

SEVERE SERVICE CONTROL VALVES FOR OFFSHORE PLATFORMS:

A DEBRIS-TOLERANT SOLUTION

Offshore oil and gas platforms are surely among the most hostile operating environments on Earth, and they are becoming even more so as offshore production ventures into ever-more remote and inhospitable areas such as deep water and arctic exploration. These are settings where a vast number of things can go wrong, and equipment uptime must be maximized for a platform to operate successfully, safely and profitably. Because of this, proper equipment design is essential.

Certainly, this importance applies to severe service control valves. These valves are among the most critical pieces of equipment on an offshore platform, and proper specification, installation and maintenance are crucial to safe and efficient operation of the platform. This article highlights one of the unique factors that must be considered when specifying severe service control valves for offshore applications—the need for valves that can address high-pressure liquid or gas letdown while also tackling the “real world” problem of debris in the flow stream.

When requesting control valves, an engineer’s first instinct may be to define the valve by a standard set of basic valve construction and operational data found on a specification sheet. These standards, however, do not fully account for the complicated issues that may be present in a severe service or critical application. Those issues can include poor system tuning, operating the valve outside its intended functional

CONSIDER SPECIFYING CONTROL VALVES THAT WILL NOT ONLY ADDRESS HIGH-PRESSURE LIQUID OR GAS LETDOWN, BUT ALSO SOLVE THE “REAL WORLD” PROBLEM OF DEBRIS IN THE FLOW STREAM. **BY STEPHEN B. JAMES**



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range, changes in the corrosion level of the process fluid, hydrate formation and external damage to the valve. Some of these potential problems can be avoided by following proper operating procedures, using advanced diagnostic tools and selecting more robust valves.

DEFINE THE SOURCE OF THE VALVE ISSUES

An additional factor beyond those valve issues listed above, which can defeat even the best operating procedures and most advanced diagnostic monitoring equipment, is cleanliness of the process fluid. In nearly all cases, valve specification sheets assume that the process fluid flowing through the valve—whether it is a gas, a liquid or a mix—is clean and free of foreign debris. In the “real world,” this often is not the case, and the presence of foreign debris should be expected in many severe service or critical applications on offshore platforms. Such debris can quickly damage or clog a traditional control valve, which can ultimately cause a critical system to fail.

The first step in preventing this is determining which valves are critical or severe service, a step that can sometimes be challenging. Often such applications are only identified as “a control valve with a high-pressure rating,” and this over-simplification can lead to poor valve selection for critical or severe service applications. A better approach is to fully understand each specific

application and the difficulties that particular process may present. This approach makes it easier to put greater focus on the critical or severe service control valves.

When designing control systems for offshore oil and gas platforms, engineers can target applications that should be considered critical or severe service and where debris may be entrained in the flow stream. Some examples include the high-pressure separator letdown valve, overboard dump valve and produced water reinjection pump recirculation valve.

While each of these is a unique application, all three have the common thread of being on liquid service with a high-pressure drop. In such applications, the valve supplier’s initial direction is to provide a control valve with suitable trim to safely drop the pressure without creating cavitation damage.

UNDERSTAND MECHANICAL CONSIDERATIONS

Cavitation occurs in a control valve when the process fluid pressure drops below vapor pressure and then recovers back above that vapor pressure. As the process fluid pressure drops below the vapor pressure, the fluid tries to turn into a gas. Small bubbles begin forming, but before the liquid can completely change phases, the sudden increase in pressure during the recovery phase of the valve forces the bubbles to collapse.

A pressure imbalance on the surface of the bubbles causes them to take on a toroidal shape. At the final point of collapse, a small jet of very high pressure is formed in the center of the torus. If located near a solid surface, these high-pressure jets can cause erosion.

In severely cavitating applications, damage to the control valve can occur very rapidly, leading to equipment failure. Figure 1 shows an example of cavitation damage. Figure 2 illustrates an example of the pressure drop in a single-stage control valve that would exhibit cavitation.

