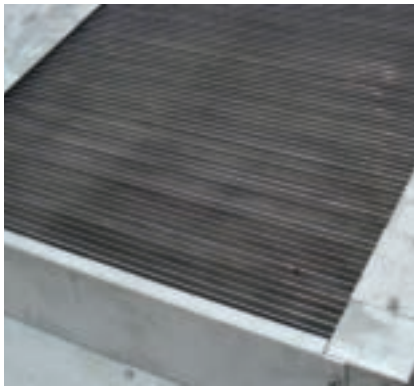
Liquid is collected in the sump and drained through the downcomer pipe connection.

	Mellachevron – simple vanes			**Mellachevron – Complex profiles with drainage channels**		
Type	C – profile	Z - profile	C or Z - profile with large vane spacing	Complex profile - integral drainage channel	Z-profile with drainage hooks	Z-profile with large vane spacing
Profile						
Flow Direction	Vertical	Vertical	Vertical	Vertical or horizontal	Horizontal	Horizontal
Installation	No housing	No housing	No housing	Housing and drainage system required.	Housing and drainage system required.	Housing and drainage system required.
Gas handling capacity (K-values)	0.17 m/s	0.14 m/s	0.14 – 0.17 m/s	0.17 – 0.45 m/s	0.35 m/s	0.35 m/s
Turndown capability	≈ 30 - 50 %	≈ 30 - 50 %	≈ 30 - 50 %	≈ 30 - 50 %	≈ 30 - 50 %	≈ 30 - 50 %
Efficiency	Medium down to ≈ 30 – 40 µ	Medium – High down to ≈ 25 µ	Low – Medium down to ≈ 30 – 50 µ	High down to ≈ 10 – 15 µ	Medium down to ≈ 25 – 30 µ	Low – Medium down to ≈ 35 – 40 µ
Liquid load capacity	Moderate	Moderate	High	Moderate to High	High	Very High
Solids handling capability	Moderate to High	Moderate	High	Low	Low	Low to Moderate
Liquid viscosity	Suitable for high viscosities/waxes	Suitable for high viscosities/waxes	Very suitable for high viscosities/waxes	Prone to fouling with high viscosities/waxes	Prone to fouling with viscosities/waxes	Suitable for high viscosities/waxes
Typical applications	Vacuum, general use, fouling service	Desalination, general use, fouling service	As for C and Z profiles but high fouling / low pressure drop services	Debottlenecking, offshore, clean services, gas & steam processing	Horizontal scrubbers	As for C and Z profiles but high fouling / low pressure drop services
Pressure drop	Very low	Low	Very low	Moderate	Low	Low

Table C: Sulzer Mellachevron Mist Eliminator Styles

Mellachevron

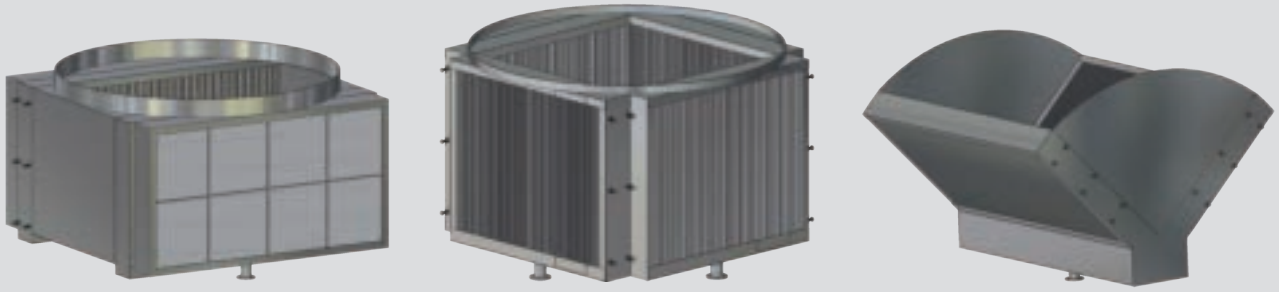
Sulzer Mellachevrons can be installed in a variety of vessel configurations and as arrangement of multiple vane boxes to provide optimum flow and drainage characteristics within the space available. Typical box and vessel arrangements are illustrated below in Fig. 5a and 5b.



Sulzer Mellachevron H45D cross flow high capacity vane pack for installation in a discharge drum of an ethylene plant.

