The case for top-entry in cryogenic LNG

Specifying top entry buttweld triple offset valve design in LNG cryogenic applications

The requirement for a port entry in buttweld valves in the LNG industry has become extremely common. The end user's key objective is to align with regulatory requirements such as EN 1473 or NFPA 59A and comply with local regulation (especially for LNG terminals). For this reason, specifying valves with a lower amount of flange connections is critical and welding valve bodies to the pipe appears to be an obvious solution. However, what happens when things go wrong? How can operators gain access to the key components and carry out maintenance?

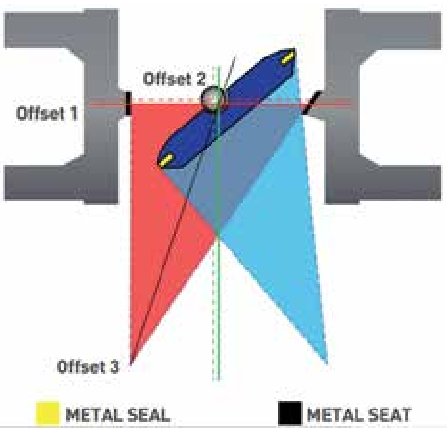
Even today, the typical journey for triple offset valve (TOV) specification goes from double flanged to buttweld to top entry buttweld body design during the different stages of a project to strike a balance between lowering the risk of fugitive emissions and making maintenance and repairs feasible tasks.

Consensus needs to be reached within the valve engineering and manufacturing industry about how to define a "top entry" valve, how the top flange should be designed, and how it will benefit end users in carrying out repair/ maintenance tasks. This article explores these issues as a means of providing a level of understanding about what to consider when specifying TOV valves in cryogenic applications based on Emerson's leadership in developing a top entry solution for the LNG industry.

Analysis

Significant technological developments have been made in the butterfly valve segment over the past 40 years - the reduction or complete elimination of rubbing during rotation being part of the evolution of this type of valve. These relatively new designs (namely double offset, also known as high performance, and triple offset) ensure longer lifecycles, require lower maintenance, and provide an improved leakage performance compared to concentric types.

Nonetheless, the differences in terms of capability and functionality between double offset valves and triple offset valves (TOVs) are still somewhat confused. The concept of a top entry design is here applied to a TOV, a valve that provides closing with no rubbing across the 90° rotation (differently from double offset valves) in view of a single, instantaneous point of contact between sealing elements only when closed position is reached. TOVs can handle bidirectional flow and are tight in both sealing directions up to extreme pressures due to torque seating and non-rubbing rotation achieved with three "offsets" (fig. 1):



1. The shaft is placed behind the plane of the sealing surface;
2. The shaft is placed to one side of the pipe/ valve centerline;
3. The seat and seal cone centerlines are inclined in respect to the pipe/valve centerline.

Figure 1 triple offset design

Based on these premises, the seal ring (and not the disc itself as in the case of concentric butterfly valves) is the critical component as it represents the key flexible element necessary to perform sealing against a seat typically overlaid with Stellite grade 21. A dynamic spiral wound gasket ensures an adequate expansion and contraction of the seal ring during opening and closing (fig. 2).

Figure 2: Exploded view of a Vanessa disc

A cryogenic TOV is a valve with an extended bonnet and a solid seal ring, available across a wide range of body styles. The Vanessa seal ring is always a one-piece solid ring in Neutronic 50, a material highly resistant to corrosion able to preserve important mechanical features at low temperatures.

Available solutions: Side entry Buttweld design

Side entry buttweld TOVs are designed to be maintainable from an access on the body (located to one side of the trim) and they always feature a removable seat (necessary to uninstall the seal ring). Paradoxically, the seats, which are often in 316 Stainless Steel with no

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Figure 3 Vanessa top entry buttweld TOV: Offline Reparability in total safety

Stellite overlays, and the graphite multi-layered (or "laminated") seals of side entry TOVs are typically made of materials with a shorter life expectancy. Graphite exposed to cryogenic temperatures becomes brittle over time. Furthermore, the number of bolts exposed to the flow is doubled compared with integral seat TOVs and there is no effective prevention against bolt loosening. Overall, this design makes trim components prone to deterioration; therefore, regular maintenance becomes necessary.

In side entry valves, the trim cannot be extracted and maintenance must be performed with direct exposure of service personnel to safety risks. Other issues include the ability to carry out maintenance operations only on limited valve sizes/pressure classes. It is very difficult – if not impossible – to access valve internals for sizes lower than 12" and dangerous/difficult to replace sealing components for large sizes and high-pressure classes. In the latter case, a service person is required to enter the line, with direct exposure to pockets of residual gas (gas masks, extra ordinary safety measures and constant monitoring of oxygen may be necessary), accidental pressurisation, accidental strokes of the valve and risky removal of heavy components without a safe way to stably lift them up.

Available solutions: Top entry Buttweld design

On clean liquid/gaseous cryogenic applications, some TOVs are virtually maintenance free and do not require any specific maintenance programs. To do so, cryogenic TOVs must be able to guarantee the same performance irrespective of body style designs. Typically, this is linked to the valve trim components operating at temperatures down to -254 °C (-425 °F).

Whenever inline access is mandatory, similarly to a top entry ball valve, the top entry buttweld TOV allows for all possible extraordinary repairs via complete removal of internal components. It is safe to claim that on a clean LNG service maintenance requirements are unnecessary thanks to the 100% metal seating and only extraordinary repairs may become necessary to fix tightness and operability-related issues. Emerson's Vanessa triple offset valve experience shows that in such a compact body, the top flange is also minimally affected by pipe loads.

