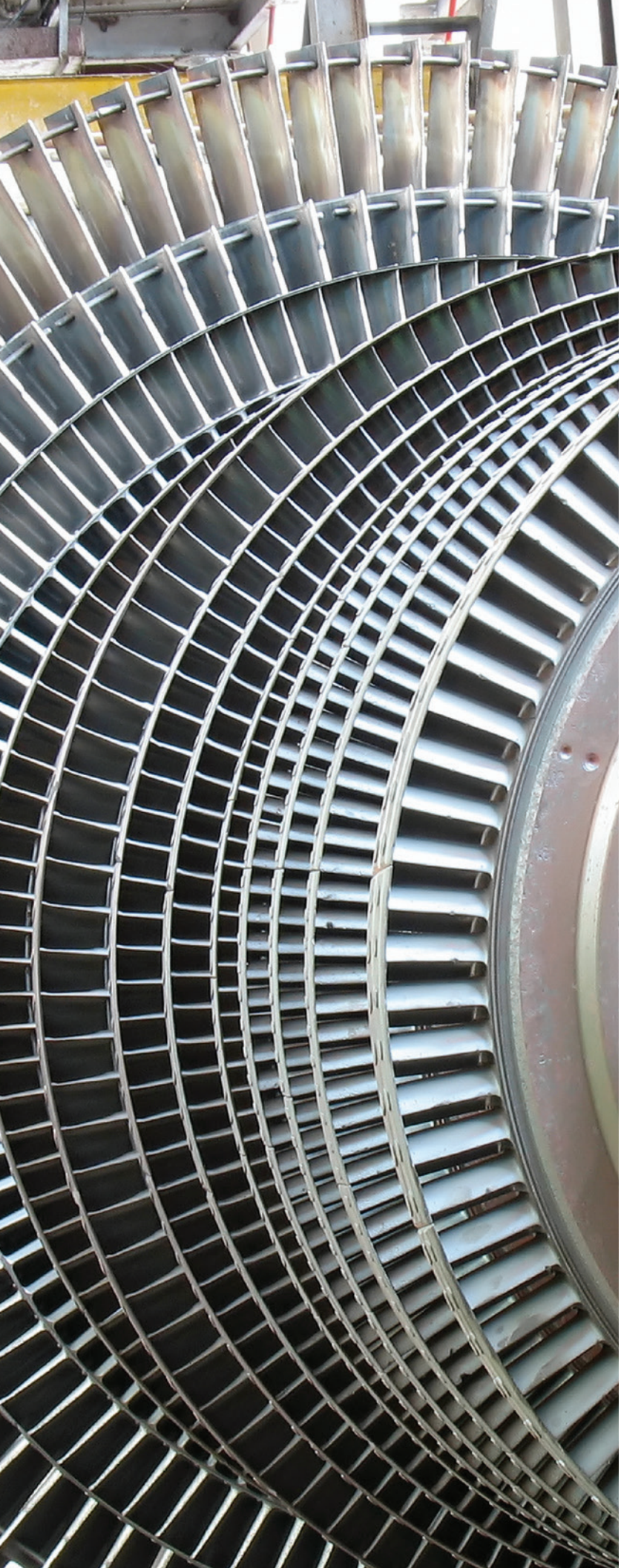

Control Valve Sourcebook — Chemical Unit Operations

Compressor

EMERSON™
Process Management

Compressor

I. How It Operates

A compressor is a complex machine that is used in a variety of manufacturing applications to increase the pressure of a gas by reducing its volume. Compressors are available in many different types and sizes but only work in one direction. There are two different types of compressors, displacement and aerodynamics, or turbo. Figure 1 shows the breakdown of each compressor type.

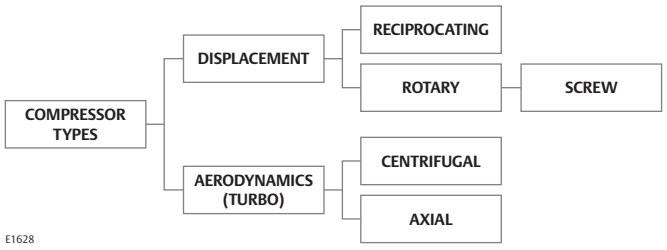

Figure 1. Compressor types

Screw compressors, a type of rotary compressor, use displacement mechanisms to move a large volume of gas. They operate at a constant flow and are displacement compressors. The gas is compressed by funneling it through spiral screws. The screws decrease the total volume, causing the process pressure and temperature to increase. A screw compressor can be aided by a temperature-controlling oil system. The oil system helps seal the gas and regulate the temperature of the compressor.

Another type of compressor is a reciprocating compressor, also known as a piston compressor. A reciprocating compressor uses a piston to compress the gas. An intake orifice valve at the opening of the compressor lets process gas into a compression cylinder. A piston compresses the gas to the desired pressure and then the gas is discharged through an exhaust valve. An example of this action is shown in Figure 2. Reciprocating compressors are also displacement compressors, meaning they displace gas at a constant rate. Some reciprocating compressors will run cool water, oil, or air around the compression cylinder to regulate the temperature of the system.

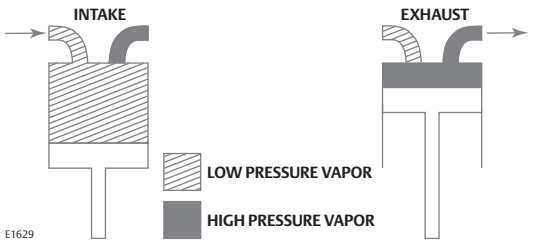

Figure 2. Reciprocating compressor

Unlike displacement compressors, the performance of axial and centrifugal compressors is affected by process changes at the inlet. For example, if the pressure at the inlet increases, then the pressure at the outlet will also increase.