The sophisticated vane profile and integral drainage channels of our Mellachevron H45D high performance mist eliminator provide significant advantages over conventional vane mist eliminators, including:

- reduced pressure drop at high gas load factors
- improved liquid drainage based on hollow blade concept
- up to 40 % higher gas load capacity



Double Box
with KnitMesh Pre-conditioner

Four Box

V-bank

Fig. 5a

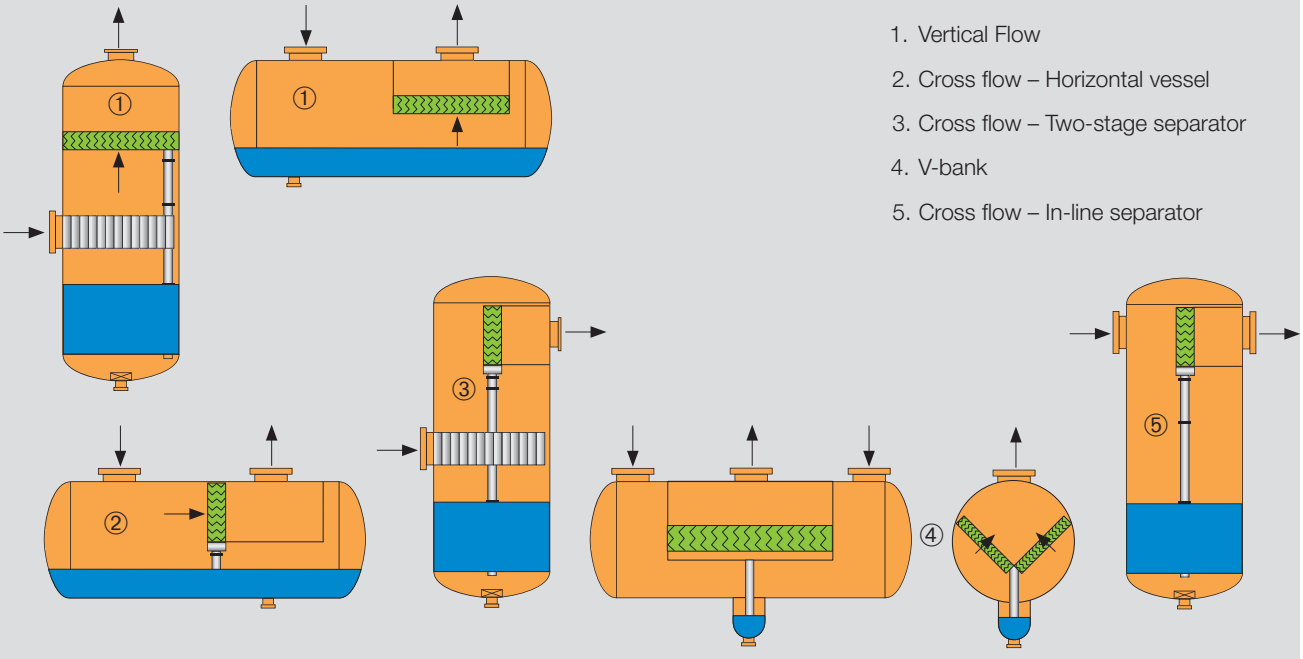


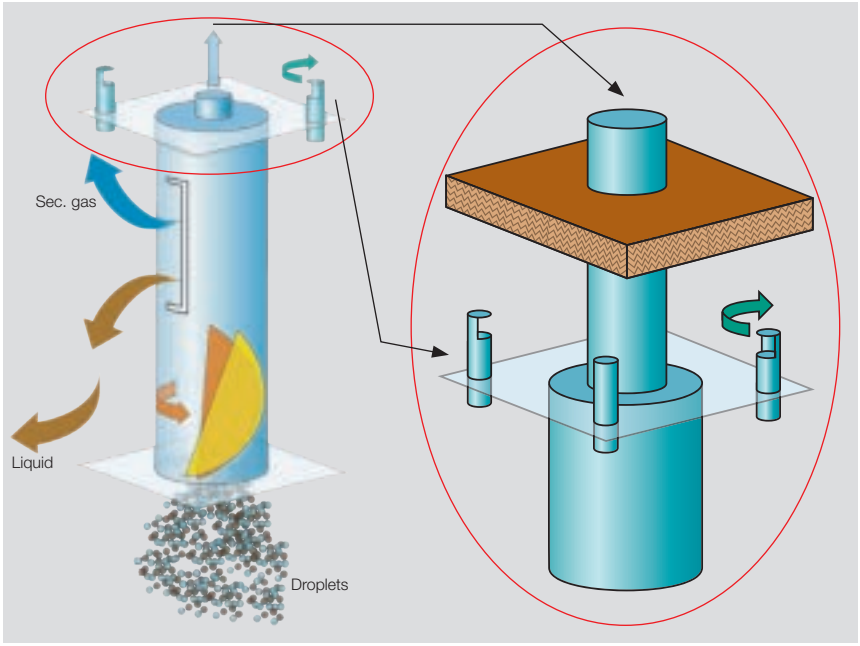
Fig. 5b

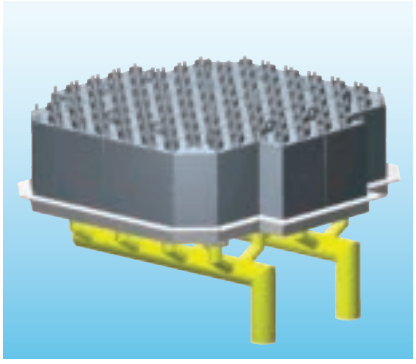
Shell Swirltube™

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 on the tube wall by the centrifugal forces induced by the swirling gas flow.

