

Gas/liquid separation technology



Sulzer Chemtech – separation technology

Your partner in separation and mixing technology

The highest level of application know-how

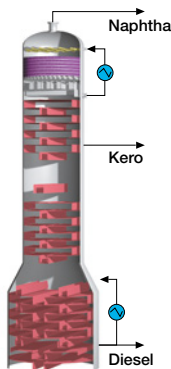
Our team provides expert knowledge for more than 500 applications in 100 processes, enabling us to optimize the performance and your installation.

Fast and reliable turnaround services

We don't shut-down, when you shut-down. You can rely on Sulzer professionals, expertise and procedures to get you back and running in the shortest possible time.

Comprehensive engineering and technology services

We provide a full scope of associated engineering and technology services to optimize or trouble-shoot your installation.



A broad range of innovative and high-performing products

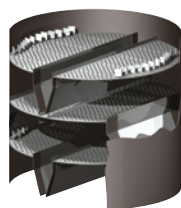
More than 200 of our products cover a wide range of needs in the field of separation and mixing technology.

They have proven their performance in more than 100'000 columns, 50'000 gas/liquid or liquid/liquid separators and 100'000 static mixers in operations worldwide.



MellapakPlus™ packing

Often copied, never equaled



UFMPPlus™ trays

One of the best high performance trays ever tested at FRI



NeXRing™

The next big thing in random packing



SMV™ static mixer

High mixing efficiency combined with large turn-down processing capabilities



Dusec Plus™ coalescer

High performance liquid/liquid coalescer

Gas/liquid separation technology

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

Our expertise gained from thousands of successful installations in a broad spectrum of applications ensures 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 VersiSwirl™ and Schoepentoeter™. The oil and gas industry is increasingly pursuing compact and lower weight processing technology to meet the technological and

economic demands of offshore, onshore, remote and challenged gas processing. Compact Mass Transfer and Inline Separation Technology (cMIST™), incorporating our patented compact HiPer TwinLine™ Separator, can replace conventional TEG contactors and associated separators to meet pipeline dew point specifications. It allows significant reductions in weight, footprint and cost. cMIST™ is an innovative dehydration system licensed from ExxonMobil to Sulzer.

Enhanced liquid-liquid separation is provided by the Sulzer VIEC™ (Vessel Internal Electrostatic Coalescer), system that uses alternating high voltage electrical fields. With the ability to tolerate 100% water and 100% gas in a robust and stable process, the system is well-suited for the separation of water dispersed in oil and the handling of stable emulsions.



Sulzer vessel based separator portfolio

Type of separator	Typical materials*										Product facts on page
	Stainless steels	Alloy C22	Alloy C276	Alloy 400	Alloy 625	Alloy 825	Alloy 20	Copper	PP, FEP, ETFE, PTFE	Glass fibers	
KnitMesh™ Mist Eliminator	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	5
KnitMesh V-MISTER™	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	5
KnitMesh™ 9797 High Performance Mist Eliminator	✓ **			✓ **	✓ **	✓ **					5
Mellachevron™ Mist Eliminator	✓	✓	✓	✓	✓	✓	✓		✓ ***		6
Shell VersiSwirl™	✓				✓	✓					6
Shell Swirltube Light™	✓				✓	✓					6
MKS Multi Cassette™ Mist Eliminator	✓					✓					7
Shell Schoepentoeter™ and Schoepentoeter Plus™ Inlet Device	✓				✓	✓					7
TreelInlet™ Device	✓				✓	✓					7
HiPer™ Cyclone Inlet Device	✓				✓	✓					8
GITV Vapor Horn	✓				✓	✓					8

* other materials on request

** can contain PTFE multifilaments in addition to the metal wire

*** if not metallic then typically: PP, PP-TF, PVC, PVDF or FRP

Product overview

KnitMesh Mist Eliminator

Features and benefits

- 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

Key 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 2.5 mbar.
- Designs available for installation in either horizontal or vertical gas flow.



Key areas of application

- 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

KnitMesh V-MISTER™

Features and benefits

- 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.

Key characteristics

- Enhanced capacity with K-values typically up to 0.13 m/s (0.45 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.



Key areas of application

- 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

KnitMesh™ 9797 High Performance Mist Eliminator

Features and benefits

- Manufactured as a knitted wire mesh packing.
- Can be easily tailor-made to suit most vessel shapes and sizes.
- Provides optimized designs to meet the challenges of specific applications.

Key characteristics

- Optimally designed capacity with K-values typically up to 0.12 m/s (0.4 ft/s).
- Optimized efficiency separation for selected applications down to droplet sizes of 1.5 to 3 μm .
- Pressure drop typically less than 2.5 mbar.
- Designs available for installation in either horizontal or vertical gas flow.



Key areas of application

- Broad range of gas/liquid separation problems
- Glycol contactors
- Amine contactors
- Steam drums
- Optimized coalescing and de-entrainment in critical services such as dew-point or LT separators
- Compressor knock-out drums

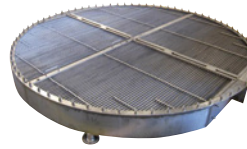
Mellachevron™ Mist Eliminator

Features and benefits

- 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.

Key characteristics

- 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 ~20µm.
- 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.



Key areas of application

- 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)

Shell VersiSwirl™

Features and benefits

- VersiSwirls arrayed in boxes or banks provide compact separators and are ideal for gas processing at all pressures.
- Suitable for use in fouling or waxy services.

Key characteristics

- High capacity systems with vessel K-values of typically 0.15-0.3 m/s (0.5-1 ft/s) or higher for selected cases.
- Effective droplet separation down to ~10 µm.
- Efficiency can be enhanced by combination with KnitMesh or Mellachevron pre-conditioners.
- Pressure drop is typically < 30 mbar.



Key areas of application

Gas processing applications;

- Inlet separators
- Turbo-expander suction drums
- Dew-point separators
- Compressor suction drums
- Glycol contactors

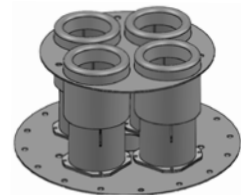
Shell Swirltube Light™

Features and benefits

- 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 in the range of high performance vane packs or above.

Key characteristics

- High capacity systems with vessel K-values up to 0.25 m/s (0.82 ft/s).
- 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.



Key areas of application

General gas processing applications and mist removal in mass transfer towers such as in the PEB neutralization column.

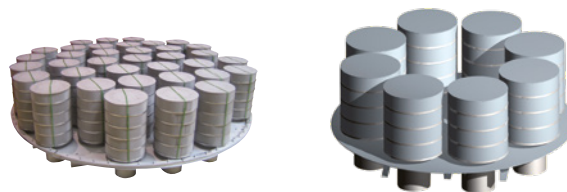
MKS Multi Cassette™ Mist Eliminator

Features and benefits

- The patented MKS Multi Cassette device combines axial cyclonic and cross flow separation Technology to create a very 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.

Key characteristics

- High capacity device with vessel K-values of typically 0.1-0.3 m/s (0.33-1 ft/s) or higher for selected cases.
- 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 losses ≤0.1 USgal/MMscf) and for systems with very low liquid densities and surface tensions.



Key areas of application

Gas processing applications;

- Inlet separators
- Turbo-expander suction drums
- Compressor suction drums
- Glycol contactors
- Dew-point separators
- Steam drums
- Knock-out drums
- Discharge drums

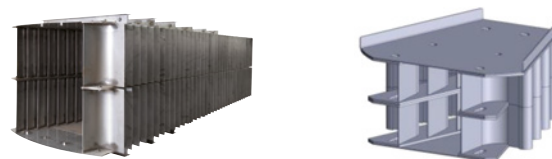
Shell Schoepentoeter™ and Schoepentoeter Plus™ Inlet Device

Features and benefits

- 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.

Key characteristics

- 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.



Key areas of application

- 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.

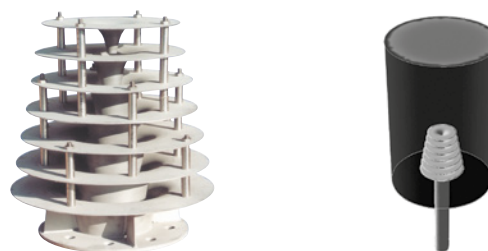
Treelnlet™ Device

Features and benefits

- By installing a Treelnlet and a high efficiency KnitMesh mist eliminator, liquid carryover losses are reduced to virtually zero.

