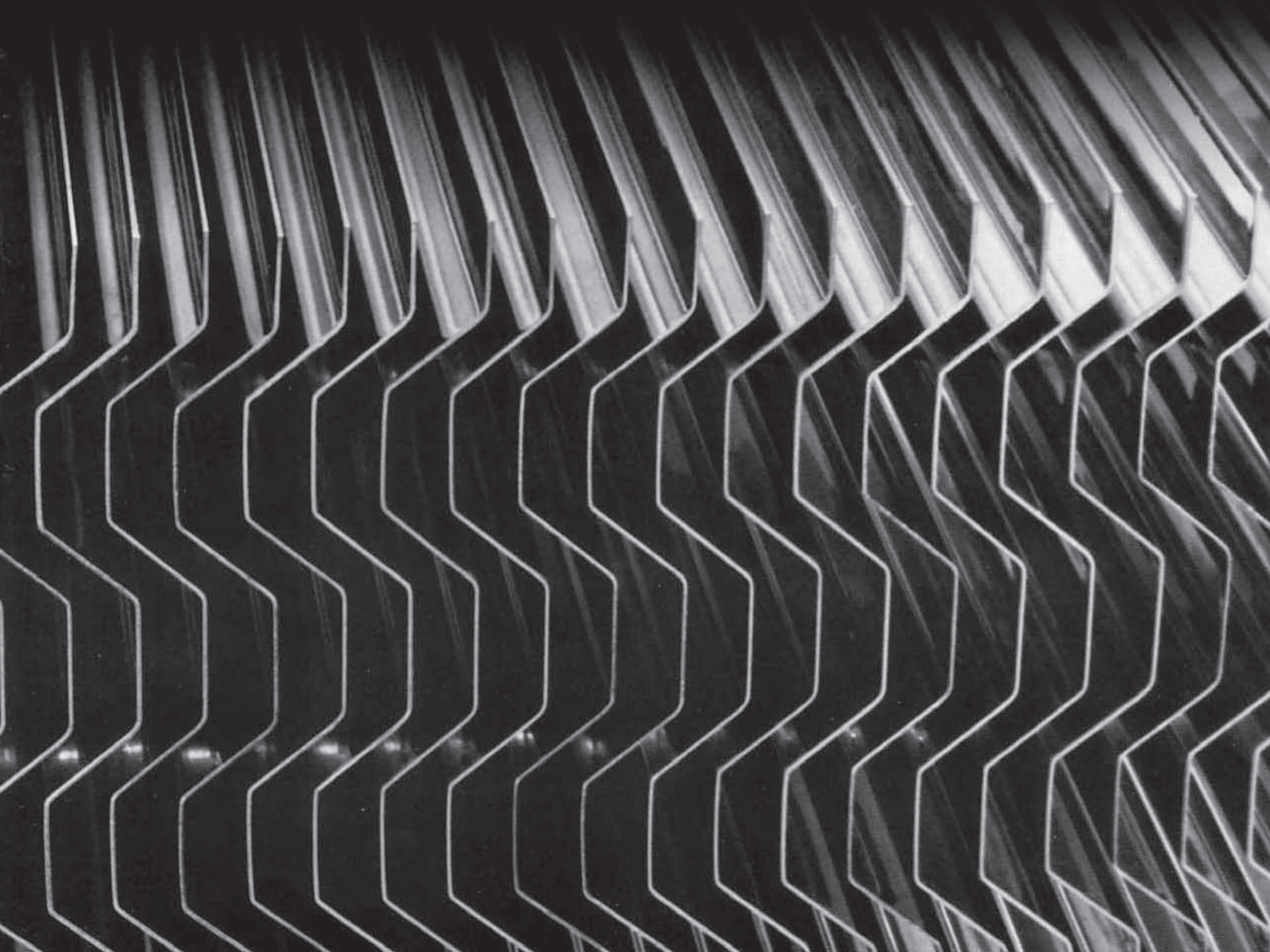
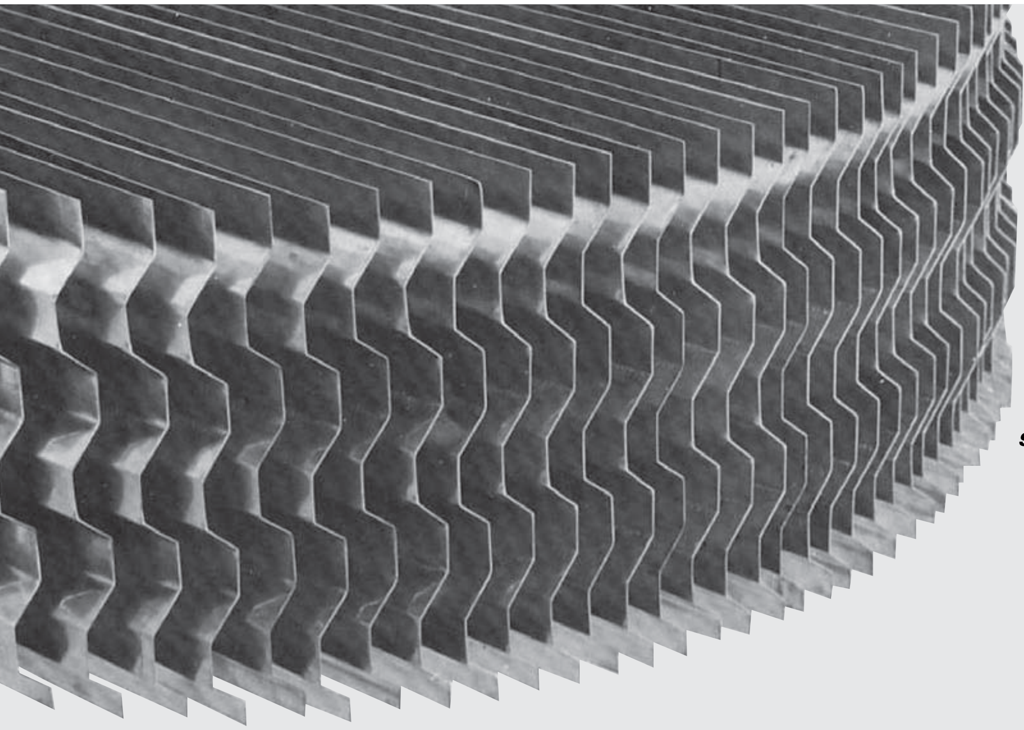
AMACS

