

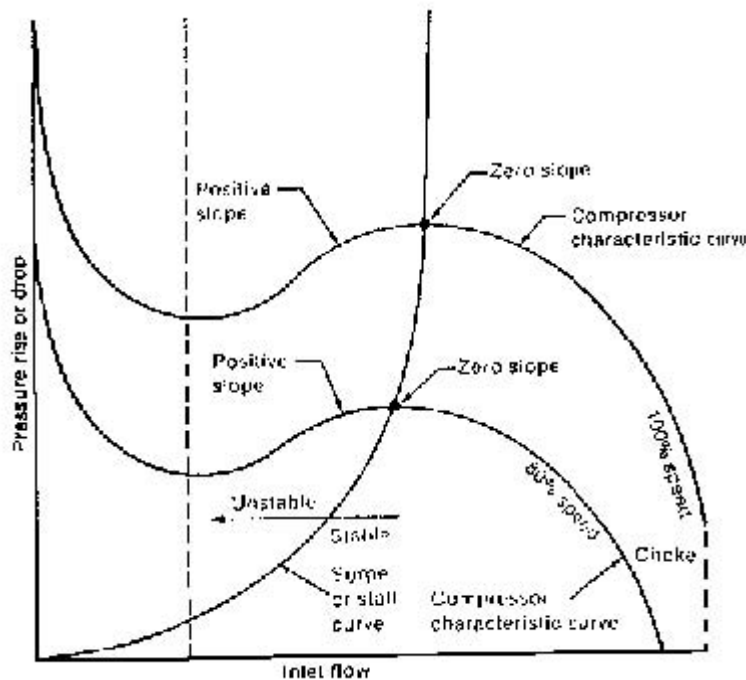
Compressor Anti-Surge Control Valves

MOKVELD RZD DESIGN AXIAL FLOW TECHNOLOGY



Introduction

Centrifugal compressors, as commonly used in gas transmission compressor stations, petro-chemical installations, display a potentially destructive phenomenon called "surge". Surge can be best explained when reviewing in detail the total theoretical curve of a centrifugal compressor.



This compressor map shows the relationship between flow-rate and head of the compressor for various shaft speeds. Important for explaining surge is the fact that the **typical compressor curve at one point is flat, i.e. an inverted parabolic function.**

At either side of the point where the $\Delta P/\Delta Q = 0$, the compressor finds a stable operating point for one specific compressor head. **Surge occurs when, at a certain compressor head, the flow-rate is reduced to the extent that the operating point approaches the $\Delta P/\Delta Q = 0$ point.** Upon further reduction of the flow-rate, the operating point of the compressor will oscillate between a point left and a point right of this point $\Delta P/\Delta Q = 0$.

The surge limit line connects all the points $\Delta P/\Delta Q = 0$ for the various shaft speeds.

The result of such oscillation is a fluctuation of head (discharge pressure) and flow reversal. It is significant that these fluctuations are very fast; various cycles per second. The destructive power of surge is enormous. Ranging from changes in clearances, which result in a penalty in compressor efficiency, to destruction of parts leading to bearing replacement, turbine-rotor replacement or dry gas seal replacements.

The Anti-Surge Control System is the system that prohibits the compressor to operate in the unstable surge zone, by means of opening the anti-surge control valve(s) ensuring that the compressor flow-rate remains on the right-hand side of the surge limit line. Hence the anti-surge control valve(s) are the final control element(s) in the protection against this destructive surge phenomenon in centrifugal compressors.

Surge prevention

Surge is a very fast phenomenon, even too fast to be detected by conventional instruments. Therefore surge must be prevented rather than controlled. These systems, although they prevent surge rather than control surge, are commonly called "surge control systems".

Apart from measurement and control, the surge control system consists of a surge control valve installed in a bypass line of the compressor.

As the consequences of surge in a gas compressor can be catastrophic, the integrity of the surge control system is of the utmost importance.

Major requirements of these surge control system, are:

- minimized overshooting during valve adjustment steps
- reduction of stroke time in response to control signal step changes
- stable response to sinusoidal signals

Unfortunately, as in all closed loop control systems, these requirements are always a compromise. Too fast a response can result in excessive overshoot and poor accuracy. However, too slow a response will result in sluggish opening of the anti-surge control valve and possible inadequate protection of the compressor.

Sizing / selection of surge control valves

Surge Control Valves must be capable to operate the compressor below the surge control line. The surge control line is always depicted to the right of the surge limit line in the compressor curves (maps). Most information required for the sizing of the surge control valves is available on the compressor map. As the compressor suction pressure may vary, various calculations need to be made.

Most compressor users or surge control system suppliers have their own standard for the safety margin included in the valve capacity. This figure is based on the system dynamics, valve response and characteristic. Commonly used margins are that the valve must be capable of passing 100% surge flow-rate at 50% percent valve opening.

