Valve Safety & the Environment

Roderick Stanley explains industry efforts towards leak-free valves

PROTECTION of the environment from leaking valves is gaining greater attention from the Environmental Protection Agency (EPA), the Occupational Safety and Health Administration (OSHA), concerned citizens, and operating companies. This includes leakage during normal operation, during maintenance, and during an operational upset. Recent developments by responsible valve manufacturers show that valves designed with lower emissions reduce one of the major causes of valve accidents.

According to OSHA, in an April 1990 report, the massive and devastating explosion and subsequent fire at Phillips 66's Houston Chemical Complex in October, 1989 was caused by an improperly-operated valve. "The valve actuator mechanism did not have its lockout device in place ... The valve lockout system for this maintenance operation was inadequate to prevent someone from inadvertently or deliberately opening the valve during a maintenance procedure. Among other findings of this study are that free-flow sensing valves, redundant instrumentation, or other fail-safe systems that would shut down in the event of a failure might reduce the amount of flammable material released." Valve manufacturers continue to modify their designs to provide industry with valves which are leak free in all modes, which have positive lockout mechanisms, and which are fire-safe by design.

Figures 1 and 2 provide a summary of industrial accidents over the last 30 years and indicate that refineries have the highest percentage of losses while mechanical failure and piping system breakdown are the greatest cause of these accidents.

Although, not specifically mentioned in Figures 1 and 2, careful consideration must be given to the selection of the proper valve for any industrial application. The valve must

FIGURE 1: 30 YEARS OF INDUSTRIAL ACCIDENTS

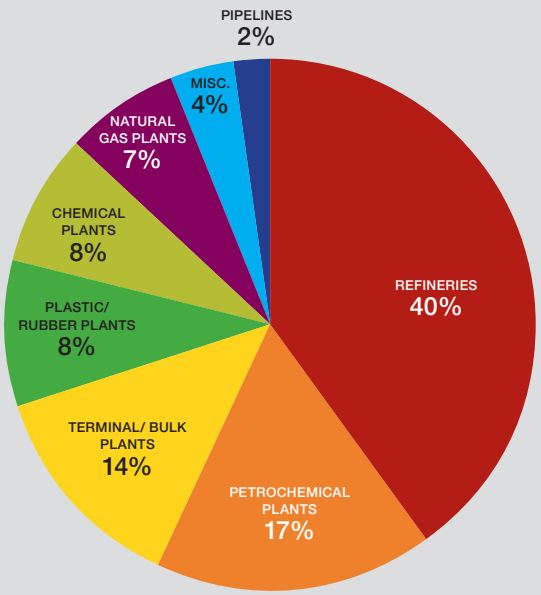
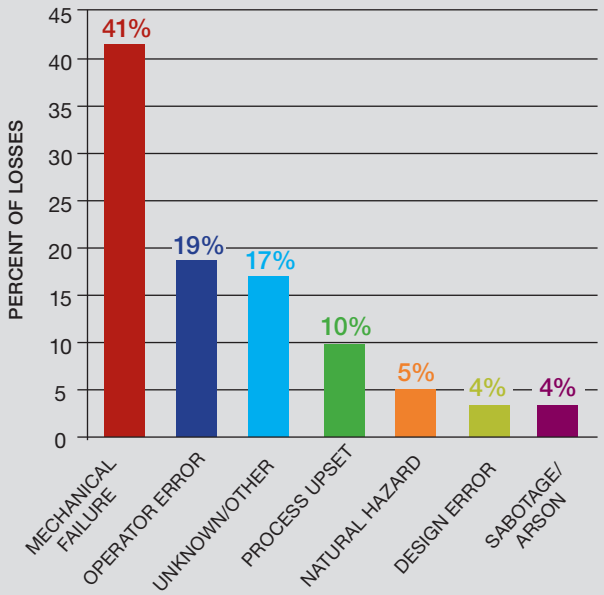


FIGURE 2: CAUSE OF LOSS



Source: Compiled from OSHA accident report data

perform its primary function: that of stopping or controlling the downstream flow of the process medium. Attention should also be given to the following details during both normal and upset conditions, particularly as to the effects on the system as well as the environment:

- downstream valve leakage;
- leakage to the atmosphere;
- valve lockout systems;
- fire-safe designs;
- fail-safe systems; and
- line blinds.