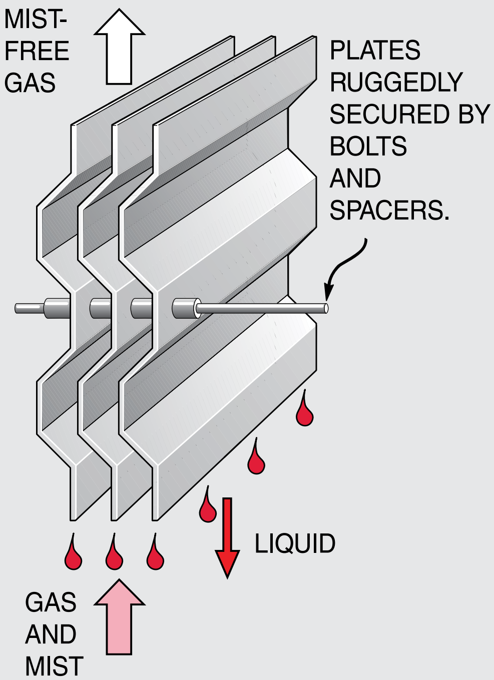
# Plate-Pak™
## vane mist eliminators



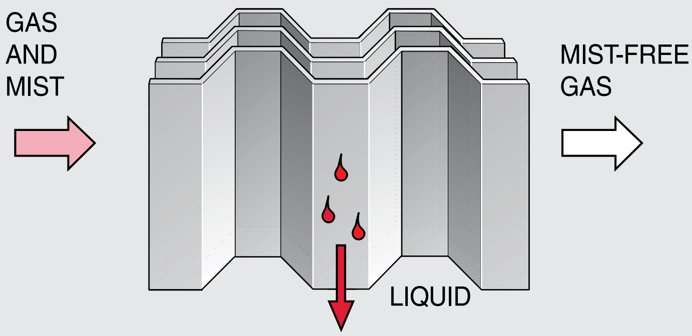
# Plate-Pak™ Mist



***Section of a typical stainless steel Plate-Pak™ unit for vertical gas flow as in Drawing B on Page 3. Nonmetallic construction is also available. Mist eliminators using vanes of this general type are sometimes called chevron style.***




**Vertical Flow Configuration:** *(Same as photo here and on front cover): Gas flows upward, mist droplets strike the plates, and collected liquid drains down.*




**Horizontal Flow Configuration:** *Gas flows horizontally, collected liquid drains down the plates.*

## Quality you can count on.

Superior Design: AMACS doesn't compromise in design, construction, and application of Plate-Pak™ units. Mist droplets are thrown out of the gas by multiple gentle angles instead of sharp zig-zags, minimizing disruptive eddies at the corners. Metal plates are held by secure through-bolts and spacers. Details are carefully engineered for each application.

Rugged Construction: You can feel the strength and stiffness of a Plate-Pak™ assembly when you walk on it. Thicker plates resist fluttering and last longer in corrosive and erosive service. Plate-Pak™ units are designed to be installed into vessels and forgotten. After an upset, you won't find the pieces jammed into the exit pipe or blown downstream into a compressor.

Lower Pressure Drop: Reduced eddy turbulence due to gentle angles means lower pressure drop than for units having sharp corners and drainage hooks. In some applications such as vacuum towers, that can make all the difference in the world.

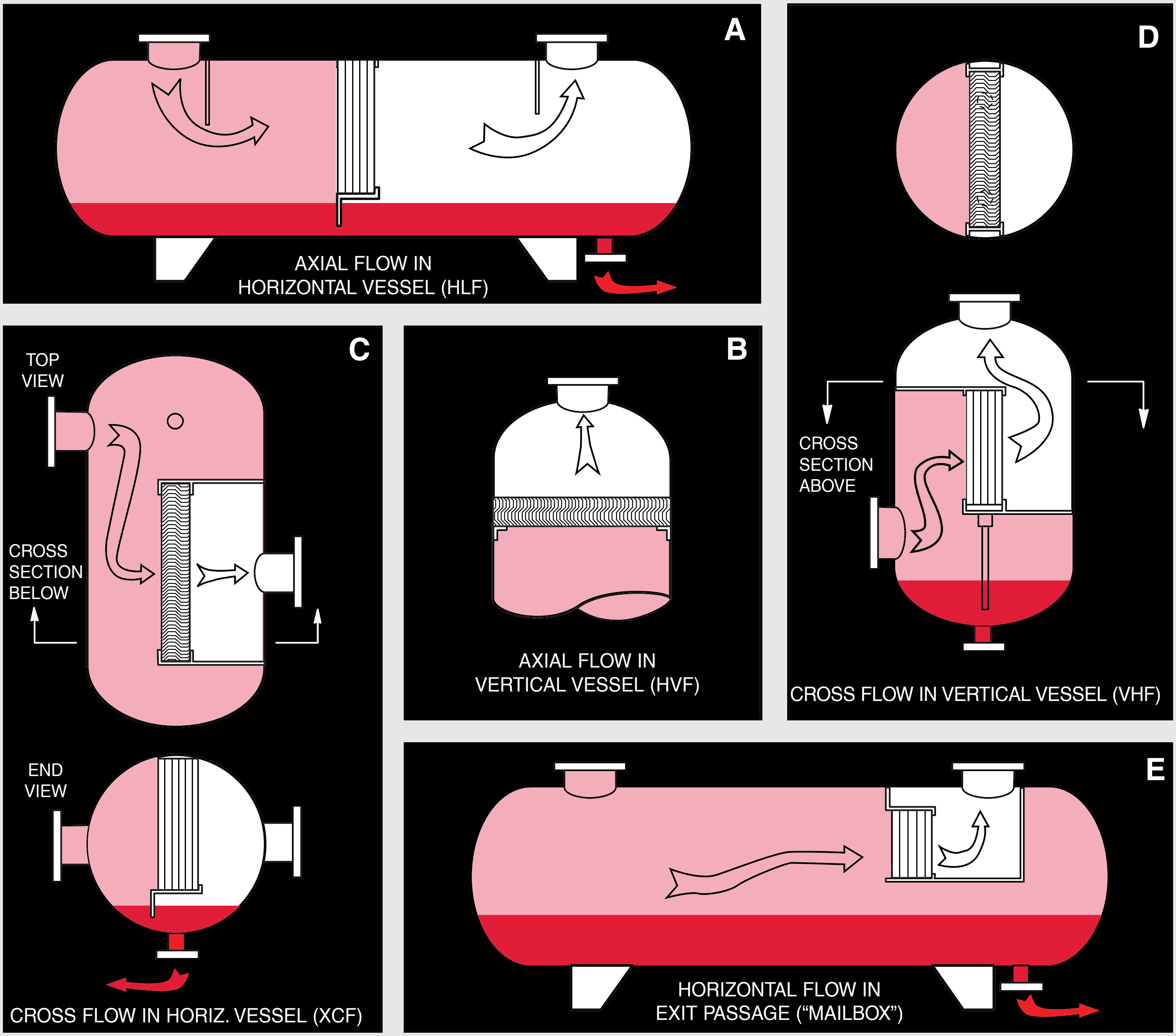
Higher Efficiency: Less turbulence around the corners also means minimal re-entrainment of liquid draining down the plates. The result is higher net efficiency in terms of percent liquid removed: typically 90% of all droplets with diameter 20 microns and larger, 99.9% of 40-micron and larger droplets.

