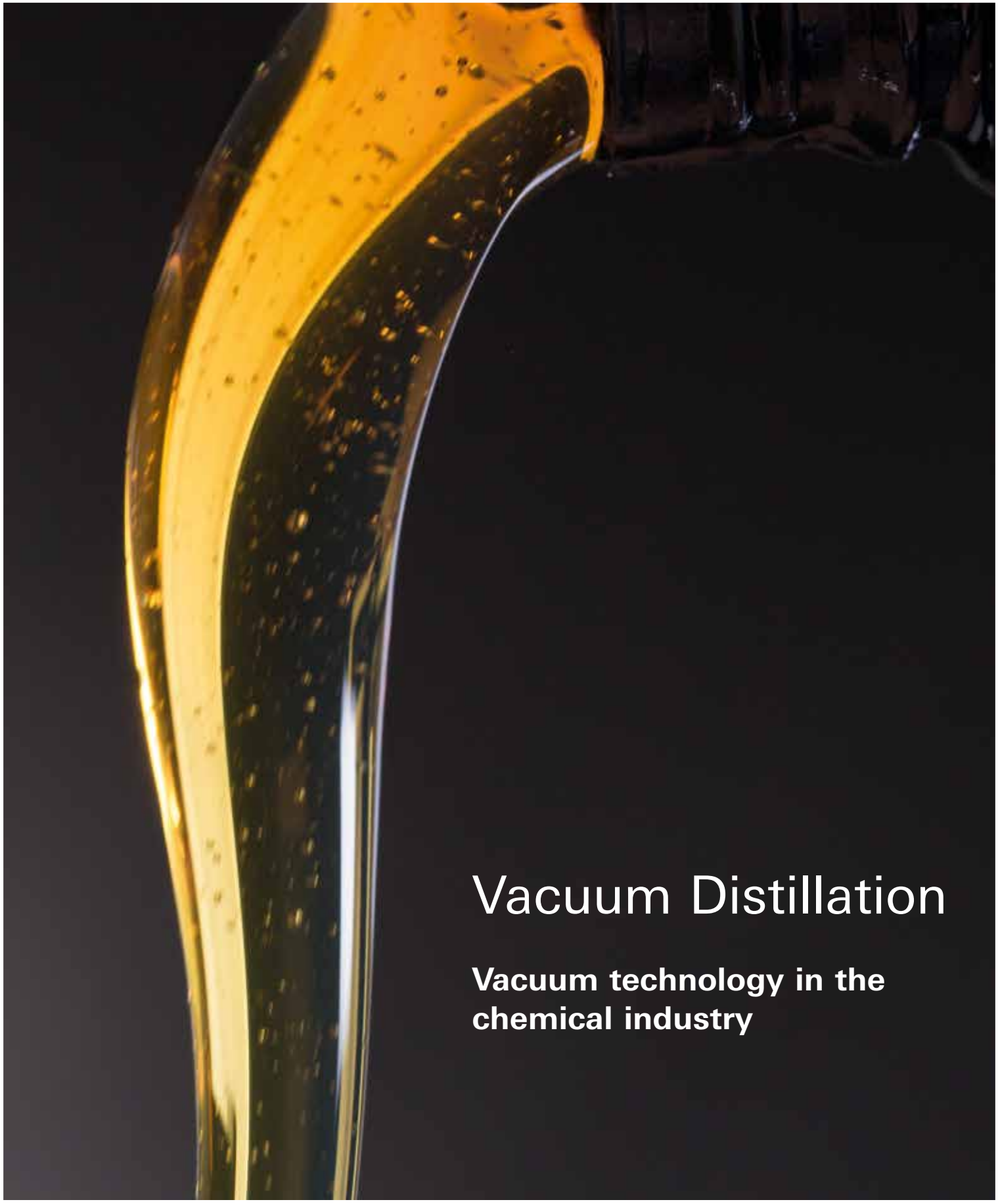

Vacuum Distillation

Vacuum technology in the chemical industry

PFEIFFER VACUUM

VTA vacuum distillation plant

Photo: VTA GmbH & Co. KG

The chemical industry is an indispensable supplier of raw materials to many economic sectors. The automotive industry, mechanical engineering, plastics, food, glass, or construction material industries, for example, all rely on substances that are produced by the chemical industry. These substances are employed in countless finished products that we use daily. A large proportion of these applications relies on vacuum technology. One of the most important applications is vacuum distillation.

