



**Mist Elimination Equipment &
Droplet Separation from Gases**

Begg Cousland Envirotec Ltd. Experts in Mist Eliminators, Demisters & Droplet Separation

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

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

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

The Range of Filter Types.

Liquid is entrained in an air or gas flow following either of 2 basic situations.

- The air or gas meeting mechanically generated spray or generating the spray as it passes through a liquid. Such mechanically formed sprays are termed 'droplets' and are usually always over 5 to 10 microns in size. The more coarse droplet filtration is done by impaction or impingement in a vane separator, and/or by knitted wire demister mesh pads.
- The air or gas reacts chemically or physically resulting in a fume or condensation mist formation. These particles are mist or aerosols mainly below 3 microns, frequently sub-micron. Fine droplet and mist filtration is achieved using co-knitted wire/fibre coalescers or, for sub-micron collection, using Candle Filters.

Collection Mechanisms.

Impaction :

The mechanism whereby a droplet cannot avoid hitting a plate surface or one of the fibres or wires randomly arrayed in the path of the gas, even though the fast flowing gas tries to 'streamline' past. There is a relationship between the blade design and spacing or diameter of wire and the size of droplet collected. The range of velocities is broad (1 to 10 m/sec) without affecting efficiency.

Interception :

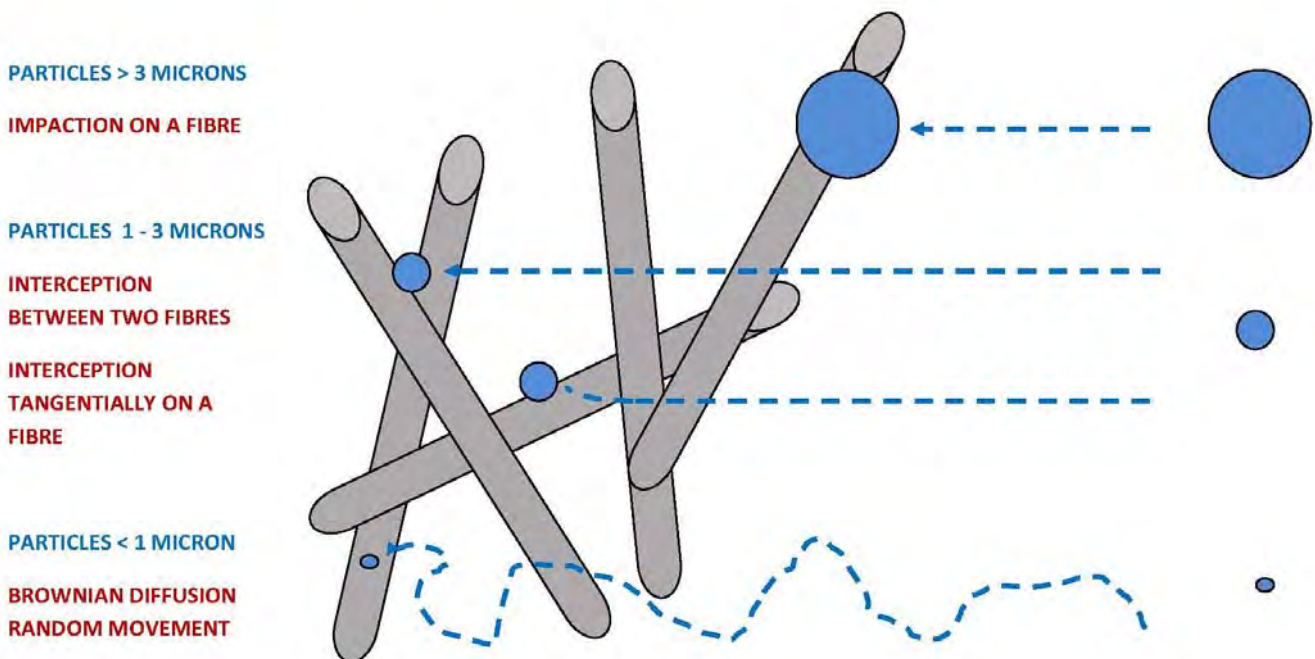
Collection is achieved by trapping the droplet between two adjacent filaments or fibres. Usually, the finer the filaments, the less space between them, which increases the rate of interception of finer mists. At higher velocities interception is a joint mechanism of coalescence, but at lower velocities it directly aids collection.

Normal velocity range for Interception is 0.2 to 0.8 m/sec

Brownian Diffusion :

At low velocities (usually below 0.2 m/sec., but max. 0.25m/sec), as the gas passes horizontally through a bed of very fine fibres, the small & sub-micron mist particles are bombarded by the gas molecules surrounding them, causing the particles to move in various directions, both towards and away from the fibres. The high number of fibres means, however, that the mist is virtually certain to be collected on the fibres. The smaller the fibre diameter, the finer the mist size that can be collected.

FIG 1. COLLECTION MECHANISMS OF LIQUID PARTICLES ON WIRES OR FIBRES



HOW TO SELECT THE RIGHT FILTER FOR YOU ?

Filter Selection Criteria.

• **By Efficiency :**

Legislation may demand a specific exit level of contaminant or the operator may need the optimum removal of a contaminant at any stage in a process, or may wish the maximum recovery of a valuable product.