More Throughput: The same reduction of corner swirls allows higher gas velocity and liquid load without losing efficiency due to re-entrainment. Maximum recommended velocity in typical air-water applications, with horizontal flow and about one gallon of liquid per minute per square foot, is about 25 feet per second.

Materials to Suit Your Process: The most common construction materials are carbon steel and 304 and 316 stainless steel. But we understand your corrosion requirements and can provide other alloys or nonmetallic construction as necessary.

Hooked Plates for Special Applications: For horizontal flow applications, AMACS can provide Plate-Pak™ units whose vanes have short extensions hooking backward from one or more corners. That style is preferred by some users to help prevent re-entrainment of liquid.

# Eliminators for ruggedness and performance




## AMACS expertise pays off in diverse applications.

Plate-Pak™ units have been providing successful and trouble-free service in a wide range of applications for many years. Included are wellhead and pipeline separators, flue gas scrubbers, pulp-mill evaporators, vacuum stills, asphalt heaters, and many others.

The drawings above indicate the variety of common flow configurations. In some instances, the vessel is designed especially as a separator or knockout drum. AMACS can design and supply the entire separator vessel, if desired. In other cases, the Plate-Pak™ unit is installed in a distillation tower or other process vessel instead of a separator. Though not shown here, Plate-Pak™ units are often used to boost the liquid capacity of mesh pads (behind the pads in clean applications, upstream in fouling service). Each configuration entails its own design and sizing considerations, discussed later.

In all cases, you get the full benefit of the expertise of AMACS . We design and make a wide range of equipment for engagement and disengagement of liquids and gases. AMACS is committed to helping you to make the optimum decision in eliminating entrained liquids from your gas streams. You can be assured of getting the optimum solution, properly selected, sized and designed.

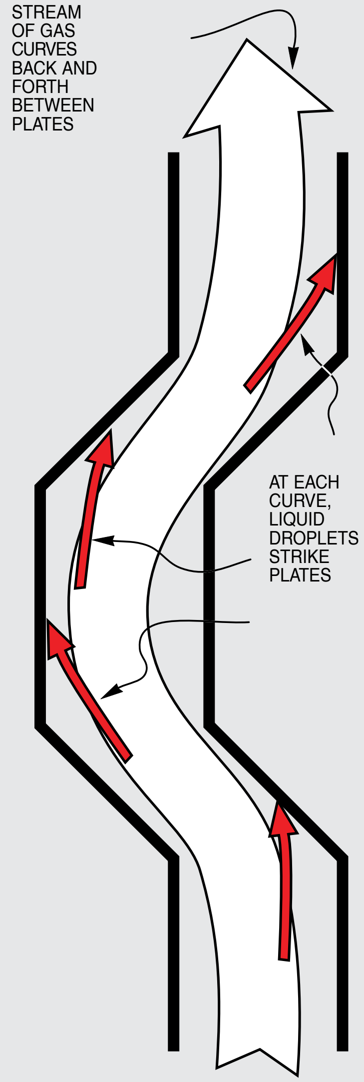
# Capturing droplets by inertial impaction

Like other vane-type mist eliminators, Plate-Pak™ units capture tiny liquid droplets entrained in a gas or vapor by a method commonly called inertial impaction. The gas flows either horizontally or upward (See drawings on Page 2), and vanes direct the flowing gas back and forth in a sinuous pattern. Mist droplets are carried along by the gas. But because of momentum due to their higher density, the droplets tend to move in straighter lines than the bulk of the gas. At every change in gas direction, some droplets strike and adhere to the surface. This effect can also be likened to the slinging action of a cyclone separator; curving flow around a bend generates centrifugal force, throwing droplets to the outside.

The captured droplets coalesce on the vanes, forming larger drops which have enough weight to trickle down. With vertical flow, collected liquid drips from the bottom of the vane unit and falls through the rising gas. With horizontal flow, a drainage path is provided from the bottom of the vanes.

The performance of a vane-type mist eliminator is influenced by a number of variables as described below. AMACS engineers consider all these factors in selecting and sizing a Plate-Pak™ unit for a particular application, paying special attention to the equation explained on Page 5.

Droplet Size: The smaller a droplet, the more readily it follows the surrounding bulk gas in flowing around bends. In a given application, nearly all the droplets larger than a certain size are captured, while those smaller than a certain size simply blow through. Vane units are typically considered to be performing well when they capture 99.9% of all droplets larger than about 40 microns.



CONCEPT OF INERTIAL CAPTURE

Relative Densities: The momentum effect necessary for capture depends on the mist droplets' having an appreciably greater density than the gas. The heavier a droplet of a given size, the more likely it is to strike a vane. But the denser the gas, the more easily it sweeps droplets along without being captured. The parameter most often used to express density effects is the square root of the relative difference in density between liquid and gas: $\sqrt{(\rho_L - \rho_G)/\rho_G}$

Gas Velocity: With a given mixture of gas and mist, a given vane unit operates best in a certain range of gas velocity. If the gas is too slow, the droplets simply drift around the bends without being captured. But if the gas is too fast, it sweeps liquid off the vanes, a process called re-entrainment. Liquid picked up is broken into droplets; the higher the velocity, the smaller the re-entrained droplets. With vertical flow, high velocity also inhibits the dripping of collected liquid from the vanes; the resulting buildup of accumulated liquid is called flooding. In a typical air-water application, the maximum velocity is 25 feet per second for horizontal flow an 18 feet per second for vertical flow.