Centrifugal compressors are the most common compressors seen in the chemical industry. They work by forcing process gas into an impeller, shown in Figure 3. The velocity of the gas increases due to centrifugal forces. The process then goes through a diffuser, converting the kinetic energy into static pressure. Next, a chamber called a compressor manifold or volute collects the high pressure gas and discharges it through an opening. It is very common to see multi-stage centrifugal compressors.

Figure 3. Components of a centrifugal compressor

II. Where Compressors are Used

Compressors, especially centrifugal compressors, are common pieces of capital equipment in the chemical industry. They can be used in many different processes such as:

- Ammonia – synthetic gas and air compression
- Ethylene – cracked gas, ethylene and propylene compression

- Urea – ammonia and carbon dioxide compression
- Methanol – synthetic gas compression
- Industrial gases - air compression

III. Compressor Application Review

A compressor is one of the largest and most expensive assets in a plant. A chemical plant cannot afford to stop production due to a problem with a compressor. The best way to protect this asset from unplanned downtime is to use control valves. A typical compressor will contain a suction valve, discharge valve, and antisurge valve. The location of these valves is shown in Figure 4. This section will first discuss the suction valve.

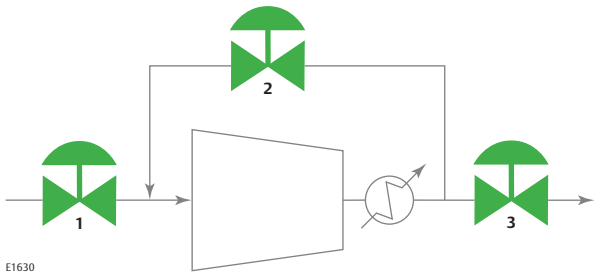

Figure 4. Simple piping and instrumentation diagram of a compressor loop

1. Suction Valve

The suction valve, also known as the inlet valve, is located at the front of the compressor. Suction valves are used to maintain the pressure at the front of the compressor, as shown in Figure 4. This is especially important with a centrifugal compressor because a dynamic compressor is controlled by the process changes in the outlet. The pressure going into the compressor needs to remain constant so that the compressed gas exiting it is also constant. The pressures can range from 69 to 97.6 bar (10 to 1400 psi). Valve sizing and material selection is dependent on the process conditions.

- **Typical process conditions:**
  - Fluid = gas
  - Pressure and temperature are dependent on process design
- **Typical valve selection:**
  - NPS 2 to 6 Fisher™ easy-e™ valve
  - NPS 8 and larger Fisher V150, V200, or V300 valve
  - ANSI rating: CL150 to CL900
  - Materials of construction: carbon steel unless otherwise specified

NPS 38 x 42 Fisher antisurge valve with ODV package next to a small NPS 1 Fisher easy-e valve for a size comparison

2. Antisurge Valve

The antisurge valve is regarded as the most important valve in the compressor system. It protects the system from an uneven balance in pressure between the inlet and outlet. When backpressure forms, the system becomes unbalanced and the process starts to travel back through the system in the opposite direction. If the process flows back into the compressor, it can cause catastrophic damage, which can shut down a plant for weeks. The antisurge valve allows the fluid to travel to the front of the system, bypassing the compressor. This keeps the compressor in balance and protects it from being damaged. Large flow rates may be expected in this application, so it is common to use noise-attenuation trim. Pressures can range from 55 to 207 bar (800 to 3000 psi). Emerson offers a package for their Fisher antisurge valves called optimized digital valve (ODV). The ODV package is a combination of an actuator, accessories, and a FIELDVUE™ digital valve controller that enables the valve to have fast and accurate throttling. This allows the compressor to operate more efficiently and further protects it from being damaged. For more information, please refer to document number D351146X012 “Fisher Optimized Antisurge Control Valves” brochure.

- **Typical process conditions:**
  - Fluid = gas
  - Pressure and temperature are dependent on process design
- **Typical small compressor valve selection:**
  - NPS 2 to 8 Fisher easy-e or HP valve
  - ANSI rating: CL300 to CL1500
  - Materials of construction: carbon steel unless otherwise specified
- **Typical large compressor valve selection:**
  - NPS 2 to 8 Fisher HP or EH valve
  - NPS 8 and larger Fisher EWT, EUT, EA or FB valve
  - ANSI rating: CL600 to CL1500
  - Materials of construction: carbon steel unless otherwise specified

3. Discharge Valve

The discharge valve, also known as the outlet valve, is located at the end of the compressor to release the process gas into the system. Higher pressure compressors can have valves that experience pressures ranging from 138 to 242 bar (2000 to 3500 psi). Discharge valves release a large volume of gas, causing the system to be very loud. To comply with noise standards, it is common to see noise-attenuation trim in these applications.

- **Typical process conditions:**
  - Fluid = gas
  - Pressure and temperature are dependent on process design
- **Typical valve selection:**
  - NPS 3 to 6 Fisher HP or HPA valve
  - NPS 8 and larger Fisher EH valve
  - ANSI rating: CL300 to CL1500
  - Fisher Whisper Trim™ or WhisperFlo™ noise-attenuation trim depending on process conditions
  - Materials of construction: carbon steel unless otherwise specified

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D352317X012 / MCC3/ Feb16