Advantages and applications of vacuum distillation

The boiling point of many organic substances at atmospheric pressure lies within a temperature range from 200 to 400 °C. The separation of such mixtures therefore requires a high energy input at atmospheric pressure. Thermal decomposition of the mixtures can also occur in many cases at these temperatures. Reducing the pressure into the low and medium vacuum range significantly reduces the boiling temperatures. In the case of monoglyceride, for example, which is used as an emulsifier, the boiling point is reduced from 300 °C at atmospheric pressure to about 220 °C at a pressure of < 0.1 hPa. Vacuum distillation is therefore widely used for processing

Vacuum distillation is used to gently separate temperature-sensitive substances.

temperature-sensitive substances such as those found in the food, pharmaceutical and petrochemical industries. Another important factor that influences the preparation of temperature-sensitive substances is their dwell time in the vaporization device. In many cases, batch distillation in a reactor is unsuitable due to the dwell time, which can extend to hours, and due to the inadequate vacuum resulting from the fluid column in the vessel. A fill level of 10 cm, for example, means a density-dependent pressure of about 10 hPa. For this reason, thin film vaporizers and short-path evaporators are used in industrial applications. In these cylindrical systems, a very thin film (film thickness 1 to 3 mm) of the liquid to be vaporized is applied to the inside surface of the heated cylinder using rollers or wiper blades. Depending on the size of the

system, the dwell time may be only a few seconds. Thin film vaporization works best within a pressure range from 1 to 100 hPa. Lower pressures are difficult to achieve due to pressure losses in the vaporous substances flowing from the device to the condenser.

However, for the separation of mono-, di- and triglycerides, for example, pressures in the range of 0.01 hPa are required. In this case, the so-called short-path distillation method is used. The condenser is located at the center of the cylindrical vaporizer and the distances between the hot wall and the water-cooled pipe coil are in the range of a few centimeters, depending on the size of the device. Pressure losses are minimized, since the material to be evaporated condenses directly on the cold surface. Since the mean free path of a molecule in a medium vacuum is in the range of the distance between the cylinder and the internal condenser, or is significantly greater, this method is also referred to as molecular distillation.

If the vapor pressures of the substances to be separated are very close to each other, vacuum rectification columns are used. In these counter-current distillation systems, the vapor flows through a vertically aligned column to the condensed liquid. Installations such as structured packings ensure good mixing of the two phases so that a phase equilibrium can be achieved. Dwell times and pressure levels are higher than with thin film vaporizers, however. The two processes are often combined.

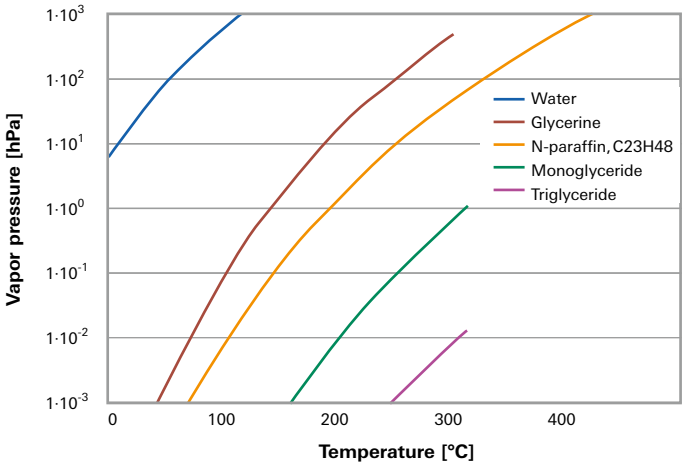

Figure 1: Vapor pressure curves for various organic substances

Roots pumping stations for thin-film and short-path distillation.
Maintaining the exact vacuum pressure required in the vaporizer is vitally important for the quality of the separation process and imposes big demands on the vacuum control system and the quality of the vacuum pumps used.