Liquid Capacity: The more rapidly liquid is captured by a given vane unit, the more liquid builds up on the vanes in the process of draining out, and the lower the gas velocity that can be tolerated without re-entrainment. The lower the liquid's viscosity, the more readily it flows off without re-entrainment.

Vane Contour and Spacing: Tighter bends in the gas path, accompanied by closer spacing of the vanes, accentuate the inertial capture effect. Thus, a higher percentage of smaller droplets can be captured. At the same time, the maximum and minimum effective velocities are lowered, and the pressure drop across the vanes for a given velocity goes up. Closer-spaced vanes are also more likely to become obstructed by solid objects, accumulated solid deposits, or high-viscosity liquid. Sharp angles in the vanes cause eddy swirls which increase pressure drop and re-entrain captured liquid more readily. For horizontal flow, some manufacturers depend on drainage hooks to keep liquid from being blown off sharp corners. Plate-Pak™ units minimize these problems by using vane contours which more nearly approach curved sinusoidal shape, although hooks are available if desired.

Surface Wettability: A vane unit generally performs better if the surface is wettable by entrained liquid. In that case, the captured droplets readily spread out into a film which adheres securely to the vane. If the surface is not wettable, captured droplets are more likely to be re-entrained. Wettability depends on the composition of the liquid and the surface, the surface roughness and texture, and whether or not there is a film of oil or wax on the surface. It may be influenced by temperature and pressure.

# Preliminary sizing of Plate-Pak™ units for gas velocity

The final design of a Plate-Pak™ unit is worked out by AMACS engineers in consultation with customer engineers. To make sure that the requirements of the particular application are met, all the variables described on Page 4 are considered. For purposes of preliminary size estimation, however, a much simpler procedure is sufficient. This involves establishing just one variable: gas velocity. In typical common applications, the optimum or design velocity for a Plate-Pak™ vane unit is determined by the following equation:

$$u_d = K\sqrt{(\rho_L - \rho_G)/\rho_G}$$

$u_d$ = optimum design velocity, feet per second; this is the superficial or average velocity, the actual volumetric flow rate divided by the cross-sectional area available for flow.

K = an empirically determined constant
= 0.65 feet per second for horizontal gas flow
= 0.50 feet per second for vertical gas flow

$\rho_L$ = density of liquid in mist droplets, in same units as $\rho_G$ (usually in pounds per cubic foot)

$\rho_G$ = density of gas or vapor in which mist is entrained

The permissible range of velocity is approximately from 30% to 110% of the calculated design velocity. Consult AMACS engineers about spacing upstream and downstream from the Plate-Pak™ unit.

## Example

Find the optimum diameter for a circular Plate-Pak™ element in a cylindrical separator with vertical axial flow as in the drawing. The gas stream is 50 million standard cubic feet per day (referenced to 60˚F and 14.7 psia) with average molecular weight of 25, at 170˚F and 250 psig, the entrained liquid having a density of 52 pounds per cubic foot.

Actual gas flow, ACFS

= SCFS (T°R / 520)(14.7 / P psia)
= (50,000,000 ft³/day) / (86,400 sec/day) x (170°F + 460) / 520 x 14.7 / (250 psig + 14.7)
= 38.9 ft³/sec

Gas density, $\rho_G$

= Mol. Wt. x P / RT (assuming perfect gas)
= 25 x (250 psig + 14.7) / (10.73)(170°F + 460)
= 0.979 lb/ft³

Optimum design velocity, $u_d$

$= K\sqrt{(\rho_L - \rho_G)/\rho_G}$

$= 0.50\sqrt{52 - 0.979 / 0.979}$ for vertical flow

= 3.61 ft/sec

Cross-sectional area of Plate-Pak™ unit, A

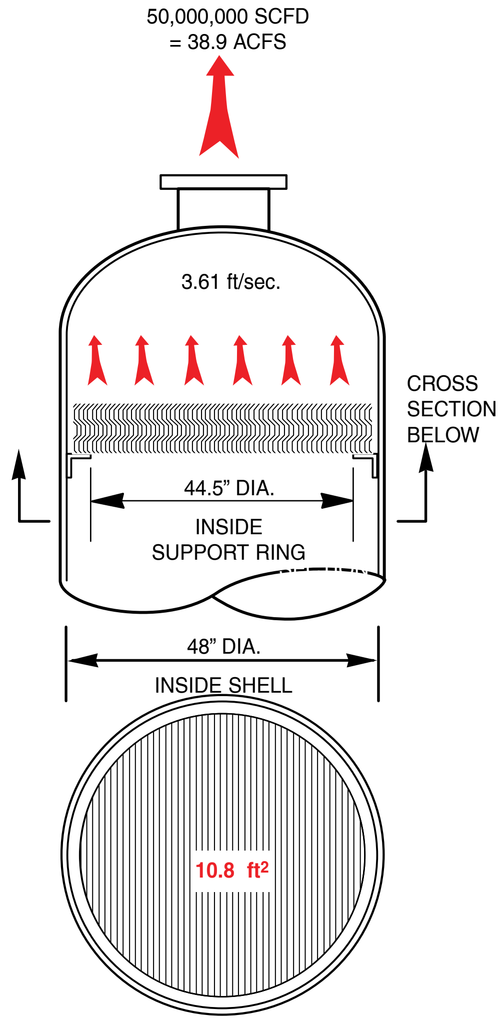
= ACFS / $u_d$
= (38.9 ft³/sec) / (3.61 ft/sec)
= 10.8 ft²

