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New Safety Valve Addresses Environmental Concerns

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Conoco Pipeline Company Inc. began testing new relief valves in 1987 to prevent over-pressuring its pipeline while enhancing the safety, environmental integrity and profitability of its pipelines.

Conoco worked jointly with Rupture Pin Technology Inc., Oklahoma City, OK, to seek a solution to a series of safety, environmental, and operational risks in the transportation of crude oil and refined products through pipelines.

Several of the identified problems were traced to a single equipment source: the reliability of rupture discs used at pipeline stations to relieve pressure by diverting flow to tanks during over-pressure conditions.

Conoco's corporate safety and environmental policies requires solving problems that deal with exposure to hydrocarbon vapors, chemical spills or the atmospheric release of fugitive emissions, such as during rupture disc maintenance.

The company had used rupture pin valves as vent relief devices in conjunction with developments by Rick Austin of inert gas methods to protect the inner casing walls and outer carrier pipeline wall in pipeline road crossings.

The design relies on rupture pin valves set at 5 psi to isolate vent openings from the atmosphere prior to purging the annular space between the pipeline and casing with inert gas to prevent corrosion. Specialty Pipeline Inspection and Engineering Inc. of Houston, is licensed to distribute the equipment for the new cased-crossing procedure.

Special Valves

With the success of the road-crossing procedure, Austin secured Conoco management support for Rupture Pin Technology to begin development of new valves designed specifically to prevent over-pressuring upstream of metering facilities for natural gas, oil and refined products pipelines.

In addition to safety and environmental concerns, design parameters were also to address on-going problems with meter failures, plugged strainers and product bypasses of meters.

In station applications, the rupture pin valves offer protection against accidental valve closings as well as those occurring due to control valve failures.

Disc Problems

With the rupture discs, early failures were common. Attempts to reduce the incidence of varying disc material or substituting components from various manufacturers proved unsuccessful. In addition, all manufacturers recommended annual disc replacement.

With some stations experiencing frequent disc ruptures, parts and maintenance costs had become prohibitive. For example, four-inch discs rated at 600 psi cost the company approximately $125 each. It took maintenance personnel between 45 minutes and one hour to complete each disc change. Often, partial disc failure was insufficient to trigger flow switch alarms, so it was necessary to open the pipeline to remove suspect discs for visual inspection.

In addition to being labor intensive and costly, disc changes presented safety considerations. Unbolting and separating flanges for disc removal, inspection and replacement presented an unacceptable risk of pinch-point hazards.

Available in more than a dozen basic configurations, rupture pin valves used in Conoco's facilities are designed specifically to relieve fluids to downstream piping and storage tanks.

Wrenches could slip on flange nuts or the weight of rupture disc assemblies could cause flanges to spring together, providing a risk for pinching workers' fingers or hands between the separated points.

Operational problems stemming from poor disc performance included inaccurate meter counts. In custody transfer applications, the measure of the crude oil transported depends upon accurate meter counts. Partial rupture disc cracks enabled product to bypass the meters, so the metered product movement varied from the number of barrels actually transported.

Pin Advantages

One of the major factors contributing to the selection of rupture pin valves to replace rupture discs at pipeline stations included the ability of the new valves to operate at an accuracy of plus or minus 5 percent set points ranging to 1,440 psi. Other factors included:

■ The valve design's inherent full-bore opening mode during pressure relief.

■ The ability of a single worker to reset the piston quickly without opening the valve or pipeline to get isolated piping back on-line without exposing personnel or the environmental fugitive emissions or spills.

Installation of rupture pin valves to replace the discs provided a visual means to verify the occurrence of over-pressure conditions relieved by the valves, as well as alarms activated in the station control center signaled by contactors attached to the outside of the valve body for that purpose. Any failure of flow switches installed to indicate disc ruptures made their diagnosis difficult.

Principles

The basic principle behind the rupture pin design is simple.

Hold a piston, subject to the system pressure, on seat by a pin that precisely reaches axial force. When the axial force reaches a critical, exact value (governed by Euler's Law), the pin buckles and the piston instantly moves to a full open position.

Factors controlling this precise opening point are the diameter of the piston on which the system pressure acts (acting force) and the characteristics (resisting force) of the pin.

Generally round with flat ends, the rupture pins are manufactured with regard for three precise variables; metallurgy/heat treatment, diameter and length. These variables are subject to exact control, traceability and tolerance.

Other important factors affecting performance include:

■ Precise, consistent holding of the pin ends.

■ Exact axial alignment of the end-holding recesses.

■ Orienting the device consistent with factory tests to take into account the weight of the piston on the pin.

If pressure on a ductile rupture disc exceeds the proportional limits, but does not stress the disc to its rupture point, the disc's molecular structure is damaged and it can fail early at a subsequent pressure increase.

In contrast, the pin at no time exceeds its proportional limit prior to buckling. The buckling mechanism is not a molecular failure, but the applications of Euler's Law relating to slender columns. The buckling action is rapid, usually occurring in a few milliseconds, much faster than rupture disc failures.

Temperature is not a factor when pin materials are used that have a constant modulus of elasticity over a wide temperature range. Application studies on mud pumps used on drilling rigs have shown that vibration, mechanical shock and fluid shock do not cause pin fatigue or early opening.

Available in more than a dozen basic configurations, the rupture pin valves used at Conoco's facilities are designed specifically to relieve fluids to downstream piping and storage tanks. The valves relieve excess pressure in the pipelines, sealing bubble-tight to exact set points.

Once triggered by over-pressure conditions, the valves can be reset without opening the pipeline or valve. An explosion-proof limit switch sensing piston stem rise has proven reliable for remote indication of opening. This provides instant warning of opening. Visual inspections for pin buckling also indicate opening.

Regulating pin variables during manufacturing provides measurable levels of control, traceability and tolerance that have proven impossible to achieve in rupture disc manufacturing. Disc manufacturing costs increase in direct proportion to increases in diameter. Rupture discs require delicate handling and careful storage, while the relatively inexpensive spare pins are rugged and can be stored at the valve inside hollow guide posts. It takes only minutes to replace a pin. The valve body and line remain closed at all times during maintenance operations, providing no opportunity for fugitive emissions.

When relieving excess pressure, the externally mounted pin merely deforms rather than breaking. As a result, pins do not throw off downstream metal, plastic or graphite shards.

Conoco currently uses rupture pin valves in cased-crossing applications, receipt meter facilities and at pipeline stations experiencing several system switches on a daily basis. In station applications, the valves offer protection against accidental valve closings as well as those occurring because of control valve failures.

Although the application of the new Rupture Pin Technology devices at Conoco Pipeline locations remains a decision for individual district managers and supervisors at pipeline stations, the potential for system-wide use of the valve exists.

As Conoco continues to evaluate safe, environmentally sound and cost-effective engineering solutions to a wide variety of pipeline operation challenges, its recent application of rupture pin valves to solve problems is certain to remain a factor in the company's ongoing search for improved operating procedures and technology.

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