Pfeiffer Vacuum therefore offers a large selection of suitable vacuum equipment for thin-film and short-path distillation. In practice, Roots pumping stations with liquid ring pumps have proven to be the ideal solution. Depending on the number of Roots piston stages, a pressure of 10^{-3} hPa can be reached without great effort. It is also possible to operate the liquid ring pump with the substance that needs to be distilled. One

Figure 2: Three-stage pumping station for distillation processes

example is the processing of rolling oil. The oil contaminated by the rolling operation is reprocessed through distillation. For this, three-stage Roots pumping stations consisting of two Roots pumps and a liquid ring pump are used. The rolling oil to be distilled serves as the operating liquid for the liquid ring pump. At a pressure of approximately 5 hPa, the rolling oil evaporates and is condensed in the downstream condenser. The possibility of leakage air saturated with oil vapors being sucked into the vacuum pump system, where the oil vapors can then condense again in the liquid ring pump, cannot be completely ruled out, however. But if the rolling oil is used as the operating liquid, this will not negatively affect the throughput of the pump. The level of the liquid in the circulatory container of the liquid ring pump rises slowly. When the maximum permitted level is reached, the operating liquid is automatically discharged and fed to a suitable treatment process. Depending on the application, dry backing pumps can also be used instead of the liquid ring pump.

Vacuum solutions for vacuum distillation
Based on its comprehensive range of products, Pfeiffer Vacuum offers customized solutions to create the vacuum conditions required for the various applications. Especially with regard to applications in the chemical industry that require a pressure of less than 33 hPa, the Roots pumping stations of Pfeiffer Vacuum's OktaLine have established themselves as ideal solutions. Depending on the required pumping speed and ultimate pressure, different pumping stages can be built in. Roots pumps with a pumping capacity of 145 m^3/h to 8,000 m^3/h are available as standard. In special cases, Roots pumps with a pumping speed of up to 25,000 m^3/h can be manufactured.

The gas circulation cooled version of the Okta allows compression to ambient pressure and is used predominantly in critical processes in the chemical industry. The standard pumps are made of spheroidal graphite cast iron (GGG40), which ensures the high pressure shock resistance (16 bar) of the pump housing. This is particularly important for ATEX applications. For particularly corrosive applications, the Okta can be made of stainless steel. It is also possible to apply a

plasma-polymer coating to the parts of the suction chamber that come into contact with the product. More demanding requirements regarding the tightness of the pump are achieved with the aid of magnetically coupled drives with leakage rates of less than $1 \cdot 10^{-6}$ Pa m^3/s.

Rotary vane, screw and gas circulation cooled Roots pumps from Pfeiffer Vacuum are available as backing pumps.

For ATEX applications including Zone 1 indoor/outdoor, suitably certified pumps are available.

From conception to implementation, the experts at Pfeiffer Vacuum work closely with customers from all different areas of the chemical industry to develop customized solutions that are exactly tailored to the requirements of the individual application.

Figure 3: Okta 500 ATEX

VACUUM SOLUTIONS FROM A SINGLE SOURCE

Pfeiffer Vacuum stands for innovative and custom vacuum solutions worldwide, technological perfection, competent advice and reliable service.

COMPLETE RANGE OF PRODUCTS

From a single component to complex systems:
We are the only supplier of vacuum technology that provides a complete product portfolio.

COMPETENCE IN THEORY AND PRACTICE

Benefit from our know-how and our portfolio of training opportunities!
We support you with your plant layout and provide first-class on-site service worldwide.

Are you looking for a perfect vacuum solution? Please contact us:

Pfeiffer Vacuum GmbH
Headquarters · Germany
T +49 6441 802-0
www.pfeiffer-vacuum.com

PFEIFFER VACUUM