

# Screw Compressors

Engineered for the process industry



Engineering the Future – since 1758.

**MAN Diesel & Turbo**





1 Large-scale rotors of SKUEL type screw compressor

Designed for suction flows up to 100,000 m<sup>3</sup>/h and discharge pressures reaching 50 bar, the robust process-gas screw compressor model series from MAN Diesel & Turbo is designed to handle highly contaminated gases and other gas mixtures under heavy-duty conditions that would curtail the availability and life expectancy of other compressor types.

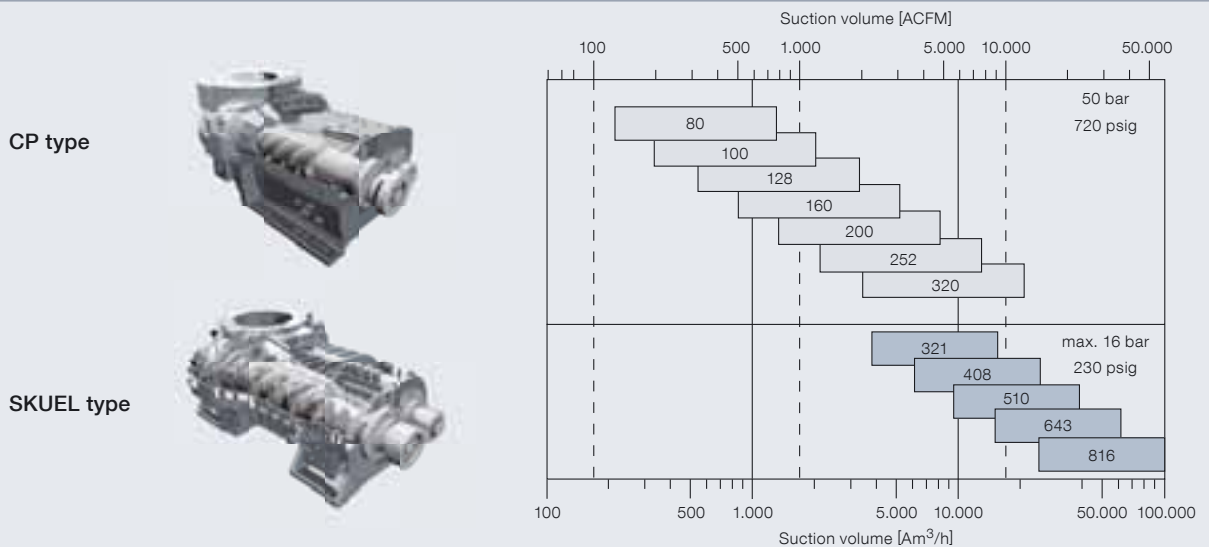
### **Introduction**

The great versatility of the process-gas screw compressor increasingly leads more customers within the process and hydrocarbon industry to select this type of compressor. Harsh process conditions imply a need for durable rotating machinery, and screw compressors are ideally suited for applications where reciprocating or centrifugal compressors are not up to coping with the impacts of corrosion and erosion. This article discusses the main aspects of process-gas screw compressors, provides examples of applications and offers an overview of the current technical status of this compressor type.

### **Process applications**

The process-gas screw compressor finds application in a multitude of different processes in numerous industrial branches. These include the mining industry, iron and steel mills, chemical plants, the petrochemical industry, and refineries and oil fields, the latter including onshore and offshore applications. For virtually every application, the screw compressor can be adjusted to fit the particular process requirements. The process-gas screw compressor has a number of significant advantages, therefore, compared to other compressor types:

- The compressor can handle gases containing dust or droplets, making the unit less vulnerable to process upsets or off-design cases.
  - A change in gas composition, molecular weight or pressure ratio has almost no effect on the actual gas flow rate. This favorable behavior of the process-gas screw compressor offers the option of selecting main machine parameters such as the frame size at an early project stage, leading to a reduction in the compressor package cost. A further customer benefit results from the distinctive feature that process modifications at a later stage or changes in actual operating conditions do not necessarily have a significant impact on the compressor selection and design.
  - Operating as a positive displacement machine, the screw compressor is ideally suited for compressing light gases. A typical application is the compression of hydrogen, e.g. for PSA (Pressure Swing Adsorption) units.
  - The compressor can incorporate a liquid injection system for cooling or washing purposes, thus making it the prime choice for processes with polymerizing, contaminated or thermally unstable gases such as flare gas, butadiene, styrene monomer or acetylene, to mention just a few. Water is the most common injection fluid, but a number of different condensates can be used depending on compatibility with the process.
  - In addition to the cooling and washing effect, the injected liquid also contributes to sealing the gaps between both rotors and between the rotors and casing, thus contributing to a significant increase in volumetric efficiency.
  - The excellent part-load behavior of the screw compressor, with approximately 50% flow and approximately 50% power consumption at 50% speed, permits the use of easy and inexpensive capacity control by utilizing variable-speed electric motor drivers or steam turbines.
  - Another positive feature of the screw compressor is the fact that the compressor cannot surge like a centrifugal compressor, hence providing more security for process stability.
  - The screw compressor lubricant does not come into contact with the process gas.
  - There are no oscillating masses and therefore foundation costs are low.
  - The process-gas screw compressor has a high availability up to 99%, depending on the applied service level. Coupled with a minimum service life of 20 years, process-gas screw compressors therefore offer superb value for money.
  - Screw compressor service costs are much lower than those of reciprocating compressors.
  - All gases can be compressed, with the exception of pure oxygen.
  - Designed for suction flow rates up to 100,000 m<sup>3</sup>/h and discharge pressures up to 50 bar, process-gas screw compressors define a large design envelope and represent a robust alternative to reciprocating or centrifugal compressors.
- Consequently, screw compressors from MAN Diesel & Turbo have moved into areas of application and pressure ranges that have formerly been dominated by reciprocating compressors and other compressor types.



2 Overview of oil-free process-gas screw compressors

### Product features

Figure 2 shows MAN Diesel & Turbo's screw compressor program covering the oil-free CP and SKUEL model series. The respective frame size can be selected from the diagram.

With seven different rotor diameters available and each diameter with three different length-to-diameter ratios, the CP series is designed for suction flow rates ranging from 200 m<sup>3</sup>/h up to 20,000 m<sup>3</sup>/h. The robust barrel-type casing allows for discharge pressures up to a record-breaking 50 bar.



The SKUEL series is available with five different rotor diameters, each with two different length-to-diameter ratios. Suction flow rates are available between 4,000 m<sup>3</sup>/h and 100,000 m<sup>3</sup>/h with discharge pressures up to 16 bar. A horizontally split casing design allows ease of maintenance.

The modular design concept of the process-gas screw compressors ensures that a model is available for every combination of flow and pressure within the complete design envelope. Furthermore, the modular design system utilizes standard parts and a well-proven design, making an accurate prediction of compressor performance possible.

Depending on the type of gas compressed, pressure ratios between 1.3 and 6 can be realized in a single stage. Multistage arrangements or liquid injection allow for even higher pressure ratios.



3 Steam-turbine-driven SKUEL type process-gas screw compressor packages for a styrene monomer process

### Engineered for large capacities

In many industries, continuous growth in plant and process size can be observed and this therefore also calls for continuous growth in equipment size. One application which has experienced significant production growth over several years is the styrene monomer process, resulting in a demand for larger compression capacities. With its large flow rates and the capability to inject water into the compressor during operation, MAN Diesel & Turbo's SKUEL type compressors are the prime choice for styrene off-gas compression.

In response to the requirements for larger units and anticipating future industrial needs, MAN Diesel & Turbo passed a milestone in 2003 with the introduction of a compressor with 816 mm rotor diameter. In 2004, two of these units were delivered to a customer

in the Middle East. With this reference, MAN Diesel & Turbo set the world record for the largest screw compressor and volume flows. With a single-lift design of approximately 75 tons, the package shown in Figure 3 will form the heart of a styrene monomer process in an olefin plant. Based on this reference where the newly developed machine has proved its high availability during operation, MAN Diesel & Turbo has been selected to supply several SKUEL type compressors with volume flows up to 77,000 m<sup>3</sup>/h to different clients in the Middle East and Asia.

