FLEXICHEVRON®

The mist eliminator for fouling service

KOCH-GLITSCH

WHAT IS A FLEXICHEVRON® MIST ELIMINATOR

Flexichevron® or baffle-type mist eliminators are widely used in industry to separate liquid droplets from a gas stream and thereby provide process improvements or reduction of air pollution caused by mist carryover.
These mist eliminators are manufactured in a broad variety of materials, sizes, and configurations. To evaluate or size a mist eliminator that is optimal for a particular application, one must have detailed knowledge of each device's droplet removal efficiency, pressure drop, capacity, and propensity to plug or foul.
Of these parameters, the droplet removal efficiency has been, by far, the most difficult to determine accurately.
The chevron mist eliminator causes the mist-laden gas stream to change direction suddenly as it flows through the baffle arrangement.
The liquid droplets cannot follow the gas streamlines due to their momentum. They impact on the chevron blades where they coalesce, drain and are collected and removed from the gas stream. The device is therefore an inertial separator.

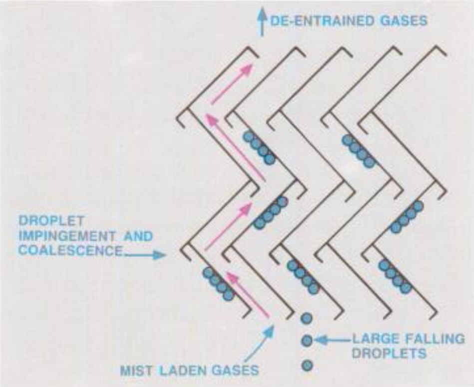
Resistance to fouling

When a mist eliminator is used in a fouling application (e.g., in the flue gas downstream of a wet flue gas desulfurization system), the mist eliminator's resistance to plugging is critical.
As material builds up on the chevron blades, the local velocities increase due to the restrictions of open area.
This substantially increases pressure drop, which is proportional to the square of gas velocity, and may result in premature reentrainment of coalesced droplets, negating the benefits of the mist eliminator.
In such applications, chevrons are invariably washed with spray nozzles to minimize buildup and plugging.

Flexichevron® Style I in stainless steel

Pressure drop

There are several theoretical models for predicting chevron pressure drop. In general, these models predict that higher pressure drops result from narrower blade spacing, greater blade angles to the gas flow, greater number of direction changes (or baffles), greater velocity, greater gas density, and greater thickness of material used to fabricate the chevron blades.
For a given chevron at zero liquid loading, $\Delta P \approx k p_g U_g^2$ where ΔP is the pressure drop, k is a constant, p_g is the gas density, and U_g is the gas velocity. The constant k takes into account the geometric factors listed above and varys substantially from one chevron to another. It is difficult to predict k theoretically; a chevron's pressure drop is best determined experimentally.