In a control valve, pressure is dropped by forcing the fluid to flow through geometry that changes flow direction and/or passage size and by separating or combining flow streams. In high-pressure drop applications, it is common to do this in series, creating a control valve that uses multiple stages to safely drop the pressure. The ultimate goal is to provide a sufficient number of stages to always keep the fluid pressure above the vapor pressure. Figure 3 shows an example of the pressure drop in a multi-stage control valve that would prevent cavitation.

COMPARE EFFECTIVE AND INEFFECTIVE DESIGN

The most common types of control valve trim used to provide multi-stage pressure reduction incorporate a flow element with a series of concentric drilled-



Figure 1. An example of cavitation damage.

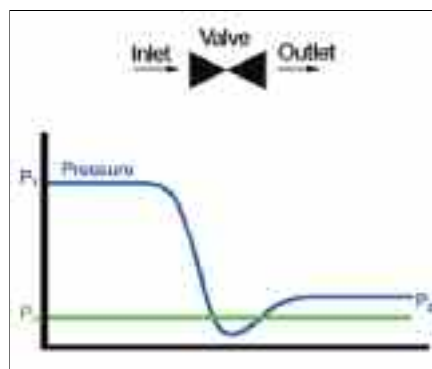


Figure 2. This graph shows the pressure drop in a single stage control valve that would exhibit cavitation.

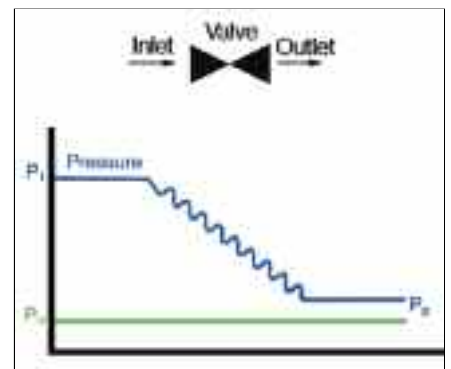


Figure 3. Here is an example of the pressure drop in a multi-stage control valve that would prevent cavitation.



Figure 4. Examples of small passage drilled-hole and tortuous-path control valve trim for liquid service. These would reliably prevent cavitation in clean service applications, but could become clogged if exposed to a flow stream with entrained debris.

hole cages or a series of stacked plates that force the flow through a tortuous flow path. Figure 4 shows typical examples of each design. Both designs are regularly used in clean service applications on offshore platforms, where they deliver effective and reliable protection against cavitation.

However, such traditional designs can be unreliable in offshore applications where debris will be entrained in the flow stream, as their small flow passages make them susceptible to clogging and damage. In an offshore platform, the most common debris would be sand, though other trash associated with industrial construction, such as weld slag, pipe scale and fasteners, can also be present. Most traditional anti-cavitation control valves would easily clog and become damaged if forced to pass such debris.

In critical or severe service applications, damage to the control valve can have a ripple effect on the surrounding system. In the case of a produced water pump recirculation valve, for example, the control valve provides flow from the discharge side of the pump back to the suction side. This typically occurs during start-up or shut-down of the pump, when recirculation flow is required. If the valve cannot pass sufficient flow because it is clogged, the pump could be starved of flow, leading to interstage cavitation in the pump and, potentially, to total pump failure. The resulting cost to repair or replace the pump would far exceed the cost to repair or replace the offending valve, which illustrates why investing in a control system appropriately designed to meet the needs of the

specific application is a wise decision.

A SOLUTION TO REDUCE VALVE FAILURE

Those not experienced in offshore applications may feel they face a no-win situation: fail to apply anti-cavitation techniques and cavitation could cause equipment to fail; specify anti-cavitation trim with small passages, and clogging may result in equipment failure.

There are solutions to this dilemma. Among them is a set of unique control valve trim designs in which small flow passages are replaced by a series of specially engineered, large-area expansion and contraction regions. Figure 5 shows such a control valve trim. This design delivers a high level of cavitation protection by safely staging the pressure drop, while also providing large flow passage areas that can pass entrained solids with no troubles. These control valves also offer a high level of reliability because they eliminate clogging and damage by debris as a failure mechanism.