Diameter of circular Plate-Pak™ unit, D

$= 2\sqrt{A/\pi}$

$= 2\sqrt{10.8/\pi}$

= 3.71 feet
= 44.5 inches



# When to use a Plate-Pak™

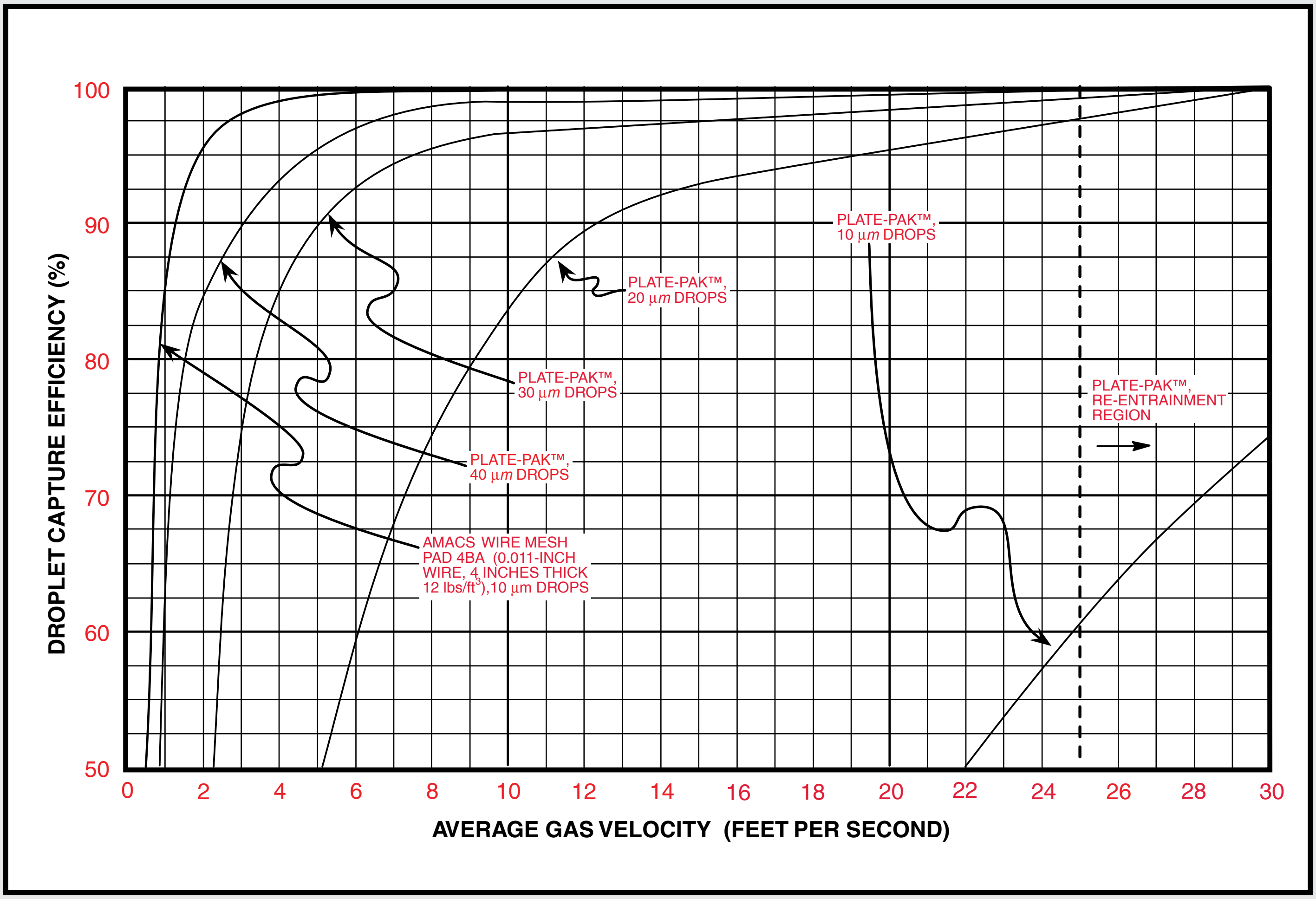
For a given mist-elimination task, the most likely alternative to a vane-type unit such as the Plate-Pak™ unit is knitted mesh pads. AMACS has been a recognized leader in mesh-type mist eliminators for many years, and the Separations & Mass-Transfer Products Division proves expert application assistance in deciding among its products. For tentative preliminary selection, here are some general guidelines:

Larger Droplets: First, for reasons explained before, vane-type units are not generally applicable to very fine mist and fog. Plate-Pak™ separators routinely remove 99.9% of droplets with diameters of 40 microns and above, and 90% of droplets as small as 20 microns. (See graphs below.) For reference, sprays produced by hydraulic and pneumatic nozzles generally have droplet diameters in the range from 10 to 1,000 microns. Droplets blown from a surface condenser or cooling coil typically range from one to 10 microns. And droplets from bubbling liquid as in a boiler may be as small as one micron. (The lower the viscosity and surface tension, the smaller the droplets produced by such entrainment processes.) Droplets created from the bulk of a gas, by chemical reaction or condensation, are generally smaller than one micron. AMACS can provide mesh pads for capturing 99.9% of droplets down to one micron in size.

High Gas Velocity: The maximum and minimum gas velocities for Plate-Pak™ units, in both horizontal and vertical flow configurations, are much higher than for mesh pads. When maximum throughput is required in a vessel of a given diameter, a Plate-Pak™ unit is indicated. For reference, a plot on the next page shows the capacity per square foot of a Plate-Pak™ separator with horizontal axial flow in typical natural gas applications.

Low Pressure Drop: Even at the lower design velocities of typical mesh pads, the pressure drop is considerably higher than for a Plate-Pak™ unit at its higher design velocity. In a typical application, the drop is only about 0.1 inch of water. (See graph on next page.) In most cases, the pressure drop would be negligible for both types. But a Plate-Pak™ unit may be preferred when very little pressure drop is available for the mist eliminator, as in a multiple-effect evaporator.

High Liquid Load: The principal limitation of throughput in a mesh pad is flooding, meaning choking with liquid due to excessive quantities of mist (or excessive gas velocity, in the case of vertical flow). But liquid loads high enough to affect a Plate-Pak™ unit's operation are extremely unlikely in ordinary industrial processes.




*Capture efficiency versus gas velocity for droplets of various diameters in a typical Plate-Pak™ mist eliminator and for 10-micron droplets in a typical AMACS mesh pad (air and water at ambient condition and moderate liquid load)*

# unit instead of mesh

Extremely Viscous Liquid: The higher the viscosity of the collected liquid, the more slowly it drains from a mesh pad or vane unit, so the greater the accumulation of draining liquid and the likelihood of flooding. Typical mesh pads are unsuitable for appreciable loads with liquid viscosities higher than about 100 centipoise (approximately like honey). Since Plate-Pak™ units drain much more freely, they can handle much higher viscosities.

Accumulated Residues: In some services, solid or semi-solid residues form in the mist eliminator due to processes such as dust capture, evaporation and polymerization. These deposits may be called cake, sludge, varnish, etc. A Plate-Pak™ unit can be cleaned much more easily and economically than a mesh pad, which may have to be replaced instead. Furthermore, it can operate much longer without shutdown due to residues.

