MESH & VANE
MIST ELIMINATOR

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FILTERS®

ACHIEVING THE POTENTIAL OF TODAY'S MIST ELIMINATOR

IN EVERY PROCESS involving contact between liq-uid and flowing gas, tin mist droplets are carried away with the gas. (See Figure 1) This phenomenon is called entrainment.

Beginning about 1947, special devices were developed to remove mist from gas streams. Now known as mist eliminators, these devices provide a large surface area in a small volume to collect liquid without substantially impeding gas flow. Unlike filters, which hold particles indefinitely mist eliminators coalesce (merge) fine droplets and allow the liquid to drain away. Gas typically flows upward through a horizontal mist eliminator.

More recently, advances in technology have enabled substantial progress in mist eliminator designs, materials, and application expertise. New products and methods of use have been found highly effective for many purposes, especially the following:

- Increasing throughput
- Downsizing new vessels
- Improving product purity
- Cutting operating costs
- Reducing environmental pollution
- Reducing downstream corrosion
- Increasing recovery of valuable liquids

In today's era of higher expectations of mist eliminators, achieving such benefits requires better knowledge on the part of users. It is no longer ade-quate for a designer simply to indicate "mist elimi-nator" in a drawing. The results will depend on proper specification of mist eliminator type (or combination of types), orientation, thickness, inter-nal details, support and spacing in the vessel, vapor velocity and flow pattern, and many other consider-ations.

Despite the advances that have been made, mist eliminator specification is still as much art as sci-ence. For all but the most experienced users, proper application depends on consultation with a manufacturer's engineers. Such help should be considered for every new mist eliminator application as well as every upgrade or debottlenecking of existing applications.

TO MAKE THE MOST of a mist eliminator investment, the designer should become familiar with the considerations and possibilities involved. The purpose of this publication is to provide general guidelines and an overview of the field of mist elimination. Due to the numerous variables involved in specifying mist eliminators, designers and purchasers should consult with Filters®' sepa-ration specialists before making a final decision.

Figure 1. Typical mist eliminator application in distillation column

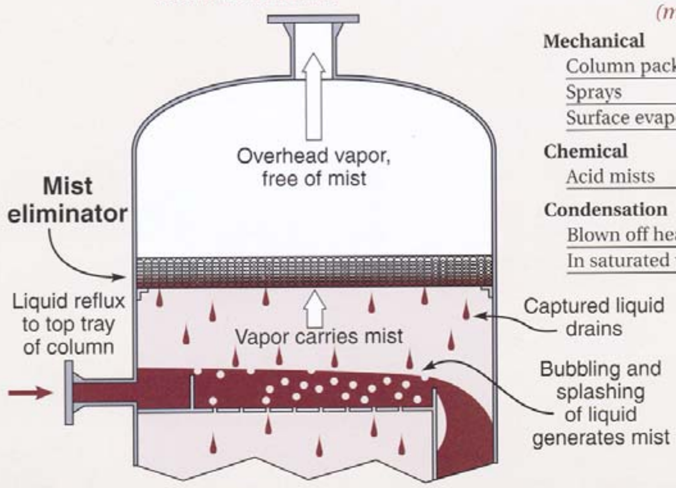


Table 1. Typical size range of mist droplets created by various processes (microns, micrometers)

Mechanical	
Column packing or trays	5 to 800 μm
Sprays	10 to 1,000 μm
Surface evaporation	3 to 1,000 μm
Chemical	
Acid mists	0.1 to 15 μm
Condensation	
Blown off heat exchanger surface	3 to 500 μm
In saturated vapor	0.1 to 50 μm

TYPES OF MIST ELIMINATORS

THERE ARE THREE general types of mist eliminators mesh, vane, and fiber bed and Filters® makes all three. Each is suited for a different class of applications, either alone or combined with another type.

Mesh-pads and insertion type

The most widely applicable type of mist eliminator is made of metal or plastic wire with typical diameter of 0.006 to 0.011 inch, loosely knitted in a form resembling a cylindrical net. This tube is flattened to form a two-layer strip typically 12 inches wide, which is then crimped in a diago-nal pattern with ridges as shown in Figure 2. When these strips are laid together, the ridges slant in alternate directions, forming an open structure through which gas flows freely.
Such mesh can efficiently capture mist droplets as small as 5 microns (micrometers).
For eliminating droplets down to 1 micron in diameter, multifilament yarns of various plastics or glass are knitted into the mesh. The result is called a composite or co-knit mesh (Figure 3).

Figure 2. Flattened tube of knitted 0.011-inch wire with diagonal crimps

Figure 3. "Co-knit" mesh, including multifilament glass fibers knitted along with the wire

Mesh pads

In the most familiar application of knitted mesh, the crimped strips are stacked to form a pad with typical thickness of four or six inches. (See Figure 4.) Rigidity is provided by a frame usually metal consisting of a grid on each side and rods passing through the mesh. Pads larger than about three feet across are fabricated in sections narrow enough to pass through a manway for assembly inside a vessel. Mesh pads can be made in almost any shape, but most are round (as in Figure 4) or rectangular.

Figure 4. Typical mesh-type mist eliminator pad

MistFix insertion mist eliminator

In an exclusive Filters® innovation , knitted wire mesh is wrapped into a cylindrical core with a flange at one end. (See Figure 5.) MistFix mist eliminators extend vertically into a vessel from the vapor exit nozzle. As replacements or substitutes for pads, they greatly speed turnaround time, avoid entry of hazardous vessels, and eliminate the need for vessel cut-ting where there is no access port. They are ideally suited for existing vessels that do not have mist eliminators.

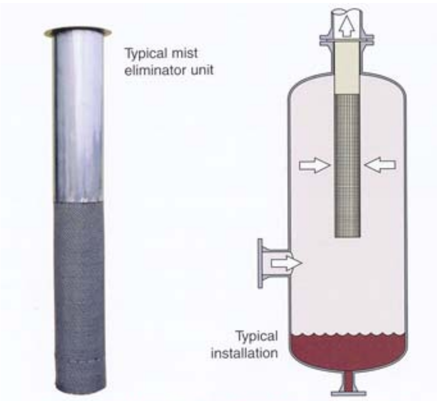
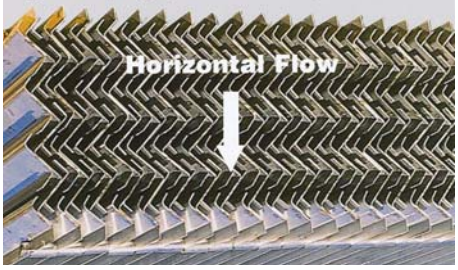


Figure 5. MistFix™ insertion mist eliminator

Double-pocket vanes

Filters®' high-performance double-pocket vanes (Figure 7) can operate at higher capacity and higher efficiency than conventional vanes. The design features liquid pockets that prevent re-entrainment of the separated liquid droplets. This helps increase the capacity up to twice that of conventional vanes. The higher gas velocities also help in obtaining 100% removal of 8-micron droplets.