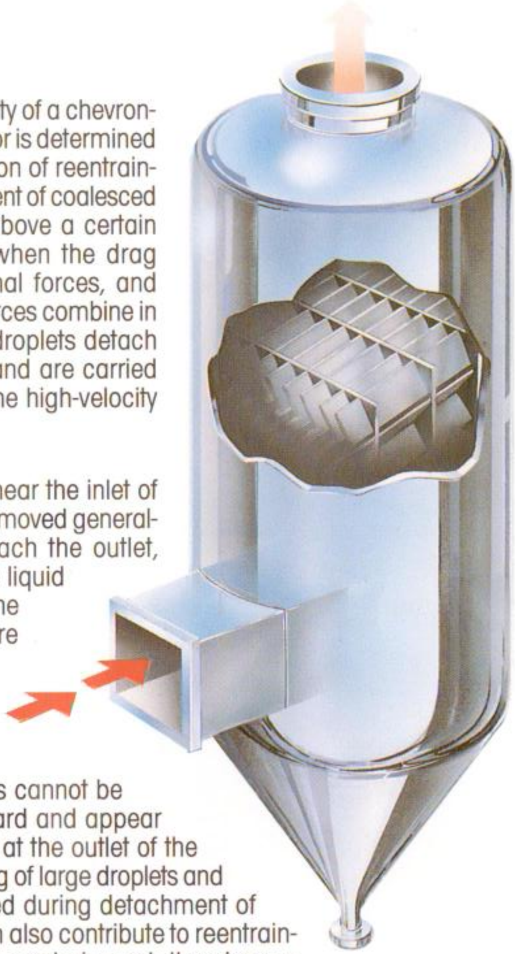


The Chevron impingement principle

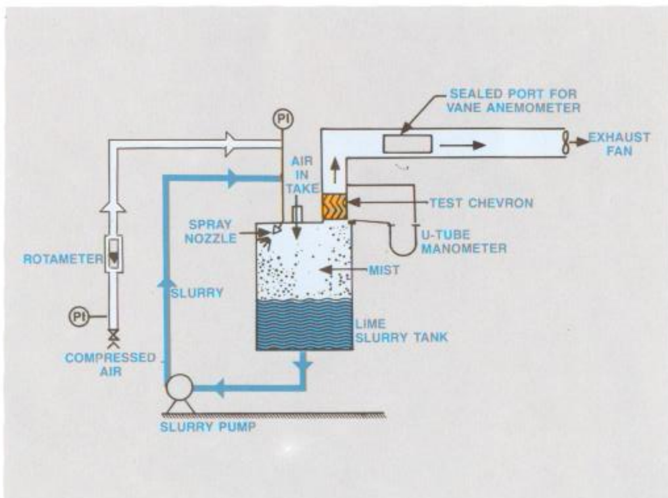
HOW DOES A FLEXICHEVRON® MIST ELIMINATOR WORK

Capacity

The capacity of a chevron-type mist eliminator is determined by the phenomenon of reentrainment. Reentrainment of coalesced droplets occurs above a certain critical velocity, when the drag forces, gravitational forces, and surface tension forces combine in such a way that droplets detach from the blades and are carried downstream by the high-velocity gas flow.

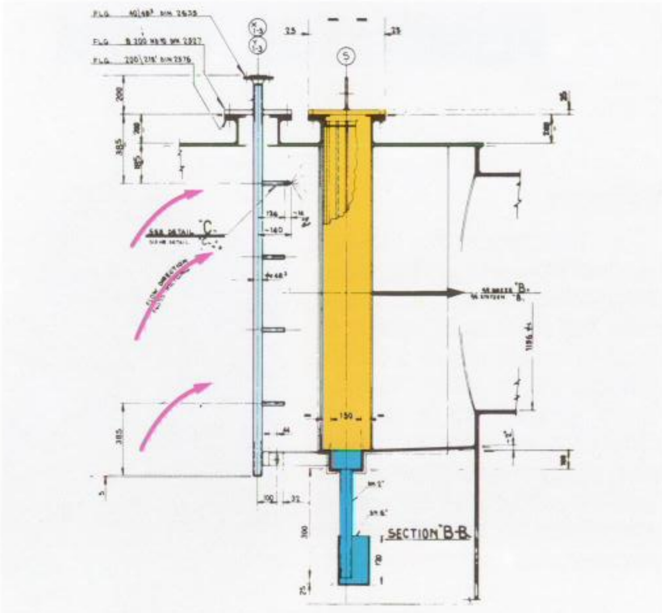


Droplets formed near the inlet of the chevron are removed generally before they reach the outlet, but eventually the liquid holdup reaches the outlet region where detached droplets cannot be removed downward and appear as reentrainment at the outlet of the chevron. Shattering of large droplets and satellites produced during detachment of large droplets can also contribute to reentrainment. To prevent reentrainment, the chevron must be designed and sized so that the design velocity is below the critical velocity.

