

# Operation and Maintenance of different valve types

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The logo for Kötter Consulting Engineers consists of a stylized graphic of vertical bars of varying heights to the left of the company name 'KÖTTER CONSULTING ENGINEERS' in a bold, sans-serif font.

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## 1. Abstract

The suction and discharge valves are key parts of every reciprocating compressor. Valve failure is the single most reason for a scheduled or unscheduled shut down. The valve manufacturers are constantly working to improve lifetime and performance of valves. However, compromises are unavoidable for economic reasons.

Some expectations of the compressor operators are:

- high efficiency
- good lifetime also of wear parts
- low maintenance costs
- maintenance friendly design
- etc.

The right choice of valves for any application is therefore very important. It is challenging to develop a reliable compressor valve. The design must impose minimum flow resistance and form an effective seal at the proper time. Suitable geometric flow areas, small clearance volumes, simple and rugged design should be combined. There are a variety of designs available where a few main types prevail. Most commonly used are plate valves, ring type valves and poppet valves. Depending on the application different types could be used for a recip compressor.

Valve designs and their performance and maintenance will be compared in the following chapters. It will be obvious that the poppet valve should be of particular interest despite the fact that it is not so commonly used in Europe so far.

## 2. Introduction of the COP<sup>®</sup> Valve

### 2.1 History of the poppet valve

Poppets have been used in the earliest valve designs for compressors. Weight and impact forces limited the use of bronze and steel poppets. Various steps in the development lead to the plate and ring type valves and others.

The modern poppet valve was introduced in the 1950's. It used mushroom shaped sealing elements made of metallic materials or thermoplastics. The poppet material determines the application range of the valves. The use of metallic poppets limits the compressor speed to about 450 rpm. The development of heavy-duty thermoplastic materials like PEEK and their application for sealing elements has extended the range for poppet valves significantly. Compressor speed of up to 1800 rpm, temperatures up to 220°C and differential pressures of 100 bars are no longer a problem.

## 2.2 COP<sup>®</sup> Valve design

The COP<sup>®</sup> valve is a poppet valve of special design. The valve guard, poppets, springs and wear shims are conventional. The valve seat on the other hand is made of two pieces. A seat plate covers the seat body. This plate is a wear part. The new concept for the sealing area has significant advantages concerning maintenance.

Expensive overhaul with remachining of valve seats is no longer required. *The valve is field repairable without special tools.*

Materials: The valve guard, seat and seat plate are usually made of stainless steel and the poppets are made of PEEK. There are little limitations for the use of this valve