Figure 7. Top edge of Amistco double-pocket vane unit


Vane packs

Also known as chevron or plate type, vane mist eliminators consist of closely spaced corrugated plates that force mist-laden gas to follow serpentine paths. These devices are generally not efficient for mist droplets smaller than about 20 microns, but they are sturdier than mesh pads and impose less pressure drop. Vane arrays can be mounted horizontally or vertically. They are preferred in applications involving high vapor velocities, low available pressure drop, viscous or foaming liquids, lodging or cak-ing of solids, slugs of liquid, or violent upsets. Like mesh pads, vane units are usually round or rectangular.

They are sometimes used in combination with mesh pads for optimum performance in special situations. Filters®' standard vanes (front cover) are available in metal or plastics and have various blade spacings and profiles. For special requirements, Filters® also supplies curved vanes such as the non-metallic variety shown in Figure 6.


Figure 6. Mist eliminator with curved non-metallic vanes

Fiber candles and panels

Fiber mist eliminators can capture mist droplets so small (below 1 micron) that they appear as smoke or nearly invisible haze. These units employ fine fibers—typical-ly cellulose, glass, or plastic—packed into a mat with thickness of a few inches. Fiber mist eliminators are most-ly used in cylindrical form called candles (Figure 8) but are also available in flat panels.


Figure 8. Typical fiber mist eliminator candle

FUNDAMENTAL CONSIDERATION

PROPER APPLICATION of mist eliminators is based on understanding how they work. Vane and mesh devices both employ the same mechanism known as inertial impaction and thus are subject to the same basic design rules. Fiber mist eliminators, however, capture submicron droplets (those smaller than one micron) by an entirely different phenomenon known as Brownian motion leading to very different behavior.

Inertial capture in vanes

As shown in Figure 9, vanes bend the path of mist laden gas into relatively tight curves. As the gas changes direction, inertia or momentum keeps mist droplets moving in straighter paths, and some strike adjacent vanes. There, they are held by surface forces and coalesce (merge) with other droplets , eventually trickling down. If the vane material is wettable, a surface film promotes coalescence and drainage. In the case of upward flow, coalesced liquid disengages from the bottom of the vanes as droplets large enough to fall through rising gas. In the case of horizontal flow (Figure 10), the liquid trickles down vanes to a drain below.

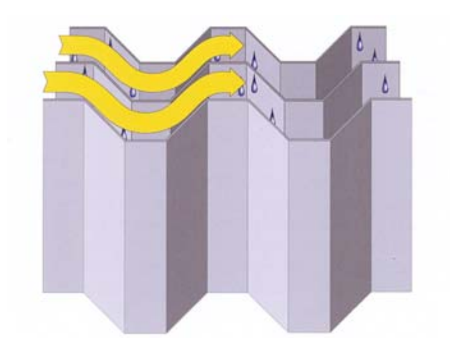


Figure 10. Vane array with horizontal flow

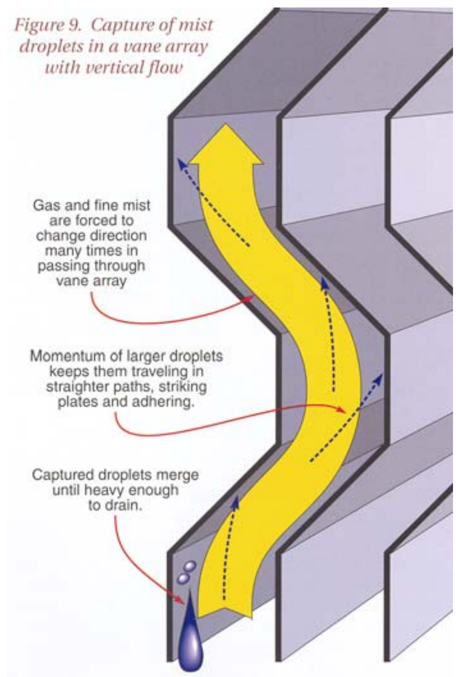
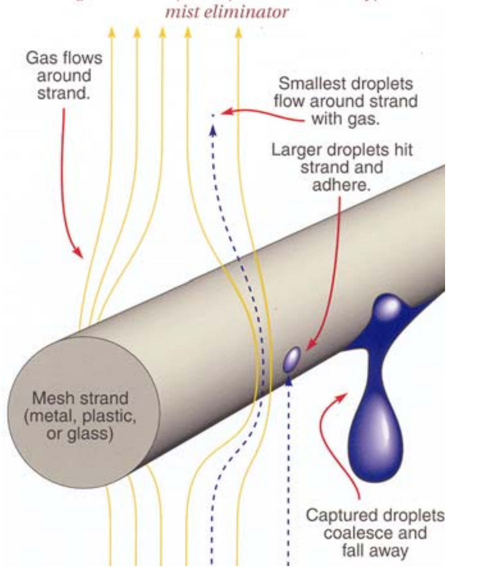


Figure 9. Capture of mist droplets in a vane array with vertical flow

Inertial capture in mesh

In a mesh-type mist eliminator (Figure 11), each strand acts as an obstruction around which gas must flow. Within a very short distance upstream of a filament, the gas turns aside sharply, but some mist droplets are unable to follow. They strike the filament, adhere, and coalesce to form droplets that are large enough to trickle down and fall away.