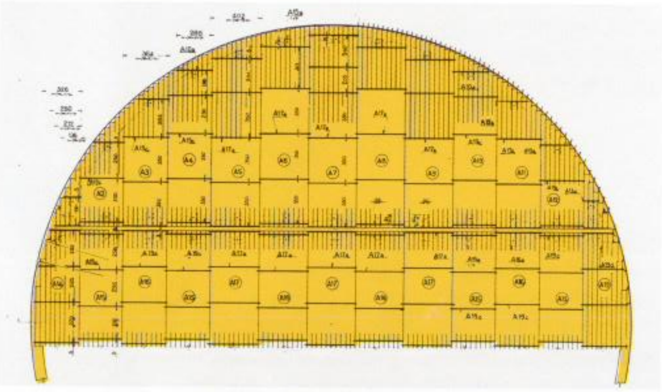


Test system for checking plugging resistance of Flexichevron®

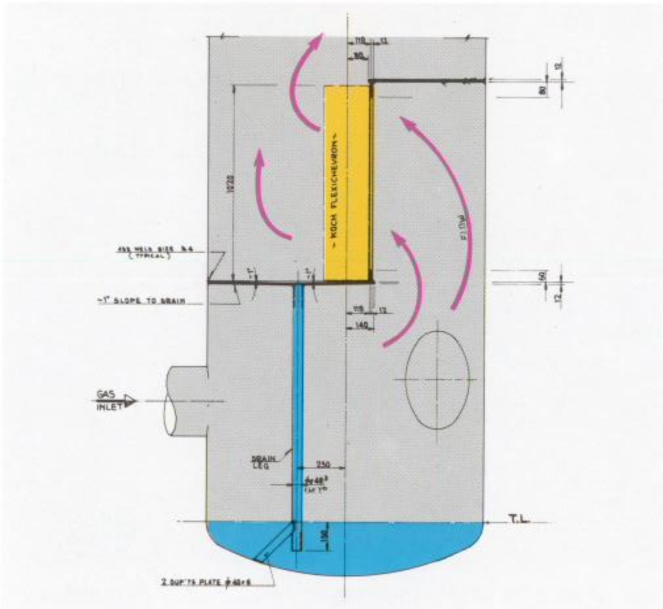
WHERE ARE FLEXICHEVRON® MIST ELIMINATORS USED



Front view of a horizontal flow Flexichevron® installation in a scrubber with uspstream spray system.



Plan view of a vertical flow Flexichevron® installation in a large evaporator.



Front view of a horizontal flow Flexichevron® installation in a pressure vessel.

Mist elimination is a relatively old science. Simple impingement type separators are described in the literature as early as 1939. Mist eliminators are used to remove liquid droplets from a gas stream to:

- control stack emissions to the atmosphere
- eliminate or reduce damage of equipment caused by corrosive or fouling liquid droplets
- recover valuable liquids
- improve purity of a vapor or gas for future processing
- improve overall process economics of an operation
- remove hazardous liquid mists from reactive gases to yield safer operations.

Many processes for the production of sulfuric acid, chlorine, inorganic fertilizers, and refine oil products rely heavily on well designed mist elimination equipment to achieve one or more of the above mentioned benefits. Mist eliminators are critical to the proper operation of various types of process equipment such as absorbers, distillation columns, evaporators, scrubbers, and steam drums. Mist eliminators are used in a wide variety of industries.

Limit drop size

It shows the smallest droplet which is 100% removed by the Flexichevron® at the indicated operating conditions.

Pressure drop

The diagrams next page show Flexichevron® pressure drop as a function of face velocity.

Koch technical department issues detailed drawings for customer's approval with the help of an advanced C.A.D. system.

HOW DO YOU RATE A FLEXICHEVRON®

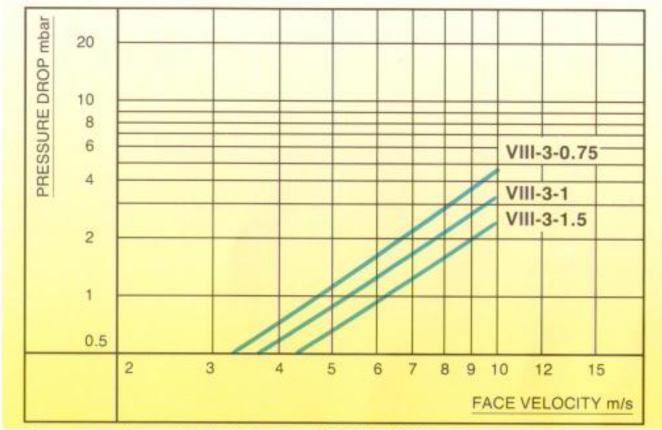
By considering various force balances for detachment or shattering of droplets and by considering the terminal velocity of the droplets so formed, it can be shown that reentrainment is controlled by a dimensionless reentrainment number:

$$R_n = \frac{F_s^4}{\sigma \rho_l g}$$

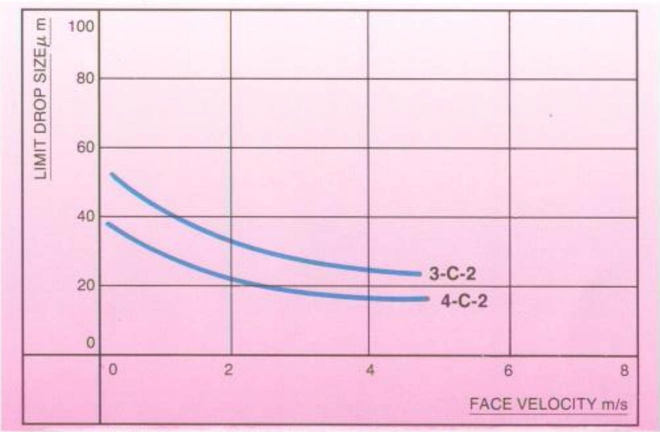
where: F_s = F factor based on superficial velocity $= U_g\sqrt{\rho_g}$
σ = liquid surface tension
ρ_l = liquid density
g = acceleration of gravity
U_g = *superficial gas velocity*
ρ_g = gas density

Reentrainment will occur if R_n is above a certain critical value. In practice, the critical value of R_n can be determined by measuring the critical velocity for the chevron of interest with an air-water system at ambient conditions. From the critical velocity, above which reentrainment occurs, and the known physical properties of the air-water system, $(F_s)_{critical}$ and $(R_n)_{critical}$ can be determined. The critical reentrainment number can then be applied to other systems or conditions to determine the maximum capacity for a given chevron.
Unfortunately, the difference between droplet penetration and reentrainment is often misunderstood. Droplets that penetrate the chevron are too small to be effectively removed by impaction. On the other hand, reentrained droplets are generally quite large and originate from droplets that have coalesced on the chevron blades. At high gas velocities, a chevron can have a removal efficiency of 100% and simultaneously reentrain extensively. Conversely, at low gas velocities, the chevron may not reentrain but has poor removal. **Optimal chevron performance is achieved at a gas velocity that is as high as possible but not so high that it yields reentrainment.** It is a challenge to design engineers to develop chevron blade profiles for which the critical velocity is as high as possible.

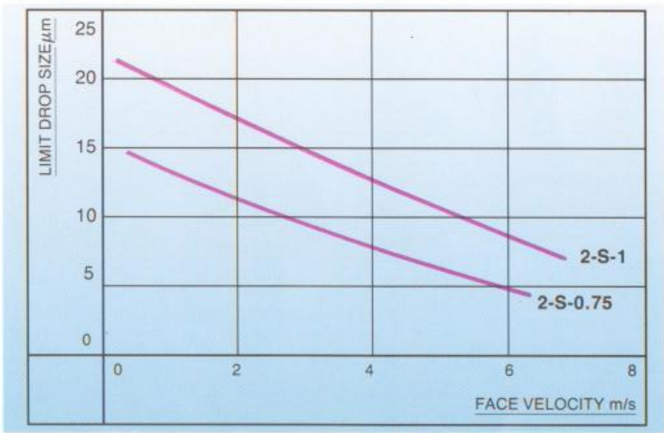
Removal efficiency of Flexichevron® Style VIII



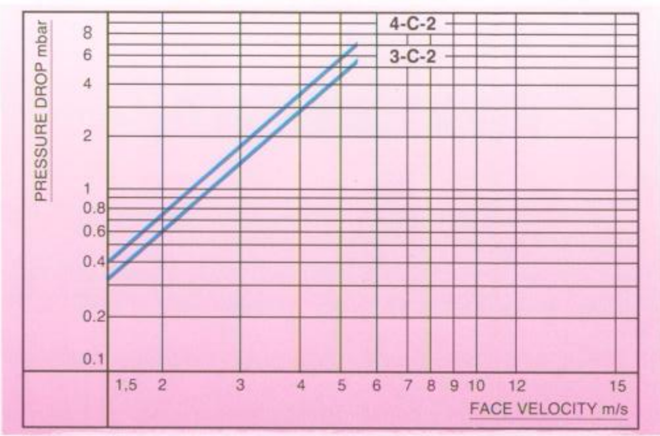
Pressure drop of Flexichevron® Style VIII