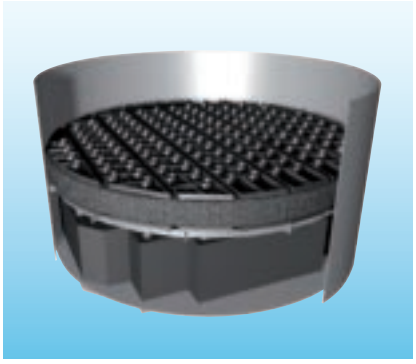
Re-entrainment of this liquid is prevented by draining the film via the slits to the liquid collection chamber outside the tube. To ensure the proper functioning of the Swirltube it is essential that some gas is also bled through these slits. This gas leaves the liquid collection chamber via the secondary outlets at the top of the Swirldeck 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 Swirldeck, to below the liquid level.

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





Swirldeck



Swirldeck with secondary KnitMesh

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 offers combined systems which optimize the benefits of individual types of equipment and improve overall performance.

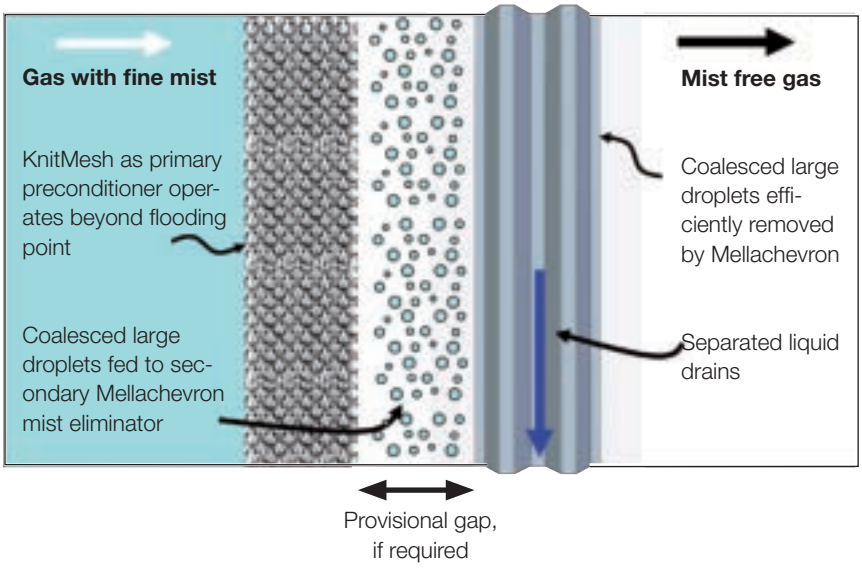
For example, KnitMesh mist eliminators can be used in combination with Sulzer Mellachevron vane packs or Shell Swirltubes to produce very high separation efficiencies at high gas loadings. By using the KnitMesh mist eliminator as a pre-conditioner for the Mellachevron, it is operated above its normal 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 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



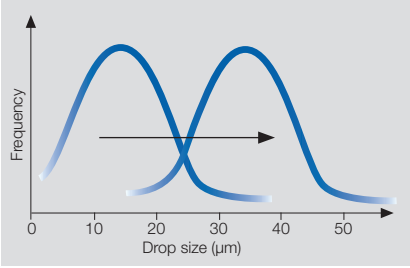
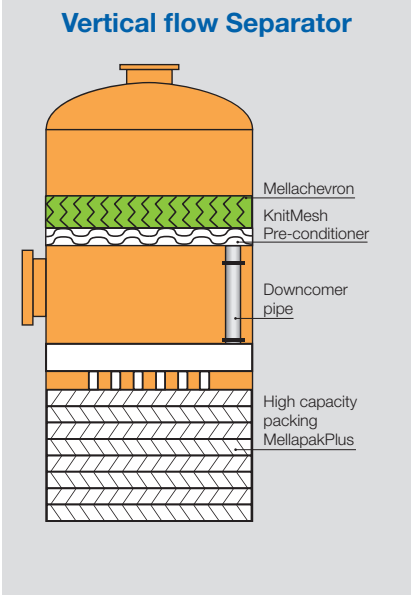