When the surge control valve is opened by the surge control system, the compressor outlet is connected to the compressor inlet. The surge control valve then dissipates the full operating power of the compressor. Part of the power dissipated by the valve is converted to acoustic energy that translates to valve noise. Specifically when the anti surge control valve is mounted outside the compressor building the noise abatement capabilities of the valve shall be sufficient to meet the design criteria. Apart from noise, consideration should also be given to the fluid velocity in the valve outlet. This shall be kept within limits to avoid pipe vibrations.

Generally, [valve noise limits range from 85 dBA to 100 dBA](#). The anticipated noise level, before external attenuation, shall never exceed 110 dBA with fluid velocities below [0.3 Mach](#). Above these levels structural damage may occur to piping components and /or valve components and accessories.

The Mokveld Axial Flow Technology

Since the surge control system inherently includes the surge control valve(s), these key parameters indicated above are also demanded from the surge control valve(s).

1. High integrity
2. Fast response
3. Accuracy
4. Noise abatement

The Mokveld Surge Control Valves are uniquely qualified to meet these requirements of surge protection on large compression facilities.

1.1 High Integrity

With over 1500 references of anti surge control valve(s) in Russia alone, all operating under extreme environmental conditions, statistical calculations indicate a failure rate of 2.7×10^{-7} /hr for the Mokveld anti-surge valve.

1.2 Fast response

Typically our surge control valve(s) are certified to operate within 2 seconds on a control signal and 1 second on emergency trip signal (via a solenoid).

1.3 Accuracy

Typically from 8", to 20" Mokveld anti surge control valve will operate with less than 1% hysteresis / deadband and less than 1% overshoot.

1.4 Noise abatement

Various trims ranging from single stage to dual stage to a patented labyrinth style, 'multiimpingement' principle with any number of pressure reduction stages offering upto more than 35dBA attenuation.

