The Curse of Knowledge & Valve Packing

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In 1996, Idaho National Engineering and Environmental Laboratory's Advanced Test Nuclear Reactor operators manually shut down the reactor after noticing pressure oscillations. A control valve, which was sluggish in responding to input from the pressure control system, caused the fluctuations.

A root-cause investigation revealed that mechanics had adjusted the valve packing gland according to the vendor technical manual during the outage, tightening it because it had a visible leak. The action resulted in higher friction on the valve stem, which caused the valve's sluggish response.

Engineers concluded that the packing requires some leakage or it dries out and prevents smooth operation of the valve. Mechanics loosened the packing to allow for minor leakage and restarted the plant.

As corrective action, engineers contacted the vendor to determine why the technical manual instructions did not include warnings that the packing needs to leak to run the valve smoothly.

The truth is that valve packing does not need to leak to seal a control valve. This particular case is a perfect example of the complex dynamic between valve sealability, gland loading and stem friction. These three values must be balanced to create a valve that can operate leak-free within the actuators' margin window.

When an engineer who has worked on these packing issues for many years and who has gained a wealth of knowledge becomes a trainer, he or she may find it difficult to explain the basic information—not because of lack of knowledge, but because he or she knows too much.

The Curse of Knowledge

This case study demonstrates the "curse of knowledge." These nuclear engineers were not negligent when they came to this conclusion; instead, they mistakenly used a rule-of-thumb applicable to pump packing—packing needs to leak—and applied it to valve packing. They had access to thousands of pages of Electric Power Research Institute (EPRI) and Nuclear Regulatory Commission (NRC) documents about valve packing but instead jumped to a conclusion.

Chip and Dan Heath describe the curse of knowledge in their book *Ideas That Stick* as "once we know something ... we find it hard to imagine not knowing it. Our knowledge has 'cursed' us. We have difficulty sharing it with others, because we can't readily understand their state of mind."

This curse is prevalent in the world of industry training. When an engineer who has worked on these packing issues for many years and who has gained a wealth of knowledge becomes a trainer, he or she may find it difficult to explain the basic information—not because of lack of knowledge, but because he or she knows too much.

What is obvious to one person can be a mystery to someone else. Packing is often overlooked and not viewed as essential to the plant's operation, but the opposite is actually true.

An example of this knowledge curse has to do with gland follower insertion into the stuffing box. Installing valve packing requires many steps that can sometimes be overlooked or not stressed properly during training.

Corrosion-Resistant Paint

One example involves troubleshooting a valve that failed right after it was put in service. The valve, including the gland nose, had recently been painted for corrosion resistance. The valve had been torqued to a value provided by the packing manufacturer but leaked profusely during startup.

A good training program instructs operators on valve maintenance fundamentals and on how to identify problems before valve damage can occur.

Once all the packing was out of the stuffing box, the first step before repacking was to see if the gland moved freely into the box. As it dropped down, it was apparent that the gland and new paint restricted movement.

This resistance was enough to click the torque wrench without applying the load to the packing, leaving the packing unloaded and unable to seal the pressure in the valve. After cleaning and checking that the gland could move freely, the user repacked the valve and placed it into service without any issues. Missing this simple installation step caused massive costs by interrupting plant operation.

Packing Arrangements

Another common problem is poor packing set arrangements that result in the gland follower bottoming out on the top of the stuffing box. When this condition occurs, no load can be further transferred to the packing because the gland is metal-to-metal, and more force on the gland bolts strains the gland, not the packing. This condition can result in uncontrollable leakage.

The principal problem is the incomplete training of operators who adjust the gland followers during the course of the packing life. Training programs often lack an explanation of the damage that over-straining the bolts can cause once the gland is bottomed out. This results in serious metal damage such as bent gland flanges, worn inside diameters of gland followers and even bolt breakage. A good training program instructs operators on valve maintenance fundamentals and on how to identify problems before valve damage can occur.

In addition to knowing how to handle the situation mentioned above, users must know how to prevent it. A large percentage of valves that are bottomed out prematurely have a poor packing stack-up design.

There are two main causes for this problem. The first problem is having too many rings in the stuffing box (five to seven rings maximum), resulting in too much of the gland nose being engaged during consolidation and not enough left for service life. In this case, the user should consider retrofitting the valve with a carbon spacer to shorten the stuffing box.

The second problem is a short gland nose on the valve in relation to the packing cross section, which can leave little gland nose after installation. In this case, the arrangement can be configured to maximize the gland follower by shortening the stuffing box and installing the last few rings after the first rings are compressed. One more important step that is often overlooked because of the knowledge curse is ensuring that everyone who installs packing understands the environment in which the packing is being installed and the product's physical and thermal limitations.

Product Limits

An example of exceeding product limits happened at the McGuire Nuclear Station in 2005 when a main steam isolation valve failed to close.

The failure occurred when the polytetrafluoroethylene (PTFE) packing extruded and caused excessive corrosion from the release of fluoride gas. This, in turn, resulted in the valve failing to actuate properly. The root-cause investigation revealed the packing material's thermal limits had been exceeded and the material's breakdown caused the failure.

Thermal Limits

Another common problem is choosing the packing based on the system temperature, not the design temperature. In the case of PTFE, operation only a few degrees above its thermal limit makes the product become ineffective in sealing. At certain plants, the valve can exceed operating temperature when the system is upset, pushing the design limits.

Regarding PTFE temperature limits, one of the best success stories is the implementation of American Petroleum Institute (API) fire testing. Some refinery process streams ignite at atmospheric pressure. When these gases leak out, they ignite spontaneously. Because the process is at room temperature, valves are often specified with PTFE packing. If a leak occurs, the flames make the equipment glow red and heat the pipes. By the time the plant's fire department can arrive and start controlling the fire, the heat from the faulty equipment could travel up the pipe to an adjacent valve that was sealing perfectly. Because of the leaking valve's excess heat, the PTFE packing can overheat, fail and become engulfed in flames.

When this hazard was identified, it needed to be addressed by a specification that not only included the application's pressure and temperature limits but also the possible conditions in case of a fire. As a result of this occurrence, API specified testing to confirm packing performance during a fire.

This excluded PTFE packings from certain applications and has had cascading effects on actuator sizing for these valves when switching to a higher friction packing.

Conclusion

These scenarios demonstrate that basic packing information cannot be taken for granted and can greatly affect a plant's safety and reliability.

Additional resources for this type of comprehensive knowledge can be found on the Fluid Sealing Association website, fluidsealing.com. The FSA and its members can assist in training and have manuals on valve packing and installation. ■

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