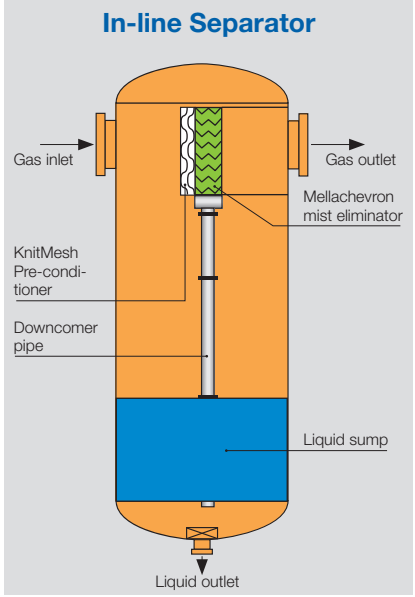
Fig. 6

High Capacity Separators with Sulzer Mellachevrons™

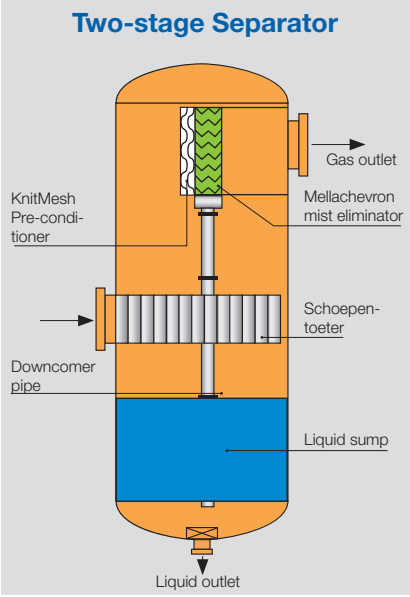
Vertical flow Separator



In-line Separator

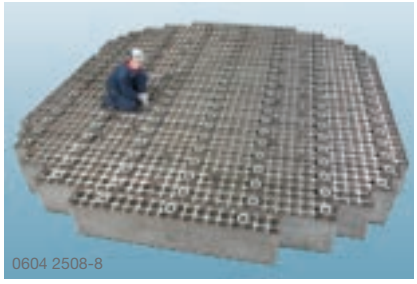


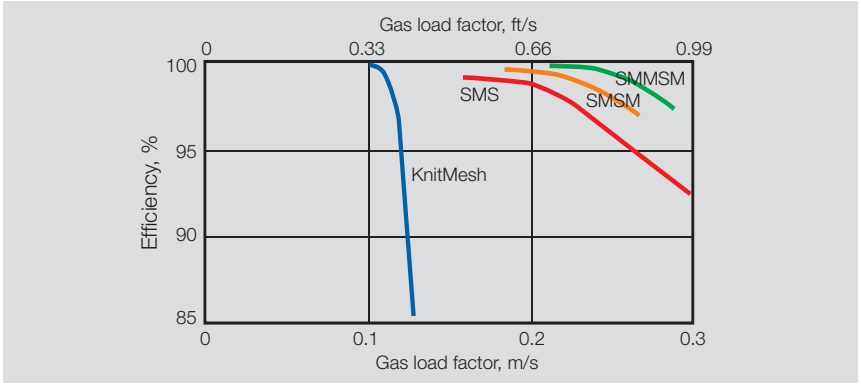
Two-stage Separator



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'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.