Figure 11. Droplet capture in a mesh-type mist eliminator



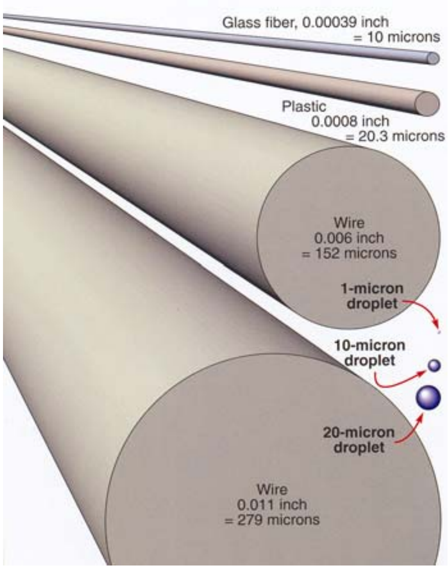
Inertial capture efficiency

Based on the principle of inertial capture, it is easy to understand the behavior of a vane or mesh mist eliminator in terms of the efficiency with which it captures mist droplets. Consider a droplet encountering a mesh strand or a bend in a vane. (To help imagine the relative dimensions involved in the case of a mesh pad, see Figure 12.) The following factors determine whether the droplet strikes the surface or turns and flows around with the gas:

1. Droplet size: The larger the droplet, the greater its momentum and the straighter its path when surrounding gas flows around an obstacle. Consequently, as seen in Figure 13, the efficiency of a given mist eliminator varies steeply with droplet size (keeping the same velocity and liquid and gas composition). For the example mesh pad made of 0.011-inch wire, efficiency jumps from nearly zero for 2-micron droplets to nearly 100% for 20-micron droplets. In a real situation, droplet sizes will be distributed over a range from less than one micron to well over 100 microns. The distribution curve may be narrow or broad, peaking any where within that range.

2. Strand diameter or corrugation spacing: The smaller the diameter of a mesh strand (or the closer the spacing between the corrugations of a vane), the more abruptly oncoming gas turns aside, and the more difficult it is for mist droplets to follow the gas. Thus, finer strands can capture smaller droplets (again assuming the same velocity and liquid and gas composition).

Figure 12. Relative sizes of droplets and strands
1 micron (µm) = 1 millionth of a meter



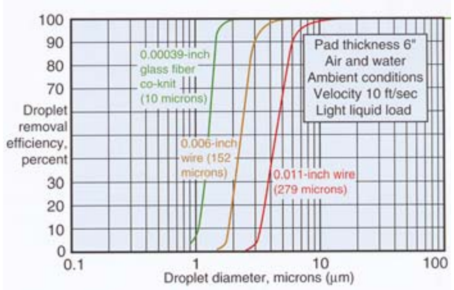


Figure 13. Examples of variation of droplet capture efficiency with droplet size and filament diameter

This effect can be seen by comparing the three curves in Figure 13, representing mesh pads having different strand thicknesses. The 279-micron (0.011-inch) wire is 90% efficient for 6-micron droplets, compared to 3-micron droplets for the 152-micron (0.006-inch) wire and 1.5-micron droplets for 10-micron co-knit glass fibers. (See appendix for efficiency curves for various other types of Filters® mesh and vanes.)

3. Gas velocity: The more rapidly a droplet approaches a mesh strand or vane corrugation, the greater its momentum, carrying it in a straighter path. Further more, at higher velocities, gas flow streamlines approach the obstacle more closely, resulting in tighter bends. Thus, the capture efficiency of a mist elimina tor increases sharply with velocity until an upper limit is reached due to re-entrainment or flooding (discussed later).

4. Liquid density relative to gas density: What causes a droplet to deviate from curving gas streamlines is not its momentum alone, but the difference or ratio between the droplet's momentum and that of the gas around it. In cases where the gas is nearly as dense as the liquid for instance, at high pressures the gas sweeps droplets around the obstacle more strongly, preventing capture.

5. Gas viscosity: The more viscous the gas, the more drag it exerts on suspended droplets as the gas flows around mesh strands and vane corrugations, leading to reduced capture efficiency. The viscosity of a gas generally goes up with higher temperature.

6. Pad density and thickness: Finally, the efficiency of a mesh pad also depends on how closely the strands are packed and on the thickness of the pad. Packing density is increased by knitting with more loops per inch and crimping with narrower ridges. It is measured in terms of pounds per cubic foot of pad. Thickness, in turn, is increased by piling on more layers of crimped mesh sheets. Thicker, denser pads bring trade-offs in terms of higher pressure drop and susceptibility to re-entrain ment and flooding. Typical densities for stainless steel mesh are 9 and 12 pounds per cubic feet, and typical thicknesses are 4, 6, and 8 inches.

Interception capture

There is another capture mechanism, usually called interception, that theoretically applies to both mesh and fiber mist eliminators. (See Figure 14.) Droplets that cannot be captured efficiently by inertial effects due to small size, low density, low velocity, etc., may nevertheless head so close to the centerline of a strand that they brush against the surface and adhere. In practice, however, interception is indistinguishable from inertial impaction and may be ignored in vanes and mesh.

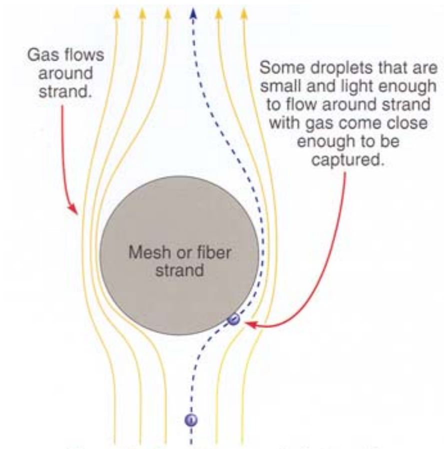


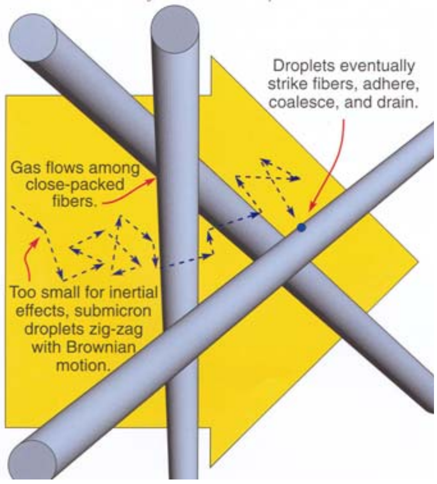
Figure 14. Droplet capture by interception

Brownian capture

Brownian motion, the main capture mechanism for submicron droplets in fiber mist eliminators, is the frequent random jerks experienced by microscopic particles suspended in a gas or liquid. The cause is momentary inequalities in the number and speed of surrounding molecules hitting the particle from various directions. This tiny motion is enough to throw small droplets out of gas streamlines and against fibers that they would otherwise flow around. {See Figure 15.) Since flow momentum is not involved, capture efficiency is not improved by larger droplets, higher velocity, higher relative liquid density, or lower gas viscosity as for vanes and mesh. Instead, efficiency goes up with higher temperature, longer residence time in the mat (due to greater mat thickness or lower gas velocity), and closer packing of fibers, and down with greater droplet size and pressure.

