

Another step ahead in distillation technology

# Mini-umbrella valves maximize performance

The oil and gas industry requires high-performance distillation columns. In crude oil refineries, petrochemical plants, liquefied natural gas plants, and gas fields, it is important to maximize distillation efficiency and capacity without compromising the operating range and flexibility of the column. Sulzer's new UFM™ (umbrella floating mini-valve) tray meets all these demands and thereby saves a great deal of energy.

In many industrial applications, a large portion of the energy demand is consumed in distillation towers. Therefore, the development of energy-saving mass transfer technologies is becoming essential. In the last 20 years,

a lot of effort and research work has been done to improve the capacity and the efficiency of the fractionation trays, with the intent of pushing the distillation columns up to the hydraulic limit set by their vessel diameter. In most cases, an

increase in hydraulic capacity has been achieved but often with a loss of mass transfer efficiency and operating range, i.e., with multiple-downcomer trays. Sulzer has recently developed a new type of valve, UFM: umbrella floating mini-

1 The new UFM™ valve tray provides outstanding mass transfer efficiency, great hydraulic capacity, and a wide operating range.



valve (Fig. 1), that substantially improves all three main performance characteristics of the fractionation tray: mass transfer efficiency, hydraulic capacity, and operating range.

### An idea is born

Sulzer carried out extensive research and development work in the form of experimental tests and computational fluid dynamics (CFD) analysis at the pilot plant in Winterthur, Switzerland, and at a globally recognized institute for testing fractionation devices. The aim of the work was to maximize both the mass transfer efficiency and the hydraulic capacity of the fractionation trays without compromising the operating range and without any penalty (or even with some gain) in terms of pressure drop per actual fractionation stage.

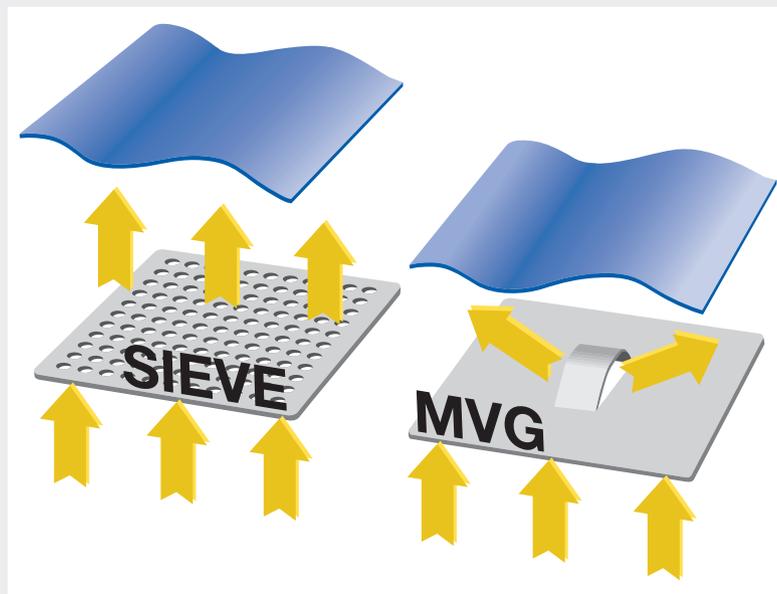
The idea for the new valve was born from the observation of the mechanism of vapor-liquid mixing that occurs in conventional and first-generation high-performance valves. In a fractionation tray, the ascending vapor comes into contact with the liquid on the active area through openings. Sieve holes, fixed valves, or moving valves distribute and diffuse the vapor into the liquid to create a frothy mixture where the mass transfer will occur (see infobox). Mass transfer efficiency is determined by:

- The physical properties of the vapor and liquid
- The geometry of the tray
- The mechanism of the vapor release to the tray deck
- The cross flow movement of the liquid passing from one downcomer to the next

In sieve trays—the most simple type of tray deck—the vapor is released in vertical jets, which generate the highest froth, and consequently, the lowest capacity per given tray spacing and tower diameter. The first-generation high-performance valves, i.e., Sulzer V-Grid trays MVG™ or the original Glitsch fixed-valve tray VG-0™, have partially addressed these phenomena. A consistent gain was achieved over sieve or conventional valves a couple of decades ago.

### How distillation trays work

Distillation separates a mixture of substances with different boiling points (e.g., crude oil). Lighter components are vaporized and flow to the top of the column; heavier components are condensed to liquid and flow to the bottom of the column. To get the necessary purities of the column products, the vapor and liquid must mix on several trays. The liquid flows horizontally across the trays and the vapor flows upward through the tray orifices and bubbles through the liquid. Conventional trays are perforated (SIEVE), that means the orifice in the deck is a simple hole. More modern valve trays (like the MVG shown below) have an orifice with a “roof” that prevents the vapor from blowing vertically out of the orifice. This creates a lower froth on the tray deck and allows more vapor to be processed through the trays.



