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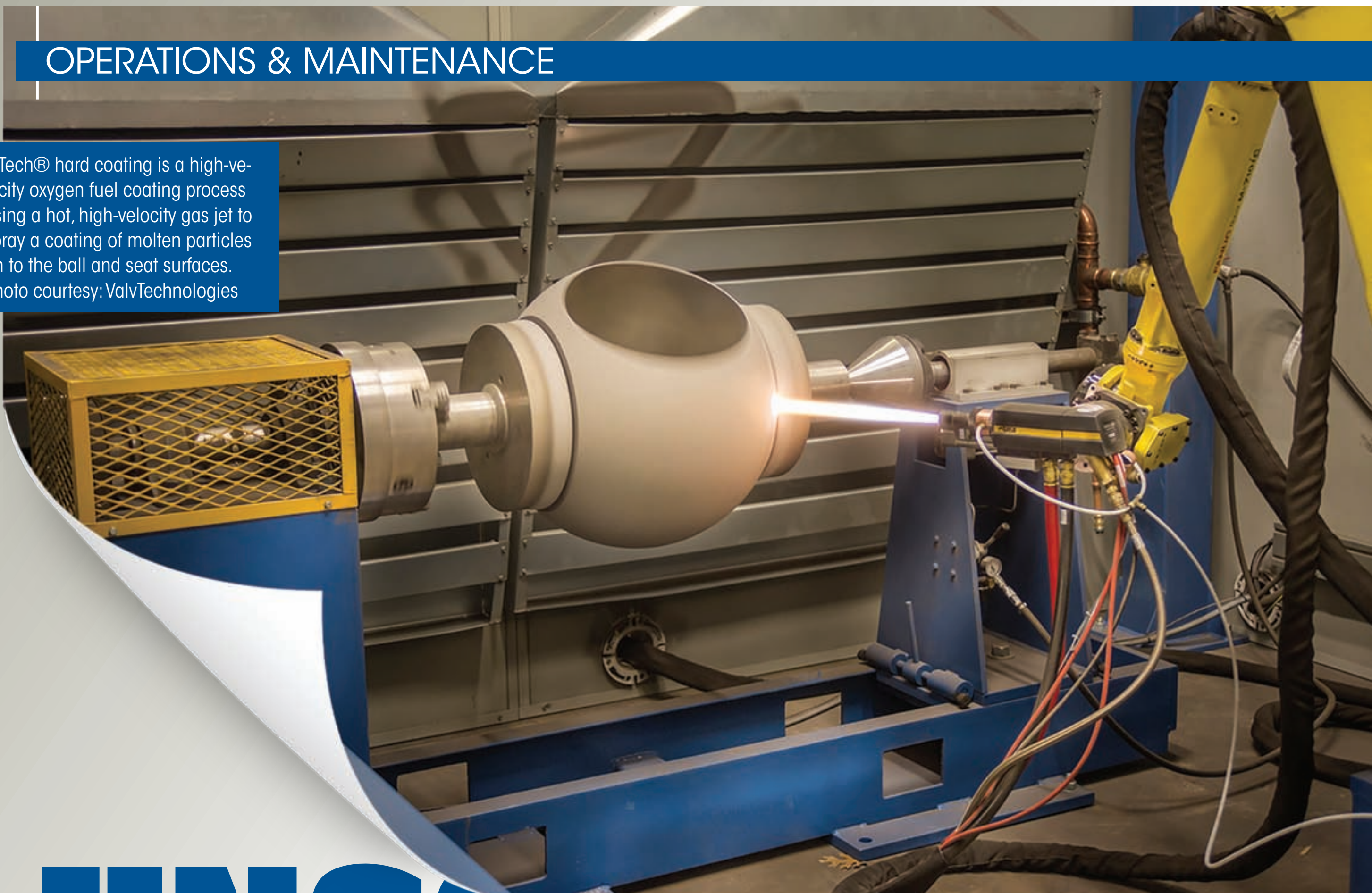
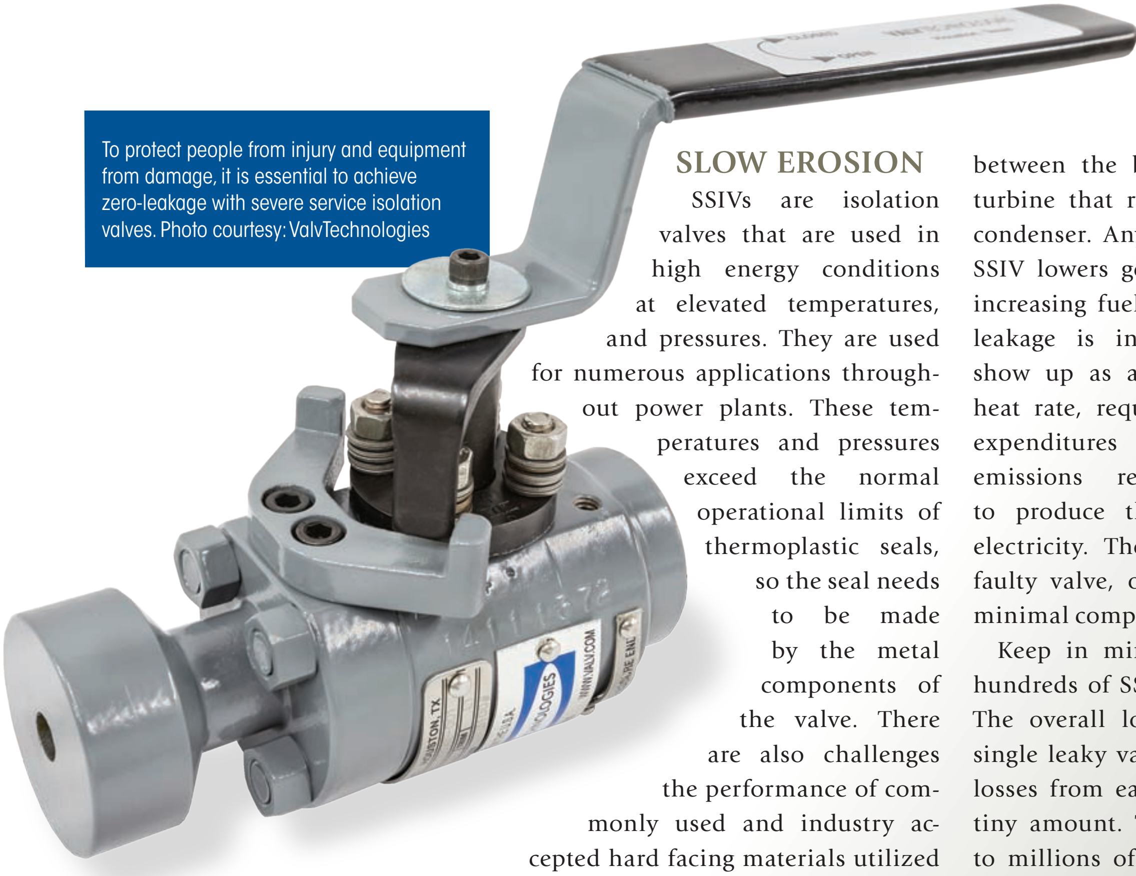