Because fiber mist eliminators are so different from vane and mesh units in application and specification, further technical information about them is provided in separate Filters® publications.

Figure 15. Droplet capture by Brownian motion in a fiber candle or panel



Capacity limits

The throughput capacity of a mesh or vane mist eliminator is limited by either of two related phenomena: flooding (choking with liquid) and re-entrainment (dislodging, suspension, and escape of coalesced droplets). In some low-pressure applications, the pressure drop across the device can also be an important consideration. These limiting factors are illustrated in Figures 16 and 17.

Figure 16 is based on experimental data for a typical horizontal mesh pad (Filters® mesh type TM-1109), using water sprayed at various rates into rising air. It shows how pressure drop varies with velocity and mist load in the vicinity of the typical operating range. The mist droplets are assumed to be within a size range suitable for capture by a pad of this sort larger than 10 microns.

In Figure 16, notice that the pressure drop would be considered small in most applications only about 2 or 3 inches of water column even at the most extreme velocity and load combination.

Also notice that pressure drop increases markedly with mist load. At 10 feet per second, the pressure drop for 1 GPM/ft2 is more than three times that for a dry pad.

Figure 17, in turn, provides a subjective impression of what happens in a typical horizontal mesh pad at three different conditions of flow rate and mist load indicated as Points A, B, and C in Figure 16.

Point A represents a light mist load and a velocity of about 8 feet per second. Nearly all the incoming mist is captured well below the middle of the pad. The rest of the pad remains dry. In the active zone, coalesced droplets slip rapidly down the mesh wire. At the bottom, however, surface tension makes water accumulate on and between wires before falling away as streams and large drops. The result is a thin flooded layer agitated by rising gas, generating a small amount of additional mist that is immediately captured again.

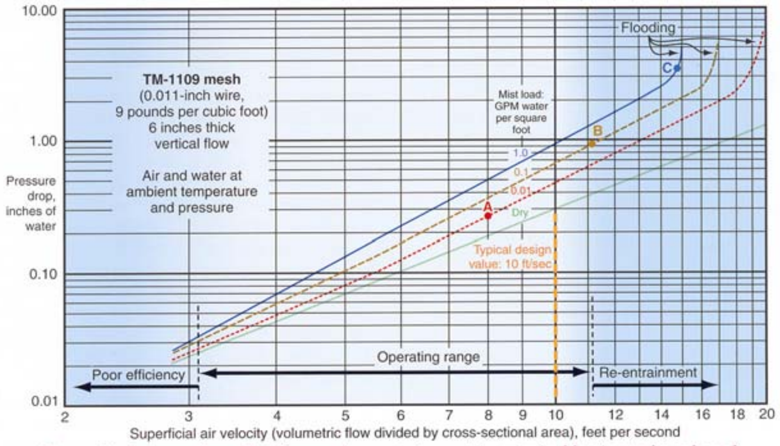


Figure 16. Pressure drop, flooding, and re-entrainment in a typical horizontal mesh pad

Point B, in turn, lies on a "moderate" load line at the velocity where a few re-entrained droplets begin to blow upward from the pad about 11 ft/sec, under these conditions. Re-entrainment is roughly indicated by the darker background at the right side of the plot. (The darker area on the left, in turn, signifies poor capture efficiency.) The higher the liquid load, the lower the velocity at which re-entrainment occurs. **At Point B**, velocity is high enough to detach coalesced droplets and lift some of them against the force of gravity. Most re-entrained droplets are relatively large up to 1,000 microns (1 millimeter). Because of the higher liquid flow rate in the approaching mist and greater upward drag on captured liquid due to higher air velocity, the flooded zone fills an appreciable layer. Incoming mist rises higher in the pad before being captured.

Finally, **at Point C**, the velocity is high enough not only to lift even the largest re-entrained droplets, but also to retard drainage within the pad virtually to zero. The mesh is entirely choked with agitated liquid , generating mist droplets downstream across a wide range of size.

Flooding has caused the pressure-drop curve to begin turning up sharply. If flow were increased beyond this point, the line would become almost vertical. For lower liquid loads, flooding occurs at higher velocities.

Similar behavior governs capacity limits also for vane mist eliminators and for horizontal flow through vertical mist eliminators of both types.

As to the influence of operating variables on these phenomena, flooding is promoted by high liquid load (volume percent mist in the incoming mixture), high gas velocity (especially for upward flow as in this example), and high liquid viscosity and surface tension (inhibiting drainage).

At very light liquid loads, re-entrainment can occur without appreciable flooding. However, with or without flooding, re-entrainment is promoted by higher gas velocity, smaller strand diameter or vane corrugation spacing, sharper corrugation angles, greater liquid load, lower liquid density relative to gas, lower liquid surface tension, and lower wettability of the mesh or vane surface.

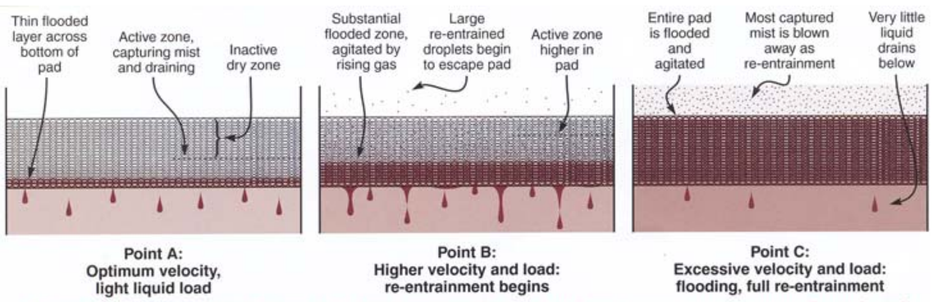


Figure 17. Envisioning stages in mesh pad performance in preceding figure (vertical cross-sections through pad)

SIZING FOR GAS VELOCITY USING SOUDERS-BROWN EQUATION

THE FOREGOING fundamental considerations lead directly to procedures for sizing a mesh or vane mist eliminator in terms of cross-sectional area, to handle the throughput for a particular application.