The operator may not know the size of particles to be removed, but guarantees would favour caution, and the most efficient would be considered. Or the operator may know he has only droplets and so only the lower efficiency types will be considered.

• **By Pressure Loss :**

The gas flow in a process is generated by a fan or compressor, which generates a vacuum or discharge pressure. The pressure is energy and so is a cost to be carefully considered, how and how much is used. Generally, the lower the pressure loss of a filter the better, except where the operator correctly understands the problems lower efficiency may cause, or where the resultant filter space requirement and filter size and ultimately cost are out of proportion to the benefit of pressure loss saving.

Re-vamp projects usually require a maximum pressure loss to be maintained.

• **By Housing Space :**

Most filters are fitted in a vessel near the exit or on top of a process tower. Minimising the filter housing height and/or diameter mean cost savings.

Re-vamp projects may mean space constraints. However, what can physically be fitted into a given space must still allow correct operating velocities to be achieved.

As a general guide we show in Fig. 2 a table of different filter types and their main performance data, from a basic impingement Chevron Vane to a Highest Efficiency Brownian Diffusion Candle Filter. There are of course 'intermediate' filters not shown, and each can be custom designed and fabricated to suit each specific application's needs of size and duty.

Design considerations.

As well as the design factors of gas volume, pressure, pressure loss, temperature and housing space, the gas flow direction, the filter orientation & installation arrangement are very important.

In most applications the gas flow to the filter is vertically upwards. This suits horizontally oriented demisters and coalescers where the liquid can then drain downwards by gravity. It also suits candle filters as, although the gas will pass horizontally through the fibre bed, the fibre bed is cylindrically formed with an open end and a closed end. An upward flowing gas can pass from the outside of the cylinder to the inside if the candle filter is hanging from a support plate, or the gas can pass from the inside of the cylinder to the outside if the candle filter is standing on a support plate.

We call the hanging arrangement HT (see back page) and each HT1 candle filter has its own drain and liquid seal pot to prevent by-pass. Styles HT3 & HT4 have drain tube only and flanged drain tube, respectively.

Fig. 2 Table of Most Common Mist Eliminator Types & Main Performance Indicators

Filter Type	Typical Velocity Range (m/sec)	Typical Pressure Loss Range (mm H ₂ O)	Typical Particle Size Efficiencies
STV Chevron Vane	5.0 – 10.0	20 – 100	100% >15µ
DPV Double Pocket Vane	5.0 – 8.0	50 - 150	100% >8µ
Light Density Demister	> 2.0	10 - 80	100% >10µ
High Density Demister	> 2.0	20 - 100	100% >5µ
Coalescing Demister	2.0 – 3.0	50 - 120	100% >5µ 95% >2µ
Coalescer + Demister	2.0 – 3.0	100 - 120	100% >5µ 98% >2µ
High Velocity Candle Filter	1.0 – 2.5	100 - 200	100% >3µ 90% >1µ 70% >0.75µ
Medium Velocity Candle Filter	0.3 – 0.5	100 - 200	100% >3µ 95% >1µ 80% >0.5µ
Brownian Diffusion Candle Filter	0.1 – 0.25	150 - 250	100% >3µ 99% <3µ
Highest Efficiency Candle Filter	0.05 – 0.15	150 - 300	100% >1µ >99% <1µ

In the F series standing arrangements (see back page) the collected liquid flows onto the support plate to drain from there. F3 & F4 types have central bolting circles and F2 type has a flat flange with outside bolting.

The F type can then be made longer than the HT type as the gas is passing from the restricted volume of the inside of the cylinder to the more open volume around the outside of the filters. The F type is therefore the only practical design for the high velocity type fibres.

More filtration area within a fixed filter housing volume is theoretically possible with more smaller cylinders or with concentric standing cylinders (see Xtra-Flow designs on back page) with the gas passing in parallel both through the inner and outer cylinders, but there is a limit to the filter's height. As a general guide, an additional 30% can be gained with an Xtra-Flow type compared to a single bed candle filter.

Sometimes the gas flow is deliberately arranged vertically downward, to enter a candle filter cylinder and flow through the fibre bed to the outside. In such an arrangement, HT2, there is no need for a drain tube / liquid seal for the filter as the liquid drains from the outside surface to the vessel sump by gravity, while the vessel's gas exit is carefully positioned relatively high up causing the cleaned gas flow to avoid the draining liquid.

For maximum efficiency use 2 Brownian Diffusion, concentric fibre beds in series (see Xtra-Pure types on back page).

'BECOVANE' Droplet Separators

Chevron droplet separators are made using multiple parallel blade profiles assembled into a pack, where the gas passes vertically or horizontally between the blades (see Fig 3).

Our STV Vane blades are relatively widely spaced, (see Fig 5) allowing a high volume throughput capacity, with relatively low pressure loss. Efficient for droplet sizes of > 20 microns in size, STV Vanes are also highly resistant to plugging.

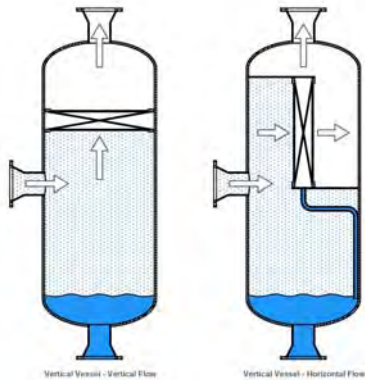


Fig. 3 Vertical Vessels + Horizontal or Vertical Vanes

Our DPV Vane blades are closer together and have a series of 'hooks' or 'pockets' attached to the blades within the pack (See Fig 6) of single or double design, to aid liquid drainage.