VALVE LEAKS

DOWNSTREAM VALVE LEAKS

Leaks through the valve into the downstream system cannot be tolerated. In the case of a reactor or tank drain, the vessel will be dewatered, with possible loss of the entire batch, or a chemical imbalance could occur which could cause loss of product or possible runaway reaction resulting in explosion or fire.

Downstream leakage could cause personnel injury if workers assume the upstream valve is holding (not leaking) and open piping for maintenance or repair. Additionally, downstream leakage may cause process upset by admitting a partially-reacted fluid to a continuing process downstream. A leaking injection valve can cause all manner of costly problems, particularly if it is designed to admit a "kill" solution during an upset chemical reaction. A well-run reactor could be unnecessarily shut down, or the batch could be ruined by improper insertion of an unwanted ingredient.

System sampling or drain valves often have discharge connections open to the atmosphere and are only connected when a sample is to be taken or a system drained. Leakage through the valve would fall to the ground, and vapours to the atmosphere cause all sorts of surface and atmospheric pollution problems.

CAREFUL CONSIDERATION MUST BE GIVEN TO THE SELECTION OF THE PROPER VALVE FOR ANY INDUSTRIAL APPLICATION...(AND ITS) EFFECTS ON THE SYSTEM AS WELL AS THE ENVIRONMENT

Likewise, valves isolating chemical reactions under vacuum should provide zero leakage of air or gas into the system, which could cause a loss or contamination of product and possible unwanted reaction leading to an explosion or fire.

Process industries should insist on valving which provides zero leakage through the valve, as a minimum satisfying the requirements of ANSI B16.34 Class V or VI, regardless of the operating pressure and temperature of the system or the type of fluid or vapour handled.

Fetterolf Ram-Seal valves provide absolute drop-tight closure for systems operating up to 5,000 psi (350 bar) and 540°C degrees. A major chemical company recently tested a 6" Ram-Seal valve in gas service. The leakage rate was found

to be 1x10^{-8} mL/s (equating to around 1 mL every 3 years) and was unchanged after more than 9,000 cycles involving both pressure and temperature shock.

LEAKS TO ATMOSPHERE

Leaks to the atmosphere come through valve stem packing. Careful consideration must therefore be given not only to the particular packing material selected but also to the design of the stuffing box, packing gland arrangement, tightening arrangement, plus stuffing box and stem finishes. Today's packing manufacturers provide a vast array of materials for all types of services. The following packing features must be taken into account:

- Is it compatible with the process fluid?
- Will it withstand system design pressure and temperature?
- Will packing deterioration cause leakage or product contamination?
- Is fire-safe, food-grade, etc packing required?
- Are special tools required for packing removal?
- Is packing material reinforcement required?

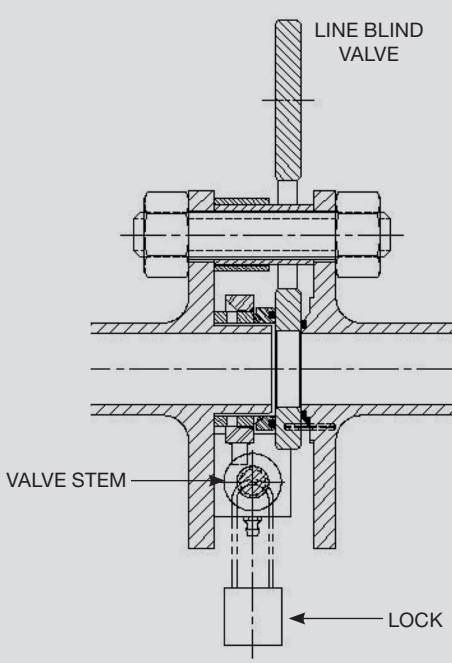
In the past, valve manufacturers have focussed on providing extra-deep stuffing boxes with fine finishes, polished plungers and standard packing materials such as Teflon reinforced with Kevlar or graphite, graphitic braids etc. Today we know that shallow stuffing boxes that enable only 4 or 5 rings of specialised low emissions packing – that allow all rings to be fully compressed – is the correct approach. These low emission packing sets can be specified to a number of emission standards such as TA-Luft, ISO 15848 or the more stringent API 624. In addition, designs that avoid the packing being damaged during installation, live loading or spring-loaded packing systems should also be used.

Lantern rings within the packing provide an excellent and inexpensive means of verifying zero packing leakage when the lantern ring is charged with an inert gas such as nitrogen. This ensures gas leakage into the system rather than outward into the atmosphere. Lantern rings may also be piped to a closed waste system or continuously flushed to carry away any first-stage packing leakage.

