

EVERYTHING'S UNDER CONTROL

Alan Wong, Compressor Controls Corp. (CCC), Singapore, underlines the importance of correctly-sized and equipped recycle valves, and details a petrochemical plant user's experience of replacing an uncontrollable compressor recycle valve.

Centrifugal compressors are widely utilised in petrochemical plants across the globe. Most of them are equipped with recycle loops, each of which consists of a recycle valve and recycle pipes both upstream and downstream of the valve to circulate compressed gas from the compressor's discharge back to the suction. This protects the compressors from surge. A correctly-sized and functional recycle valve equipped with a complete set of suitable auxiliary equipment is vital for effective compressor antisurge control. However, Compressor Controls Corp. (CCC) notes from experience that some valves are not properly sized. Worse still, some valves – whether properly sized or not – are not equipped with all of the required proper auxiliary equipment, compromising antisurge control quality and endangering the safety of site personnel. This article highlights the importance of both a correctly-sized and properly-equipped valve.

Recycle valve sizing

The recycle valve is the control element of the compressor antisurge controller. A properly-sized valve yields safe compressor operation (countering the potential surge before the compressor actually goes to surge); control stability (no valve hunting); and efficiency (opening the recycle valve just enough to counter the process disturbance without excessive opening) to the compressor and process operations. An oversized recycle valve erodes antisurge control resolution and quality, and results in excessive recycling,



which ultimately destabilises the process. On the other hand, an undersized valve may not be able to retrieve the compressor from the surge, exposing it to potential surge-induced damage, and opening up the possibility of placing site personnel in danger. Generally, based on CCC's experience, the recommended recycle valve capacity (C_v) is in the range of 1.8 – 2.2 times the larger calculated C_v of compressor surge line minimum point and maximum point flow rates (see Figure 1).

Case study

A user's recycle valve was oversized and uncontrollable due to an issue with the valve positioner. There was a manual bypass valve that was parallel to and bypassing the uncontrollable recycle valve. When the user's original outdated antisurge controller detected surge and de-energised the air supply to the uncontrollable recycle valve (the valve still would not respond), operators needed to rush to the site to manually open the parallel bypass valve. As compressor surge can happen in the range of milliseconds, it is impossible for humans to act fast enough and to operate the valve to prevent a compressor surge. The uncontrollable recycle valve and manual bypass valve operation posed a serious threat to the compressor operation's safety and reliability. As such, the user chose to replace the original outdated antisurge controller with CCC's antisurge controller a couple of years ago. As per CCC's recommendation, the decision was eventually made to replace the recycle valve with a suitably-sized and properly-equipped new recycle valve, and the user commissioned CCC to conduct a detailed study of the recycle valve.

CCC examined the compressor and valve technical data, performed valve sizing calculations, and confirmed that the valve was oversized. The company then carried out a detailed valve replacement study onsite with a valve manufacturer to determine the details of the valve and its auxiliary equipment. This was to ensure that the valve was not only correctly sized, but that it was also equipped with

a complete set of proper auxiliary equipment for its effective functioning.

Recycle valve auxiliary equipment set

Due to the dynamics of compressor antisurge control, a recycle valve requires a complete auxiliary equipment set to facilitate its effective functionality. However, the details of the set are often overlooked, resulting in poor valve performance and a lack of antisurge control quality. At a minimum, a complete auxiliary equipment set should include the following:

- A smart valve positioner.
- A volume booster (or two if the valve's actuator is a piston type) to ensure that the valve travels quickly in the direction of both opening and closing, for ease of antisurge controller tuning.
- An adequately-sized pneumatic line and fittings supplying pneumatic air to the volume booster(s); a pneumatic line fitted with an air regulator/filter set; and connection to an air tank for piston-actuated valve.

A smart valve positioner provides accurate, quick and consistent valve position control to improve valve control resolution and precision to suit the antisurge control dynamics, and prevent overshoot and valve hysteresis. It also sends a position feedback signal to the antisurge controller for monitoring and trending purposes.