Key characteristics

- The Treelnlet provides a superior liquid pre-separation and gas distribution and is normally effective up to dynamic pressures of about 10'000 Pa.



Key areas of application

- The Sulzer Treelnlet 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.

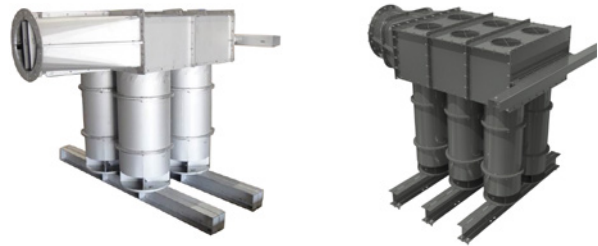
HiPer™ Cyclone Inlet Device

Features and benefits

- The HiPer cyclone inlet device consists of an arrangement of one or more cyclones symmetrically arranged off a common, centrally located header box.
- The device can be installed in vertical or horizontal vessels.
- If required, special elements at the cyclone gas outlet will improve the distribution to the downstream device.

Key characteristics

- The HiPer 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'.



Key areas of application

The HiPer cyclone inlet device is applicable for high gas and liquid handling capacities. Useful 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.

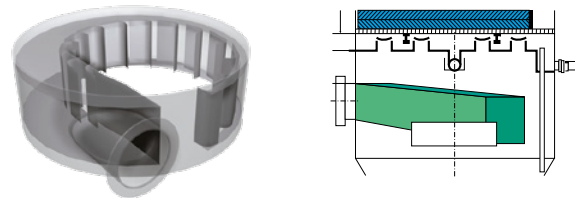
GITV Vapor Horn

Features and benefits

- 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.

Key characteristics

- The tangential vane gas inlet device GITV can be used for very high vapor velocities in the feed pipe of F-Factors up to $120 \text{ Pa}^{1/2}$.
- The feed flows radially around the vessel projecting and collecting the liquid droplets on the inner wall of the vessel.



Key areas of application

The Sulzer Vapor Horn GITV is primarily used in fractionators where flashing feeds require high pre-separation of any free liquids.

Mist elimination

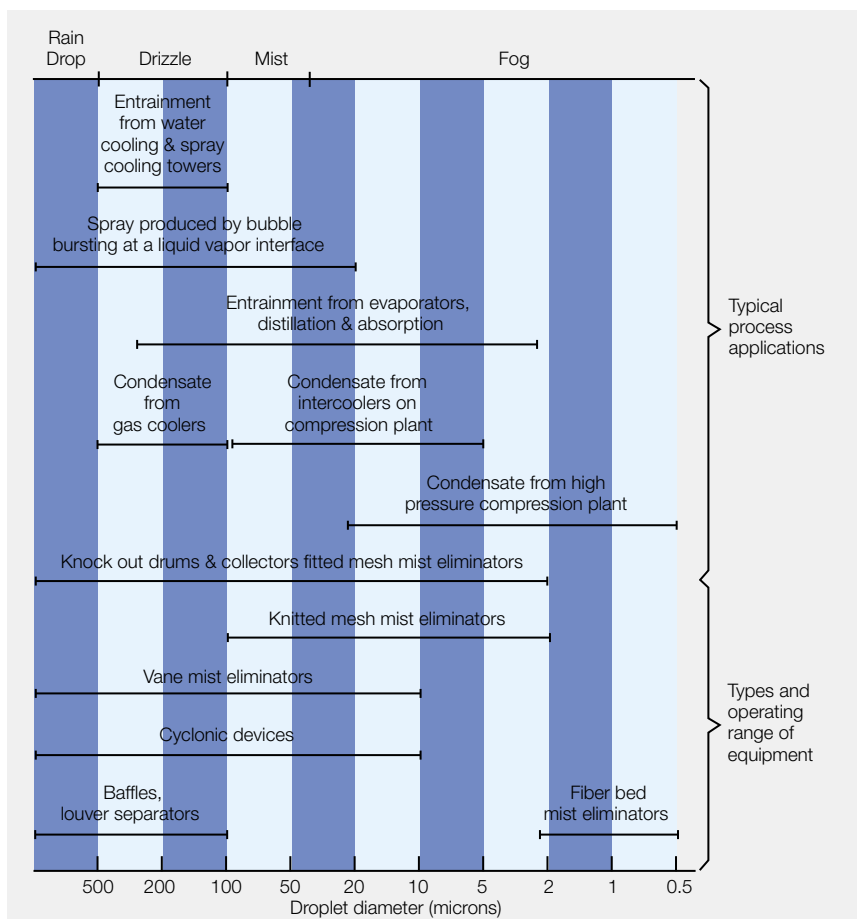
Liquid entrainment in a process gas stream can be formed by either dynamic processes, such as contact between gas and liquid phases in a mass transfer operation, or thermal processes such as condensation. For example, droplets can result from bubbles bursting or jetting at a gas/liquid interface - typically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



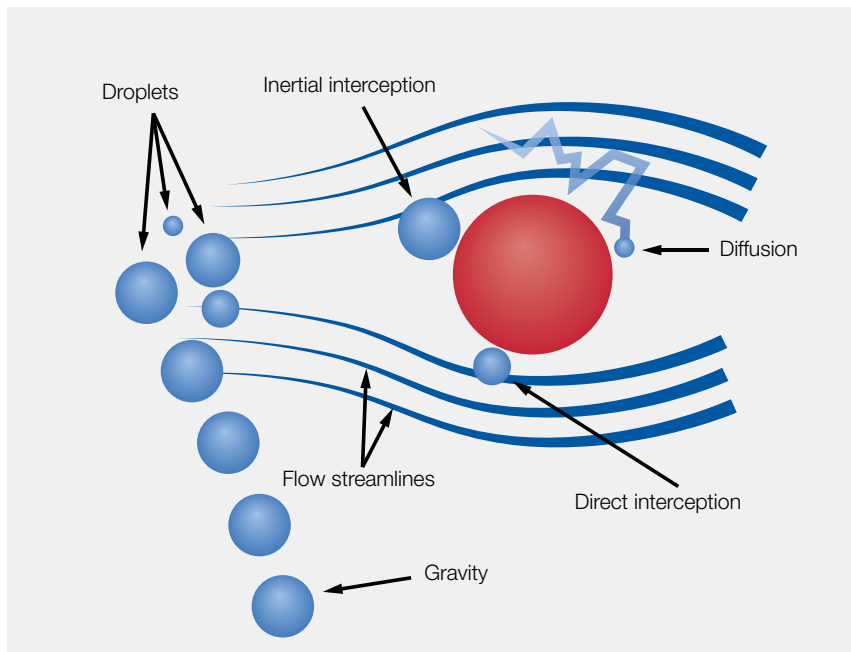
Mist elimination

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 $1\mu\text{m}$ - 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 unreasonably 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 $5\text{-}25\mu\text{m}$ 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 VersiSwirl™ and Swirltube Light™
– inertial interception
- Sulzer KnitMesh™
– inertial/direct interception
- Sulzer MKS Multi Cassette™
– inertial/direct interception

Mist elimination

	Gravity separators/ knockout drums	Baffles/ louvers	Vane packs – simple vanes	Vane packs – with drainage channels	Axial cyclone separators	Knitted mesh mist eliminators	Candles/ fiber beds
Separation mechanism	Gravitational deposition	Inertial interception	Inertial interception	Inertial interception	Inertial interception	Inertial/direct interception	Direct interception/ diffusional deposition
Gas handling capacity	Low	High	High	High	Very high	Moderate	Low
Turndown capacity	Very high	30 %	30 %-50 %	30 %-50 %	30 % Higher with preconditioner	25 %	Very high
Efficiency	Low except for large droplet sizes	Low except for large droplet sizes	High down to approx. 25 µm	High down to approx. 25 µm	High down to approx. 10 µm	Very high down to 2-5 µm	Very high at sub-micron droplet sizes
Liquid load capacity	Very high	Very high	Moderate	High	High	Moderate	Low
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 – 0.12	0.26 – 0.4
Sulzer KnitMesh V-MISTER	0.08 – 0.13	0.26 – 0.43
Sulzer MKS Multi Cassette *)	0.10 – 0.30	0.33 – 1
Shell VersiSwirl *)	0.15 – 0.30	0.5 – 1

