Reality Based Sealing: A Survivor's Guide

By David Reeves

Valve packing leaks are a continual problem. They lose your plant money in lost product, can be a health and safety hazard, and can even get your plant shut down if you run foul of current legislation. If you believe the sales talk, there are plenty of products that can help you. Or can they? David Reeves, with almost 25 years' experience in the petroleum industry, gives some hard won tips on beating emissions. "Data is the key to ensuring reliable performance."

If you are an OS&Y (Outside Screw and Yoke) valve packing end user like me, you have probably had a packing sales person in your office recently who sounded like they had the best product on the market. The sales person probably showed you test results from their own company's testing to support their claims, and gave you several testimonials about how well the packing is working for XYZ company. As you listened, in your mind, you probably tried to compare this new material to some material you have experience with, and wondered in the end how each sales person always manages to have "the best" material for your application. If you have much experience, then at some time or another you will probably have put in a new material only to have it fail.

The entire science of sealing has gotten more complex with the passage of tough environmental laws. In the days of asbestos, a leak was something you could see. Now we use high tech equipment to measure PPM leakage rates to stay in compliance with environmental laws. Vendor product lines have improved to meet these new challenges, but the addition of so many new products adds to the level of complexity.

The bottom line is that if you can't effectively manage material evaluation and change within your company, there are lots of people willing to step in to help you. However, you might not like the results. Most sales people do not have the technical depth to completely understand every aspect of their own packing material, or to completely understand your application. You have the responsibility to figure out which packing material will work best in your application. Guess wrong, and you expose yourself to a range of safety and environmental problems. If you go back to your packing sales person after a failure, they will probably provide a list of things YOU did wrong when installing the material.

Testing

Testing has to be done to predict a material's ability to maintain a tight connection under your operating conditions. This includes end user testing, vendor testing and independent third party testing.

Tests can be run in a laboratory or in-situ, but they must mirror the worst possible process conditions that the packing is likely to be exposed to. "Testing" will be done one way or another.

The question is, do you want to do the testing where conditions are controlled, or do you want to do the testing in your plant the first time you install the material? End users can avoid unexpected problems by following a few simple steps:

- Keep asking questions until you know how the material is made, and every component that it contains.
- Insist that the vendor supply test results, with real data (not testimonials or "war" stories) to back up and support whatever claims they make.
- If there is any doubt in your mind that the test results might not be applicable to your process conditions, have additional tests run that match your process conditions.
- And finally, and most importantly, vendors need to supply independent third party test results that will directly compare their material to the other materials you are interested in, as well as the material you are presently using. This is the only way to factually document performance differences, and every material is different.

End users will only get the data they demand. A credible vendor that has the same interest in your company that he wants you to have in his company, will work closely with you to supply the information you need, so both parties will be successful. If a vendor is unwilling to test, then there is no reason for you to continue to consider their products unless you want to accept all the responsibility for the outcome when you "test" the material the first time you put it into your plant.

The most effective relationships between vendors and manufacturers are formed when the two companies come together in a partnership. In every case I have found that both companies come out ahead. The vendor is in a position to gain an excellent understanding

of the end user's problems and challenges. Vendors also get a clear idea of how their products perform in the long term and, from this, have the opportunity to make improvements that will improve competitiveness in other markets. The partnership must be based on performance, and must be open to the consideration and evaluation of all materials that might meet the end users' needs. If the material being considered is not performing as expected, move on. If done correctly, the end user ends up with a product line that is the best available. Until a product has gone through the entire process of being installed in your plant, by your plant's mechanics, and watched closely for a reasonable length of time, its true performance cannot be understood.

