Assessing fugitive emissions performance in valves and packing

By David W. Reeves (ChevronTexaco Refining), J.W.(Bill) Ross, P.E. (ChevronTexaco Refining) and Matt Wasielewski (Yarmouth Research).

This paper describes a simple test and testing procedure for valve emissions developed by ChevronTexaco together with Yarmouth Research. Also presented are the results of various tests run on valves typically found in refineries. The authors conclude that, with today's technology, it is possible to significantly reduce fugitive emissions to the point where almost all valves should remain in compliance. ChevronTexaco's Testing Procedure is included as an Appendix.

If you are a refinery end-user that has to comply with environmental regulations for fugitive emissions, you know how important it is to select valves that will meet or exceed Volatile Organic Compound (VOC) fugitive emission limits. You also know the costs involved when a valve fails to meet these limits, and how hard it has been to get test data that will allow direct comparisons between valve and packing manufacturers. Without data that can be used to directly compare performance results, end-users are left with educated guess work, field trials and past experience from others as a basis for their valve and packing selection decisions.

While most end users would like to see realistic testing done that will provide comparable VOC results in ppm levels of hydrocarbons, and include multiple thermal and mechanical cycles that are representative of real plant operating conditions, up to now this testing has not been easily available from an independent laboratory at a cost effective price. That has now changed.

ChevronTexaco, together with Yarmouth Research, has developed a simple test and testing procedure that can be easily adjusted to accommodate any off the shelf valve and provide the VOC data needed to understand how a valve is likely to perform once in service. For the recent set of screening tests performed on valves from five major US valve suppliers, an off-the-shelf four inch class 300 valve was used with methane gas at 600 psi (41.37 bar). A stuffing box temperature of 500°F (260°C) was obtained every 500 cycles, and the test was run for 5,000 cycles or until a leak rate of 500 ppm was reached for the third time. Not only was each valve's original OEM (Original Equipment Manufacturer) packing tested, but a second valve was tested using off the shelf spool packing that might be used for repacking valves in the field. Both packed valves and bellow seal valves were tested, along with different packings from major suppliers and small bore forged steel valves. The results are amazing. No two valves performed the same, and there exists a very significant difference in VOC performance. As an example, two new four inch packed valves failed to complete the first 500 cycles without leaking >500 ppm. Only one new packed valve made it the entire 5,000 cycles. Spool packing results were equally diverse, with one packing only lasting 1,000 cycles while another packing combination went 5,000 without ever exceeding 500 ppm.

This type of testing benefits end-users by providing the data they need to reduce plant emissions and negative environmental impacts, as well as reducing maintenance costs and environmental fines. It also benefits the manufacture by providing a relatively inexpensive way to obtain comparable product emission performance results which can lead to valve designs with lower emissions levels.

Refinery data

A large refinery study was undertaken over a 3-1/2 year period which covered five plants and 15,042 fugitive emission components. The components were broken down into 37 different categories. These components were required to be sniffed once every quarter, and each component was required by local Air Quality District rules to remain below a VOC limit of 1,000 ppm. (This limit has now dropped to 500 ppm for Southern California and 100 ppm for Northern California, USA.)

In order to gain as much information from the study as possible, components with readings of 100 ppm or more were studied. Of the 37 categories, 9 categories contributed a combined total of 81.1% of the total number of readings of 100 ppm or more. (See Figure 1: Component leak rates.) The highest single source over 100 ppm was "Gate Valve" packing at just over 10% of the total number of monitored valves in service for the 5 plants. Once the number of repeat readings is factored in, this category accounts for just over 33% of the total readings over 100 ppm. If we look at all valves for the 5 plants, we find that this category accounts for just over 45.5% of the total readings over 100 ppm. (See Figure 2: Component leak rates.)

The likelihood of getting a second high ppm reading on a component after the first reading has been recorded is pretty significant, unless steps are taken to reduce the reading. Of the 1,137 components with readings over 100 ppm, 454 recorded a second reading over 100 ppm during the study. (See Figure 3: Components with multiple readings over 100 ppm.) This works out to a ratio of 1 in 2-1/2, or 40% with of the components with one high readings can be expected to have high readings a second time.