RiTech® hard coating is a high-velocity oxygen fuel coating process using a hot, high-velocity gas jet to spray a coating of molten particles on to the ball and seat surfaces. Photo courtesy: ValvTechnologies

UNCOVERING the Hidden Story of Valve Leakage

BY KEVIN HUNT

History shows us that valve failures can be catastrophic. Although it occurred in 2010, the effects of the Deepwater Horizon disaster can still be felt on the Gulf Coast and in the courts. From April to July of that year, engineers were scrambling to stop the hundreds of millions of gallons of crude being released into the Gulf of Mexico after the blowout preventer (BOP) on the rig failed to seal the pipe. Of course, major disasters are typically preceded by known, but uncorrected errors, and this was not the first time a company had trouble with isolation valves. As *The Washington Post* reported in June 2010, an operational integrity report written in 2001 covering



To protect people from injury and equipment from damage, it is essential to achieve zero-leakage with severe service isolation valves. Photo courtesy: ValvTechnologies

the operations found that, "workers believe internal leak-through of isolation valves is a significant problem and under certain circumstances may pose a potential hazard to workers and equipment."

Such incidents attract a lot of attention, but most leaks are well hidden somewhere deep inside the equipment and piping covering the grounds of a power plant. These valves gradually eat away at performance and profits, a problem that is particularly critical with severe service isolation valves (SSIV). These issues, though, are preventable by using properly designed valves that allow zero leakage. The problem is that "zero-leakage" does not always mean zero-leakage. The usual definition actually means acceptably slow leakage internally, with no visible external leakage. But by applying best available technology and adopting new standards, zero can equal zero, both internally and externally.

SLOW EROSION

SSIVs are isolation valves that are used in high energy conditions at elevated temperatures, and pressures. They are used for numerous applications throughout power plants. These temperatures and pressures exceed the normal operational limits of thermoplastic seals, so the seal needs to be made by the metal components of the valve. There are also challenges the performance of commonly used and industry accepted hard facing materials utilized in high pressure and temperature valve seats. Further complicating the matter, the fluids involved may contain some solid content or abrasive materials that erode the seal surfaces, thereby producing leakage paths.