Case history I

The refinery where I work had been using a particular packing for years. This material was also highly recommended by the contractor responsible for re-packing our valves during

In comparative testing in a coker plant, 71% of block valves with the 'old' packing were found to leak after seven days as opposed to 16% packed with a new material.

major shutdowns, but our data suggested that there was a problem with this material. After a lot of research, discussion, and with reputations on the line (which is what it takes sometimes to implement a change), we put a new material into a delayed coker plant. To document the performance differences, we repacked half the block valves on three furnaces with the old material, and half with the new material, using the same person to do all the packing. Both materials were considered to be "graphite packing." The old material **claimed** a "Non-Oxidizing" temperature limit of 5400°F, while the new material claimed a "Non-Oxidizing" temperature limit of 800°F.

(Note: the term "Non-Oxidizing" is misleading. At high temperatures, the packing will pick up oxygen out of the air from the end of the packing gland that is exposed to the atmosphere. Graphite starts to oxidize at 650°F, while inhibited grade graphite is rated for around 850°F. The effects of oxidation on graphite are one of the most hotly debated and misunderstood concepts. The amount and speed at which oxidation takes place is impossible to predict as it depends

"Our experience and testing shows that the combination of die formed packing with braided end rings is problematic."

on the process temperature, form and quantity of oxygen that is present. Chemical oxidizers raise another set of concerns.)

After seven days of operation, 71% of the old material (with the 5400°F rating) was leaking, versus 16% of the new material. We changed packing materials refinery-wide, and the contractor made the same change. From this test we also determined how to get 100% leak free operation from this new material. Several other facilities are also making changes in the packing materials they use and the way they install them.

Case history II

In the past six months this facility has had five valve packing failures which have resulted in three plant shutdowns. All five failures share the same root cause: Die formed packing rings which disintegrated when the braided end rings suffered a major temperature induced relaxation cycle. This causes a major loss in stud load. All these packing materials were supplied by the original valve manufacturer and approved for the temperature (between 300°F and 600°F) and process conditions.

Our experience and testing shows that the combination of die formed packing with braided end rings is problematic. Once a leak starts, the die formed rings can quickly get shredded by the process that is leaking. A small leak can turn into a major leak before a mechanic can tighten the gland. Braided packing has a high enough internal strength so that there is usually plenty of time to stop a small weeping leak before it turns into a major event. This conflicts with what many OEM's would suggest, as many of them use die formed packing with braided end rings in new valves. This difference results from the fact that real field conditions are much different than the controlled lab environments where valve manufacturers do their testing. Valves in the field wear and corrode as a normal result of usage, and so tolerances will change over time. This is a problem as tolerances must be very close for die formed rings to work. Changes of as little as .002 of an inch in the stuffing box or valve stem diameter, or a changes in the valve stem finish from an original 16 rms to a 32 rms, will have a major impact on die formed ring performance. Some valves do not even hold tight-enough tolerances when they are originally manufactured.

We have had a much better success rate with valves that we repack ourselves in the field with braided packing, either with in-plant mechanics or the outside contractor we use during major shutdowns. We therefore have much better control over which packing is used to repack valves than we do over the packing used by valve manufactures. Because of this performance difference, I will be working with all our valve suppliers to see if we can get the same new material we use to repack valves in the field installed into new valves. If this is not possible or cost effective, we may follow the example set by the nuclear industry some years ago, and repack all new valves before they are put into the field. We have found that refinery-wide, we need only three materials to meet our OS&Y sealing requirements. We cannot stay competitive if we keep having plants come off-line after the packing in a new valve has failed.

Product stability

Vendors can sometimes confuse or mislead end users. You have to be careful. Vendors may claim their graphite will take 5,000°F,

but won't volunteer information as to how long it will work at this temperature, or in what environment, or supply the long-term test results to back up the claim. A vendor might tell you that they use a "high density" graphite, but neglect to tell you that it is a man-made graphite filament yarn that only has half the density of expanded or flexible graphite that is mined out of the ground. It is the difference between "weight by volume," as opposed to how dense or compacted the material is.