While most debris problems in valves are associated with control valves on

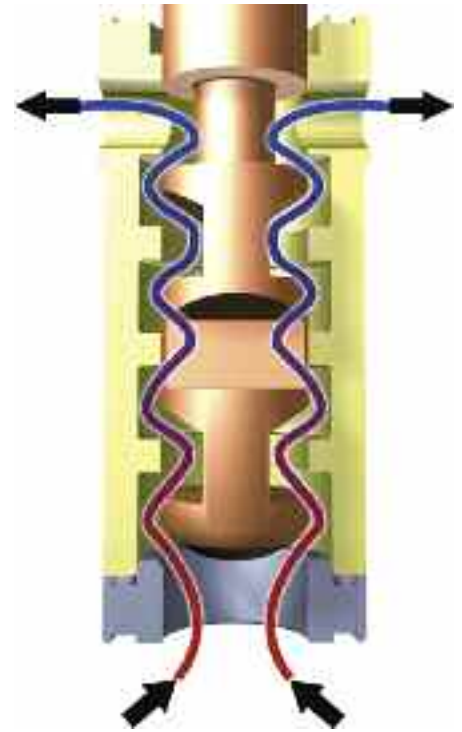


Figure 5. Shown here is an example of multi-stage, debris-tolerant trim for liquid service.

liquid service, the same types of considerations apply to control valves used in severe service gas applications. Figure 6 shows two examples of specialty control valve trims commonly used in high-pressure gas letdown applications. Similar to anti-cavitation liquid control valve trims for clean service applications, the technology uses small drilled holes or tortuous flow passages. The purpose, however, is to minimize noise and vibration levels associated with the high-pressure reduction of a compressible gas.

While the risk of clogging and damage is less in gas service than in liquid



Figure 6. Depicted are small-passage drilled-hole and tortuous-path control valve trim for gas service. These are reliable in clean service applications, but could become clogged if exposed to a flow stream with entrained debris.

service, the potential still exists for these issues to occur in some critical or severe service applications on offshore platforms. A wellhead choke valve is one example of a common gas application that may be subjected to entrained solids.

While not usually thought of as a control valve, many wellhead choke valves are designed and operated more like a control valve than a traditional choke. This is because choke valves typically rely on simple trim geometries that can pass entrained solids. However, rising global demand for natural gas has led to increasing production from higher-pressure gas fields. Choke valves operating in these high-pressure fields require more complex trim to combat the noise and vibration associated with high-pressure gas letdown, while also providing protection



Figure 7. An example of multi-stage, debris-tolerant trim for gas service

against clogging or damage due to foreign debris, such as sand.

As with specialty liquid valves, there are options to accommodate these situations. Among them are unique control valve trim designs that safely reduce the pressure on high-pressure gas applications while also passing entrained solids or liquids without risk of clogging or damage. Figure 7 shows an example of such a control valve trim. One major difference between this trim and those associated with dirty liquids is that each pressure drop stage expands. Because gases are compressible, each pressure drop has a reduction in density and expansion in volume; thus, these control valve technologies must have expanded areas to operate properly without choking the flow.

ACHIEVE MORE RELIABLE PERFORMANCE

Standardized approaches to control valve specification, coupled with advancements in diagnostic technology, are certainly important to everyday operation. When working on offshore oil and gas platforms, however, unique issues that will arise in those harsh and remote environments also are critical.

Questions such as, "Is this control valve debris-tolerant?" should be addressed, especially when determining proper solutions for critical or severe service applications. The answers will ensure the proper valve is specified, providing safe and reliable performance while protecting the total operation of the platform. **VM**

STEPHEN B. JAMES is a global manager of engineered products for Dresser Masoneilan in Avon, MA. Reach him at 508.586.4600 or stephen.james@dresser.com.