(Yellow: vapor, blue: liquid)

Sulzer offers the largest tray portfolio on the market. The available trays range from conventional to high-performance trays. Sulzer led the way with the MVG high-performance tray decks and now continues to provide cutting-edge, high-performance tray technology with the newest UFM valve.

More information: [www.sulzer.com/high-performance-trays](http://www.sulzer.com/high-performance-trays)

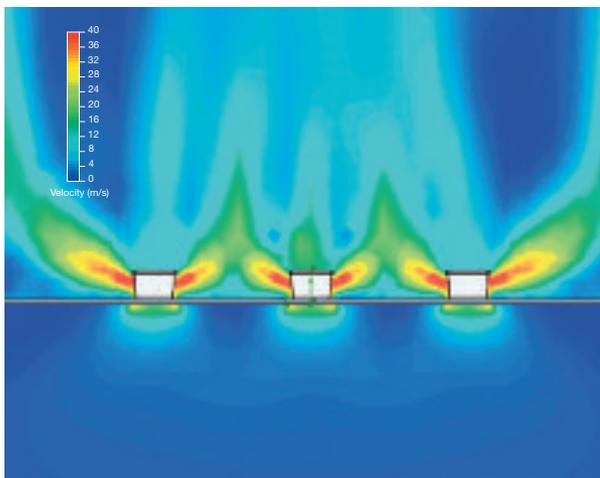
Now Sulzer has taken another innovative step ahead with the new UFM second-generation high-performance valves. Sulzer analyzed and developed the valve shape by means of CFD and subsequently validated it in actual distillation pilot columns.

### Analyzing the fluid dynamics

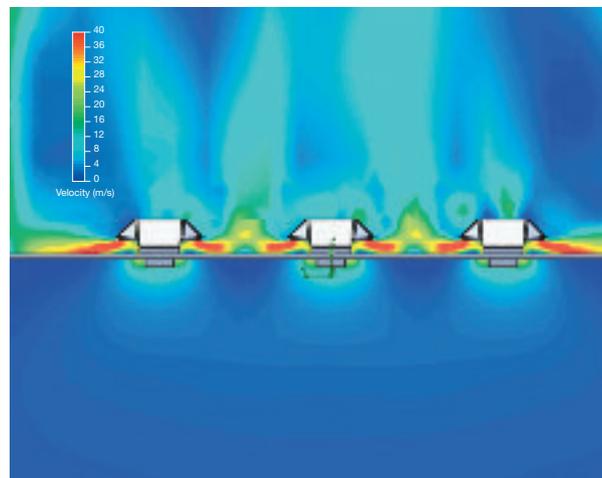
Within the last decade, CFD has reached such maturity that it is now considered an indispensable analysis and design tool in a wide range of industrial applications, including fractionation trays for distillation towers. Therefore, several CFD studies were performed to check the perfor-

mance of conventional valves, their limitations, and the potential improvements. These studies provided the shape and geometrical dimensions of the new UFM second-generation high-performance valve.

For conventional valves, which are generally equipped with a flat hat, the vapor is released diagonally upward (Fig. 2). This results in a reduced interfacial area and less contact time between liquid and vapor on the tray. The upward momentum is great enough to carry over the liquid, thus lowering efficiency and achievable capacity. To overcome these limitations, Sulzer developed a new type



2 CFD simulations show that in conventional valves, the vapor is released upward.



3 In UFM valves, the vapor is directed downward, which results in a low vapor velocity above the valves.

of valve, which directs the vapor to the tray deck for the optimum utilization of the contacting device. Figure 3 shows the simulation results of the new valve: high-velocity zones are present only at the level of the tray deck, whereas, above the valves, the velocity is approximately 40% lower than for conventional ones. These simulation results indicate a substantial performance improvement of the tray. To validate the findings of the CFD model, Sulzer tested the new UFM valves extensively in actual distillation columns.