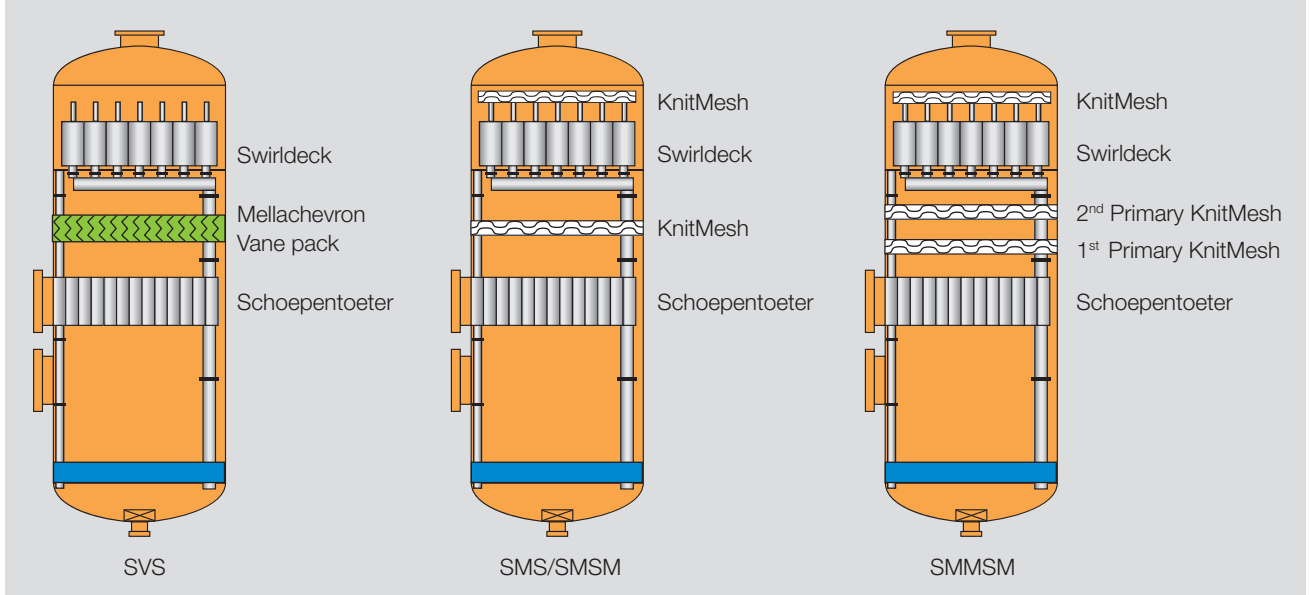
Description

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

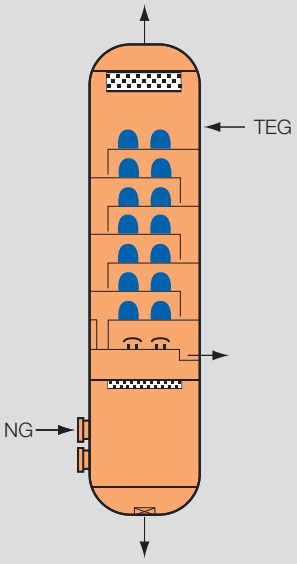
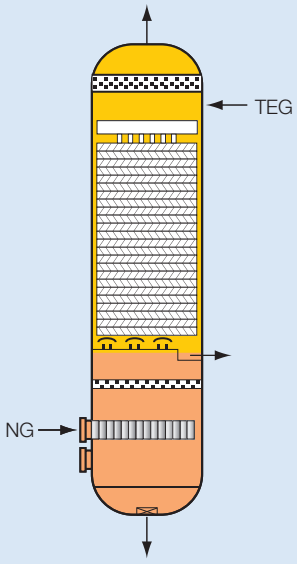
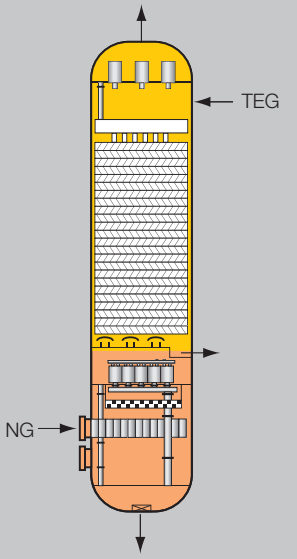
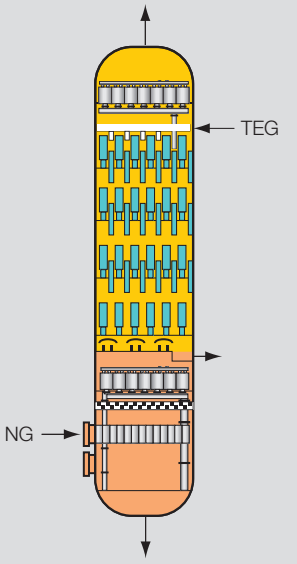
- Schoepentoeter or Schoepentoeter Plus (S) - used as feed inlet device for vapor distribution with bulk liquid removal
- KnitMesh (M) - which acts as coalescer and separator, depending on the gas flow rate
- Double Primary KnitMesh (MM) - specially developed for applications with two immiscible liquid 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).