*) refers to the vessel K-Value

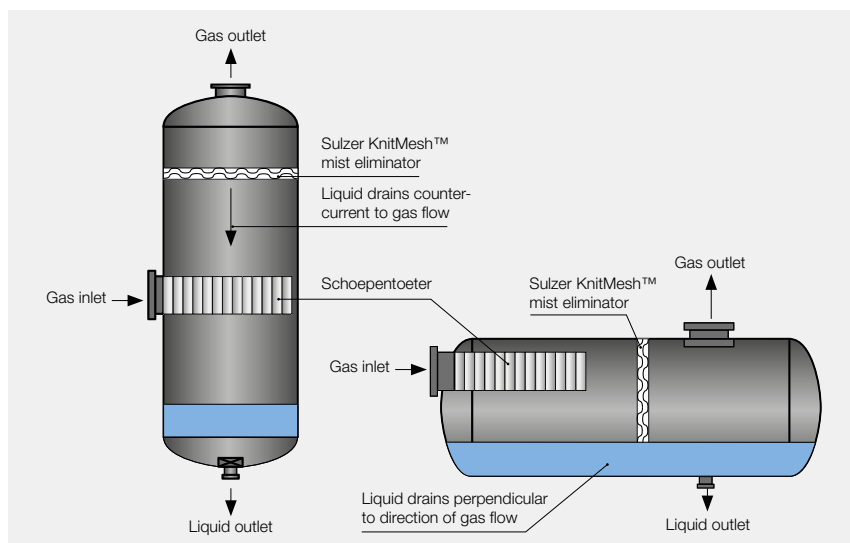
KnitMesh mist eliminators

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 2.5 mbar. 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		Specific surface area		Application
			(lb/ft ³)	(kg/m ³)	(ft ² /ft ³)	(m ² /m ³)	
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							
Material	Type number	Free volume	Density		Specific surface area		Application
			(lb/ft ³)	(kg/m ³)	(ft ² /ft ³)	(m ² /m ³)	
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

KnitMesh mist eliminators

Sulzer KnitMesh V-MISTER™

The Sulzer KnitMesh V-MISTER 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 Fig. 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 Fig. 1b) where a two phase 'fluidized' zone of gas and liquid develops in the bottom third 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 Fig. 2).

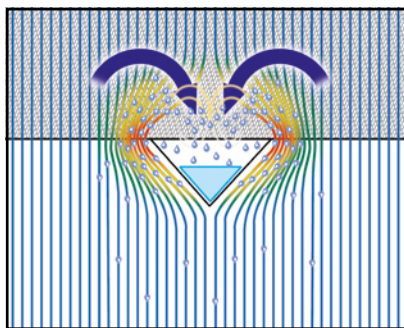


Figure 1a

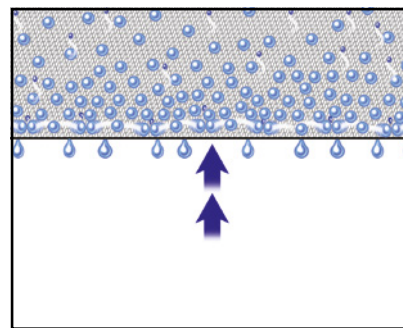
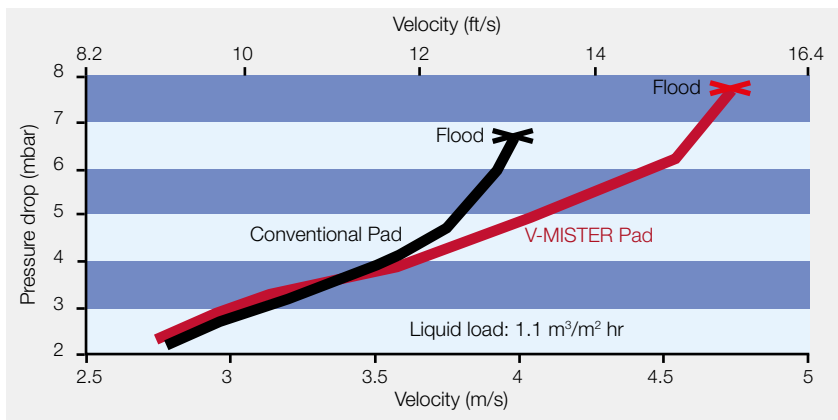


Figure 1b



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 %.

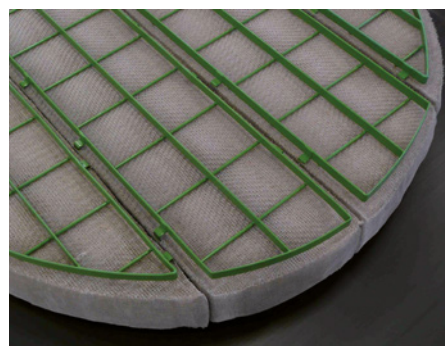


The unique Sulzer KnitMesh XCOAT™ mist eliminator: the perfect solution for corrosive services

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 PFA. 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 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 in several industrial applications.



Sulzer KnitMesh XCOAT mist eliminator for a sulfuric acid drying column

KnitMesh mist eliminators

High performance Sulzer KnitMesh™ 9797 mist eliminators

The Sulzer KnitMesh 9797 Mist Eliminator technology provides 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.

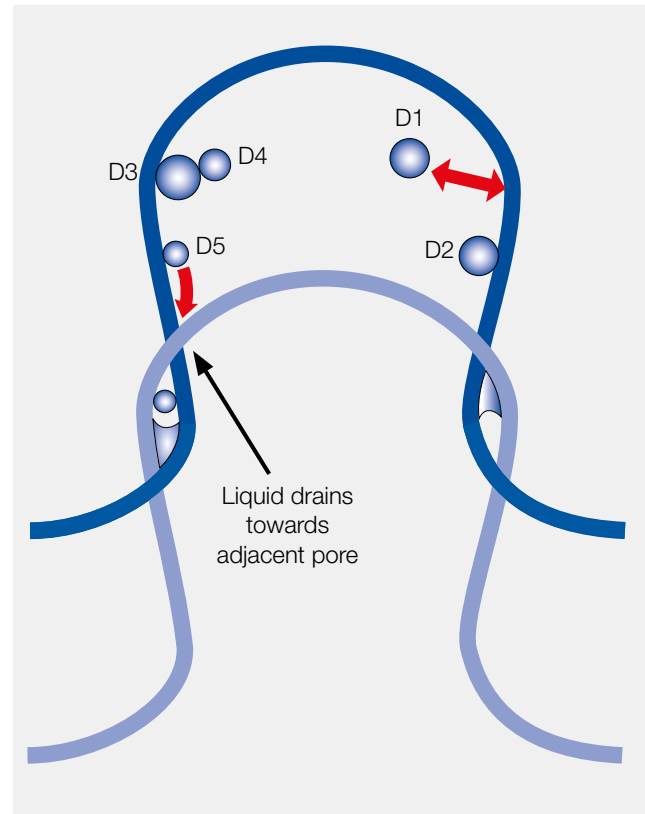


Fig. 3: The stages of droplet separation on a wire mesh.