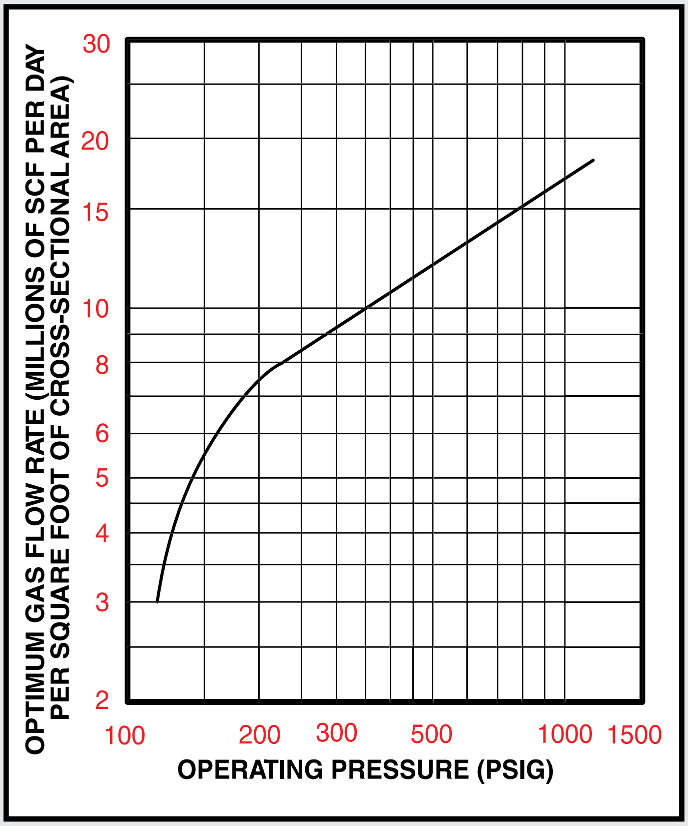
Clogging Particulates: Similarly, mesh pads are much more susceptible to clogging by solid particles which are too large to pass through the mesh. Such matter may be called trash, scale, cinders, etc. It may be impractical to clean a clogged pad, so replacement would be required. If potential clogging is expected, it is particularly important to consult with AMACS engineers in the design of the mist eliminator.

Severe Corrosion: In services where corrosion cannot be entirely eliminated by the choice of material, a Plate-Pak™ unit lasts much longer than a mesh pad made of the same substance. This is mainly due to the greater thickness of the vanes, typically 0.030 to 0.050 inch for metal vanes (18 to 26 gage) compared to 0.011 inch for wire mesh.

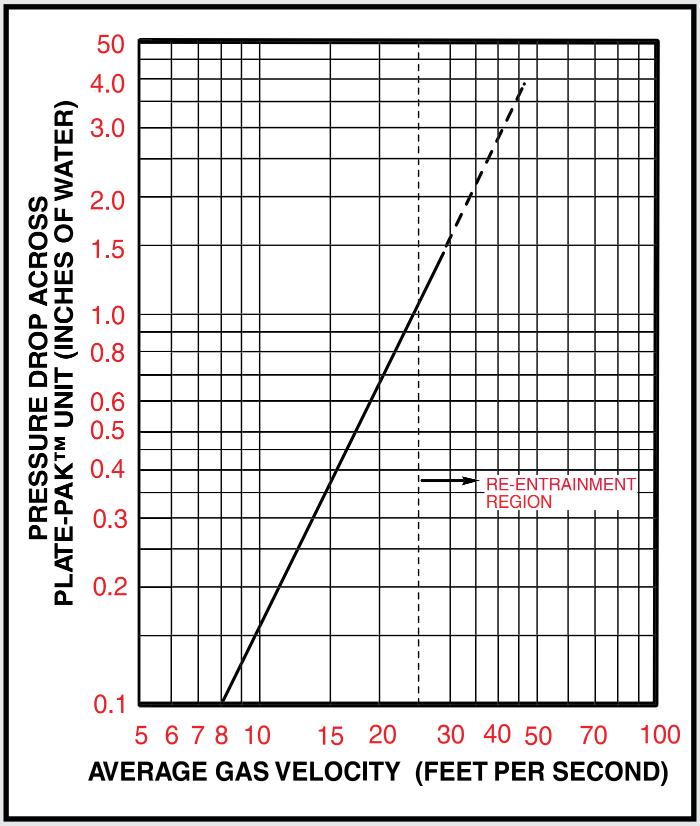
Surge Buffeting: When operated within the design ranges of velocity and load, the structural strength of the mist-eliminator element is of no concern. But in installations which are subject to violent surges of gas or liquid, mesh pads can be dislocated and even destroyed; Plate-Pak™ units are required on account of their strength and stiffness.

Foam Problems: When the entrained liquid contains foaming agents, agitation in a mesh pad can generate foam that greatly decreases the pad's efficiency. Being relatively immune to this problem, Plate-Pak™ units are preferred in a foaming environment. They can even break foam which has been generated upstream.

Tandem Mesh and Plate-Pak™ Element: In some circumstances, a Plate-Pak™ element is useful in combination with a mesh pad. The Plate-Pak™ unit may be mounted upstream, to remove the bulk of a liquid load. This keeps the pad from flooding, thereby preserving its superior efficiency for very fine droplets. (Clogging particulates will also be screened out, as mentioned before.) Or the Plate-Pak™ unit may be mounted downstream. There, it captures relatively large droplets blown from a mesh pad designed to coalesce or agglomerate extremely fine droplets. For proper design of tandem systems, consult with AMACS Engineers.




*Design flow capacity versus pressure for a typical Plate-Pak™ mist eliminator with axial flow of natural gas in a horizontal vessel*