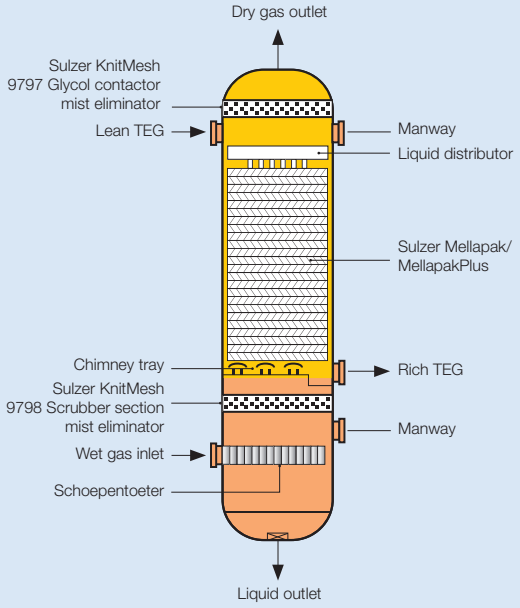


Natural Gas Dehydration with TEG

Old Fashioned	State of the Art	High Capacity	The Ultimate
Bubble Cap trays and KnitMesh™ mist eliminators	Mellapak™ and KnitMesh™ mist eliminators incl. the sophisticated KnitMesh 9797 type	MellapakPlus™ and our high capacity mist eliminators such as MKS Multi Cassette™, Mellachevron™, Shell SMS™	Shell Swirl Tube™ Trays and Shell SMS™ (see also the Brochure Trays for any Applications)
			
Characteristics	**Characteristics**	**Characteristics**	**Characteristics**
100 % capacity	190 % capacity	300 % capacity	400 % capacity
	> 20 % more efficiency	> 20 % more efficiency	20 % more efficiency
~ 1.5 F-Factor $(\sqrt{Pa})$	~ 2.9 F-Factor	~ 4.5 F-Factor	~ 6.0 F-Factor

Using Sulzer's sophisticated KnitMesh 9797 Technology in Glycol Contactors

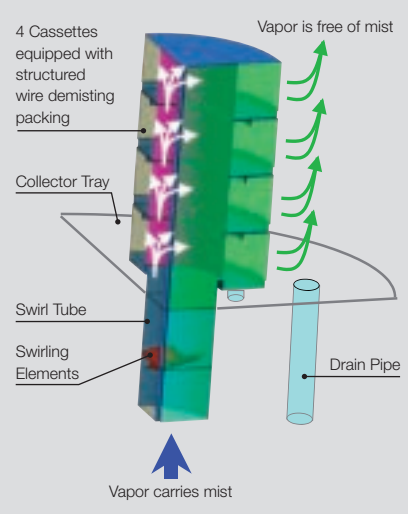
The first application for Sulzer KnitMesh 9797 mist eliminators was for installation on an offshore platform in the North Sea. The requirement was to control and reduce the glycol entrainment (as liquid drops) in the gas prior to compression and export. In off-shore facilities the implications of entrainment 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. Not withstanding 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 0.1US 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.

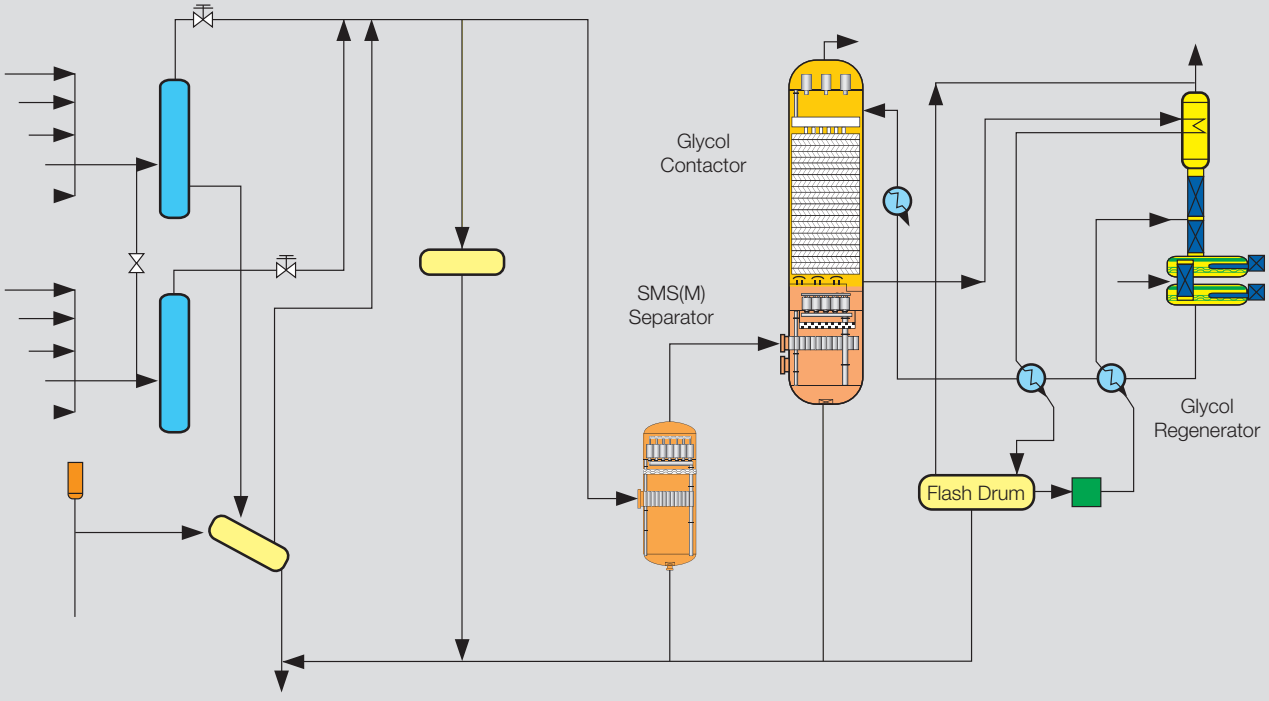
The patented Sulzer MKS Multi Cassette mist eliminator combines the useful centrifugal forces in cyclones with the high separation efficiency of wire mesh packings to give a new superior demisting device.