Fig. 5 STV Vane Pack



Fig. 6 DPV Vane Pack

DPV Vanes are almost always installed vertically with a horizontal gas flow (see Fig 3), and droplets collected on the surface of the blades flow along the surface until they reach a pocket. The liquid then enters the pocket where it is protected from the gas flow and drains freely downwards by gravity. There is a higher pressure loss as a result but the benefits are :

- Efficiency 99.9% above 8 microns
- Higher gas throughput / debottlenecking or minimising size of new vessels

As shown in Fig 11, the K Values are higher than for knitted wire demisters, increasing plant capacity

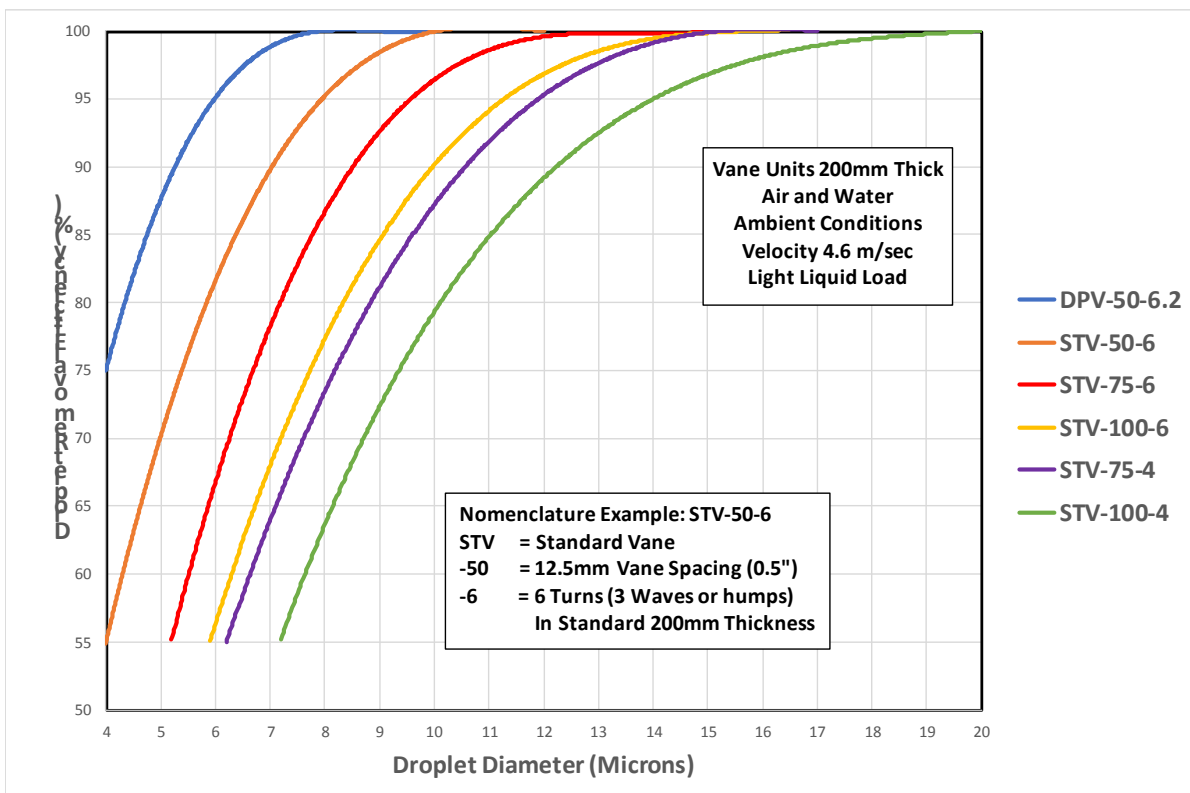


Fig. 4 Graph of Vane Pack Efficiencies

'BECOIL' Demisters

'Becoil' Demisters are impingement type separators made of mesh knitted from metal wire or plastic monofilaments, then crimped and assembled in multiple layers into meshpads. They have a very uniform void with an extremely high ratio of random filament surface area per unit volume of pad. Collected liquid in the mesh forms droplets on the filaments, which fall off by gravity.

The high voidage means pressure losses are quite low, while removal efficiencies of droplets larger than 5 microns are essentially 100% when correctly designed for the operating conditions. The operating range is illustrated in Fig 8, and Pressure loss graph (Fig 9) shows most common filter values.

Demisters, usually have support grids, and are made in one piece or in sections to pass through manways. Standard metal grids are made from 25 x 3 mm flat bar & 6 mm diameter rod.

Demister Design Data

The Saunders-Brown expression is a good way to express the equation to calculate allowable vapour velocity based on liquid and gas densities. The basic equation is:

$$V_{max} = K \sqrt{\frac{\sigma L - \sigma G}{\sigma G}}$$

Where :

V Max = Maximum allowable velocity

σL = Liquid density

σG = Gas density

(σL and σG expressed in same units)

K = Constant dependent upon liquid and gas densities, viscosity & surface tensions of the entrained liquid.