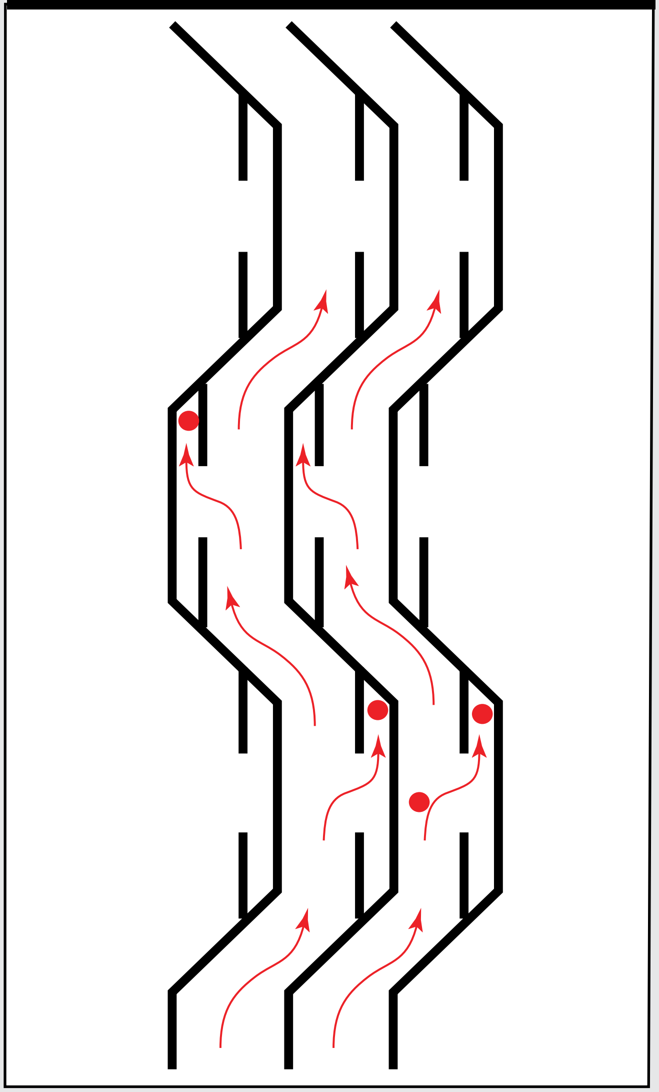

*Pressure drop versus superficial (average) gas velocity for a typical Plate-Pak™ unit with air and water (1 gpm / ft²) at ambient conditions*

# MultiPocket® vanes

The capacity of vertical vanes (with horizontal vapor flow) can also be increased by enhancing liquid drainage. As discussed, captured liquids are re-entrained when the velocity of the vapor exceeds the ideal velocity. To prevent liquid re-entrainment, the serpentine path offered by the vane is augmented with obstructions to allow for the pooling of liquid with protection from the passing vapor stream. This design increases the capacity of the vane by as much as 45%. In vertical gas compressor knock-out drums, in which the vessel size is dictated by the capacity of the mist eliminator, MultiPocket® vanes considerably reduce the Foot-print and cost of skids.

FIGURE 1. summarizes the approaches used by AMACS and the reduction in vessel dimensions possible using these advanced designs.

**FIGURE 1**



# Pockets Improve This Mist Eliminator's Efficiency

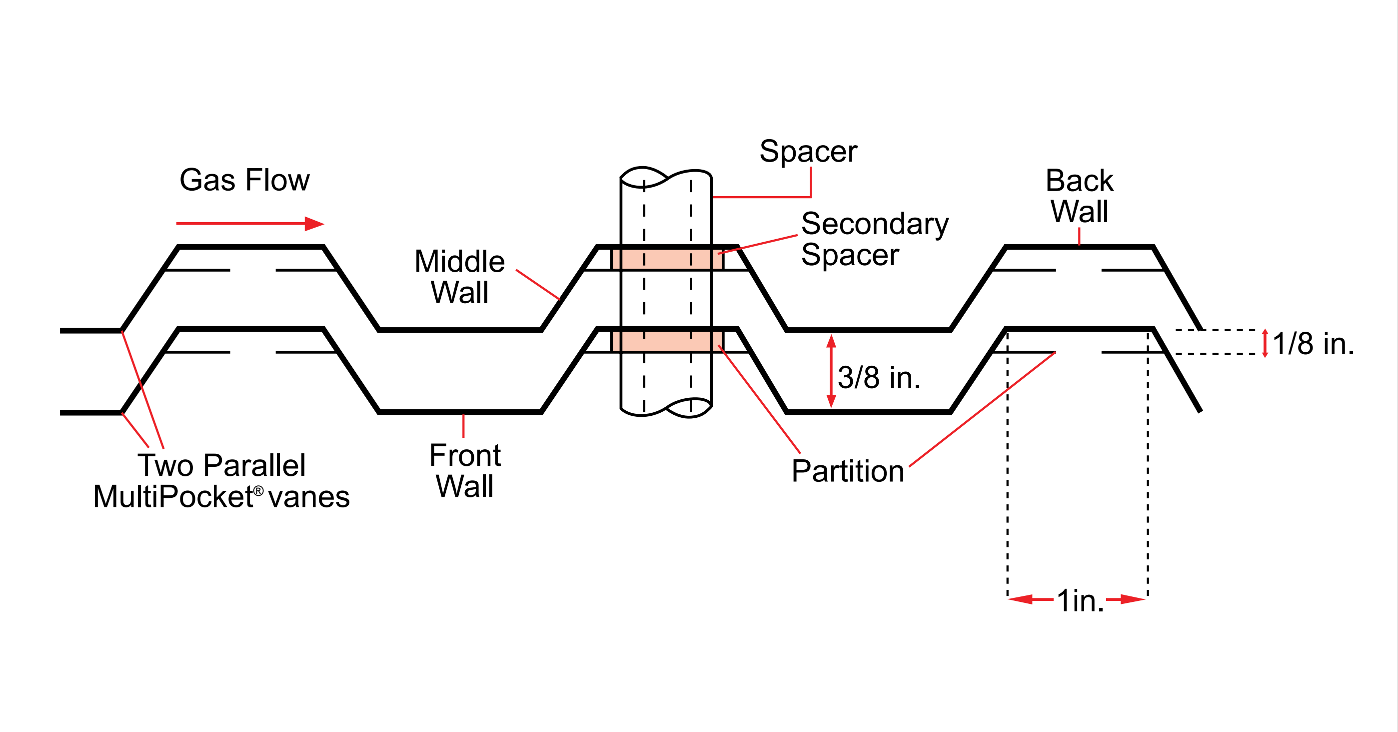
AMACS, previously known as ACS Separation & Mass Transfer Products was awarded US Patent #6,852,146 for a vane-type mist eliminator that removes entrained liquid droplets from high-velocity gas streams. Available commercially as the MultiPocket® vane assembly (Figure), it comprises a sheet fabricated from one piece of metal and featuring parallel rows of serpentine-like vanes. These sheets are held in their arrangement by bolts and spacers, not welds, as used in conventional designs. "This design prevents corrosion caused by internal welding and tights radius bends common in other high performance vane designs," says Kanti Patel, AMACS engineering manager.