Existing applications for Sulzer KnitMesh 9797 Mist Eliminators include:

- glycol contactors – minimization of TEG entrainment from natural gas dehydration columns (see p 21).
- 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 23).
- 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

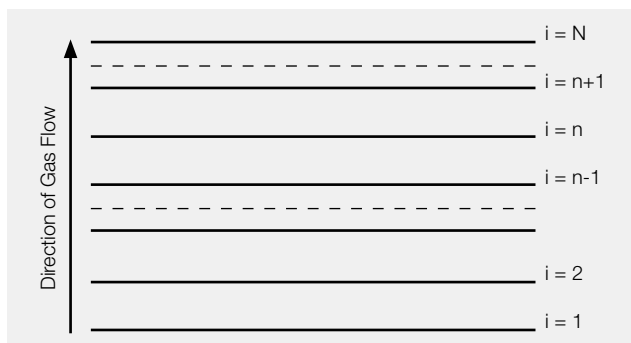


Fig. 4

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:

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

Mellachevron

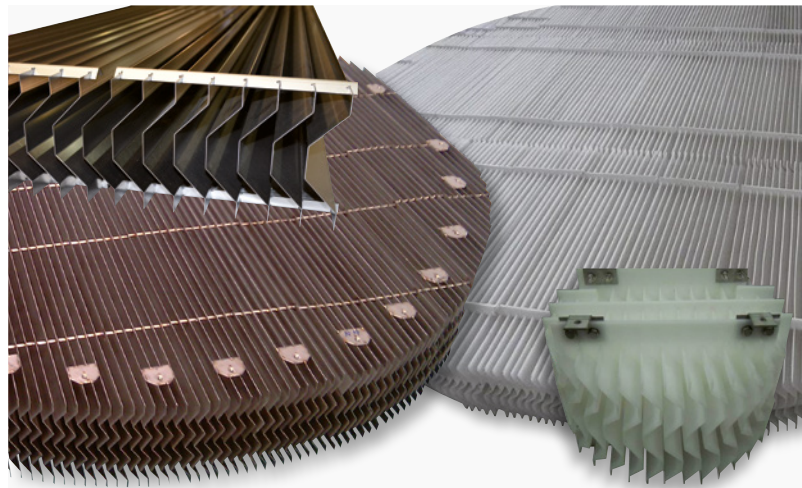
Sulzer Mellachevron™ mist eliminators

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.

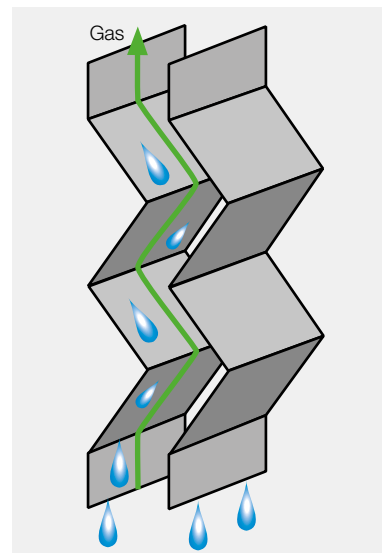
The Sulzer Mellachevron range is divided into a number of categories depending on direction of gas flow and the complexity of the vane profile.

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.

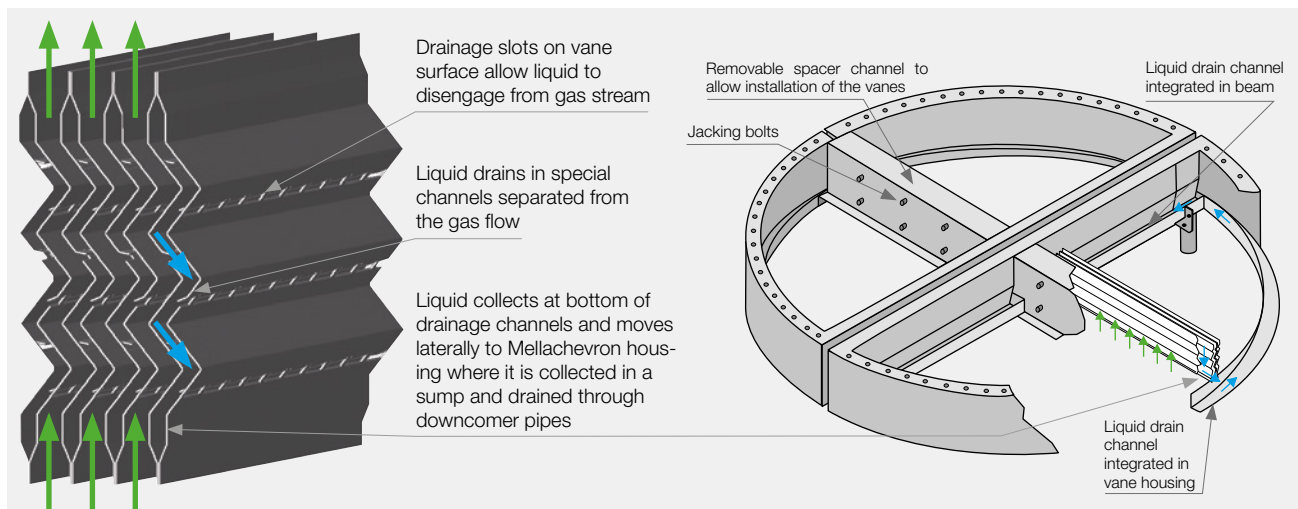
More sophisticated designs provide special separation channels to allow disengagement of liquid and drainage from the vane surface. This increases the capacity of the separator and gas load factors of up to 0.45 m/s are possible. This makes them an excellent choice when equipment size is critical, for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



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.

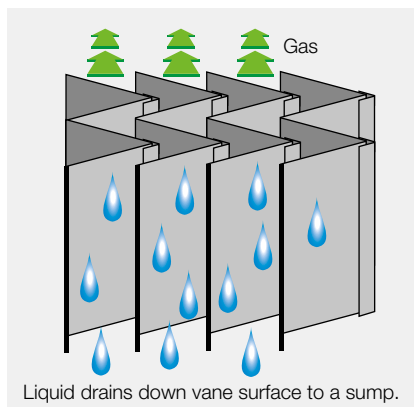


Mellachevron

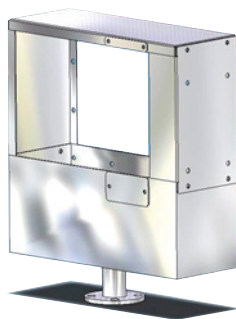
Mellachevron designs are available for installation in either vertical or horizontal gas flow. When gas flow is horizontal, the liquid film on the surface of the vane drains vertically downwards into a liquid sump. Complex Mellachevron profiles are used with hooks or drainage channels which help to disengage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

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.



Horizontal gas flow arrangement.



	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, off-shore, 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