Glycol Dehydration Process using Shell SMSM internals in the Feed Inlet Scrubber and MKS Multi Cassette in the 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, Sulzer MKS Multi Cassette and Shell Separators meet for these high process demands.

Sulzer MKS Multi Cassette at top of glycol contactor



Condensate Treatment Unit

Application of Sulzer's liquid/liquid separator products such as:

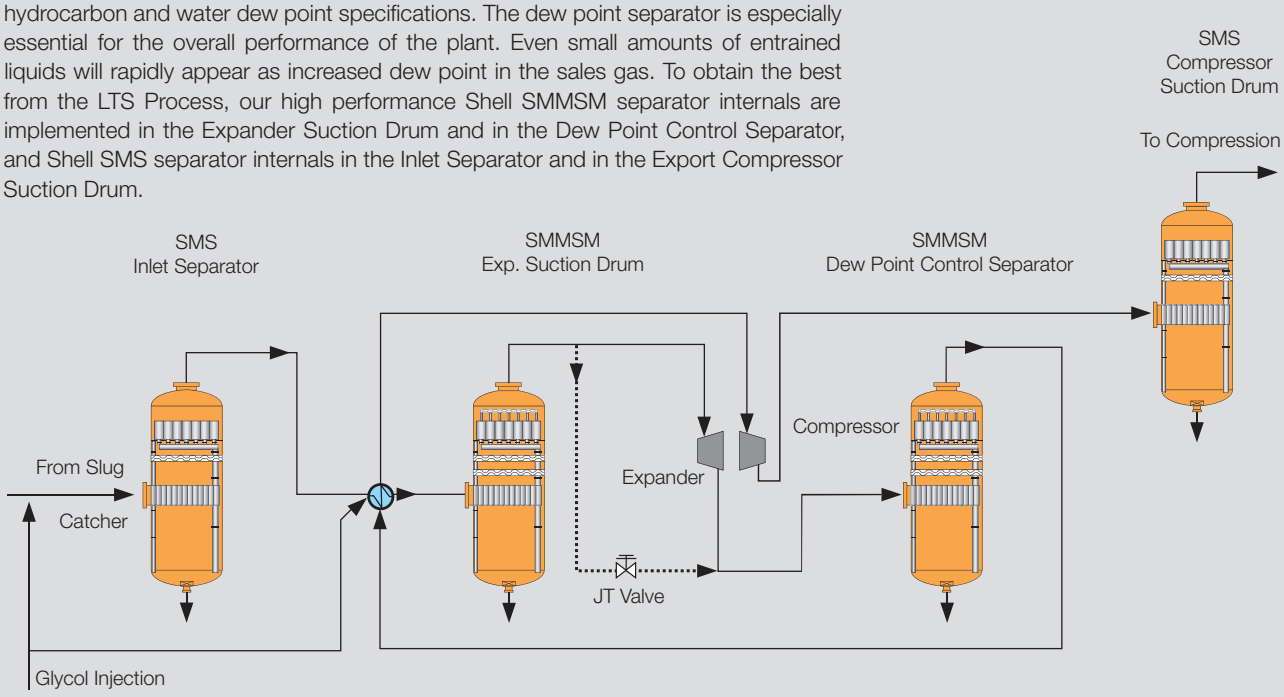
- Sulzer Mellaplate™ plate pack
- Sulzer DC Coalescer™
- Sulzer Dusec™ and Dusec Plus™
- Sulzer Static Mixers

Glycol Regeneration Unit

Application of Sulzer's mass transfer products in the glycol regeneration facility.