For most applications the value K can be taken as 0.105 to express V in metres/second. It is usual to design working velocities at 75% of the calculated V Max.

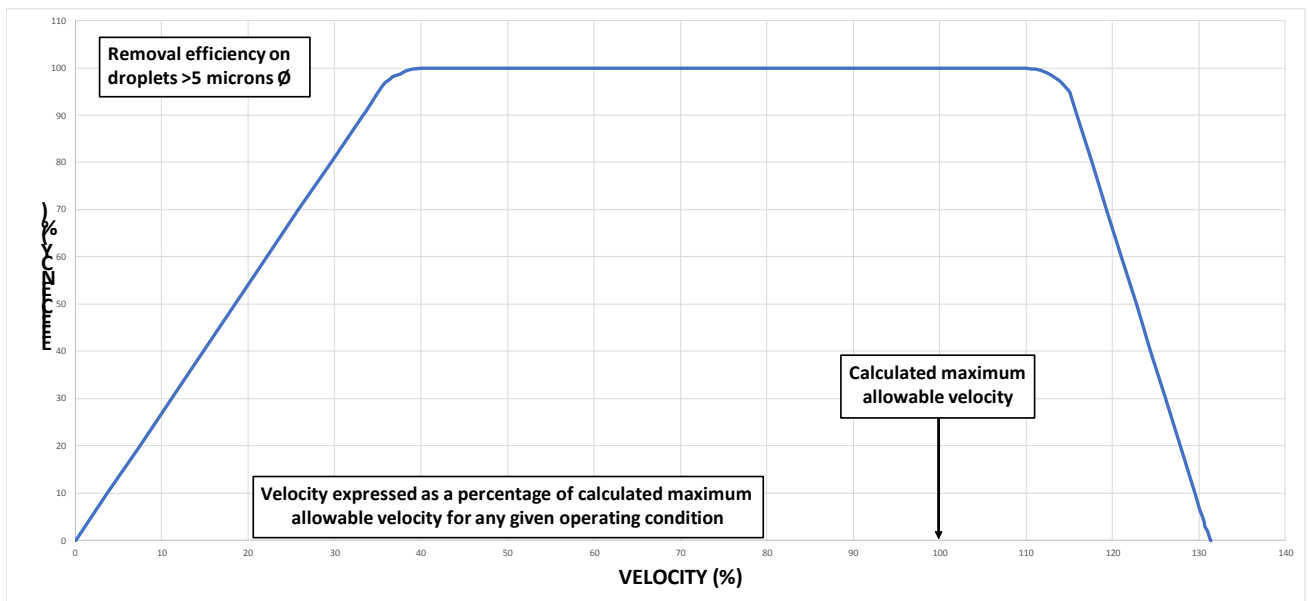


Fig. 5 Range of a Demister's Efficient Flow Conditions

WIRE MATERIAL	BEGG COUSLAND MESH STYLE	WIRE DIAMETER (mm)	DENSITY (Kg/m ³)	FREE VOLUME %	SURFACE AREA (m ² /m ³)
Stainless Steel	H	0.28	192	97.5	360
	SH	0.28	136	98.0	256
	L	0.28	112	98.5	210
	UL	0.28	80	99.0	151
	H237	0.152	135	98.3	430
	UL238	0.152	54	99.3	194
	H1241	0.112	430	94.6	1936
Polypropylene	H	0.50	69	92.4	606
	HL	0.35	65	92.9	807
Hostaflon ETFE	H	0.50	127	92.4	606
	HS3	0.27 / 0.50	59	96.5	390