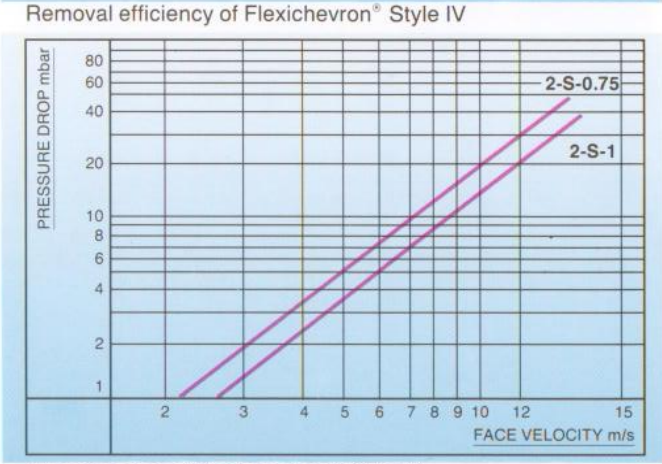
Removal efficiency of Flexichevron® Style I



Removal efficiency of Flexichevron® Style IV



Pressure drop of Flexichevron® Style I



Pressure drop of Flexichevron® Style IV

All data apply to air/water system at 21°C and 1 bar.

WHICH FLEXICHEVRON®

The above data can be used to evaluate and select commercially available chevrons for retrofit or new installations. **In arriving at an optimum design, it is often necessary to make a compromise between removal efficiency on the one hand and pressure drop and plugging tendency on the other.**
To do so, it is necessary to have some knowledge of the droplet-size distribution entering the Flexichevron®. Without some knowledge of the inlet droplet-size distribution, it is impossible to accurately design or specify a chevron to meet an overall liquid removal criterion. Unfortunately, inlet droplet-size distributions are seldom known accurately.
Table 1 gives some droplet-size distributions for some of process equipment as reported in the literature. These data should be considered only as a rough indication of what the size distribution might be. It is, for example, apparent from this table that Flexichevron® would not be applicable to the removal of acid-plant mists.

Table 1 - Typical mist-size distributions

Mist	1% by wt. smaller than (μm)	10% by wt. smaller than (μm)	50% by wt. smaller than (μm)	90% by wt. smaller than (μm)	99% by wt. smaller than (μm)
H_2SO_4 Mist/Acid Plants:					
Drying Tower Exhaust	—	0.1	0.8	10	—
Primary Absorbing Tower • 98% Acid Production	0.4	0.8	1.7	10	—
• Oleum Production	0.2	0.5	0.8	2.5	—
Secondary Absorbing Tower	0.5	1.6	2.5	5	—
Ammonia Scrubber	0.3	0.4	0.7	2	25
Sulfuric Acid Plants (General)	0.3	—	—	—	26
Phosphoric Acid Mist/Acid Plant	0.5	—	—	—	5
Up-Flow Cooling Tower	200	300	400	500	600
Packed Cross-Flow Tower	150	200	500	800	1100
Venturi Scrubber	40	100	175	300	500
Reverse-Jet Scrubber	100	250	500	1250	2000
Evaporator (25 in. disengaging space)	20	50	130	240	300
Sieve-Tray Tower (5.25 in. disengaging space)	250	600	1100	1800	2500
Cooler-Condenser	0.1	5	10	20	35
2-Fluid Nozzle (Atomizing Air Pressure less than 80 psig)	1	15	35	90	120
Single-Fluide Nozzle (P = 100 psig)	60	200	500	1500	2000