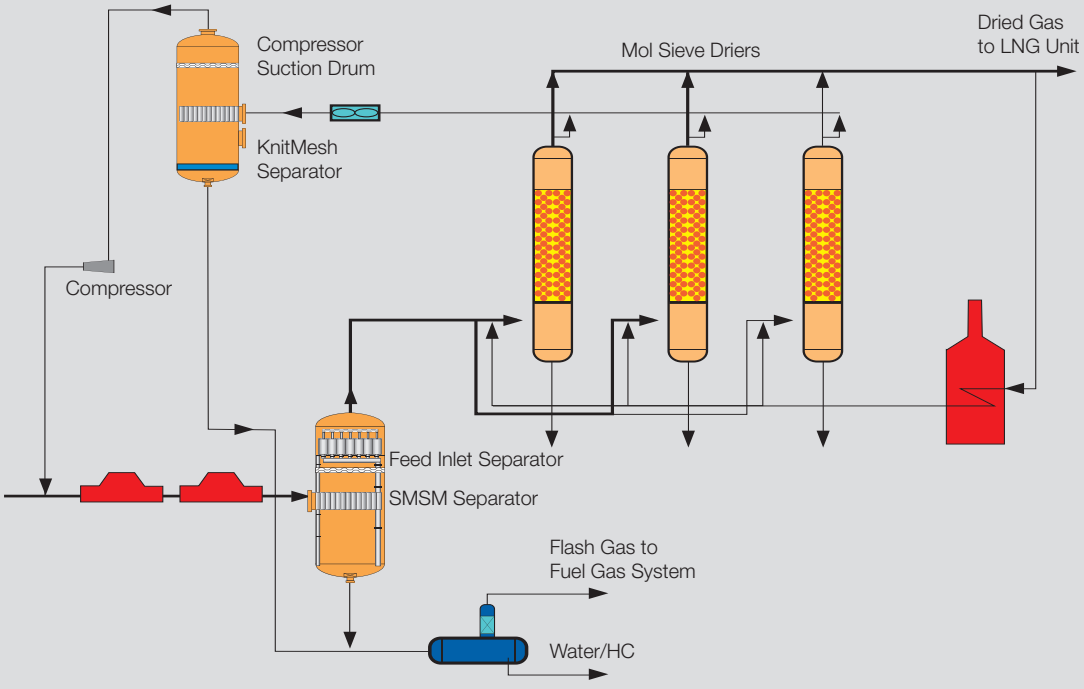
Low Temperature Separation (LTS) Process

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 recommends the use of a drum with Schoepentoeter and a high efficiency KnitMesh mist eliminator or the Shell SMSM 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.

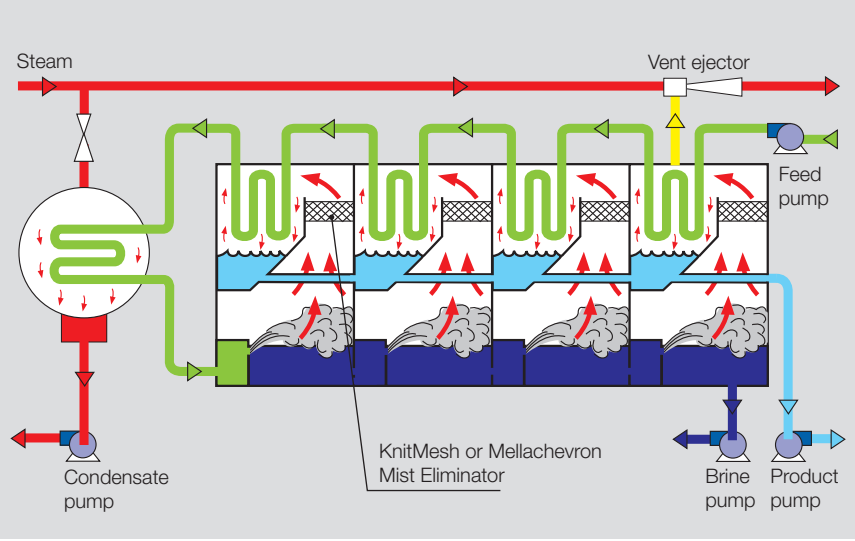
High capacity designs

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 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.



www.sulzer.com

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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 4000 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 fractionation trays, structured and random packings, liquid and gas distributors, gas-liquid separators, and internals for separation columns
- Engineering services for separation and reaction technology such as conceptual process design, feasibilities studies, plant optimizations including process validation in the test center
- Recovery of virtually any solvents used by the pharmaceutical and chemical industry, or difficult separations requiring the combination of special technologies, such as thin film/short-path evaporation, distillation under high vacuum, liquid-liquid extraction, membrane technology or crystallization.
- Complete separation process plants, in particular modular plants (skids)
- Advanced polymerization technology for the production of PLA and EPS
- Tower field services performing tray and packing installation, tower maintenance, welding, and plant turnaround projects
- Mixing and reaction technology with static mixers
- Cartridge-based metering, mixing and dispensing systems, and disposable mixers for reactive multi-component material

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