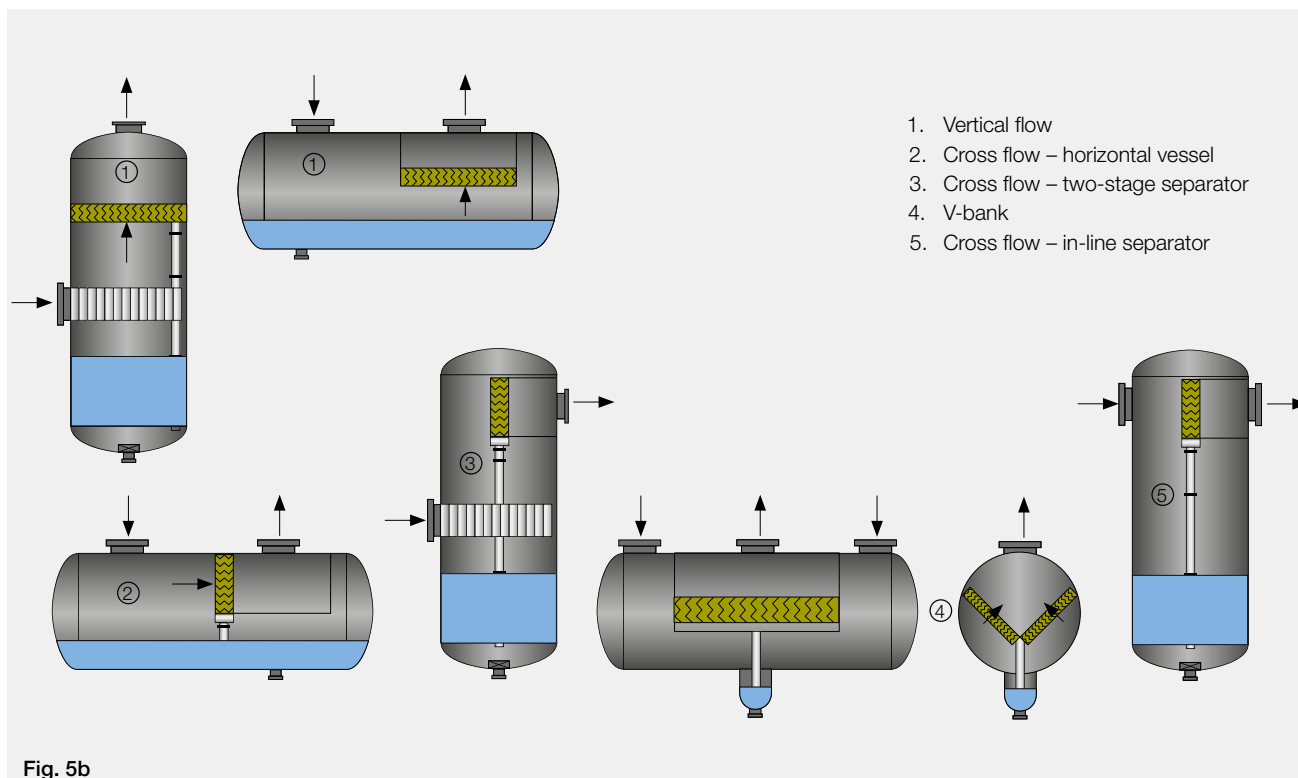
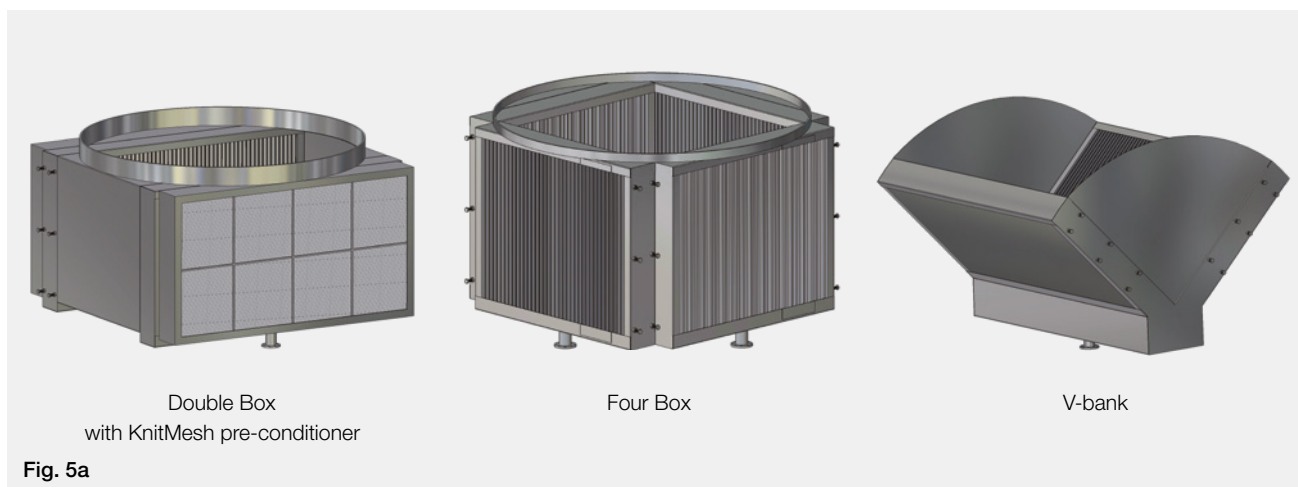
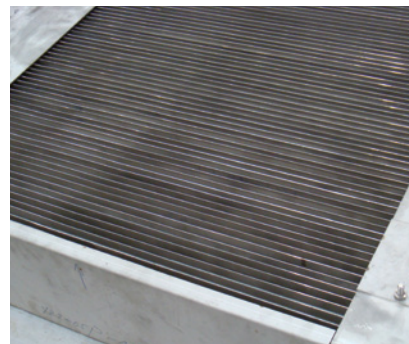
Mellachevron

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.

The sophisticated vane profile with integral drainage channels of our Mellachevron

H45D and V35D high performance vane packs provide significant advantages over conventional vane mist eliminators, including:

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

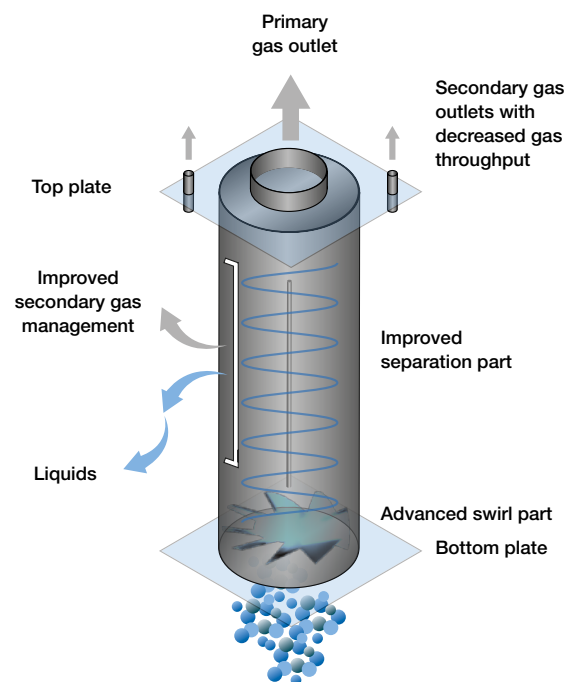
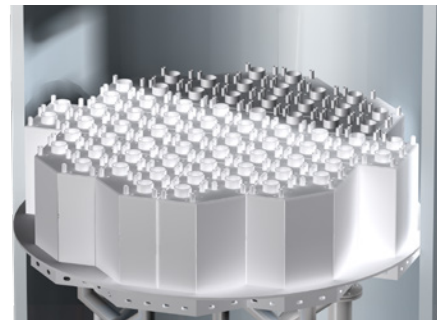
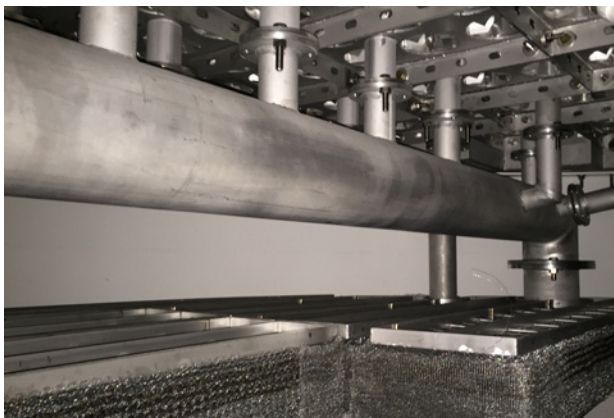


Axial cyclonic devices

Shell VersiSwirl™

Shell VersiSwirl axial cyclone represents an evolution of the long established SMS, SVS, SMSM and SMMSM family of separators. In comparison with the previous generations of technologies, Shell VersiSwirl gives a step-change in performance in terms of efficiency and capacity allowing for either smaller vessel or greater capacity. The numerous technological improvements incorporated in the Shell VersiSwirl include a new aerodynamic swirler, optimized secondary gas handling and liquid film drainage. In the Shell VersiSwirl, liquid is separated from the gas stream by impact of liquid droplets on axial cyclone tube wall which are then drained via slits into a collection chamber. The droplets are forced to the wall by centrifugal forces induced by the gas vortex generated by the swirler.

For the most demanding duties, the Shell VersiSwirl can be combined with other technologies which provide an Edge over its already impressive performance. For non-critical duties, a Shell Schoepentoeter™ is used as standard, but in challenging applications, a Schoepentoeter Plus™ will greatly reduce entrainment from the inlet zone.



A swirler creates a strong rotation in the cyclone tube. Liquid droplets are forced to the wall.

Shell Swirtube Light™

The Shell Swirtube Light is available as an attractive alternative to vane packs for high capacity bulk separation. The Swirtube 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



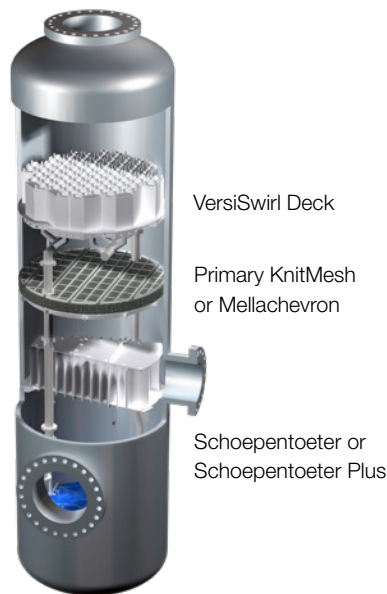
Combined systems

Selection of the appropriate primary separator is key to the system's overall performance, whether the intention is to optimize the droplet size reaching the Shell VersiSwirl or reduce liquid from the internals and prevent re-entrainment.