Based on CCC's experience, a recycle valve is best when capable of opening from a fully closed to fully open position within 2 sec., without the use of a solenoid. It should ideally have a linear valve flow characteristic (flow through the valve vs valve opening percentage), and preferably not the quick-opening or equal-percentage type. Its closing time should mirror its opening time as closely as possible. However, recycle valve actuators are not quick enough to actuate the valve per the aforementioned requirements. A volume booster, which is a device to deliver a large volume of air to the recycle valve actuator downstream of it to increase the actuator's stroking speed, is vital to the valve's responsiveness to the antisurge controller's demand. For a large recycle valve, multiple boosters may be necessary. It is important to bear in mind, however, that a larger volume booster is preferred over multiple smaller ones due to the lower cost, ease of installation, tuning, maintenance, and spare part management.

For a piston-actuated valve, dedicated volume boosters are required for both the upper and lower cylinder chambers of the piston actuator.

The size of the pneumatic line is vital. If the volume booster is not supplied with adequate pneumatic air, the recycle valve stroke speed and antisurge control quality will undoubtedly suffer, even if it is equipped with a volume booster. From CCC's experience, the pneumatic line (including the fittings) supplying pneumatic air to the volume booster and the valve actuator should be at least $\frac{3}{4}$ in. to ensure that the required valve stroking speed is met. In addition to this, CCC recommends minimising the pneumatic tubing length between the valve positioner and the volume booster, and between the volume booster and

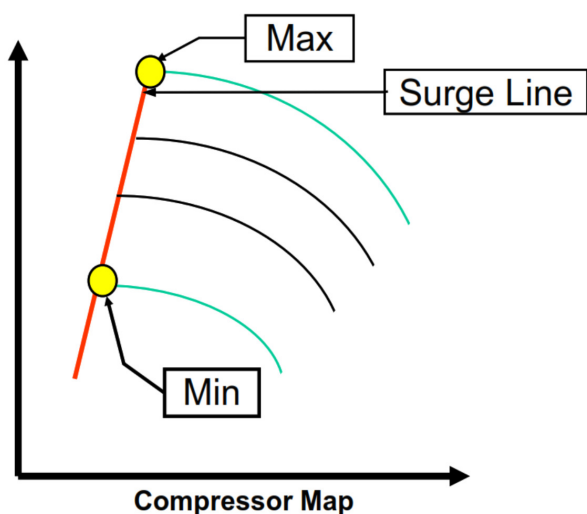


Figure 1. Minimum and maximum surge points on a compressor map.

the valve actuator, to increase the volume booster's effectiveness.

An air regulator with an air filter on the pneumatic line should also be included to regulate the pneumatic line air pressure. In its absence, a transient fluctuating pneumatic line air pressure may create recycle valve oscillation and compressor control instability. It is advisable to have a dedicated air regulator for the pneumatic line of the valve positioner because its pneumatic line size may not be the same as the one to the volume booster. Additionally, when

adjusting an air regulator of one, the pneumatic pressure of the other would not be affected.

The two general valve actuator types are spring and diaphragm, and piston. In the case of pneumatic air supply shortage, spring and diaphragm actuators will drive the valve to the safe position (fully open for antisurge control) due to spring action. Some piston actuators have spring return action. However, some do not, and therefore require the use of pneumatic air supplied from a volume tank. As such, a volume tank is a must when using piston type actuators without a

spring return action in antisurge control. The volume tank should ideally be fitted with a pressure gauge that indicates the tank's air pressure.

Figures 2 and 3 show the connections between these components for a diaphragm-actuated and piston-actuated recycle valve, respectively. Note that the solenoid valves shown in these figures are meant to immediately pop open the recycle valve during an emergency shutdown. This is not and should not be used for recycle valve control purpose.

CCC worked closely with the valve manufacturer and developed an ISA 5.20.50-compliant control valve specification sheet for the user, specifying not just the recycle valve size but also the details of the valve auxiliary equipment.