With SSIVs, the cost of the leakage is far greater than the cost of the valve. High temperatures and pressures coupled with erosive substances entrained in the fluid means that even minor leaks can grow into major ones. This results in unscheduled shutdowns and frequent equipment repair or replacement as well as wasted fuel/process liquids. To protect people from injury and equipment from damage, it is essential to achieve zero-leakage with SSIVs.

Like other valves, leakage can be either internal or external. It isn't difficult to discover external leakage: you can see the cloud of steam escaping, for instance. Internal leaks, however, are entirely different. Take an isolation valve on a bypass line between the boiler and the steam turbine that redirects steam to the condenser. Any leakage though that SSIV lowers generator output while increasing fuel consumption. Since leakage is internal, it may only show up as a gradually increasing heat rate, requiring additional fuel expenditures and accompanying emissions remediation expenses to produce the same amount of electricity. The cost of replacing a faulty valve, on the other hand, is minimal compared to the lost output.

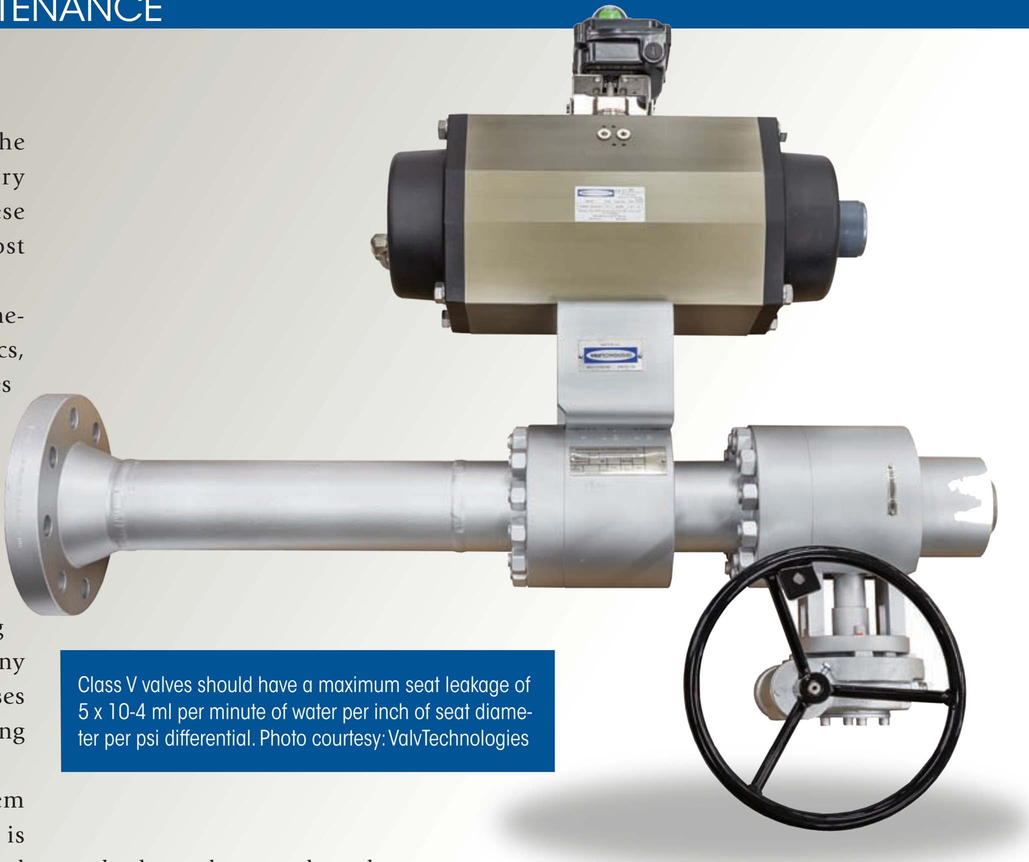
Keep in mind that there can be hundreds of SSIVs in a power plant. The overall losses are not from a single leaky valve, but the aggregate losses from each of them leaking a tiny amount. Together they add up to millions of BTUs never reaching the turbines. Zero-leakage SSIVs can typically improve a plant's heat rate performance from 1-2 percent to as high as 3 percent.

LOSS OF POWER AND PROFITS

To understand the order of magnitude of the losses, consider an industry accepted value of 2 percent in heat rate (efficiency) loss attributable to cycle isolation or passing isolation valves and assume a 300 MWe steam turbine generator.

Further assuming that this turbine generator operates 8000 hours per year at a round-the-clock average wholesale price of electricity of $50/MWh, the resulting loss in profit is $2.4 million per year.

