



Figure 1. Various noise trims are available to fit anti-surge valves. This Fisher Whisper III™ trim can be easily characterised to handle the demanding noise and capacity requirements of anti-surge valve applications.



Figure 2. Standard volume boosters, such as this Fisher SS-263, come in configurations that cover most actuator sizes, allowing a LNG plant to standardise parts.

OPTIMISING PERFORMANCE

Joe DeMonte, Emerson, USA, outlines how to select the right anti-surge valves to achieve and maintain the highest level of performance.

The efficiency and availability of a plant's compressors have a direct impact on the profitability of a LNG facility. Downtime can affect the plant's mixed refrigerant loops and lead to reduced LNG production, along with substantial contractual penalties. One cause of unexpected downtime is often poorly performing anti-surge valves.

Compressors represent some of the most valuable pieces of equipment within an LNG facility and it is the job of the anti-surge valve to protect them. If the valve

does not perform as required, potential damage can occur to the compressor. Not only will damage cause unexpected production downtime, it can also lead to very costly repairs.

This article will discuss how to achieve and maintain the highest level of performance with anti-surge valves, from startup and commissioning, to demand changes and production optimisation, throughout the lifetime of the plant.

Inside anti-surge valves

The anti-surge valve provides recycle flow to each stage of multi-stage compression trains commonly used in LNG liquefaction processes. The primary purpose of the anti-surge valve is to protect the most critical and expensive pieces of equipment in many LNG facilities – the compressors.

During startup, the anti-surge valve provides throttling control to recycle a portion of the discharge flow as the compressor is brought up to capacity. To prevent surge, the compressor's controller modulates the anti-surge valve for throttling control. This requires a fast, stable response to its open-loop step command. During the onset of a potential surge event, the valve must open quickly –

in less than two seconds – to recycle the discharge gas back to the suction side of the compressor. If the valve fails to react quickly, severe damage to the compressor can occur. In a potential compressor trip scenario, a signal will be sent to a solenoid that commands the anti-surge valve to open in less than one second.

During normal operation of the plant the anti-surge valve will remain closed, but it could be called upon to open to catch a surge event or due to changes in demand or production optimisation. When closed, it is important that the valve provides tight shutoff to prevent unwanted recycle flow. ANSI FCI 70-2 Class V Seat Leakage is preferred to prevent unwanted recycle flow past the valve and optimise compressor efficiency.

Anti-surge valves at any given LNG facility can range in size from small NPS 4 or 6 valves up to size NPS 48 (Figure 3) handling more than 19 000 Cv. These applications can range from anti-surge valves for boil-off gas compressors to valves for mixed refrigerant compressors.

Noise abatement

Many factors come into play when selecting an anti-surge control valve, but the most important are reducing noise and vibration. There is a considerable pressure drop across the anti-surge valve, which can be a source of excessive noise and vibration. A typical customer requirement for control valves is to keep this noise below 85dBA for any extended period of time. This noise is calculated per the IEC 60534-8-3 Aerodynamic Noise standard, taking into account both trim and outlet noise.

There is also a rule of thumb applied to anti-surge valves when it comes to the flow coefficient Cv. Typically the maximum capacity of the valve is increased by some factor to ensure the valve has enough Cv to minimise discharge volume in the piping during a trip scenario. A common requirement is 2x the Cv. This combination of increased Cv and an 85dBA noise limit can often lead to an oversized valve.

Typically, the additional 2x Cv case is difficult to determine since it does not have a corresponding flow rate or dP. Trying to apply an 85dBA noise limit to an unknown 2x Cv case means valve port size, travel and body size may all need to increase to flow the required Cv and still meet the noise requirement.

Noise requirements also apply to hot gas bypass valves, parallel cold recycle valves and bi-linear trim valves used in the anti-surge system.

The 85dBA limit is a requirement for continuous service, but the anti-surge valve spends most of its life closed. When it operates, it does so to catch a surge event, and then returns to the closed position.

For these and other reasons, it is a good idea to look closely at noise requirements. Is 85dBA really necessary? If so, is it just for normal operating cases? Does one really need to apply 85dBA in an all-out trip scenario when the valve goes full open? Can the noise limit above normal operating conditions be relaxed?

An ideal valve would use characterised noise trim (Figure 1) to meet the plant's required noise limit during normal operation, and trade off excess noise versus Cv during a trip scenario. Tortuous path style trims can



Figure 3. A Fisher™ 42x48 in. FBT Anti-Surge Valve with Optimised Digital Valve (ODV) package.

reduce noise, but should be avoided due to potential plugging. Drilled hole trims using hardened trim materials with matched thermal expansion rates are the preferred alternative.

Characterising trim leads to smaller valve bodies, port sizes, and valve travel – saving money and improving performance. As the required valve size increases above NPS 12 or NPS 16, an angle valve can offer more overall capacity in a smaller, more compact valve package. This can lead to less weight, smaller actuators, fewer accessories, and less piping complexity.

Speed and dynamic performance

Anti-surge valve performance has traditionally been defined by stroking time in the opening direction. As noted above, this is less than two seconds full open under positioner control, and less than one second full open under a solenoid trip.

Legacy anti-surge valves were built for speed to meet these requirements. To stroke a valve quickly, air needs to be exhausted from the actuator as fast as possible. Quick exhaust valves were commonly used to achieve this strict stroking speed requirement. However, an anti-surge valve was soon being asked to do more than just open. Advances in compressor controller technology have allowed compressors to operate closer to surge limits without increasing the risk of initiating a surge event. This puts new demands on the anti-surge valve.