The vane blades are configured in such a way as to create pockets that allow droplets entrained in a gas stream to impinge and cling to the vane, and then drain, without being re-entrained. With horizontal flow, the separated liquid drains perpendicularly to the gas stream, thereby preventing gas-liquid traffic below the Plate-Pak™ vanes. This feature allows higher flows. Third party testing shows that the MultiPocket® vanes exhibited a 3.4 — 14.1% capacity increase before breakthrough (liquid carryover) occurs downstream.

For any given installation thickness of the vanes, the number of pockets, spacing of the vanes, and other parameters can be varied to achieve the desired separation. The prefabricated unit comes in either a single piece ready for installation, or in smaller sections that can be installed through a vessel manway. To complete the installation a fabricated housing and a liquid drain are added, followed by welding or bolting of the entire unit in the vessel.

Gaston Rodriguez, process equipment proposals manager at the Hanover Co. (Houston, TX; www.hanover-co.com) provided the following case data in support of the MultiPocket® vane. A recent application for this product was in a vertical 2-phase scrubber handling 125 million ft$^3$/d of natural gas at an operating pressure of 350 psig and 90˚F. Using the MultiPocket® vane allowed for the reduction of the vessel diameter from 60 inches to 54 inches. The material, labor and installation savings was $6,500.

In other applications where pressure drop is critical, such as gas pipeline and utility contracts, the MultiPocket® vane provides the minimum pressure drop at the highest mist elimination efficiency. Tests has shown that for an inlet water spray loading of 2 gpm/ft$^2$ and air velocities of 10–25 ft/s, the pressure drop for a horizontal orientation is about 15% less than with the conventional vane.




*The MultiPocket® vane is a thin sheet that is formed into hills and valleys. The gas stream enters one side and take a zig-zag path to reach the other side. Pockets formed by partitions allow droplets entrained in a gas stream to impinge and cling to the vane, and then drain, without being re-entrained.*

AMACS
PROCESS TOWER INTERNALS

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# TECHNICAL DATA SHEET • MIST ELIMINATION

## COMPANY INFORMATION

| | |
|---|---|
| Company: | Contact (Name/Title): |
| Address: | TEL: ( ) <br> FAX: ( ) <br> E-mail: |

## STATE YOUR MIST ELIMINATION APPLICATION

| |
|---|
| |
| |
| |
| |

## PROCESS CONDITIONS (Provide appropriate units)

| | | | |
|---|---|---|---|
| Operating Temperature: deg F / deg C | | Operating Pressure: psia (psig) | |
| Gas Type: | Flow Rate: MAX.: | MIN.: | lb/hr/(acfm) |
| Vapor Density or SG or Mol. Wt.: | | Compressibility Factor: | Viscosity: cp |
| Liquid Type: | Qty.: gpm | Density or SG: | Viscosity: cp |
| Solids/Foulants: o Yes o No | If Yes, Explain: | | |

## VESSEL DETAILS o NEW o EXISTING

| | |
|---|---|
| Dia: | Ht./Length: |
| Manway Size: | Horiz.: Vert. |
| Material: | Housing Required? o YES o NO |

## DESIRED SEPARATION

____________________% removal of________________µm Droplets

__________________________________________________________

____________________ wt% / vol% / ppm in exit gas

## MIST ELIMINATOR

| |
|---|
| Preferred Type: o Wire Mesh o Vane |
| Materials: |
| Remarks: |
| |

## SKETCH

# Notes

# Separations technology is our business.

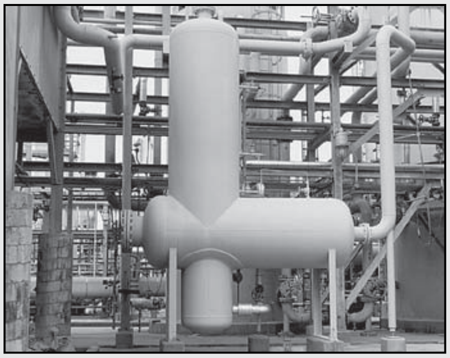
MIST ELIMINATION is one of many liquid-vapor and liquid-liquid separation processes for which AMACS has been providing effective solutions for more than half a century.

AMACS Process Tower Internals is recognized for its leader ship in developing separations technology reflected in a variety of products such as those summarized below. Our experience includes numerous materials of construction covering a wide range of conditions. We regularly perform product testing and pilot-scale experiments, both in-house and at customer locations. This unusually broad-based experience works to your advantage by allowing us to understand the total problem, often integrating several of our products in the solution.

Contact AMACS for resolution of all your difficult mass-transfer and other separation challenges.

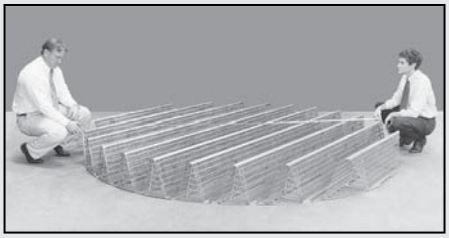
## Mesh-type mist eliminators

The exclusive, patented MisterMesh® type Mist Eliminator (photo) enhances drainage for higher throughput and efficiency with reduced pressure drop.
For high efficiency with micron-scale fog, threads such as fiberglass can be "co-knit" with the mesh.



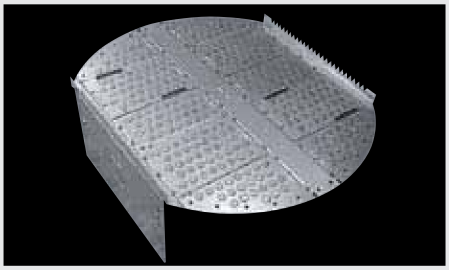
## Liquid-liquid coalescers

These units separate immiscible liquids of differing specific gravities. Coalescing of droplets is promoted by knitted mesh, Plate-Pak™ vanes, or both. Meshes with co-knit fibers coalesce extremely fine droplets, such as those generated by centrifugal pumping. The results can be impressive in terms of performance, compactness, and low cost. Similar separators remove traces of oil from wastewater and marine skimmer discharge.



## Column packing and internals

AMACS is the sole North American licensee for Julius Montz GmbH sheet metal and wire gauze packing and associated internals. AMACS also supplies high efficiency knitted wire mesh packing. In random (dumped) packing, we supply a wide variety of industry standard and proprietary types in all sizes, both plastic and metal.



## Fractionation trays

In providing a complete line of sieve, valve, bubble-cap, and specialty trays, our experienced design engineers meet challenging process demands by applying the latest technologies and software. The company's strong commitment to testing, research, and development has kept AMACS in a leadership position in mass-transfer technology.

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