The key variable is gas velocity. In a given application, a mist eliminator has a definite operating range, indicated by the lighter background color in Figure 16. At velocities above this range, performance is impaired by re-entrainment, accompanied by flooding for all but the lightest mist loads. As velocity decreases within the operating range, droplet capture efficiency declines more steeply for smaller droplets than for larger ones. At some point, the efficiency for droplets at the lower end of the size range has fallen to an unacceptable level. This is the bottom of the operating velocity range. For the typical case in Figure 16, it is roughly 3 ft/sec. Dividing that into the re-entrainment limit of about 11 ft/sec yields an approximate turndown ratio of nearly four to one for the operating range.

It is generally recommended that the nominal operating velocity be established toward the top of the range about 10 feet per second for an air-water application such as this. Capture efficiency is higher there than farther down in the range, and performance is satisfactory at velocities from about 30% to 110% of that value.

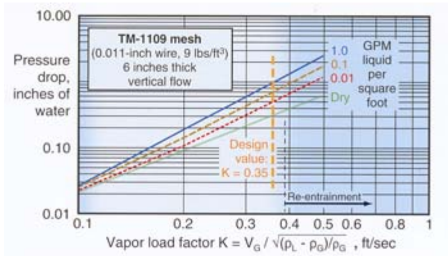
A certain formula is widely used in sizing a mesh or vane mist eliminator for a given throughput. It generalizes the characteristics reflected in Figure 16 (notably excepting the low end of the operating range) from the base case of air and water to other gases and liquids. Called the Souders-Brown equation, it has long been the customary tool for predicting the maximum allowable vapor velocity in a trayed vapor-liquid contactor column. (M. Souders and G. G. Brown, "Design of fractionating Columns. I. Entrainment and Capacity," Industrial & Engineering Chemistry, Volume 26 [1934], Pages 98-103.} The equation is similar in form to Newton's Law for the terminal velocity of falling spheres.

The version of the Souders-Brown equation commonly used for mist eliminators establishes a variable K called the vapor load factor—also known as the system load factor, Souders-Brown velocity, or K factor as follows:

$$K = V_G / \sqrt{(\rho_L - \rho_G)/\rho_G} \qquad \text{(Equation 1)}$$

K = vapor load factor (Souders-Brown velocity)
V_G = gas velocity
ρ_L = liquid density in same units as ρ_G
ρ_G = gas density in same units as ρ_L

The K factor can be considered an effective gas velocity for the purpose of expressing the throughput capacity limit, adjusted for the effects of liquid and gas density. This parameter allows data gathered for a given mist eliminator and gas-liquid system typically air and water to be used in sizing mist eliminators of the same type for different gases and liquids.



Generalizing Figure 16 by applying Souders-Brown equation $K = V_G / \sqrt{(\rho_L - \rho_G)/\rho_G}$

Water and air at 70° F and 1 atmosphere:

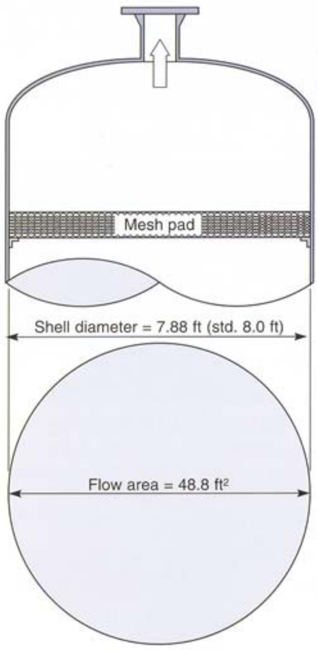
ρ_L = 62.3 pounds per cubic foot
ρ_G = 0.0749 pounds per cubic foot
$K = V_G / 28.8$
Design K = (10 ft/sec) / 28.8 = 0.35 ft/sec
Maximum K = (11 ft/sec) / 28.8 = 0.38 ft/sec

Figure 18. Graphs of Figure 16 in terms of Souders-Brown vapor load factor

For example, Figure 18 shows the graphs of Figure 16, with the X axis converted from velocity to vapor load factor. The conversion factor is 28.8, calculated as shown in the figure. The effect is to shift the graphs of Figure 16 toward the left by that amount. The recommended design velocity of 10 feet per second for this mesh pad in this horizontal configuration corresponds to a load factor of about 0.35 ft/sec. The top of the operating range, in turn (11 ft/sec in Figure 16), lies at a load factor of about 0.38. Filters® publishes graphs such as this as design aids for a number of its products. (See appendix.)

The point is that re-entrainment, flooding, and log-log pressure-drop plots (although not capture efficiency) all correlate well with vapor load factor for different liquids and gases having various densities. The correlation generally holds at pressures from atmospheric up to about 7 atmospheres (100 psia) for gases and liquids whose surface tension and viscosity vary roughly alike with density. This includes most light hydrocarbons, for instance.

As an example, consider a TM-1109 mist eliminator in the top of a distillation column or knockout drum as shown in Figure 19. In this particular case, the square-root divisor in Equation 1 is 11.7. The design velocity (corresponding to a K-factor of 0.35 ft/sec) is 4.10 ft/sec which is 41% of the value for air and water in Figure 16



Horizontal 6-inch TM-1109 pad:

Liquid droplet density . . ρ_L = 42.5 lbs/ft³
Gas density. . . . . ρ_G = 0.31 lbs/ft³
$V_G = K \sqrt{(\rho_L - \rho_G)/\rho_G}$
$V_G = 11.7\ K$ Recommended design K is 0.35 ft/sec
Design velocity: V_G = (11.7)(0.35 ft/sec) = 4.10 ft/sec

Suppose the given design vapor rate is 200 ft³/sec
Then the required cross-sectional area
= (200 ft³/sec)/(4.10 ft/sec) = 48.8 ft²

Flow area diameter = $2\sqrt{48.8\ \text{ft}^2/\pi}$ = 7.88 feet

Typically round up to next standard size: 8 feet

Figure 19. Sizing a mesh pad and vessel with Souders-Brown equation $K = V_G / \sqrt{(\rho_L - \rho_G)/\rho_G}$

The pressure-drop curves and re-entrainment and flooding points will likewise be shifted to about 41% of their positions in Figure 16.

Figure 19 also shows how the Souders-Brown equation is typically used in sizing a vessel with a mist eliminator of this type for flow area to achieve the design velocity (K = 0.35) with a given design vapor flow rate.

Capture efficiency is an entirely separate matter from sizing. As explained earlier, the inertial capture efficiency for a given velocity, wire diameter, and droplet size is enhanced by higher liquid density and lower gas density.