Fig. 6 Table of Most Common Demister Mesh Styles and Characteristics

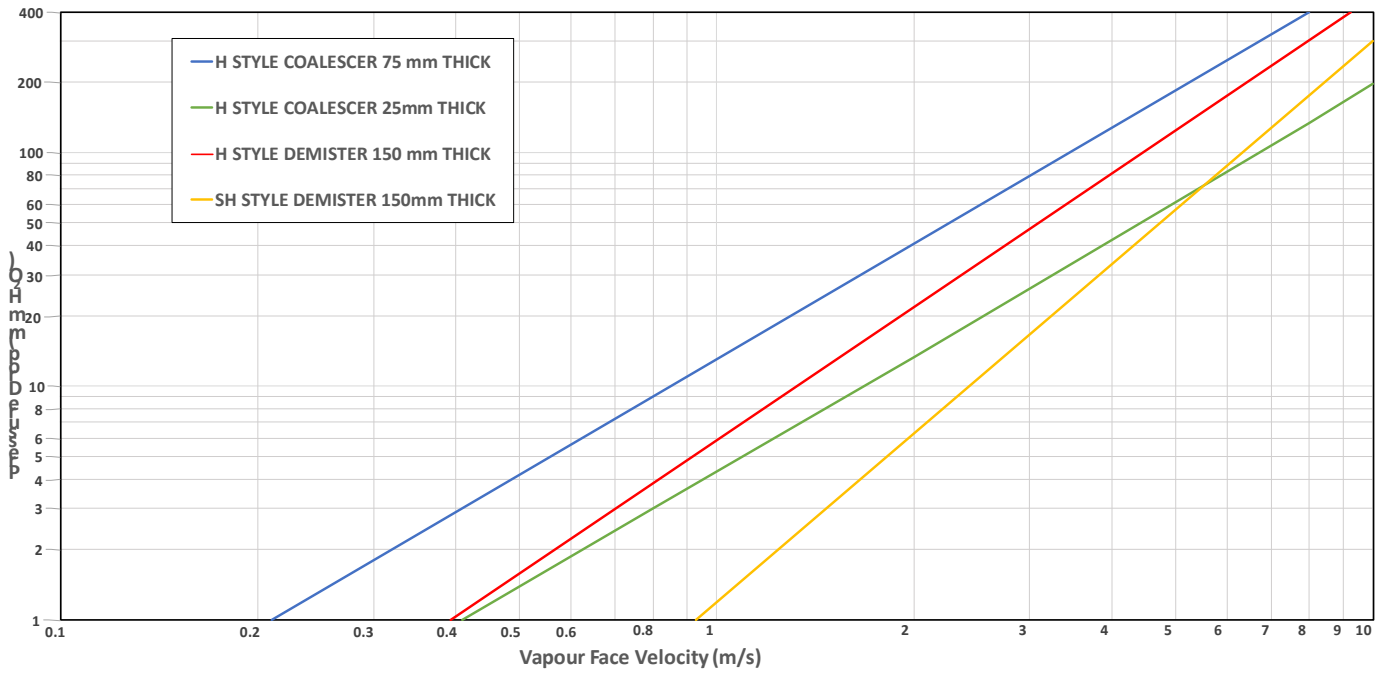


Fig. 7 Some Meshpad Demister Pressure Losses

'BECONE' Coalescers

A 'Becoil' Demister is a high efficiency, low pressure loss device to remove liquid particles > 5 microns. To help the collection efficiency < 5 microns we developed the 'Becone' Coalescer. It is a pad made from co-knitted wires or monofilaments and fibre yarn. These fibres are much smaller in diameter than either the yarn into which they are spun or the wires and monofilaments, forming a more efficient filter. The small fibres reduce the streamline effect, trapping the fine droplets within the coalescer, and any coarse droplets formed are re-entrained in the gas stream leaving the coalescer. They can then be removed by a 'Becoil' Demister.

A combined 'Becone' and 'Becoil' installation increases collection efficiency to > 98% in the 2- 5 micron range, and available fibre materials are Glass, P.T.F.E. and Polypropylene.

Typical performance figures for a 2-stage installation of a 'Becoil' Demister + 'Becone' Coalescer are:

- Efficiency 5 microns and larger = 100%
- 2 microns and larger = 98 – 99.5%
- Total Pressure Loss Approx. = 120 mm H₂O

A single stage, combination Coalescer + Demister is available in flat or coned form, depending on vessel design. This single stage can reach efficiencies almost identical to the 2 stage system, but care must be taken when liquid load is expected to be high, as the whole of the single stage can flood, with no capacity then to remove entrained droplets downstream.



Fig. 8 Demister & Single Stage Coalescer-Demister

Filter Type	K Value		Efficiency
	Vertical Flow	Horizontal Flow	
BCE-STV Vane	0.152	0.198	99.9% > 20μ
BCE-DPV Vane	-	0.365	99.9% > 8μ
Demister Mesh H, SH, L & UL	0.105	0.137	99.9% > 10μ
Demister Mesh H+L & SH+L	0.122	0.152	99.9% > 10μ
Demister Mesh H237, UL238 & H1241	0.091	0.122	99.9% > 5μ
Co-Knit Mesh	0.076	0.105	99.9% > 2μ

Fig. 9 Table of K Values & Droplet Efficiencies

'BECOFIL' Fibre Bed Mist Eliminator Filters

'Becofil' Mist Eliminators - often referred to as Candle Filters or Fibre Bed Filters – originally developed by I.C.I. remove very fine mist particles less than 3 microns diameter. Their mechanism is a combination of impingement for particles greater than 2 microns in diameter and diffusion for the sub-micron particles where Brownian motion is the key. As the gas passes through the fibre bed the small mist particles are bombarded by the gas molecules surrounding them, causing them to move in various directions, towards and away from the surface of the fibres of the filter. Each filter is composed of millions of fibres and although the efficiency of each individual fibre is low the cumulative effect is very high. Low approach velocities are necessary in order not to mask the diffusion velocities associated with Brownian movement.



Fig. 11 B14W Glass Rope Fibre Bed



Fig. 10 View inside an HT Type Glass Fibre Candle Filter

Begg Cousland has always used a technology of preformed elements packed into a 5 centimetre annular space between two concentric cylinders fabricated from corrosion resistant mesh. The candles are installed vertically and gases pass horizontally through the filter wall, the trapped particles coalescing and draining down through the filter bed.

As mentioned earlier in *Design Considerations* on Page 3, gas flow through candles can be either inside to outside or outside to inside depending upon the siting of the installation and the method of securing the candles in place. (See back page)

There is a wide range of our pre-formed fibres, (glass or other materials) shown on pages 7 to 9. In addition we have a series of wound rope types in our Brownian Diffusion range – see Type B14W on page 7.