While all valve losses ultimately affect the steam cycle efficiency, the overwhelming majority of the total loss will result from the high energy, sever services such as main steam or high pressure steam,



Class V valves should have a maximum seat leakage of 5 x 10-4 ml per minute of water per inch of seat diameter per psi differential. Photo courtesy: ValvTechnologies

hot reheat, cold reheat and the associated boiler or heat recovery steam generator sections. These high energy systems have the most impact on the output capacity.

Finally, by employing state-of-the-art valve seat leakage diagnostics, the target list of impactful valves can be reduced to the worst of the worst performers. Experience has repeatedly shown that the higher value targets yield paybacks on total replacement cost in the order of a couple of months or less. In any event, the cost of mitigating or eliminating valve leakage is tiny relative to the annual recurring losses which result from poorly performing valves in severe service.

The losses cited above may seem extreme at first glance, but is validated by other well-established research in areas such as leakage through an orifice in a pressurized pipeline, as well as heat and pressure losses in steam traps. Per the ANSI/FCI 70-2 leakage specification, a Class V valve should have a maximum seat leakage of 5 x 10^{-4} ml per minute of water per inch of seat diameter per psi differential (5 x 10^{-12} m^3 per second of water per mm of seat diameter per bar differential). Buying Class V valves, therefore, would seem to eliminate the leakage losses. However, those standards apply only at the point of installation. Over time, the continuous steam leakage past the plug seat erodes the seal, causing steam cutting and wire drawing. What was once a Class V valve evolves into a Class IV, then Class III, Class II or worse. To try to seal against the high pressures (a two inch ANSI 4500 globe valve is subject to up to 19,623 pounds of force), a hammer-blow handwheel is sometime used. This method uses up to 10 times greater torque to drive the plug against the seat, but the method can damage the valve parts and won't stop leakage through an eroded seal. Additional damage comes from vibration, flashing, cavitation and internal erosion.

CREATING A NEW STANDARD

Just as utilities must apply Best Available Control Technologies to eliminate excess emissions, so should they adopt Best Available Isolation Technology (BAIT®) design features to eliminate the problem of erosion and gradually rising losses. Here, for example are some of the elements that make up BAIT® for ball valves:

- An integral seat: The integral seat is part of the valve body rather than a slip-in seat ring. A slip in provides a leak passage behind the seat, which doesn't exist with an integral seat.
- High-strength Belleville seat springs: Belleville springs are cone shaped washers that apply a constant high thrust to create a mechanical preload on the ball and seat, and the packing. By stacking several of the washers, you can increase the deflection, while keeping the load on each washer constant. Use of Inconel 718 produces a high tensile strength (155,000 psi) with a high yield strength (125,000 psi) and high creep strength. This allows a seat spring compression of several hundred psi to fully position the ball against the seat, preventing ball misalignment or vibration and restricting particles from entering and damaging the seal.
- Full alignment/positioning of ball and seat
- RiTech® hard coating: RiTech® is a high-velocity oxygen fuel (HVOF) coating process that uses a hot, high-velocity gas jet to spray a coating of molten particles on to the ball and seat surfaces. Traditionally disks and seats of carbon, alloy or stainless steel are hardfaced, typically by welding on an overlay of Alloy

6, a cobalt-chromium which allows "excellent resistance to many forms of mechanical and chemical degradation over a wide temperature range, and retains a reasonable level of hardness up to 930°F (500°C)". However, above 800°F, Alloy 6 becomes soft and subject to heavy wear and tear and galling of the valve seating surfaces. RiTech® 31 is both harder than Alloy 6 and maintains its hardness at high temperatures. At ambient temperature, RiTech® 31 has a Rockwell C hardness of 72, vs. 39.8 for Alloy 6. At 1400°F, RiTech® 31 has a Rockwell C hardness of 62, compared to just eight for Alloy 6. RiTech® 31 is also self-repairing in operation, so over 1,000,000 valve cycles are possible.

- Mate lapping of ball and seat: The ball and seat must be precisely mated to each other to form a perfect seal. This is accomplished by precision lapping the ball and integral seat for up to several hours on a rotating fixture. The final step involves using a three-micron diamond compound and moving the ball in a figure eight motion.
- Blowout-proof stem: a typical valve stem is externally inserted and uses a slip-on collar held in place by a pin. A blow-out proof stem is internally inserted and has an integral shoulder rather than a collar. Since it is internally retained, it is 100 percent blowout proof.

Adopting BAIT® makes it possible to actually achieve absolute zero-leakage on SSIV. Therefore, is it time for a new valve classification that goes beyond the FCI 70-2 Class VI standard? Introducing a "Class VII" would be zero-visible leakage for a minimum three minutes hydro test and gas test. It's real, it is very achievable and is standard operating procedure for every valve manufactured at ValvTechnologies.

With this new standard, zero means zero, not something that we hope comes pretty close. pe