Table 2. Recommended design values of Souders-Brown vapor load factor $K = V_G / \sqrt{(\rho_L - \rho_G)/\rho_G}$

Typical wire mesh pad (no co-knit yarn):
Vertical flow . . . . K = 0.35 ft/sec
Horizontal flow . . . . K = 0.42 ft/sec
(For mist loads less than 0.1% volumetric, equivalent to 0.5 GPM/ft² at 10 ft/sec)

Typical vane unit
Vertical flow . . . . K = 0.50 ft/sec
Horizontal flow . . . . K = 0.65 ft/sec

Double-pocket vane unit
Vertical & horizontal flow K = 1.0 ft/sec

Typical operating velocity range:
30% to 110% of design K above

Effective pressure range:
Derate K as much as 40% for vacuum or pressures above 7 atmospheres (85 psig)

Such density changes result in a higher square-root divisor in the Souders-Brown equation. In the example case in Figure 19, however, the divisor (11.7) is lower than for air and water (28.5). Therefore the efficiency of this pad in this application at any given velocity will be lower than for air and water. To achieve minimal acceptable efficiency, the low end of the operating velocity range will be higher than the typical 30% of design velocity.

Table 2 shows generally recommended design values of K for various typical cases. Note that the values for vane units are higher than for mesh pads. This is because vanes are less susceptible to re-entrainment and flooding (discussed later).

Furthermore, for both mesh and vanes (except double-pocket vanes), design K-factors are higher for horizontal flow through vertical units than for vertical flow through horizontal units. This is because with horizontal flow, draining of captured liquid is not retarded by gas flowing in the opposite direction.

In all cases listed in Table 2, performance is typically acceptable over the same range of velocities discussed for vertical flow in a horizontal mesh pad from about 30% to 110% of the design value. However, as explained before, the low end of the operating range varies in the opposite direction from the design velocity; the lower the design velocity, the narrower the acceptable range.

Similarly, as mentioned earlier, this correlation breaks down at pressures outside the range of 1 to 7 atmospheres. For higher or lower pressures, the design K-factor will be as low as 60% of the tabulated value for each configuration in Table 2.

Finally, the design K-factors for both horizontal and vertical mesh pads are applicable only for low to moderate mist loads up to about 0.1% liquid by volume. For a velocity of 10 feet per second, this corresponds to about 0.5 gallons of liquid captured per minute per square foot. For higher mist loads, the design K should be derated. Vane units are not so sensitive to the effects of mist load on capacity.

MESH VERSUS VANES-OR BOTH

THE EFFICIENCY OF VANE mist eliminators is generally acceptable only for droplets larger than 10 or 20 microns in the case of air and water at ambient conditions. (Compare efficiency curves on Pages 14 and 15.) Furthermore, a vane unit is generally more expensive than a mesh pad in the same application. However, vanes have certain advantages that dictate their selection over mesh in some situations.

Vane advantages

1. High velocity: Being less susceptible to re-entrain ment and flooding than mesh pads, vane units can operate at velocities 30 to 40 percent higher in both vertical and horizontal flow. (See Table 2.) Higher velocity helps close the efficiency gap with mesh.

2. High liquid load: Vane units typically handle loads about 5 to 10 times greater than mesh pads: up to 10 gpm/ft2 for VNM-50-6 vanes, versus 1 gpm/ft2 for TM-1109 mesh (horizontal flow, air and water, ambient conditions).

3. Fouling and clogging: Solid particles and debris that would lodge in a mesh pad, eventually requiring replacement or cleaning, pass through the much larger apertures of a vane unit. In applications that are subject to buildup of deposits, vane units can operate for much longer intervals without cleaning and can be cleaned much more readily than mesh pads.

4. Longer corrosion life: The thickness of vanes gives them a substantially greater service life than mesh with the same corrosion rate. In a given corrosive service, a vane unit made of sheet metal will last much longer than a mesh pad made of the same alloy.

5. Low pressure drop: The relative openness of vanes gives them an edge over mesh in applications where pressure drops of a few inches of water column are crucial. (See graphs on Pages 14 and 15.)

6. High liquid viscosity: There are a few applications in which high viscosity impedes liquid drainage so severely that a mesh pad would flood at prohibitively low velocities and liquid loads. Vanes can handle much higher liquid viscosities.

7. Rugged construction: When properly secured in place, a typical vane unit withstands violent surges and liquid slugs that would dislodge and even destroy the most rugged mesh pad.

8. Foam accommodation: Because of liquid agitation in mesh pads, those devices are not generally recom mended in applications subject to foaming. Vane units, by contrast, not only drain without foaming, but can actually break foam generated upstream.

In view of Items 3,4 and 7 above, vane units are especially attractive in applications that require high reliability for long periods without maintenance or replacement.

Offshore platforms and long-running processes are prime examples.

Mesh-vane combinations

Vane units can be especially valuable in certain applications when used immediately upstream or downstream of mesh pads. Figures 20 and 21 illustrate these concepts with horizontal flow. With vertical flow, capacity will be reduced as explained before for mesh pads and vane units alone.

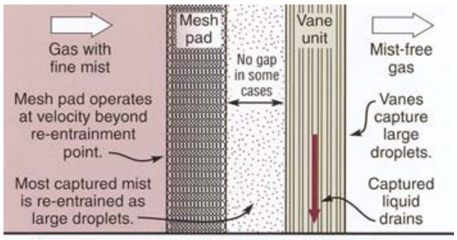


Figure 20. Boosting throughput and efficiency of a mesh pad by following it with a vane unit

Mounting a vane unit downstream of a mesh pad as in Figure 20 combines the superior efficiency of the mesh with the superior K-factor of the vanes. The typical K-factor for horizontal flow is raised from 0.42 for mesh alone (Table 2) to 0.65 for vanes. When operated at or above the resulting design velocity, the mesh pad serves as an agglomerator or coalescer of fine mist droplets. Most liquid captured in the mesh pad is re-entrained as larger droplets whose sizes are well above the lower limit of the vane unit. Higher velocity also improves the mist elimination efficiency of the mesh. In applications of co-knit mesh where the re-entrainment velocity is exceptionally low, a downstream vane unit is indispensable.

On the other hand, mounting a vane unit upstream of a mesh pad as in Figure 21 combines the superior efficiency of mesh with the superior load and solids-handling ability of vanes. The K-factor of the combination is that of the mesh pad.