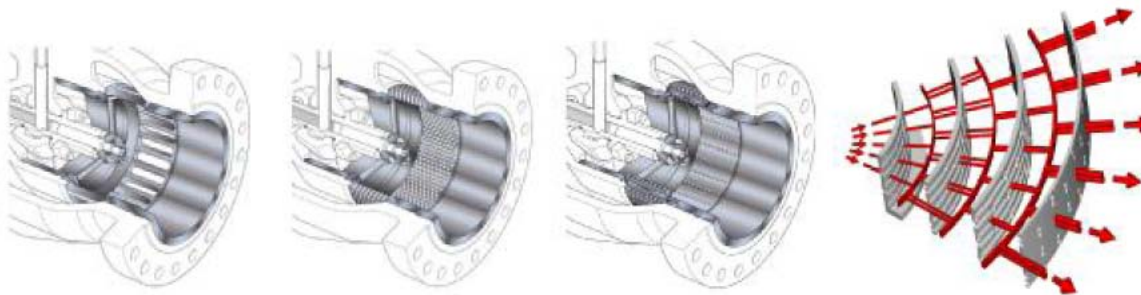


Figure 1 Noise abatement trim styles from left to right RVX, RQX, RDX1/2, RMX

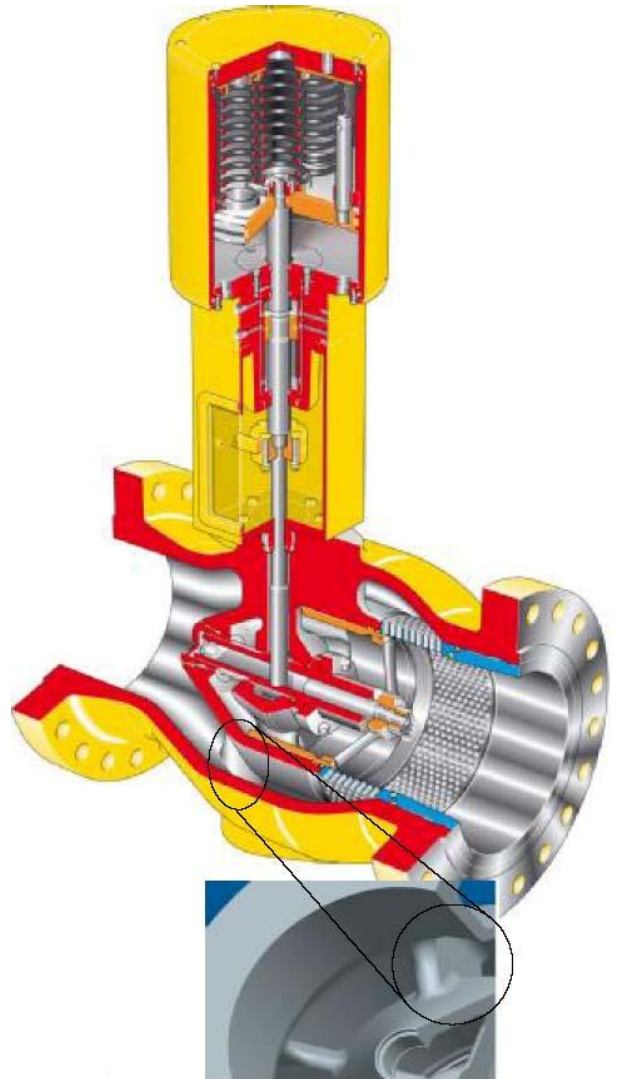
Mokveld valve design

The Mokveld axial flow anti surge control valve is a rugged high performance valve; it is highly reliable and requires little maintenance. It has been specifically designed to increase total efficiency over a wide range of control valve applications. [The in-line and symmetrical flow path](#) eliminates indirect flows and unnecessary changes in flow directions through the valve, whereby the ["breaker vanes"](#) in the downstream section of the valve body (downstream of the actual controlling plug and pressure drop) cuts and streamlines any flow turbulence. This results in significant reductions in noise and turbulence, eliminating excessive vibrations in valve / piping.

Actuator and instrumentation

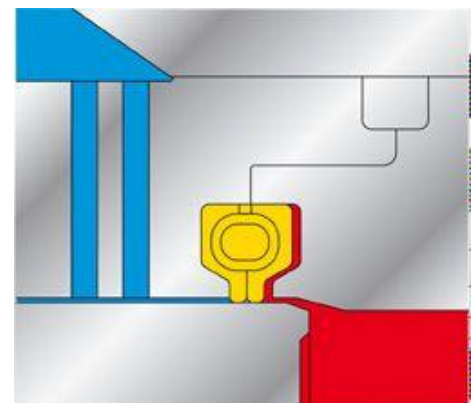
Actuators of Surge Control Valves must be capable to change valve position in a short period of time. The fail-safe position of the valve is open. For reasons of reliability a [spring-loaded actuator](#) is most desirable. Because of the pressure balancing of the valve, Mokveld is able to provide spring to open actuators over their entire valve range [up to 48" diameter](#).

The typical control instrumentation provided on a surge control valve includes a valve positioner, a volume booster and solenoid. Selection of the correct size and configuration of the required instrumentation will guarantee a [response time of less than 2 seconds](#) to fully open via a change in the positioner input from 20 to 4 mA. Overshoot on intermediate changes is kept to an absolute minimum.



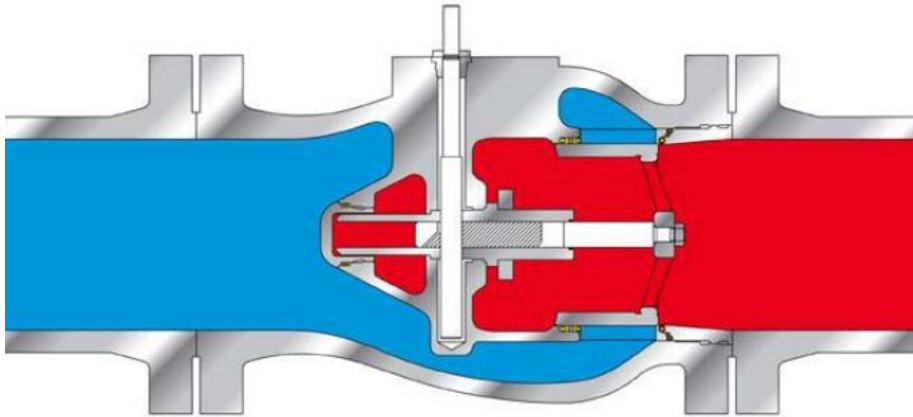
Bubble tight shut-off

Leakages across the anti surge control valve(s) will influence the efficiency of the compressor. An 8" ASME Class 900 control valve for example, with a Class IV leakage rate and 70 bar differential pressure will 'leak' approximately 150Nm³/hr. Even under the most severe working conditions, Mokveld control valves maintain tight shut-off over the full pressure range. With this feature, the compressor efficiency is maintained at the highest levels during normal operating mode. This feature is independent of the actuation method and does not require a higher force as a [standard Class VI sealing class](#) is achieved by position and not by torque.



Pressure balanced

Mokveld control valves in all trim styles are fitted with pressure balanced pistons. This means that the required thrust is [virtually independent of differential pressure across the valve](#). Rapid changes in the differential pressure across the anti surge control valve have therefore no effect on the stability of the valve position. Fast response is achieved with smaller actuators in contrast to those fitted on conventional valves. Furthermore the overall design, with a minimum number of moving parts, and short valve stroke permits stroking times within 2 seconds over a full change in positioner input signal.



Capabilities

The capabilities of Mokveld's design are virtually unlimited. Whether it is a 36" RZD-RQX, ANSI Class 300 lbs, or a 6" RZD-REDX1 ANSI Class 2500 lbs, by nature of the valve design, the Mokveld axial flow technology is able to meet all anti-surge control requirements independent of valve size / rating maintaining stable operation, compressor efficiency levels and/or safeguarding of the compressor.



The first of four 36" RZD-RQX ASME Class 150/300, single stage low noise anti-surge control valve destined for compressor station in Kuwait. Modulating speed of ≤ 3 seconds to open/close, emergency opening via solenoid in ≤ 2 seconds.