Case study

The same user as discussed earlier in the article purchased a recycle valve according to CCC's valve specifications, replaced the uncontrollable valve with the new valve, and connected it to the CCC antisurge controller. CCC tested, commissioned and tuned the new control valve and the antisurge controller. The new recycle valve satisfied CCC's requirements. The result is that the user has a controllable recycle valve and automatic antisurge control, and no longer needs to manually open the parallel bypass valve during compressor surge.

Conclusion

The recycle valve is a vital part of the compressor antisurge control system. Proper attention must be paid to both recycle valve sizing and its auxiliary equipment. An incorrectly sized and/or improperly equipped recycle valve may jeopardise compressor safety and antisurge control quality, and this may be costly to rectify. It is imperative that the recycle valve be sized and equipped correctly to avoid serious issues during commissioning and compressor operation. The recycle valve sizing and auxiliary equipment selection details should be specified and/or verified by qualified engineers of reputable compressor controls consultants. 

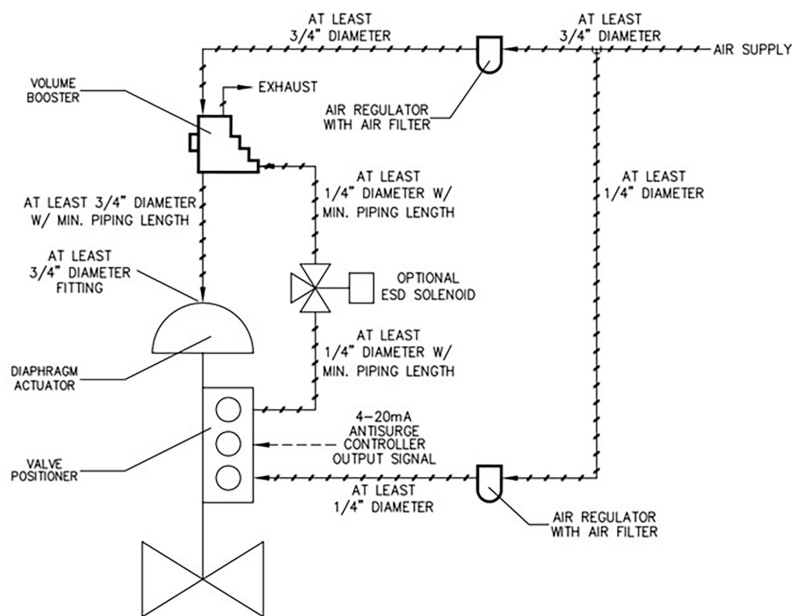


Figure 2. Diaphragm-actuated recycle valve component connection scheme.

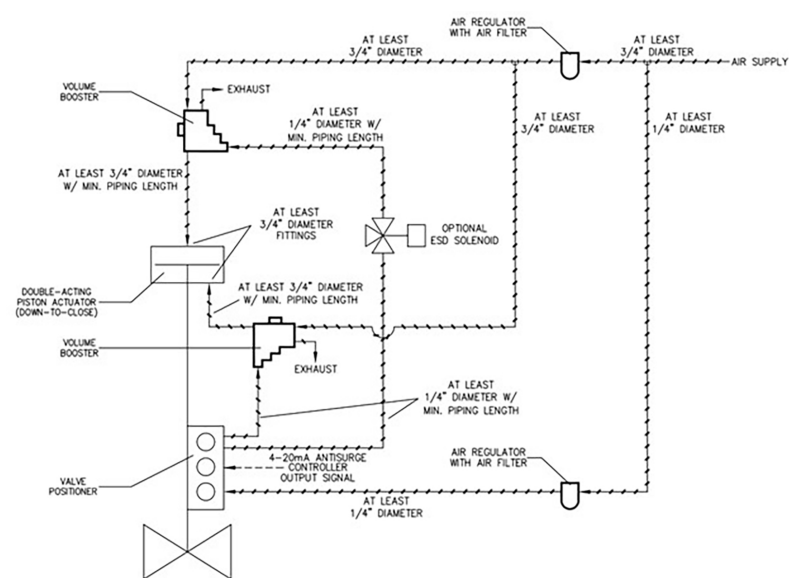


Figure 3. Piston-actuated recycle valve component connection scheme.