However, if we look at just the number of components with readings over 1,000 ppm, remedial action would have only been required by local rules on 283 of these components (or 1.8%). Of these, only 27 had a repeat reading over 1,000 ppm. ▶

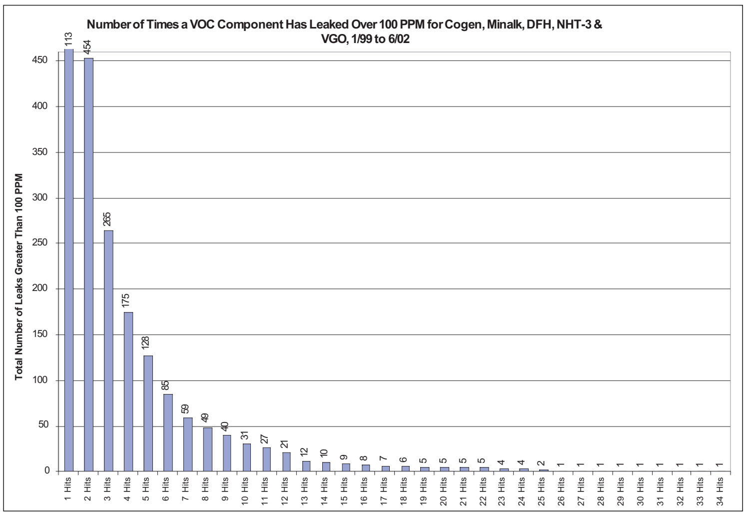

Fig. 3: Components with multiple readings over 100 ppm

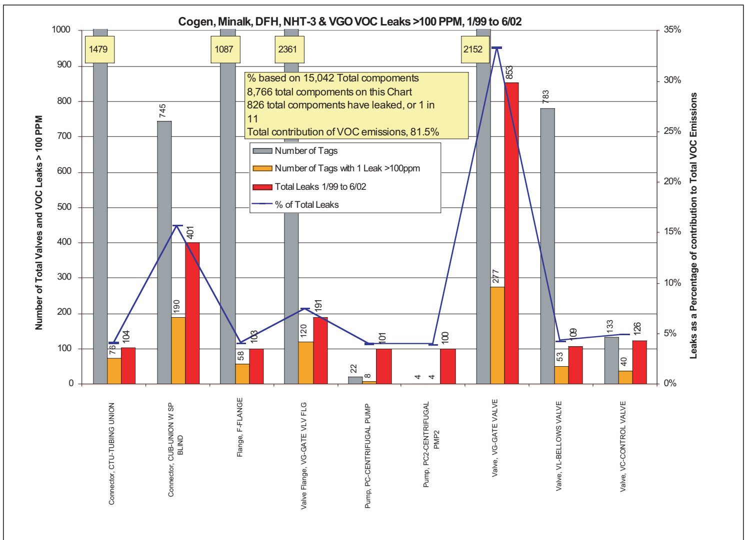

Fig. 1: Component leak rates

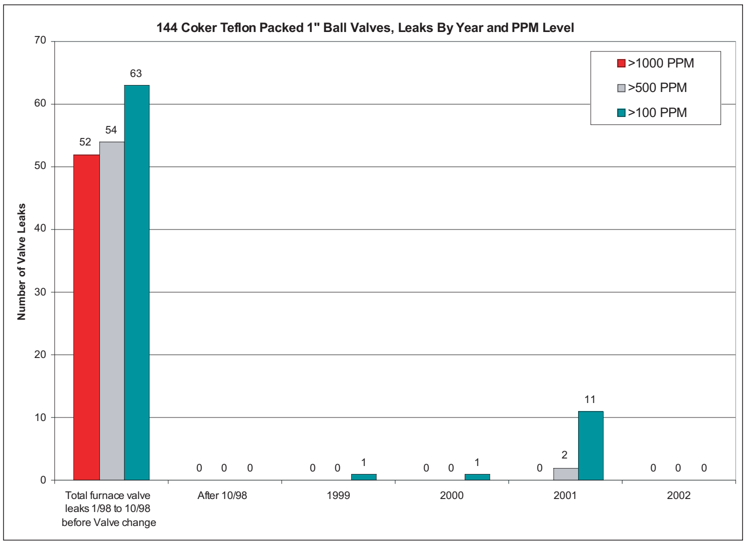

Fig. 4: Components with multiple readings over 100 ppm

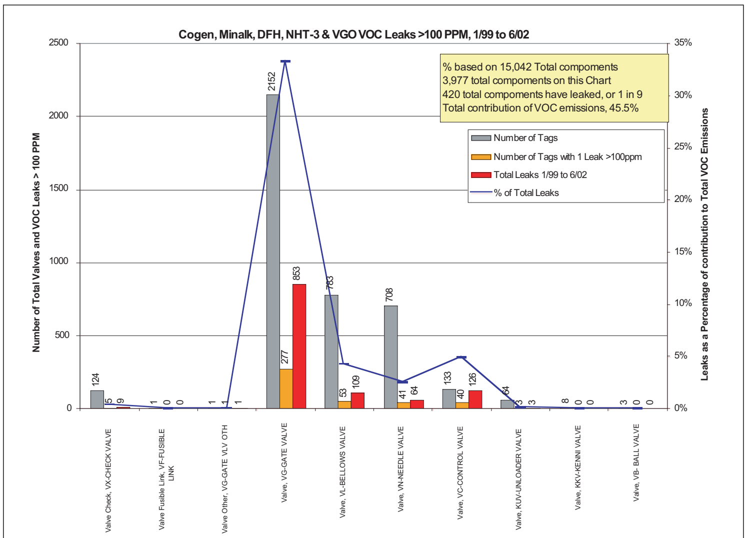

Fig. 2: VOC leaks for all valves

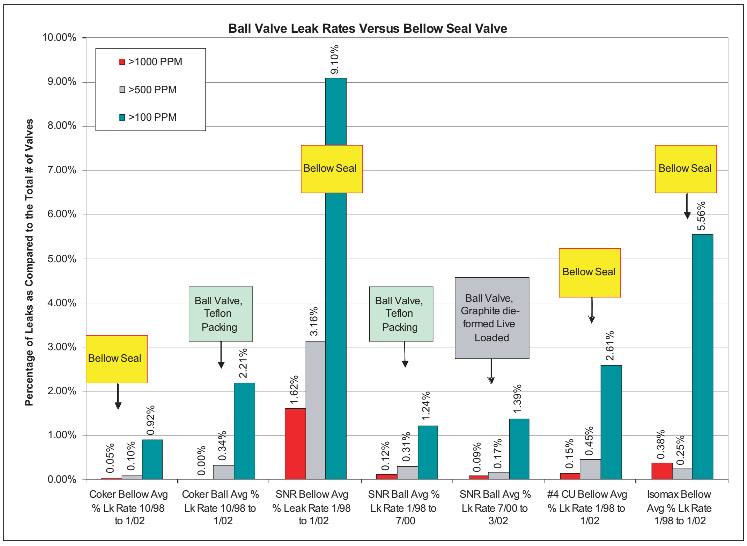

Fig. 5: Ball valves versus bellow seal valves

In a separate study, a close look was taken at burner supply valves in several different furnaces. In the first part of the study, we found that significant reductions in VOCs could be achieved by changing from plug valves to ball valves. Ball valves were then compared to bellow seal valves. (See Figure 4: Ball valves versus bellow seal valves.) Surprisingly, in most cases, ball valves recorded lower VOC levels than bellow seal valves.

The impact of non-compliance

Once a facility installs a valve in a VOC service, the facility, not the valve's manufacturer, is held responsible for the valve's VOC performance. Each reading over the mandated VOC threshold is expensive. Depending on local Air District or EPA rules, and the VOC reading that was recorded, corrective action must be taken to bring the reading back into compliance within a given amount of time or the plant may be required to be shut down. Simple adjustments to bring a valve back into compliance might cost several hundred dollars (or more than the original cost of the valve), where more complex remedies such as injections, wire wraps and clamps can cost several thousand dollars. In addition, the facility must self-report all violations which then become a matter of public record. A poor environmental record can affect operating permits and applications to expand facilities, not to mention the negative impact it can have on public relations. In addition, at the end of each year, the facility can be assessed fines based on the number of self-reported violations.

Valve manufacturer packing warrantees are usually limited to replacement of the packing set. They do not cover the cost of installation, any corrective action to keep the valve in compliance, plant down time, damage to the plant from a packing failure, the impact to a facilities environmental record or the cost of any associated fines or notices of violation. It is therefore in the best interest of each facility to carefully review each valve's VOC performance before deciding on which valve to accept.