Alternate designs of Ram-Seal plungers and body lengths will assure that the wetted surface of the plunger never exits the packing area. This configuration means that the process fluid which 'inlets' the plunger never exits the outboard packing area, thus eliminating atmospheric contamination. Bellows-sealed designs afford the best possible prevention of atmospheric leakage. Due to long strokes, however, considerable additional cost is involved.

Source: Fetterolf Corporation

FIGURE 3: SIMPLE LOCKOUT SYSTEM - A LOCK IS PLACED IN THE ACTUATING STEM OF THE VALVE, THUS PREVENTING UNAUTHORIZED USE



VALVE LOCKOUT SYSTEMS

Valves in critical systems passing toxic, flammable, explosive, or contaminating fluids should have some type of "lockout" system to ensure that they may be locked in the appropriate "safe" position during operation or during shutdown for maintenance and/or repair. As the OSHA report indicates, the Phillips 66 explosion and fire may have been prevented had the lockout system been properly employed.

Specific valve designs will dictate how lockout systems will function. Fetterolf valves use an open yoke design where a simple "U" channel may be fitted over the valve stem and padlocked in position to assure a "locked closed" position. A similar lock will assure a locked open position (not frequently required). This lockout device requires manual removal with an appropriate key (or multiple keys) and may be applied to both manual and automated valves (*see Figure 3*).

FIRE-SAFE VALVE DESIGNS

Whenever possible, a valve which has been tested for fire-safe design should be selected. This will assure that there will be no leakage (or minimal leakage) during a fire where leakage through the valve, through the packing, or due to a ruptured valve will fuel and thus increase the fire. As a minimum, fire-safe packing should be specified. Various organisations and operating companies have fire-test standards. The American Petroleum Institute, Factory Mutual, OCMA, and British Standard are frequently used.

Source: Fetterolf Corporation

STANDARDS: RAM VALVE DURING FIRE-SAFE TEST

Source: Fetterolf Corporation

VALVE: EXAMPLE OF A SLIDING LINE BLIND

The photo (*above)* shows a Fetterolf 3" Ram-Seal valve, 300# ANSI, flanged, in 316ss using graphite gland packing and metallic seal rings, which was recently tested by Factory Mutual Research (FM) to API standard 6FA. FM concluded: "The Ram-Seal 3" 300LB bottom valve satisfies the performance requirements of API-6FA, Section 3." The valve was pressurised to 540 psi and enveloped in a heptane flame at 760–982°C. There was no leakage before the test and no leakage after the test. During the test, minor leakage occurred, which was less than the allowable by a factor of 53 (9 mL vs 500 mL). There was no discernible leakage to the atmosphere (through the packing) during the test. Customers should always request that their valve manufacturer/supplier provides a copy of its fire test report or fire-safe certificate from a reputable body such as FM, TuV, or Lloyds. The certificate will state the testing standard and what size and pressure class of valve are covered.

FAIL-SAFE VALVES

Automatically actuated valves (pneumatic and hydraulic) should be capable of failing open, closed, or in last position on loss of air, hydraulic, or electric power. Safe operation of the system will dictate failure mode. Smaller valves may utilise energy stores in springs to fail open or closed while larger valves may utilise an air lock system. Additionally, a fusible link with a preset temperature actuation point may be placed in the pneumatic supply system. On temperature increase to the set point, the link will melt, actuating the fail-safe system

LINE BLINDS FOR ISOLATION

A frequently overlooked solution to the problem of total, 100%, pipeline or reactor isolation, is the use of line blinds (spectacle blinds, figure eights, etc). Had a line blind been used downstream of the shut-off valve at Phillips 66, Houston site, the disastrous explosion would have not occurred. A line blind would have totally isolated the polyethylene leg (the source of the leak and subsequent explosion) for cleaning – preventing the massive destruction and loss of life.

Line blinds offer a positive, visible, easily-operated, and inexpensive method for equipment isolation and are a critical element for valve systems safety that is overlooked. Newer designs offer pressure ratings up to ANSI 2500 Class, simple hand wheel operation, and alternate metallurgies.

CONCLUSION

Adherence to environmental standards not only protects the environment, but also helps to ensure personnel safety and plant efficiency. Plant failures or serious accidents can be reduced by specifying some or all of the features outlined in this article. While there is a cost to these valve enhancements, operators need to balance the dollar cost of prevention against the cost of an environmental or safety incident. ■

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