The trim can be completely removed from the body and every component can be repaired or replaced (fig. 3). This means the valve is safe to repair, there is no exposure of service personnel to safety risks and there is also the possibility of addressing operability problems linked to the bearing areas.

Maintenance issues: Side entry small diameters

Irrespective of the size of a valve, before removing the top flange of a side entry valve and accessing the trim components, the actuator should always be removed for safety reasons.

Although an operator may be able to use a single hand inside the open port, they may not be able to insert the appropriate tools to disassemble the components. Even if two hands can be used, it is still extremely

Figure 4 Maintenance of small-sized side entry buttweld TOVs: An unfeasible task

Choosing between an oval shaped vs. rectangular flange

Overall, rectangular ducts and joint construction are not typically used in the oil and gas industry. However, some manufacturers may opt to use this specific shape to design the top flange in view of practical and cost considerations, though unbalanced stress distribution, gasket and bolting failure may ultimately result in critical fugitive emissions.

These types of ducts are normally allowed in heating venting and air conditioning systems typically designed for extremely low pressures generated by a fan. However, even in these systems recent guidelines to minimise air leakage to increase system efficiency now recommend the use of round/oval duct and joints. For example, the SMACNA (Sheet Metal and Air Conditioning Contractors' National Association) recommends the use of round ducts having the lowest possible duct friction loss for a given perimeter.

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difficult to disengage components and take them outside the port. In addition, this operation is completely unfeasible if the valve is installed at a height/difficult location to reach (fig. 4). Overall, these critical issues may jeopardise the very reason for a side entry body specification (maintenance operation), as only a visual inspection can be carried out.

Maintenance issues: Side entry large diameters

A crane must always be used to remove the side entry flange, seat, seal ring and seat and seal retaining flanges. A 72" Class 150 side entry flange, for example, will weigh more than 1,000 kg. (over 2,200 pounds) and seal ring, seat ring, seal ring retaining flange and seat ring retaining flange will all weigh hundreds of kilograms (several hundred pounds).

Even for medium-sided entry sizes in accordance with ISO 11228 and NIOSH equation, lifting and moving of equipment with weight more than 25 kg. (55 pounds) should never be done manually.

Once the top flange is removed, a service representative should be let inside the conduit at extremely high safety risks including exposure to residue gas, pressurised equipment, and other factors (fig. 5).

Another serious risk that may remain unaccounted for during valve specification is the potential of crushing the operator during the removal of key components since lifting aids cannot be safely applied after removing bolting (fig. 6).

A less evident aspect to consider is the fact that any components to be installed on the seat/disc are offset in comparison to the side entry port where they enter the body and it is impossible to put them in/out of place by using the crane alone. The higher the diameter/pressure class, the longer the distance between the port and the seat.

Figure 5 Maintenance of large-sized side entry Buttweld TOVs: A risky task

Ultimately, the operator will not be able to dry up valve cavities or to address operability problems which are common during LNG plant/terminal start-up operations following the drying of the lines after being flushed with water.

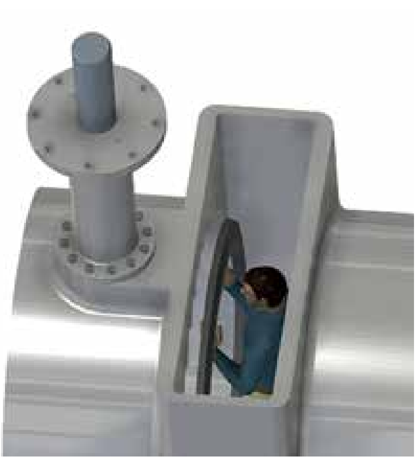

Figure 6 Risk of operator crushing during maintenance of large side entry buttweld TOVs

Conclusion

Cryogenic TOVs are installed worldwide in double flanged, lug, buttweld and buttweld top entry executions with double flanged being the most commonly adopted body style. Whenever inline access is required, the arguments in support of a top entry design are predominant.

Furthermore, the use of one piece (solid) seal rings and Stellite grade 21 seat overlays is believed to guarantee the highest level of reliability and long-term excellent performance as graphite becomes brittle at low temperature over time and the seal ring will "delaminate", creating operability and tightness problems extremely difficult to solve.

Ultimately, it appears critical that if a high-quality torque seat, metal-to-metal non-rubbing TOV is being selected, the top entry access will be used for extraordinary repairs (and not for ordinary maintenance) on clean cryogenic services. ▮

Stellite is a registered trademark of Deloro
Nitronic is a registered trademark of AK Steel

References:

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ISO 11228-1 (2003) – Ergonomics – Manual Handling – Part 1: Lifting and Carrying

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For more information:

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Repairing a top entry: A case study

A set of four identical Vanessa 24" Class 300 TOVs in cryogenic configuration top entry buttweld body were subject to extraordinary maintenance. All valves were with pneumatic, double acting actuators and had suddenly experienced operability issues (locked at 50% open).

Once the valve trim had been removed from the pipeline, a significant presence of water and unidentified solid particles were detected in the bottom bearing area.

After cleaning up and drying the bottom bearing area, all valve parts were reinstalled on the pipeline and an operability test was successfully performed. The entire maintenance cycle carried out by two technicians took 4 hours and involved the following activities:

– Removal of actuator
– Removal of trim
– Clean-up and drying of bottom bearing area
– Installation of the valve trim
– Installation of the actuator

After the installation was completed, a pneumatic test was also performed with no measurable leakage. Should this valve have been a buttweld side entry, this issue would have been impossible to address directly on the pipe – the only solution would have been to cut off the valve from the line.

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