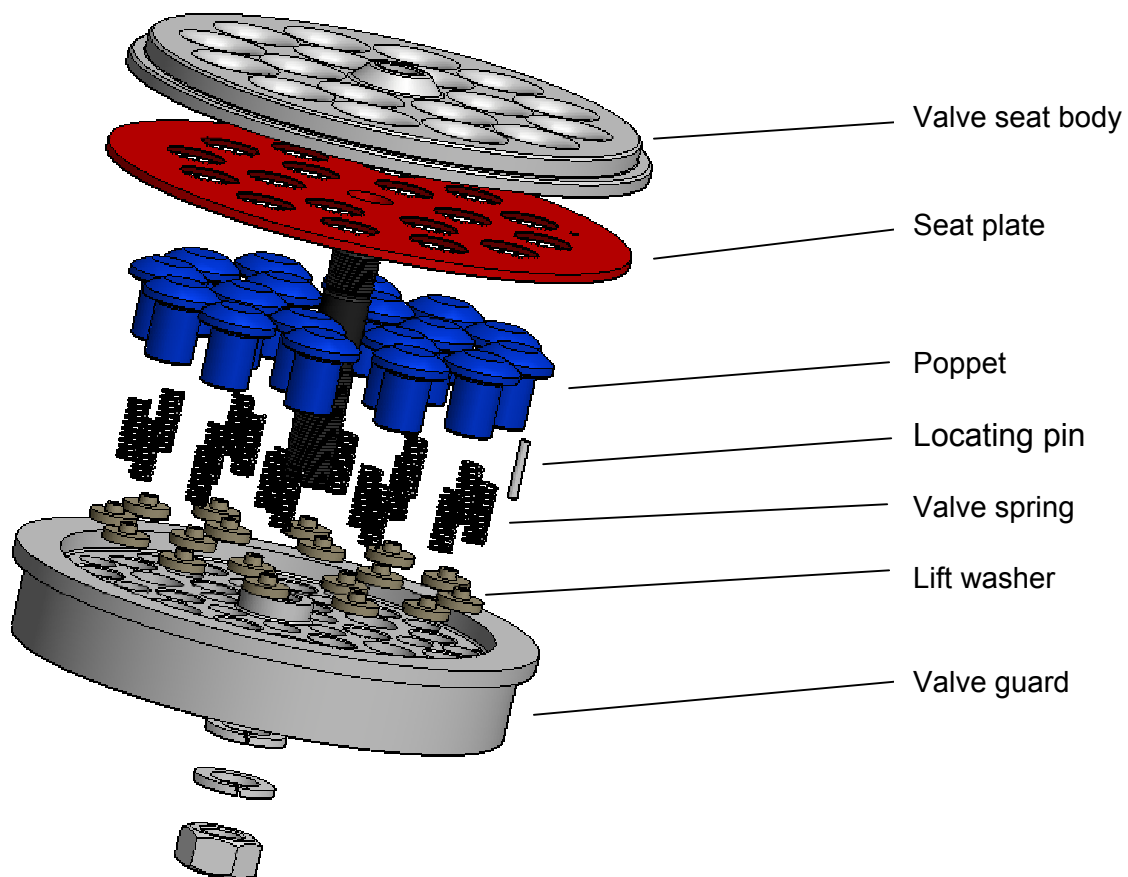


Fig. 1 – COP<sup>®</sup> valve

### 3. Field experience

#### 3.1 Replacement of traditional valves by poppet valves

Historically, operators have replaced conventional types of compressor valves with poppet valves mainly for improved reliability and improved efficiency.

#### 3.2 Operating experience with a speed controlled air compressor

The unit designed and built by a leading compressor manufacturer is compressing atmospheric air to 8 bar discharge for workshop use. On a speed range from 300 to 1000 rpm and a stroke of 160 mm the maximum piston speed is 5.33 m/s! The flow rate at maximum speed is 2500 Nm<sup>3</sup>/h.

Many years of testing and optimisation of plate valves from the OEM resulted in 4000 hrs. maximum lifetime for the valves. The problem is that a valve cannot be optimised for a wide speed range. The lay out of the springs and valve stroke is in such a case always a compromise. The better results were achieved with steel plates. The best plastic plates could do was 500 hrs.

COP<sup>®</sup> type poppet valves of MT Sealing Technology worked fine for 3000 hrs at the first attempt. Well over 5000 hrs have been achieved in the meantime and the valves are still in operation. A minimum of 8000 hrs is expected for this application. These results prove the suitability of the rugged COP<sup>®</sup> valves for demanding service.

**Note May 2003:** The valves have been in operation for well over 8300 hrs and still going strong!

#### 3.3 Performance comparison in natural gas compressors

Plate valves, Ring type valves and Poppet valves have been compared in natural gas compressors. The gas engine driven machines of horizontal design operate between 320 and 400 rpm on a stroke of 300 mm. The test results confirm the advantages of poppet valves regarding flow and power consumption.

Compressor	1	2	3
Suction valve	Ring valve	Plate valve	Poppet valve (MT Switzerland)
Suction pressure	41 bar	41 bar	41 bar
Discharge pressure	79 bar	79 bar	79 bar
Flow	18'100 Nm <sup>3</sup> /h	16'900 Nm <sup>3</sup> /h	18'500 Nm <sup>3</sup> /h
Power losses	6.0 %	7.7 %	3.5 %

A leading valve manufacturer using a „Recip-TrapTM“ 9240 machinery analyser monitored the tests.

### 3.4 Expected valve lifetime depending on the application

The following examples are based on cross head compressors of 1000 rpm maximum speed.

- The valve lifetime in some difficult applications of the hydrocarbon processing industry (HPI) - polypropylene or polyethylene production for example – is usually 4000 to 8000 hrs. Poppet valves have an advantage over plate valves because there is less accumulation of the powder like substances that are usually to be found in the gas.
- Poppet valves in recip for humid CO<sub>2</sub> run 10'000 to 15'000 hrs between overhauls.
- Poppet valves in VCM + 20% N<sub>2</sub> – dirty gas – 5'000 to 6'000 hrs. Plate valves did far less than that.
- Power savings from 5 to 12% were the result after replacing plate valves by poppet valves in refinery and gas pipeline applications.



Fig 2 - Plate valve from a PP process compressor - For contaminated gases poppet valves are more suitable

## 4. Valve maintenance

Valve overhaul can be time consuming and expensive

### 4.1 General guidelines

- Use only original spare parts from the valve manufacturer
- Make sure that springs and stroke of suction and discharge valves are correct – Do not mix if different.
- Do not grind valve plates.
- Do not change valve stroke and spring type without consultation of the manufacturer.
- Renew sealing surfaces. Install new sealing elements and rework the valve seats.
- Follow the manufactures specs. for max. wear of parts.
- Consider dimensions that must not be changed especially on timed suction valves.
- If in doubt always replace parts. Premature failure of a valve is much more expensive than savings are possible by using worn parts.
- If valves are to be shipped to a repair shop pack them properly to avoid damage during transport.