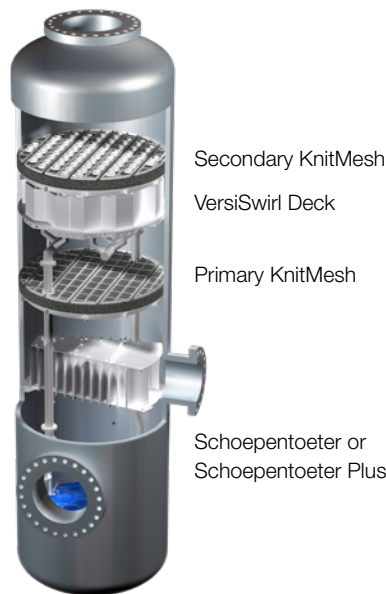
New combinations

- Shell VersiSwirl/Schoepentoeter Plus: optimized inlet device performance
- Shell VersiSwirl/V-MISTER: improved performance over the widest range of operation

Shell VersiSwirl/Drainable KnitMesh, SLR + Schoepentoeter Plus: extra drainage capacity reduces the overall load in the vessel internals where critical guaranteed performance is a must. Shell VersiSwirl gives high performance for demanding applications and when combined with optimized technologies from Sulzer's portfolio a tailored solution can be provided to meet the needs of the customer. For example, Shell VersiSwirl followed by a Sulzer MKS Multi Cassette deck to meet extra high separation efficiencies.



Shell SMS™
Shell SVS™

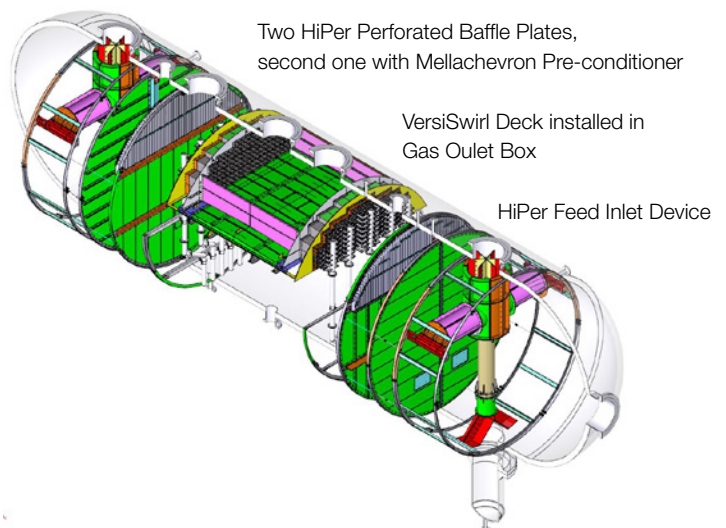


Shell SMSM™



Shell SMMSM™

Shell VersiSwirl is also available for horizontal gas flow. The cyclone deck is installed vertically and is therefore ideally suited for using in the gas cap area of 3-phase separators such as in slug catchers, production separators, etc. The Shell VersiSwirl is characterized by allowing high gas throughputs at high efficiency, rather insensitive against gas and liquid surges, and high fouling resistance.



Combined systems

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 VersiSwirl 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 Fig. 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.

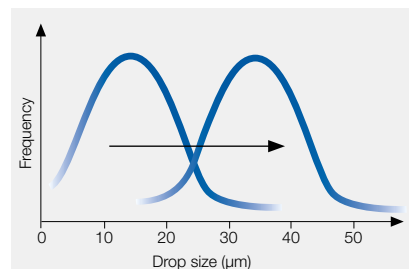
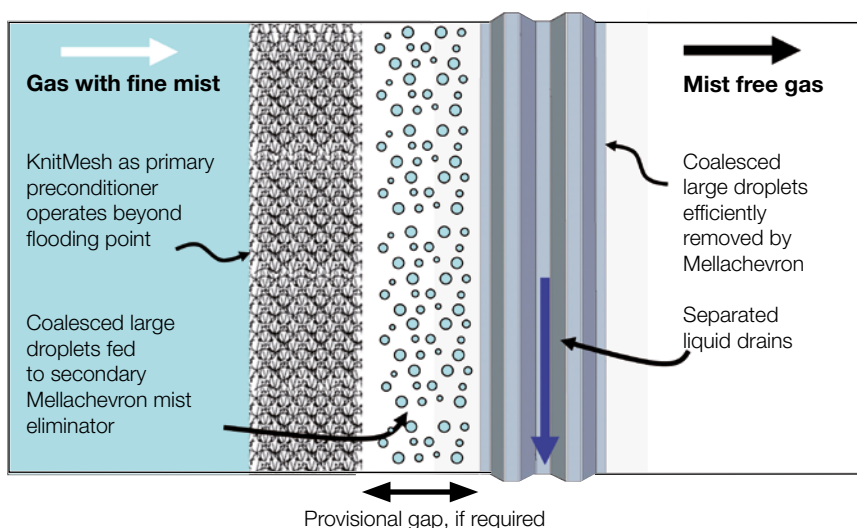
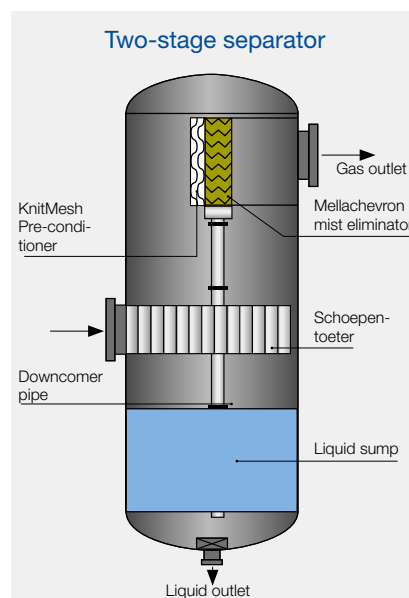
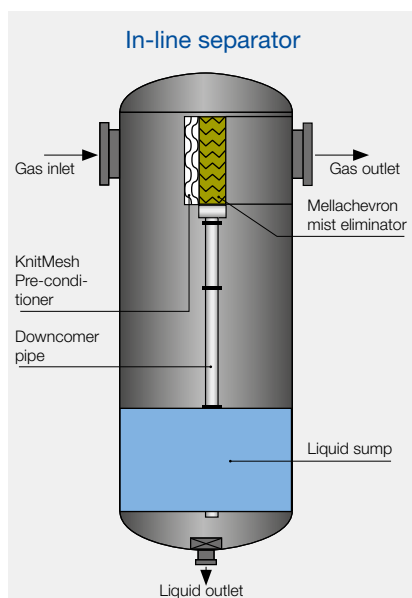
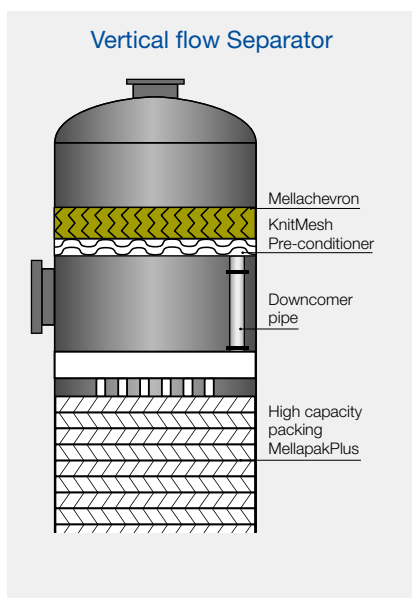