### Tests confirm performance gain

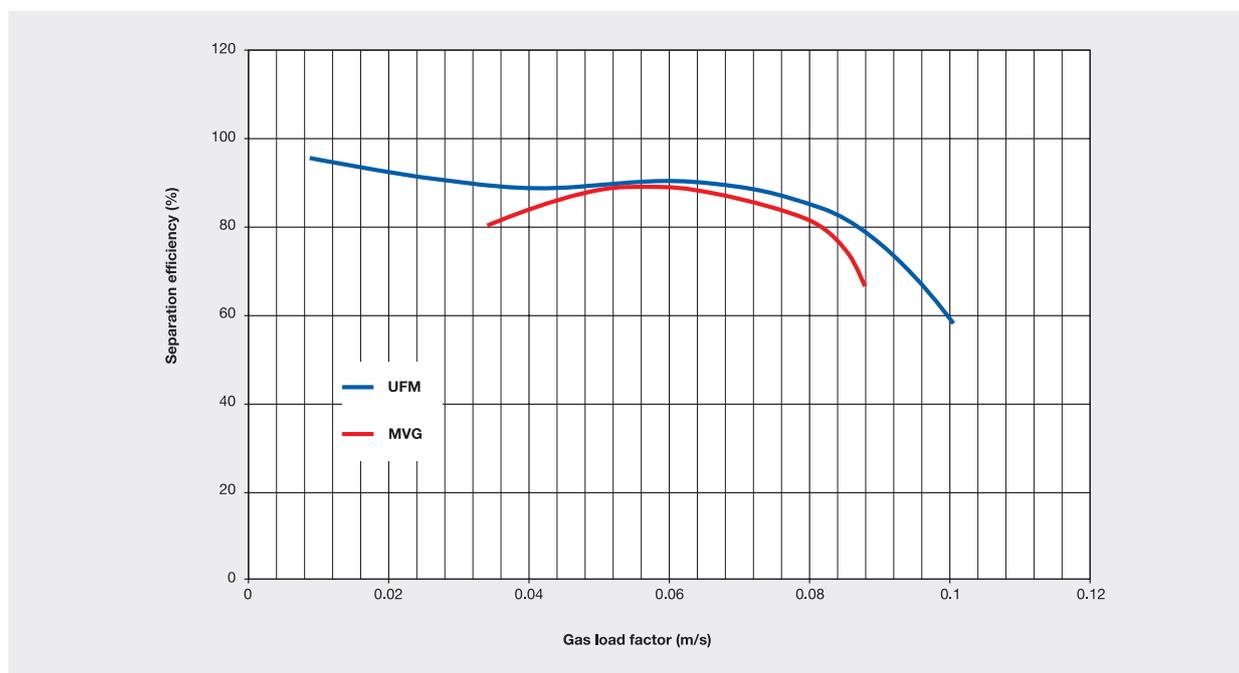
The UFM valve trays were first tested at Sulzer's Winterthur pilot plant in a 1 m diameter column, at atmospheric pressure, and with a mixture of chlorobenzene/ethylbenzene. Results were compared with those from high-capacity MVG fixed-valve trays with identical downcomer and bubbling areas (Fig. 4). The UFM valve trays are able to maintain high mass transfer efficiency over a wider operating range than the MVG fixed-valve trays. Taking 80% as baseline efficiency, the UFM valve provides approx-

imately 10% higher capacity than the MVG fixed valve, making it the highest performing valve of the Sulzer tray portfolio. The outstanding performance of the UFM valve was confirmed also by the tests carried out at a globally recognized independent institute for testing fractionation devices.

### Advanced valve features

The main functional feature of the new UFM valve is the hat (Fig. 5), which is shaped as an umbrella. It breaks down the vertical momentum of the ascending

4 The UFM trays (blue) show better mass transfer efficiency than the first-generation high-performance valves (red).



vapor and smoothly redirects it to the tray deck for the most uniform diffusion into the liquid. This, in turn, maximizes the contacting area and the associated mass transfer efficiency. It also allows for the minimum froth height, which results in lower entrainment and thus provides the highest hydraulic capacity. This contacting mechanism, somewhat similar to that of the bubble cap trays, also allows for minimal weeping rate, thus the high efficiency can be kept constant even at low operating loads. This behavior is particularly useful for

### Sulzer has installed UFM valves in more than 40 industrial columns.

those distillation columns that, for market reasons or operating requirements, have to work at feed rates lower than design capacity. At these so-called turn-down conditions, reduced efficiency of conventional devices causes an increase of energy consumption per unit of processed column feed, which can be avoided by using the new UFM second-generation high-performance valves. Additional features are:

- Two wide legs to maximize robustness, to prevent spinning, wearing, and pop-

ping out of the valves from the tray deck. This maximizes run length and minimizes maintenance costs.

- Four spacers to prevent the valves from sticking to the tray deck. This increases the fouling resistance.
- Two thicknesses and lifts. This maximizes operating range and flexibility.
- Parallel orientation to the liquid flow. This minimizes hydraulic gradient along with the flow path on the tray deck.

Customers can combine the new UFM valves with other capacity- and efficiency-enhancing features developed by Sulzer to achieve the greatest possible

mass transfer efficiency, the highest hydraulic capacity, and the widest operating range.

### Fields of application

The new UFM is a state-of-the-art movable mini-valve to be used whenever great efficiency, high capacity, and wide operating range are needed in distillation columns, absorbers, or strippers, in particular:

- Main fractionators in refineries
- Gas concentration columns in refineries

- Light ends columns in petrochemical plants
- Fractionators in gas fields for liquefied natural gas (LNG) or natural gas liquids (NGL)
- Absorbers and regenerators of gas-sweetening or acid-gas-enrichment units

Since the launch of the UFM in 2012, Sulzer has installed UFM valves in more than 40 industrial columns ranging from atmospheric to high-pressure services. All columns are performing well. In several cases, they are performing even better than expected, according to the plant feedback data coming from customers.

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5 The advanced movable UFM valve has an umbrella shape.