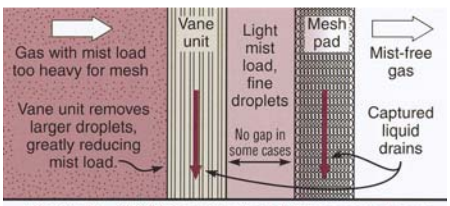


Figure 21. Shielding a mesh pad from a very heavy mist load with a vane unit ahead

APPLYING MIST ELIMINATOR

THE FOLLOWING are some additional considerations that may come into play when applying mesh and vane mist eliminators in specific situations. Like other information in this publication, these guidelines can be useful for preliminary design purposes. However, final decisions should not be made without consulting Filters®' separation specialists.

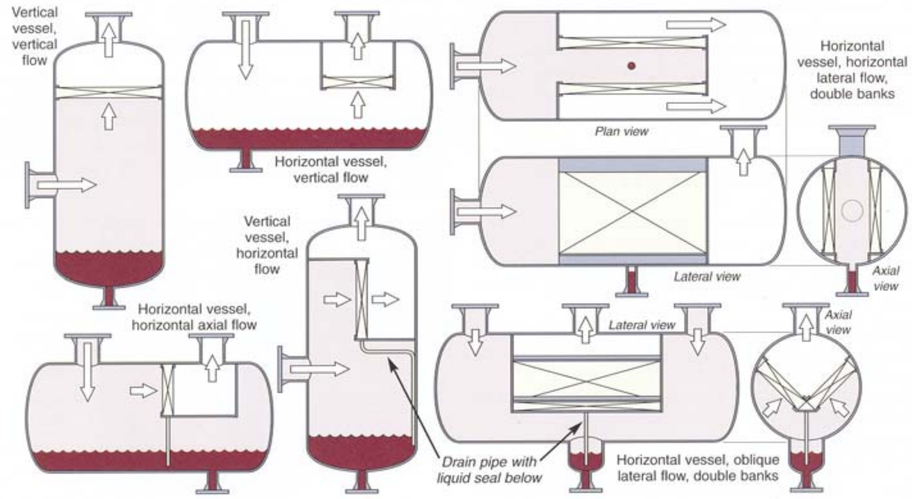


Figure 22. Typical mist eliminator configurations in cylindrical knockout drums. Similar configurations can be used in other vessels. The mist eliminators may be mesh, vane, or combinations.

Vessel configurations

The simplified diagrams in Figure 22 show several typical configurations of mist eliminators in vessels. The mist eliminators may be mesh pads, vane units, or combinations as described on Page 11. The vessels depicted are cylindrical vapor-liquid separators, often called knockout drums. However, some of the same concepts may also apply to mist eliminators in process vessels, such as vapor-liquid contactor columns, evaporators, chillers, etc. Considerations affecting selection of a mist eliminator configuration may include the following:

- Mist eliminator cross-sectional area to achieve design velocity with required vapor throughput
- Space available inside existing vessel
- Plant space available for the vessel
- Inlet and outlet locations to fit established piping
- Liquid holding capacity and drainage method
- Worker access for cleaning, replacement, etc.
- Support beams for large horizontal mist eliminators
- Internal flow constraints for efficient operation

Internal flow guidelines

The last consideration in the foregoing list internal flow constraints is often overlooked but may be of primary importance. There are two main principles:

1. Maintain an even velocity profile across the mist eliminator element whether mesh, vane, or combination. The object is to avoid situations such as shown in Figure 23.

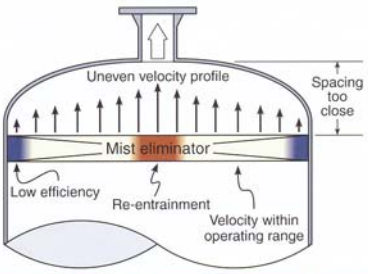


Figure 23. Example of mist eliminator performance degradation due to uneven velocity profile

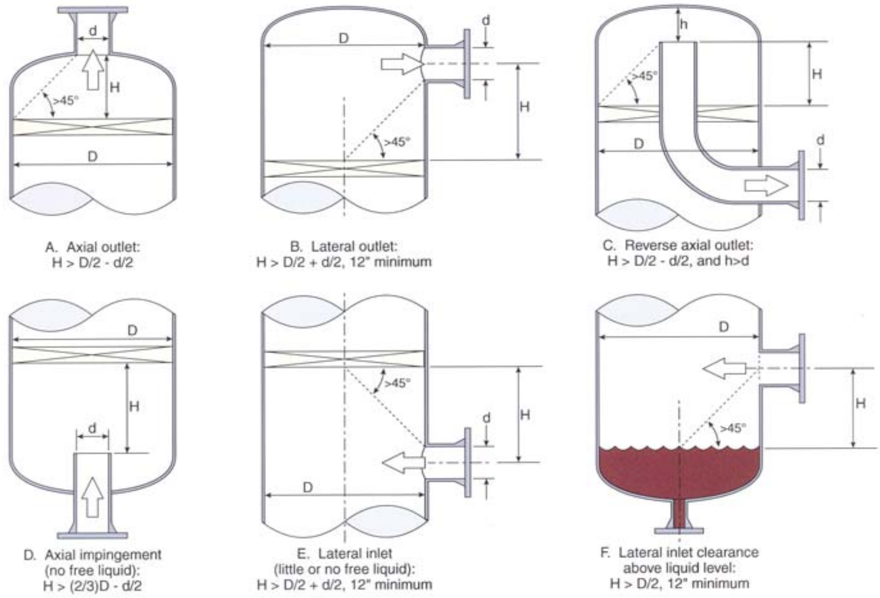


Figure 24. Generally accepted spacing guidelines to maintain even velocity profile and avoid entrainment in mist eliminators in cylindrical vessels with axial flow

Here, the mist eliminator is mounted too close to the outlet nozzle. Excessive velocity in a region near the center of the mist eliminator results in substantial re-entrainment there. Furthermore, deficient velocity in a region around the perimeter causes low droplet removal efficiency in that area. The main key to an even velocity profile is to allow sufficient spacing between the mist eliminator and gas inlets and outlets. Items A through E in Figure 24 show some generally accepted guidelines in this regard for cylindrical vessels with axial flow through the mist eliminator. Flow distribution devices of various sorts can reduce the necessary spacing, but at the risk of violating the following principle.

2. Avoid strong turbulence and fluid shear in the wet part of the vessel. The main objective is to prevent entrainment of the collected liquid. This can be achieved by maintaining adequate separation between the inlet nozzle and the liquid surface as shown in Item F of Figure 24. Another objective is to prevent shearing of droplets into smaller particles that might pass through the mist eliminator.