## 4.2 Plate valve

The common overhaul procedure of a plate valve is:

- Pre-cleaning of dirty valves. Some valves out of HPI compressors need special cleaning methods.
- Dismantling
- Visual inspection and dimensional check
- Cleaning – sand blasting etc. if necessary
- Crack detection – spot check
- Inspection of valve guard for further use.
- Rework of sealing lips of valve seat. Lapping or machining depending on condition. For a long seat lifetime only machine as little as possible. This rework limits the overall seat lifetime.
- Replacing of wear parts: Valve plates, springs, lift washers.
- Special cleaning if necessary (O<sub>2</sub>-service for example)
- Final check, assembly, leak test.

This overhaul requires a well equipped workshop and trained personnel! In most cases specialised contractors handle it.

## 4.3 Ring valve

The extent of work is comparable to that of the plate valves. The rework of the seats usually requires special tools and well trained personnel! The seal rings need to match perfectly the seat for proper sealing of the valve. Different thermal expansion of ring and seat material can lead to undesired leakage during operation.

Ring materials are Nylon, PEEK and other thermoplastic materials.



Fig. 3 – Plate valve

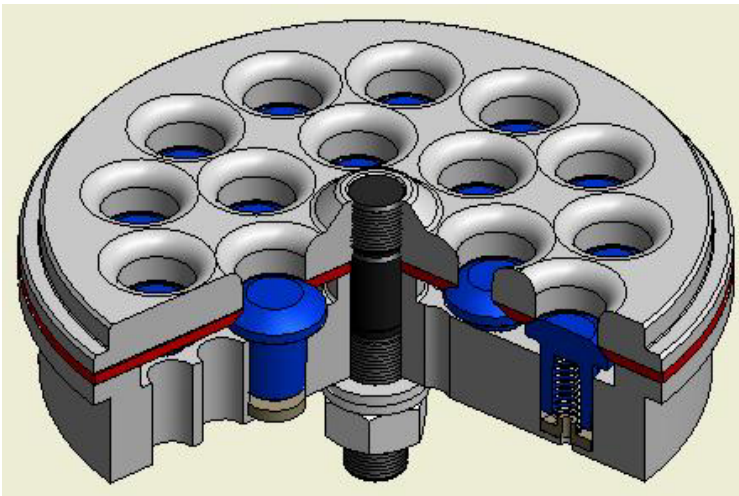


Fig. 4 – Ring valve

#### 4.4 Poppet valve

Disassembly, cleaning and checks as mentioned above under 4.2. Using special tools does the rework of the seats. This job is easier than it is for the plate and ring type valves. Wear in the bores for the poppets of the valve guard can limit its lifetime. Replacement of the wear parts: Poppets, springs and lift washers. For good sealing the poppets must correspond exactly to the seat. On this type of valve it is less difficult to achieve than on a ring type valve. Also, different thermal expansion of poppet and seat material is not critical. Poppets are usually injection molded from PEEK or Nylon material.

#### 4.5 COP<sup>®</sup> Valve



The COP<sup>®</sup> Valve is a poppet type valve that does not require any rework of the seat. The actual valve seat is the seat plate that is replaced when worn. Therefore, the overhaul of a COP<sup>®</sup> valve is very simple: Cleaning and replacing parts is all that is needed. The wear parts, poppets, springs, lift washers and seat plates are easy to stock and not expensive. The seat plate does not have to be replaced at each overhaul.

*This valve is truly field repairable!*

### 5. Valve Selection

A recip compressor operator should consider the following issues in order to make the best choice for his compressor's valves:

- What kind of suction -and discharge valves could be used?
- Are maintenance contracts in effect that limit the free choice?
- What materials can be used considering the gas composition, pressure, temperatures and compressor speed?
- How important is energy consumption?
- How critical are unscheduled shutdowns?
- Who provides support in case of a problem?
- Are valve overhaul intervals to be increased?
- Who is doing the valve overhauls? In house or external?
- What parts (complete valves and spare parts) have to be stocked?
- What is the on site spare parts inventory cost?
- What are the costs for new valves and spare parts?



## 6. Summary

	<b>COP<sup>®</sup> valve</b>	Ring valve	Plate valve
Danger for secondary damage by broken valve parts	no	no	yes, with metal plates
Valve repair shop for overhaul	no	yes	yes
Lapping of valve seats required	no	no	yes
Machining of valve seats	no	yes	yes
Limited valve seat lifetime due to rework	no	yes	yes
Special training for overhaul	no	yes	yes
Cost efficient	yes	no	no
Low cost spare parts	yes	no	no
High efficiency	yes	depends on temperature	no
Easy maintenance	yes	no	no

These types of valves are most commonly used. If different designs could be applied there are many advantages in using the **COP<sup>®</sup> valve**. It is cost effective, efficient and most maintenance friendly.

**Valve overhaul has never been easier!**