These B14W mist eliminators can be made in 3 bed depths – 50, 63 or 75mm – and can be supplied with or without an exit surface drainage mat layer. This means we can adapt our beds to meet the demands of different high mist load duties. We can also repack the structures of other suppliers.

Repacking

We are always looking for ways to assist our customers technically and commercially, and one way we can offer good savings, is to repack old filter structures with new fibre beds, to regenerate them for re-use.

In case the cages are not able to be re-used (due to corrosion, or deformation in handling), then we can take back the flange and end plates only, and add new cages as well as the new fibre bed. This often saves site cost of removing the used fibre.

Due to their unique construction, our TGW15, TGW16 and B14 preformed glass fibre elements can be used to repack original filters on site without the need to return the filters to our factory for repacking. This facility does depend on the structure / cages being in good condition.

Mist Eliminator Structure Materials

The mist eliminator structure comprises an inner and an outer support cage, made of metallic wire mesh, or perforated synthetic sheet materials, a fixing flange and an end plate (see last page for most common types).

The general material options are as follows :

316L Stainless Steel	304L Stainless Steel
Carbon Steel	Titanium
Alloy 20	904L
Polypropylene	GRP / FRP
P.V.D.F.	E.C.T.F.E.



Fig. 12 A GRP + Derakane Resin Candle Filter

Fig. 13a 'BECOFIL' Candle Filter Standing Types - High Velocity Fibres