### Reliability and operational flexibility

Offshore oil and gas production facilities are a prime example of an industrial branch that increasingly relies on process-gas screw compressors as core machinery for a successful plant design, providing high reliability and operational flexibility. Since there are many possible pitfalls associated with the design of the recompression train of an offshore gas process, the specification and selection of compression equipment need to be carried out with particular care. The following issues should therefore be taken into consideration:

- The uncertainties related to gas composition and altering production profiles make it important to design the compression train with a large degree of flexibility for unexpected operating conditions. The excellent turndown behavior of the screw compressor as well as the compressor's ability to deliver a constant flow rate and discharge pressure, largely independent of gas composition and molecular weight, therefore makes this compressor type an excellent choice for the first stages of gas recompression.
- Compared to other compressor types, the process-gas screw compressor is not very sensitive to malfunctions related to upstream scrubbing or separator equipment, provided the liquid comes in droplet form. It is quite typical for the offshore gas processing industry that separators and scrubbers can cause malfunctions that lead to significant compression train damage. Reciprocating and centrifugal compressors can suffer damage when process liquids are dragged along with the gas flow and the droplet-rich gas finally enters the compressor. Since screw compressors are designed to operate with liquid injection, they continue to operate under normal conditions even if the gas contains these droplets. With the low tip speeds of the screw compressor,

entrained liquids normally do not pose a threat as far as erosion of the rotors is concerned.

- Owing to the absence of oscillating masses, vibration problems are ruled out.
- The process-gas screw compressor does not comprise any parts that wear and require regular maintenance, resulting in lower operating and maintenance costs.
- It is widely recognized that the availability and reliability of process-gas screw compressors are comparable to the corresponding performance of centrifugal compressors. As a consequence, process-gas screw compressors are found in demanding, unsparing offshore duties, offering excellent production rates to an industry where reliability is a key parameter.
- By retrofitting a gear wheel set with a higher ratio, it is possible in many cases to increase the compressor capacity significantly at low cost, provided the driver is adequately sized. This option is a powerful tool for debottlenecking the production process.

Figure 4 is an example of a complete, single-lift offshore screw compressor package delivered by MAN Diesel & Turbo. This skid includes the compressor with all auxiliaries on a single base plate, complete with a three-point mounting support system.

### State-of-the-art technology

With a key position as manufacturer of process-gas screw compressors and with more than 50 years of accumulated experience, MAN Diesel & Turbo has demonstrated continuous technical leadership. The outcome is a screw compressor program that offers a combination of robustness and usability combined with a high degree of technical refinement, thus setting the standards for tomorrow's screw compressors:



4 *Electric-motor-driven 2-stage process-gas screw compressor package for an offshore application*

- MAN Diesel & Turbo process-gas screw compressors are designed in accordance with API619.
- All MAN Diesel & Turbo screw compressors are equipped with single piece forged rotors with an asymmetric profile. This ensures the highest efficiency when handling a wide variety of gases and gas mixtures.
- Advanced engineering methods ensure that MAN Diesel & Turbo's screw compressors do not require internal rotor cooling or casing cooling jackets. As a result, the compressor auxiliary system components are reduced to a minimum, leading to a significant reduction in possible failures (e.g. cracking of cooling jacket due to lack of anti-freeze protection).
- MAN Diesel & Turbo screw compressors are available with a wide variety of shaft sealing systems. The liquid sealing systems include labyrinths, floating rings and oil cooled mechanical contact seals, whereas the dry systems include carbon rings and sophisticated, state-of-the-art dry gas seal systems.

- The casing and rotor design allows for operation with suction temperatures down to -105 °C.

### Conclusions

The versatility and robustness of the process-gas screw compressor is increasingly being recognized by the process and hydrocarbon industry. As a result, there is virtually no industrial application where the process-gas screw compressor does not represent a viable compression solution.

There are two main application areas for screw compressors:

- In the lower suction flow range up to 20,000 m<sup>3</sup>/h, where other compressor types do not fit (e.g. reciprocating compressors owing to gas composition) or are not cost-effective (e.g. because a stock of spares is required).
- For higher suction flows ranging up to 100,000 m<sup>3</sup>/h, process-gas screw compressors are often the only alternative for processes with dirty gases involving fouling. In these cases, cleaning and cooling water injection is often required (e.g. styrene monomer).

The positive displacement operating principle of the screw compressor implies that the discharge pressure is virtually independent of gas composition and that a capacity adjustment can be easily achieved by speed variation whilst the discharge pressure remains constant. Based on a comprehensive product portfolio of turbocompressors and turbines, MAN Diesel & Turbo has the capacity to offer solutions for nearly every compressor application, from single units to complete machinery trains.

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