Reference
Duros, D.R., and E.D. Kennedy, *Chem. Eng. Prog.*, p. 70 (Sept., 1978).
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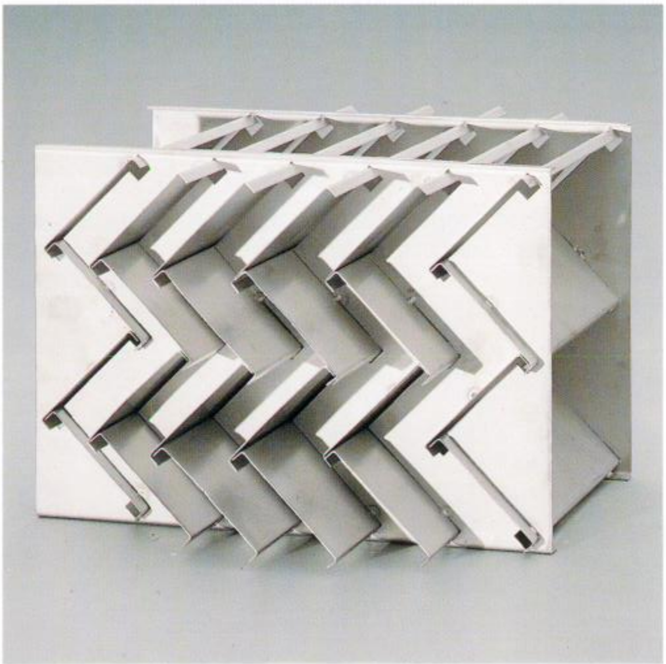
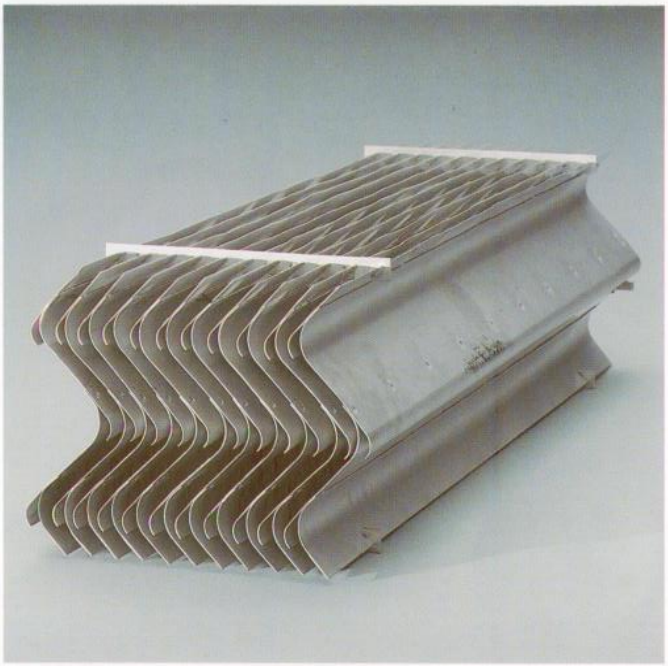
Stern, A.C., "Air Pollution," 3rd Ed., Vols. I and IV, Academic Press, pp. 80,295 (1976,1977).
Atkinson, D.S.F., and W. Strauss, *J.A.P.C.A.*, 28 (11), p. 1114 (Nov., 1978).
Chen, G.K., and T.F. Holmes, U.S. Patent #4,374,813, "Reverse jet Scrubber Apparatus and Method" (Feb. 22, 1983).
Boll., R.H., *et al.*,*J.A.P.C.A.*, 24 (10), p. 934 (Oct., 1974).