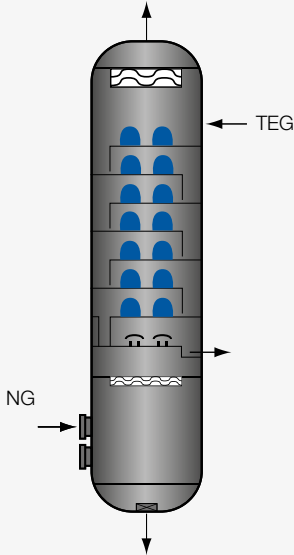
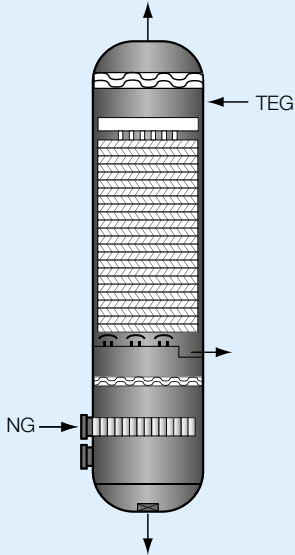
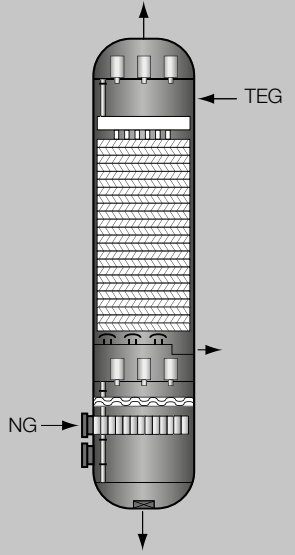

Fig. 6

High capacity separators with Sulzer Mellachevron™



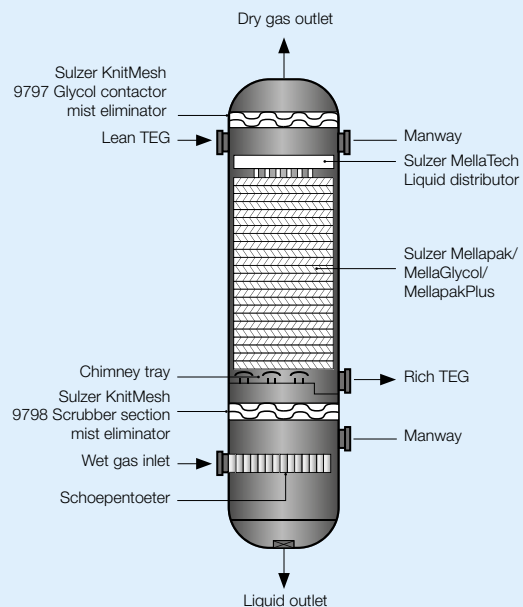
Applications

Natural gas dehydration with TEG

<p>Old fashioned Bubble Cap trays and KnitMesh™ mist eliminators</p> 	<p>State of the art Mellapak™ and KnitMesh™ mist eliminators incl. the sophisticated KnitMesh 9797 type</p> 	<p>High capacity MellapakPlus™, MellaGlycol™ and our high capacity mist eliminators such as MKS Multi Cassette™.</p> 	<p>The ultimate cMIST™ Compact Mass Transfer and Inline Separation Technology, incorporating our patented compact HiPer TwinLine™ Separator</p> 
<p>Characteristics ~ 1.8 F-Factor ($\sqrt{\text{Pa}}$)</p>	<p>Characteristics ~ 2.9 F-Factor</p>	<p>Characteristics up to ~ 5 F-Factor</p>	<p>Characteristics n/a</p>
<p>167% column diameter</p>	<p>131% column diameter</p>	<p>100% column diameter</p>	<p>21% column diameter</p>
<p>100% weight of column</p>	<p>73% weight of column</p>	<p>51% weight of column</p>	<p>35% weight of column</p>

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 offshore 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.



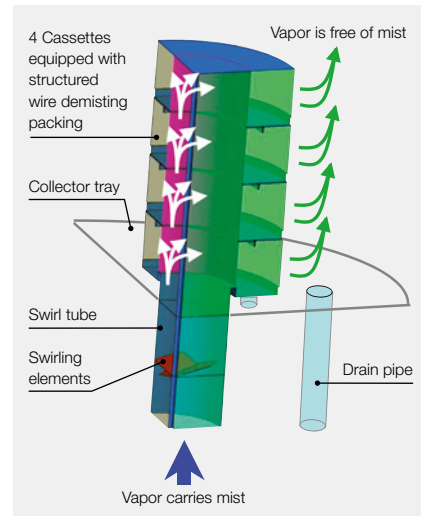
Applications

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 has shown to meet measured glycol losses of < 0.1 US 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.

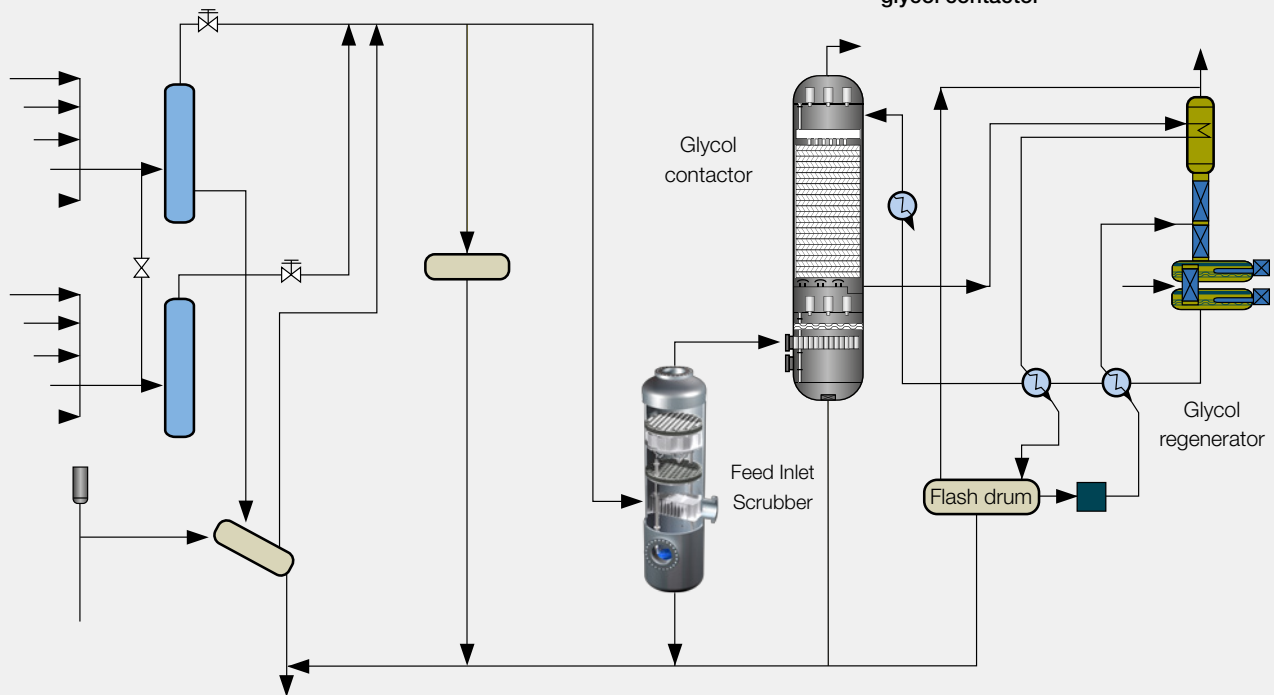


Glycol dehydration process using Shell SMSM internals in the feed inlet scrubber and MKS Multi Cassette in the glycol contactor