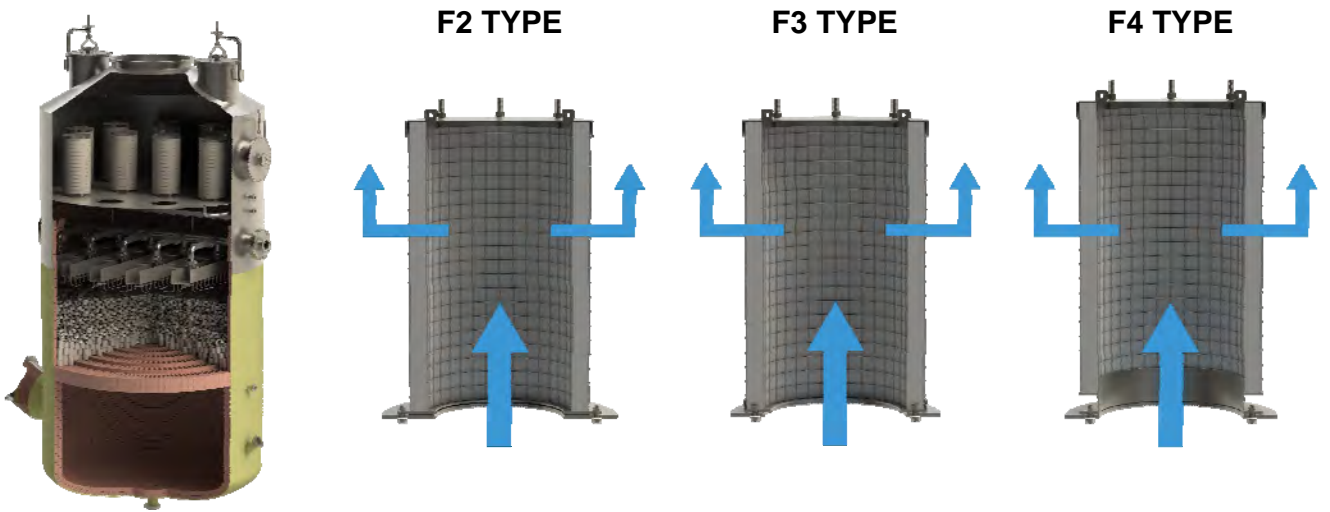


Fig. 13b 'BECOFIL' Candle Filter Standing Types – Brownian Diffusion Fibres

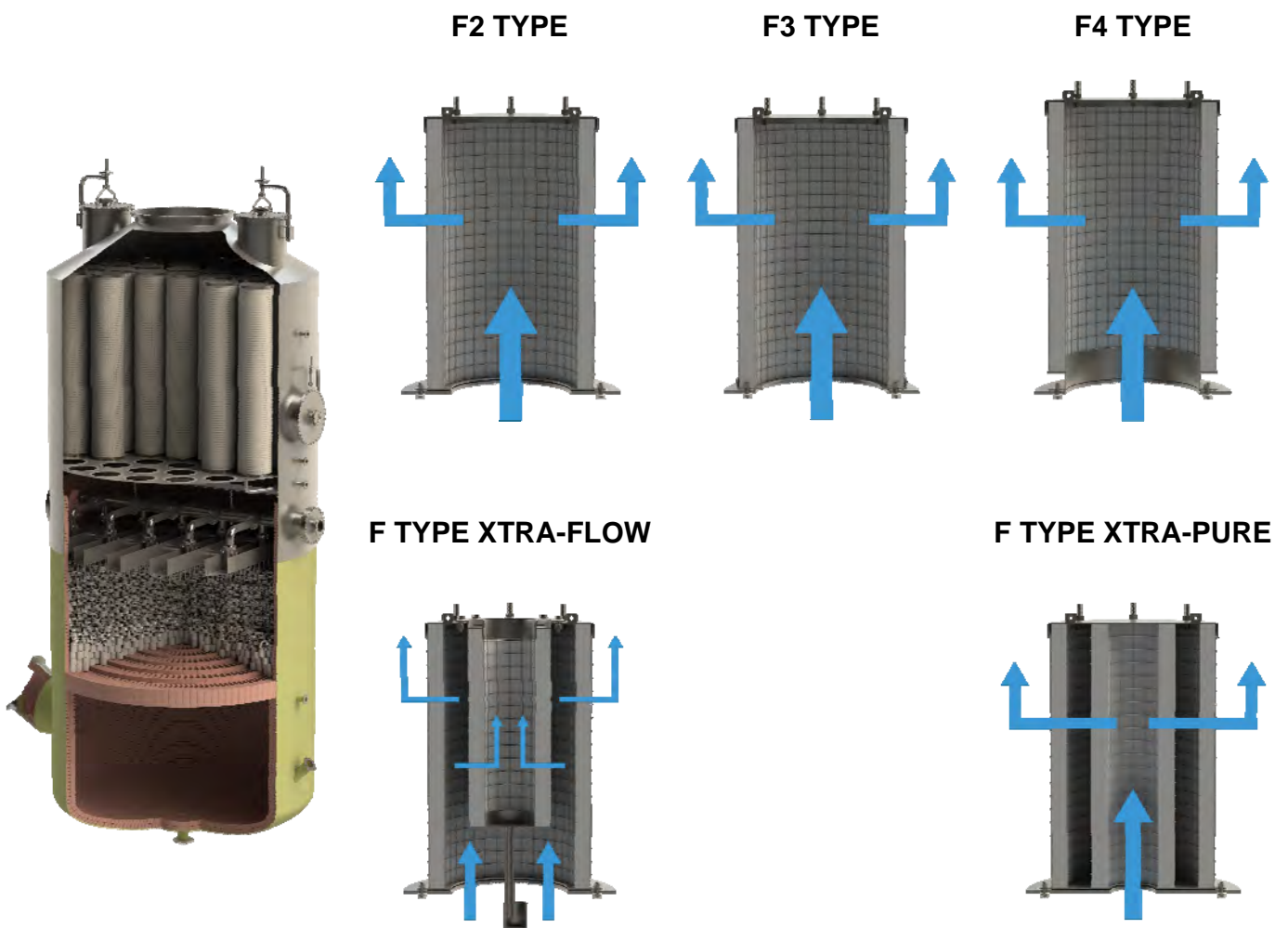


Fig. 13c 'BECOFIL' Candle Filter Hanging Types - Brownian Diffusion Fibres

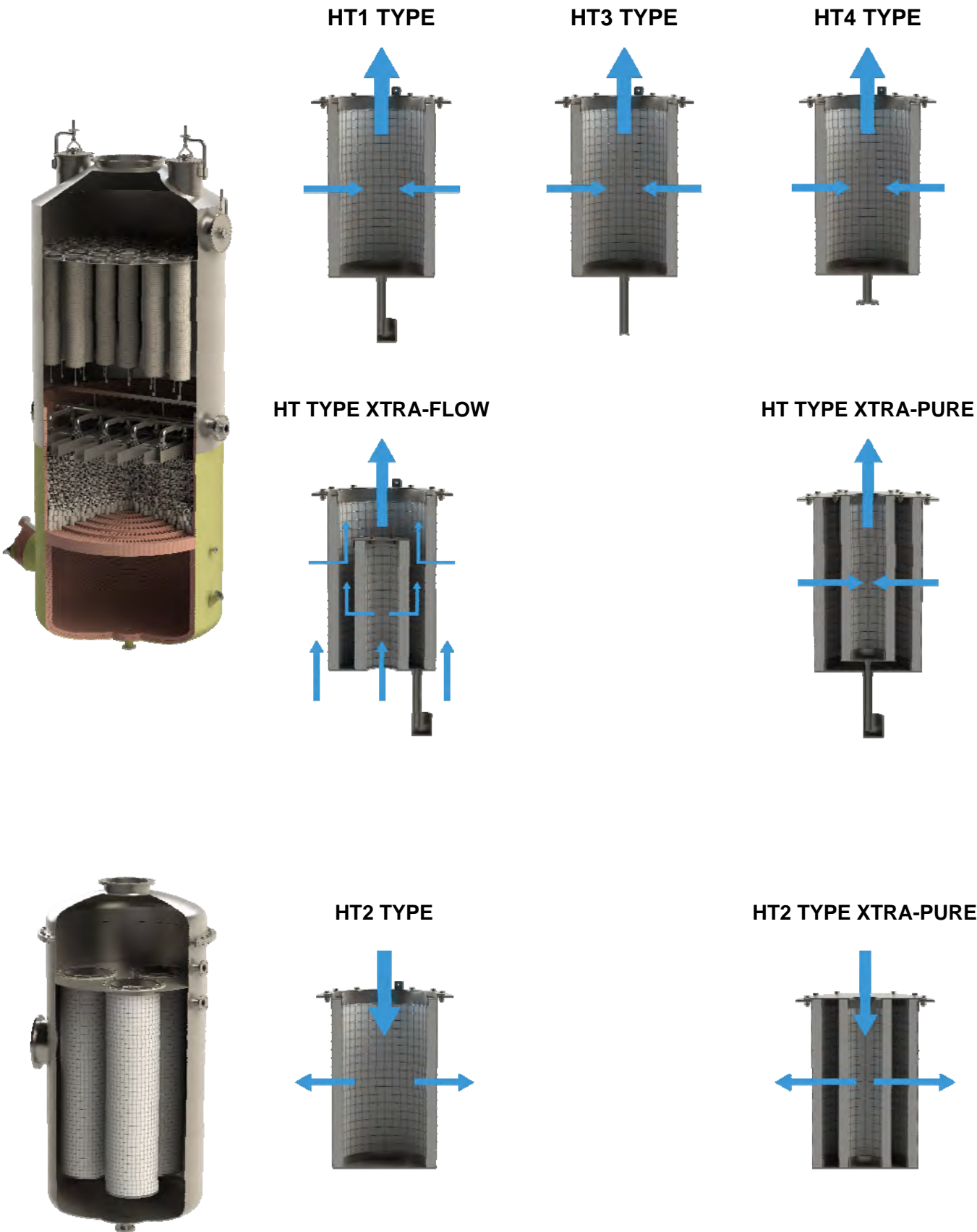


Fig. 14a 'BECOFIL' Candle Filter Fibre Options / Selection Guide

Brownian Diffusion Mist Eliminators

TGW15	Glass Fibre	Smallest Fibre Dia. Possible	Hanging or Standing Type
COLLECTION MECHANISMS	Brownian Diffusion	Interception	Impaction
DESIGN CRITERIA	100% removal >1μ >98% removal <1μ	150-250mm H ₂ O Pressure Loss	< 0.2 m/sec Bed Velocity

TGW16	Glass Fibre	Smallest Fibre Dia. Possible	Hanging or Standing Type
COLLECTION MECHANISMS	Brownian Diffusion	Interception	Impaction
DESIGN CRITERIA	100% removal >1μ >99% removal <1μ	250-300mm H ₂ O Pressure Loss	< 0.12 m/sec Bed Velocity

B14W	Wound Rope Glass Fibre	Small Fibre Dia.	Hanging or Standing Type
COLLECTION MECHANISMS	Brownian Diffusion	Interception	Impaction
DESIGN CRITERIA	100% removal >1μ or >3μ 99% removal <1μ or <3μ	150-250mm H ₂ O Pressure Loss	< 0.25 m/sec Bed Velocity

B14	Glass Fibre	Small Fibre Dia.	Hanging or Standing Type
COLLECTION MECHANISMS	Brownian Diffusion	Interception	Impaction
DESIGN CRITERIA	100% removal >3μ 99% removal <3μ	150-250mm H ₂ O Pressure Loss	< 0.25 m/sec Bed Velocity

C14	Carbon Fibre	Smallest Fibre Dia. Mat	Hanging or Standing Type
COLLECTION MECHANISMS	Brownian Diffusion	Interception	Impaction
DESIGN CRITERIA	100% removal >3μ >99% removal <3μ	120-250mm H ₂ O Pressure Loss	< 0.2 m/sec Bed Velocity