End users buy and install packing materials, yet even after they fail to provide the expected long-term performance the end user is likely to continue to purchase more of the same material. There is a great resistance in the world to change. Generally people are more comfortable with known (and to some degree accepted) failures rather than take a chance on changing to a new material. Unfortunately, many facilities lack the ability or interest to even track the performance of sealing materials. Would we settle for the same performance and reliability from our personal possessions, like our car, as our facility accepts in packing performance?

"Overall, this facility has dropped its total leak repair costs (packing included) by almost 60%."

Regardless of the sealing material, the single most import quality is the level of stability that the product has in the application. Stability has two forms, the ability to maintain load, and the ability to resist over-compression. As an example, packing materials like JM Clipper's CW2000 has an advantage as it has a more ridged core of carbon fiber, which also contains a single strand of wire, totally encapsulated by graphite, to improve density. Flexible graphite is then re-introduced to fill up the voids created by the braid, which is typically the downfall of all braided packings. This gives the packing a more stable foundation to support the outside graphite layer which provides the sealing, as well as resisting over-compression from over-tightened packing gland nuts. Packings made this way relax less, can tolerate significantly greater stuffing box tolerances, and are much more stable over long-term operation.

Key hints in plugging those leaks!

- Reliable, application-specific data is essential to make informed selects
- Die-formed packing rings may disintegrate in service
- Internal strength of braided packings found to be an advantage
- Packing materials with rigid cores provide better stability
- Get your valve supplier to pre-install your packing of choice
- Effective packings can save substantial sums!

The way forward

The way sealing materials work is much more complex than a casual review might indicate. The Pressure Vessel Research Council (PVRC) has spent a number of years studying gasket materials in the United States, and has published their test results. PVRC and is now working with CETIM, which is its European counterpart. Sadly, this same effort has not been undertaken in regards to packing. So far, there are no industry-wide, recognized standard tests to qualify the properties of packing materials. However, this is changing. A group of European companies (the CAPI Group) came together and created a group of tests performed by Akzo Nobel in the Netherlands. These tests have been reported on by *Valve World* Magazine [see Vol 3, Issue 3 (June 1998), p 61; also Vol 4, issue 4 (Aug 1999), p 37]. This is the best packing test I have seen so far, and the data is excellent. It is a little difficult to get the results, as the test results are reported back to the manufacturers. Unlike PVRC's gasket test results, you have to know which manufacturers were tested, and ask them for a copy of their Akzo Nobel test results. (As an example, JM Clipper tested CW2000 and is willing to provide the results.) Manufacturers that did poorly on the test are much less willing to share the results. The only downside to the test is that it only goes to 150°C (302°F). I would much prefer to see packing materials tested at whatever temperature the manufacturer claims the packing will withstand, or the maximum temperature the valve is rated for. Also, there is currently work going on to develop several international standards. CETIM in Europe has been working with several manufacturers to develop an industry approved test for qualifying packing materials. It is currently an ISO draft. Their efforts should be applauded and supported by end users. However, generally these tasks are much more heavily supported by packing manufacturers than end users, which can result in end user concerns being overlooked. The competitive advantage to end users in being able to effectively manage packing and sealing issues is considerable. Overall, this facility has dropped its total leak repair costs (packing included) by almost 60%. That is enough money to hire 6 new engineers and pay their salaries and benefits for a year. This amount pails in comparison to the amount it costs if a plant has to be taken off-line after a packing has blown out of a valve. Depending on the damage that is done, and the length of time the plant is off-line, these costs can easily be in the millions of dollars.

"Refinery-wide, we need only three materials to meet our OS&Y sealing requirements."

So it's your choice: either take control and demand the data you need to ensure predictable performance in the field, or deal with the consequences. ■

About the author

David Reeves has spent 24 years working for a major petroleum company, including 13 years at their research facility. Following 5 years of research he pioneered technology that eliminates large diameter exchanger leaks and is heavily involved in sealing issues on a daily basis. He has rewritten the technical standards and procedures that affect sealing across most refinery applications.

The author expresses his appreciation to Rodney Roth for his technical contributions.