Style I

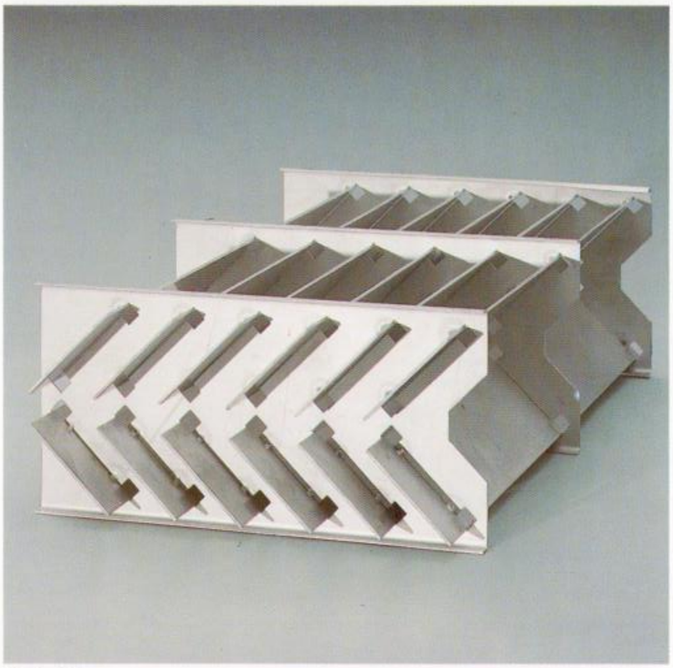

Style VIII

WHY USE FLEXICHEVRON®

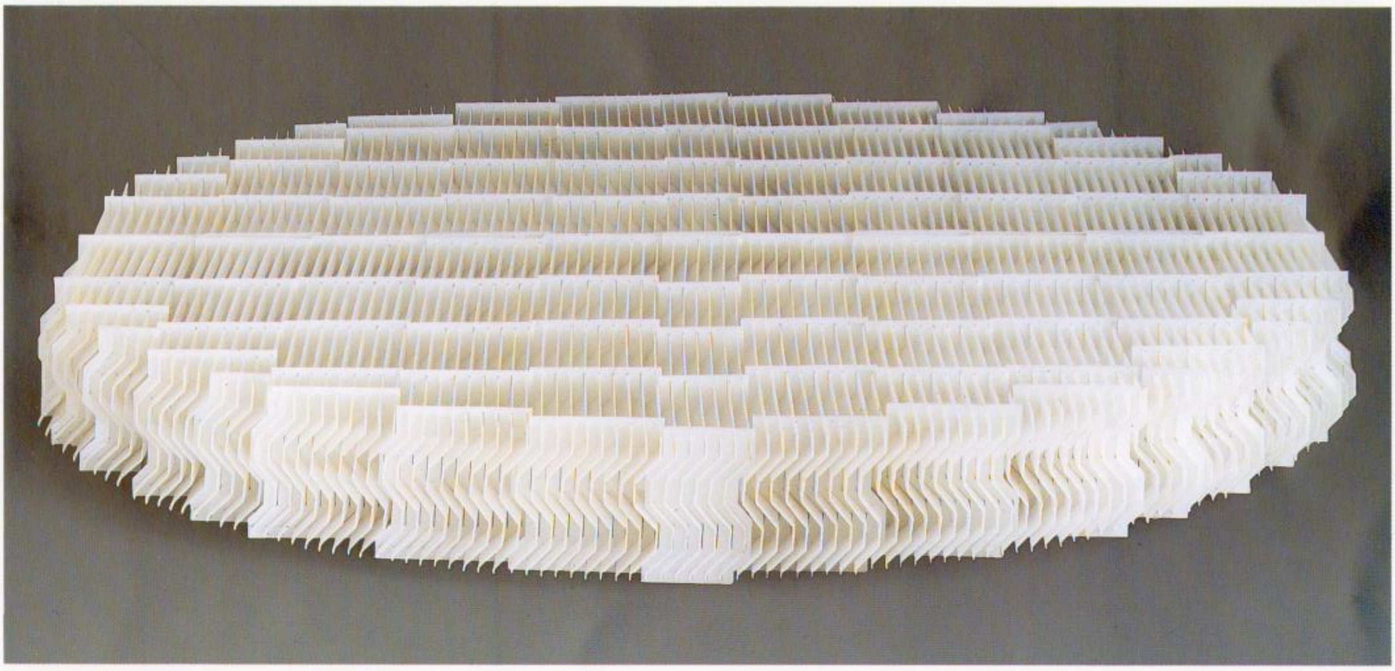
Koch has developed a wide range of Flexichevron® mist eliminators to better suit customer's needs.
Each Flexichevron® Style has been accurately studied and tested in our research and development laboratory in Wilmington (MA.) U.S.A..
Koch engineers can help customers solve most of their mist eliminator problems.
Koch engineers can choose among twelve different types of Flexichevron® mist eliminators.



Style IV



Style III



Flexichevron® Style VIII in polypropylene

In this bulletin, only the most commonly used are mentioned. Each Flexichevron® Style can be chosen for the following characteristics:

- non plugging design
- various geometric and modular designs are available
- efficiency is maintained at wide gas flow variations
- low pressure drop
- compatibility with other mist eliminators.

Units can be built in many material options.
The material of construction range is very wide.

Flexichevron® can be manufactured in:

- stainless steel
- special alloy steel
- carbon steel
- titanium
- P.T.F.E.
- P.V.D.F.
- polypropylene
- F.R.P.

Other special materials are available on request.

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