Not only does the valve need to open quickly, it also needs to have accurate throttling control. When given a signal change from the compressor controller, the valve must respond with very minimal overshoot. There should be no 'stickiness' in the movement of the valve from open to closed and vice versa. Deadband and hysteresis should be minimised.

To achieve this, the entire valve package needs to be taken into consideration. Accessories need to be used that do not just open the valve quickly, like quick exhaust valves, but open with control. The design must also allow for tight control, whether responding to a small or a large signal change. A properly selected actuator is key to a smooth valve response with no stick-slip type motion. This in turn is key to smooth start-up of a compressor.

An ideal valve package uses volume boosters rather than quick exhaust valves to achieve minimal overshoot when responding to the compressor controller. The forces on the actuator must also be symmetrical. A piston type actuator design is key to achieving a higher level of performance in the opening and closing directions. Valve stroking time in the closing direction should be roughly equal to that in the opening direction.

Good vibrations

The most common failures of an anti-surge valve occur in the accessories, such as instrument tubing, positioners, volume boosters, etc. – and the failures are often caused by vibration.

As LNG plants scale up, there is typically less room to spread out. Instead, the LNG facilities get built on floating vessels or small patches of land near shore. This leads to shorter piping runs, multiple elbows, and thinner schedule

piping needed to fit into the smaller space, creating excess vibration at the anti-surge valve.

Positioners, accessories, and even tubing exposed to such vibration can fatigue and fail in this environment. One way to improve the reliability of an anti-surge valve is to use a positioner with a non-contact valve position feedback (Figure 1). This eliminates potential early failure due to part wear.

Spool valve positioners can plug and should be avoided. Volume boosters that use an angle-body type design can be flange-mounted to the actuator, helping to prevent vibration-related issues. Flex hose should also be avoided to improve reliability. Accessory tubing should be checked to ensure the natural frequency of the tubing far exceeds that of the potential vibration levels in the field.

Scalable performance

The LNG market has changed over the last 10 years. Whereas 10 years ago there was a push toward the 'Mega' train concept, there is now a combination of traditional LNG capacity, along with smaller 'mid-scale' LNG trains, new licensors, and smaller scale floating LNG (FLNG).

Even within a single plant, anti-surge valves can range in size from NPS 4 to NPS 48. It is important that anti-surge valve performance be scalable, regardless of valve size. An NPS 48 valve is asked to meet the same stroking speed and dynamic performance (overshoot, deadband, resolution, and hysteresis) as a NPS 4 valve.

A site with a variety of different sized valves needs to be able to take advantage of common parts. An ideal anti-surge package uses the same positioners, trip valves, solenoids and boosters (Figure 2) on all sizes of valves. The only thing that should vary between the different anti-surge valves should be valve size and actuator size. As the valve gets bigger the actuator must get bigger, but that should not mean the positioner or accessories should change.

This is one reason spool valve type positioners are not an ideal solution. As valves scale up, so do the spool valve positioners, meaning parts cannot be interchanged among valve sizes. A better option is to use additional boosters to assist with larger actuator volumes. Leveraging interchangeable parts and minimising the amount of required special accessories reduces the number of valve accessories an LNG facility needs to keep on the shelf.

Complexity of tuning

If an issue arises, the plant needs to know how to interact, troubleshoot, tune and commission its anti-surge valve to get up and running again. Start-up time should also be a quick process without having to retune boosters, positioners, controllers, etc.

The valve should have a user friendly interface for tuning and set up. One way to achieve this level of familiarity is to use a common positioner across the plant; i.e., use the same positioner on anti-surge, general service, critical service, and SIS applications. This ensures a technician is comfortable with the user interface and tuning, and can thus more easily commission a valve or troubleshoot an issue. This also avoids the need for frequent vendor support or stocking special items.



Figure 4. Fisher FIELDVUE DVC6200 positioner with a magnetic array (arrow) for non-contact feedback.

Most anti-surge valves are tied to local compressor controller that may have a limited amount of valve diagnostics. Using a positioner with online diagnostic capabilities that can look at the health of the valve without interrupting the process is key to catching potential valve issues before they affect performance of the compressor.

Online diagnostics can catch early air leaks, actuator issues, positioner issues, and even valve issues before a

potential failure. With the anti-surge valve sitting closed the majority of the time it has the potential to get stuck. The capability to run a partial stroke test to ensure the valve will move when commanded to is another key reliability tool that should be used. All of these tools can lead to better preventive maintenance practices for a critical valve, helping avoid costly compressor downtime.

Emerson's Fisher Optimised Digital Valve Package (ODV) takes into account all of these key anti-surge requirements to provide a high performing and reliable product for LNG facilities. The ODV package combines Fisher valves, advanced noise abatement Whisper Trim technology, boosters and FIELDVUE positioners for anti-surge applications.

Conclusion

The primary purpose of an anti-surge valve is to protect compressors from surge damage, but it is also used during startup and commissioning to provide throttling control, and by the safety system to prevent damage during a compressor trip. Therefore, when specifying an anti-surge valve, consideration must be given to the entire valve package – the valve, positioner, volume booster, trip valve, solenoid, and valve diagnostics – so the entire valve assembly operates smoothly and efficiently, with minimal required maintenance and simple troubleshooting. **LNG**