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

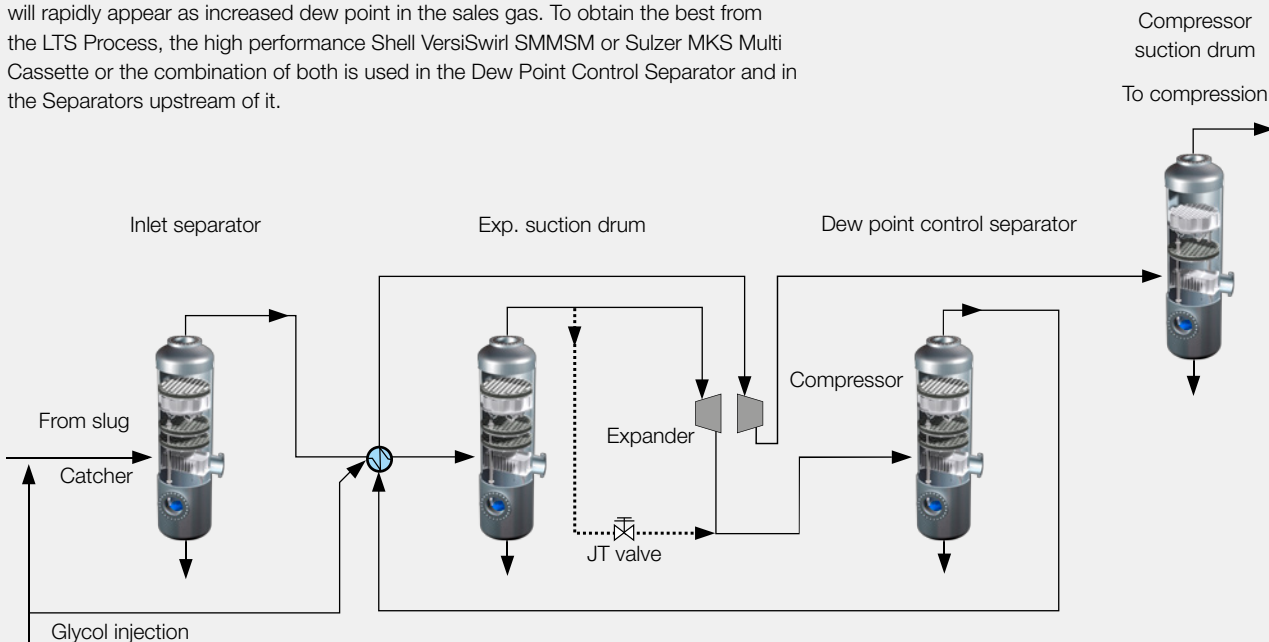
Glycol regeneration unit

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

Applications

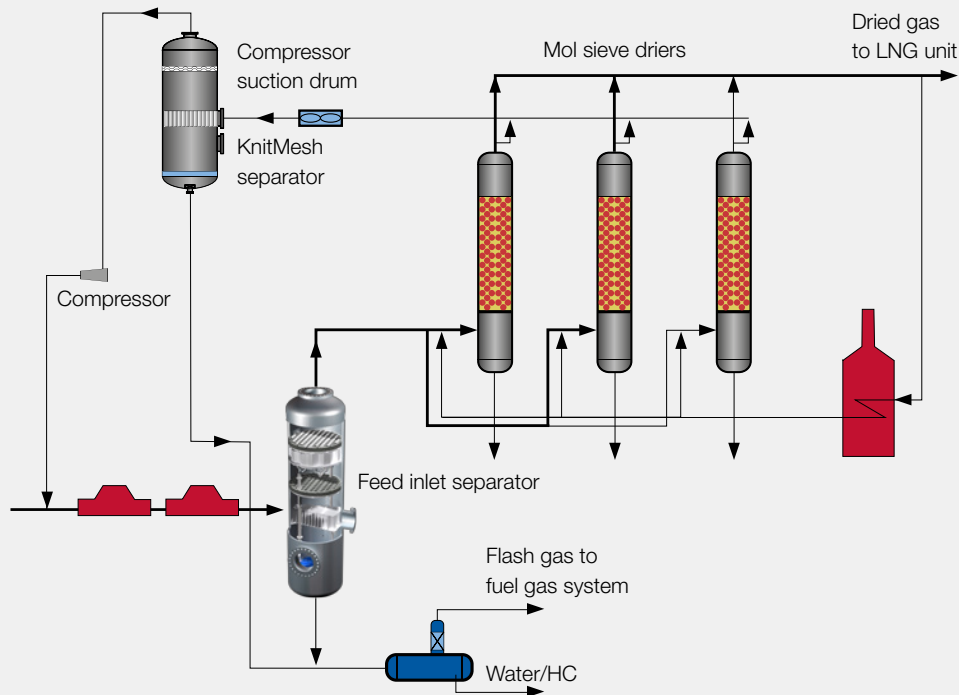
Low Temperature Separation (LTS) Process

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, the high performance Shell VersiSwirl SMMSM or Sulzer MKS Multi Cassette or the combination of both is used in the Dew Point Control Separator and in the Separators upstream of it.



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 VersiSwirl SMMSM or the Sulzer MKS Multi Cassette when high capacity and efficiency are required.



Applications

Mist eliminators in desalination processes

Desalination by multi-stage flash evaporation or multiple effect distillation unit 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

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 $5\ \mu\text{m}$ while presenting minimum pressure drop.

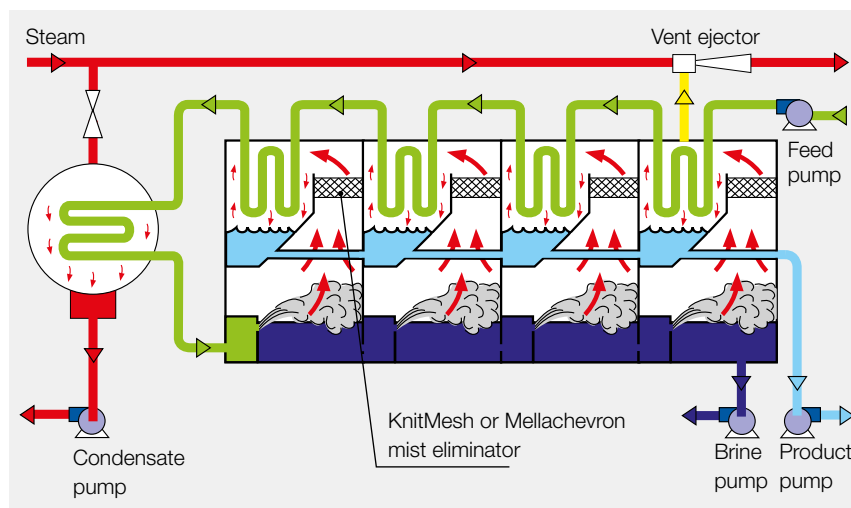
High capacity designs

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 $0.107\ \text{m/s}$ but Sulzer has developed the novel 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 $30\ \mu\text{m}$, 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.



Comprehensive engineering services markets

Development and technology

Sulzer makes every effort to support our customers and continuously improve our design tools. Engineers in the R&D lab develop new and improved products, analyze and optimize processes.

We maintain close relationships to universities and independent research organizations to support these efforts.

Engineering and manufacturing

Sulzer has a long-standing manufacturing tradition. Sulzer owns dedicated factories in many regions to produce mixers, columns, reactors, and heat exchangers.

For certain sizes and certain countries, we work with well-known and proven subcontractors who are bound by Sulzer manufacturing policies and quality standards.

Capabilities

Manufacturing according to PED 97/23/EC, ASME VIII Div.1, and ASME B31.3/U-Stamp, Gost (TR), China Stamp, Norsok, or NACE

Design codes acc. to AD2000, EN 13445, ASME Broad selection of material for construction available

Non-destructive testing (LPT, X-ray, pressure testing up to 500 bar, PMI, MT, UT etc. acc. EN and ASME)

Designing with SolidWorks

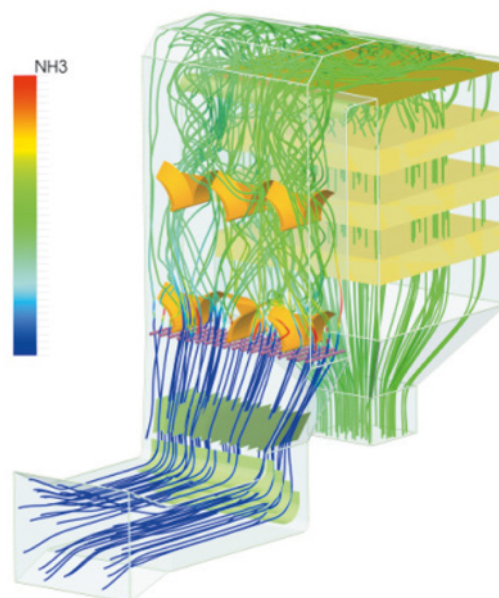
Strength calculations, FEM analysis, nozzle loads etc.

Certification for ISO 9001, ISO 14001 and ISO 18001

Experienced project management team

CFD Analysis

CFD calculations done in advance of fabrication can support the decision to go for a particular technology, and can save on the time required for commissioning and testing later. Sulzer uses CFD technology both for the modeling of existing and the development of new products.



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