PP13.5	Polypropylene Fibre	Small Fibre Dias.	Hanging or Standing Type
COLLECTION MECHANISMS	Brownian Diffusion	Interception	Impaction
DESIGN CRITERIA	100% removal >3μ 95% removal 1 - 3μ 90% removal <1μ	150-250mm H ₂ O Pressure Loss	< 0.20 m/sec Bed Velocity

Fig. 14b 'BECOFIL' Candle Filter Fibre Options / Selection Guide

Medium & High Velocity Impaction Mist Eliminators

B12	Glass Fibre	Small Fibre Dia.	Standing or HT2 Type Only
COLLECTION MECHANISMS	Coalescence	Interception	Impaction
DESIGN CRITERIA	100% removal >3μ 95% removal 1-3μ 80% removal <1μ	150-250mm H ₂ O Pressure Loss	< 0.25 m/sec Bed Velocity

G25	Glass Fibre	Medium Fibre Dia.	Standing Type Only
COLLECTION MECHANISMS	Coalescence	Interception	Impaction
DESIGN CRITERIA	100% removal >3μ 90% removal 1-3μ 70% removal <1μ	100-200mm H ₂ O Pressure Loss	0.8 - 2.5 m/sec Bed Velocity

G35	Glass Fibre	Coarse Fibre Dias.	Standing or Panel Type Only
COLLECTION MECHANISMS	Coalescence	Interception	Impaction
DESIGN CRITERIA	100% removal >3μ 80% removal 1-3μ	100-200mm H ₂ O Pressure Loss	1.0 - 2.5 m/sec Bed Velocity

G35K	Glass Fibre	Co-knit wire 316L/310/A20	Standing or Panel Type Only
COLLECTION MECHANISMS	Coalescence	Interception	Impaction
DESIGN CRITERIA	100% removal >3μ 75% removal 1-3μ	100-180mm H ₂ O Pressure Loss	1.0 - 2.5 m/sec Bed Velocity

T80.35	P.T.F.E. Fibre	Small Fibre Dia.	Standing Type
COLLECTION MECHANISMS	Limited Brownian Diffusion	Interception	Impaction
DESIGN CRITERIA	100% removal >3μ 95% removal 1 - 3μ 80% removal <1μ	120-250mm H ₂ O Pressure Loss	0.3 – 0.5 m/sec Bed Velocity



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