Application procedure

Based on all of the principles presented before, the procedure generally followed in designing a mist eliminator application involving mesh, vanes, or both is as follows:

1. Estimate the droplet size distribution (See Table 1).
2. Specify the required separation efficiency.
3. Tentatively choose a mist eliminator (mesh, vane, or combination; mesh or vane style; materials) considering droplet size, efficiency, corrosion, and wettability.
4. Tentatively select a mist eliminator orientation and placement in the vessel (Figure 22, etc.).
5. Calculate the necessary cross-sectional area and mist eliminator dimensions (Figure 19, Table 2, etc.).
6. Estimate separation efficiency and pressure drop within the required turndown range (Appendix and similar reference literature}.
7. If the estimated results are not acceptable, repeat steps 3 through 6 with a different mist eliminator or vessel configuration.
8. Check for conformance with internal flow guide lines (Figures 23 and 24, etc.) and revise as necessary.

For easy separations that are familiar to the designer, sizing (Step 5) may be the only critical step. In even the simplest applications, however, the possibility of improvements in performance and cost-effectiveness should not be overlooked. In any case, achieving an optimum design requires a great deal of experience and judgment.

Designers and purchasers should always consult with Filters®' separation specialists before making a final decision.

APPENDIX

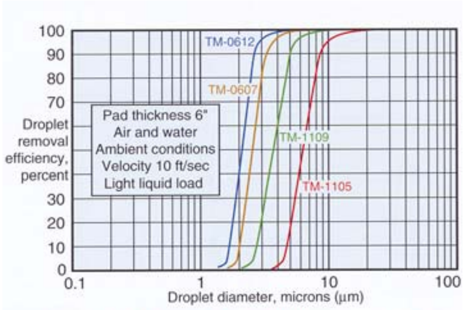


Figure A1. Efficiency of 6-inch metal mesh pads

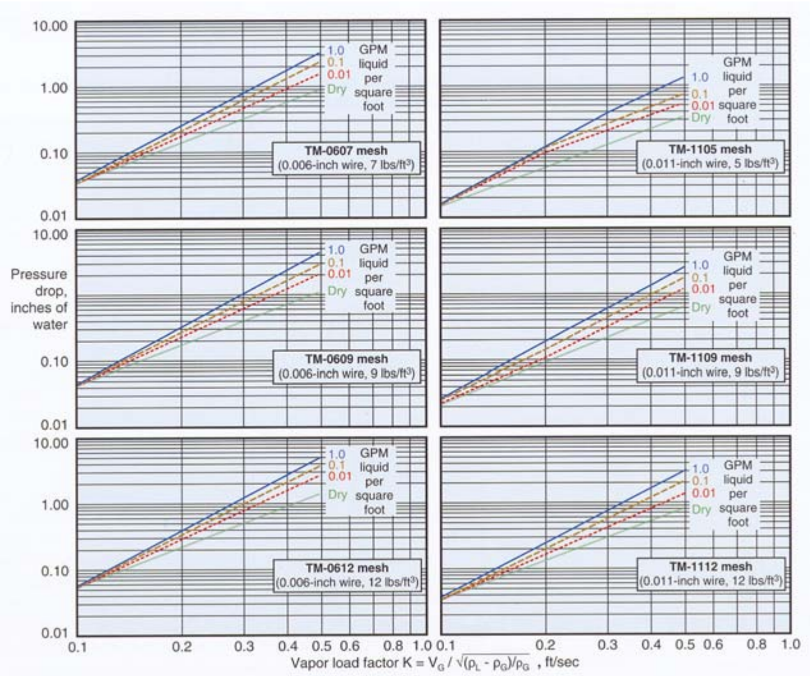


Figure A2. Pressure drop for 6-inch metal mesh pads

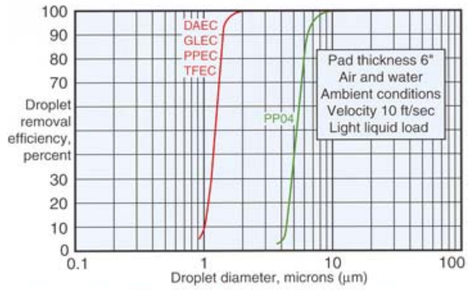


Figure A3. Efficiency of 6-inch co-knit and plastic monofilament mesh pads

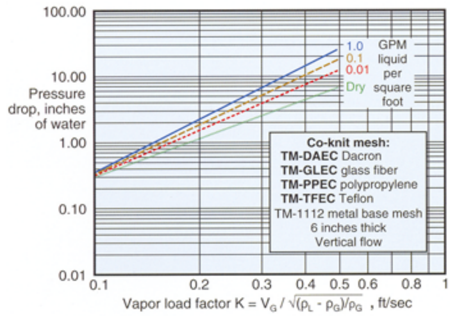


Figure A4. Pressure drop for 6-inch co-knit mesh pads

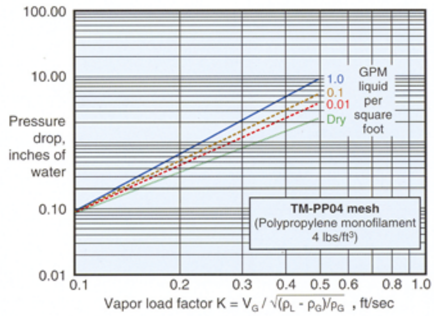


Figure A5. Pressure drop for 6-inch plastic monofilament mesh pads

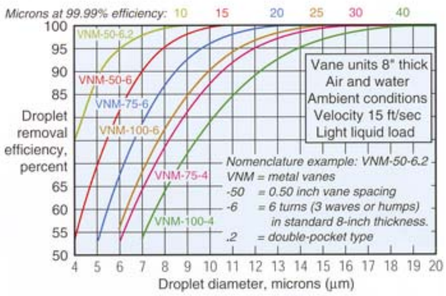


Figure A6. Efficiency of vane mist eliminators

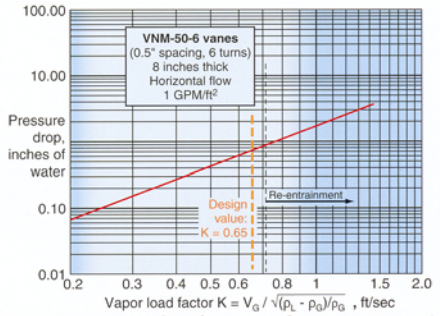


Figure A7. Pressure drop for a typical Amistco vane unit

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