Unfortunately, this has been very difficult to do. Decision makers generally have had to rely on vendor information and educated guess work as comparative testing has not been available that will easily allow direct comparisons to be made between manufacturers under realistic operating conditions.. A lot of the testing that has been done has been at temperatures and pressures below what the valve is rated for, and on testing mediums like helium that do not necessarily provide useful information to end-users or their regulatory agencies. Facilities that are capable of doing VOC testing are hard to find and expensive. It can cost over USD ▶

Fig. 6: Valve prior to testing

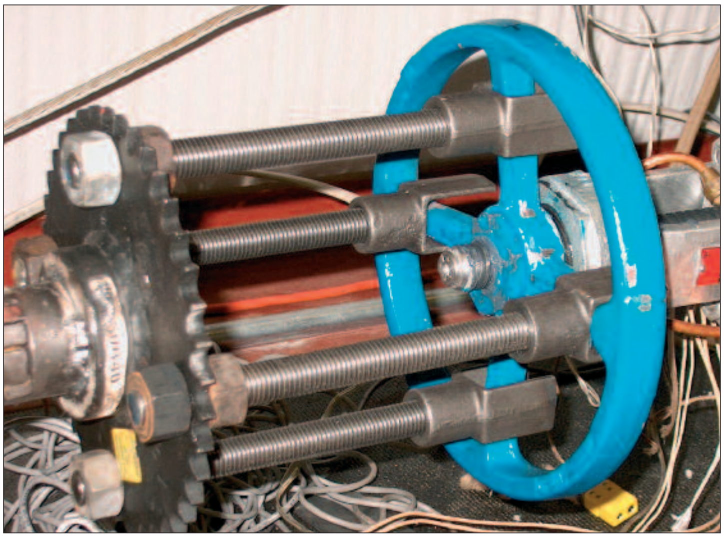

Fig. 8: Handwheel connection

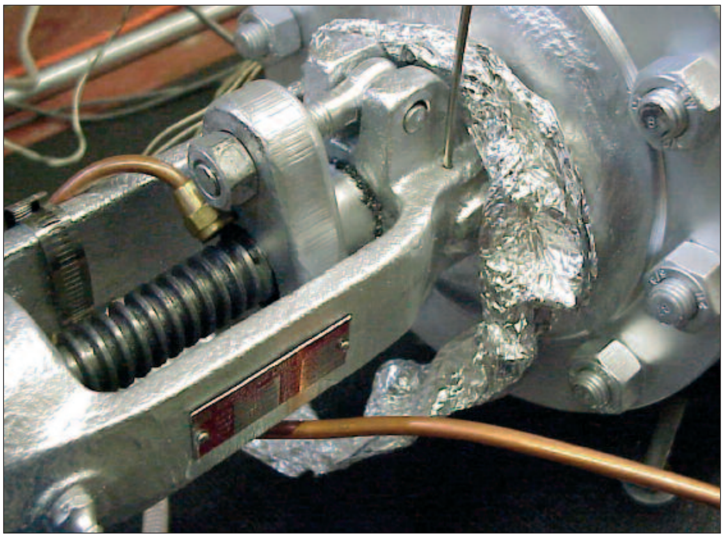

Fig. 7: Sample collection tube and thermocouple in packing gland

Fig. 9: Overview

100,000 just to get a test rig built. Then there is the issue of who will pay for the testing and if it is really needed.

VOC testing: keep it simple, make it real

In designing a test to distinguish differences in VOC performance, several objectives were identified:

Testing has to be done at the valve's maximum pressure rating and with a stuffing box temperature that is representative of the maximum temperature that is likely to be found in the field. After surveying valves in our hottest plants, 500°F (260°C) was established as the upper limit for the stuffing box. Packing materials must be able to handle the complete range of operating conditions that a valve is rated for. Testing to less stringent conditions will not provide accurate data over the entire range of operating conditions that the valve might be exposed to.

Testing must be done on methane gas. The object is to reduce hydrocarbon emissions. End users need data that directly addresses the emissions they are concerned with. Reliable and industry recognized conversions are not available to convert helium mass flow or ppm levels to equivalent hydrocarbon ppms. Articles have been written suggesting that helium has a drying effect on stems and can affect a packing's performance.

Off-the-shelf valves must be used for testing. Test fixtures have their place and have been used to provide important data, but the complete valve assembly must be tested to gain an accurate understanding of relative VOC performance. Valves should randomly be selected off the distributor's shelf to insure a representative valve is obtained that has gone through all the normal production, QA/QC, testing and distribution steps.

A recognized method for measuring emission levels in ppm must be used. EPA Method 21 is widely recognized and accepted in the USA and other countries.

Multiple temperature and mechanical cycles must be used. Graphite is more effective at sealing at elevated temperature than at room temperature. A good packing can handle both conditions. Packings need to be able to adjust to temperature changes while remaining thermally and mechanically stable in the stuffing box. Packings that are too soft can be extruded or wear quickly. Packings that are too hard can cause stem damage.

Valves must be mounted in the most demanding orientation. For most valves, this is where the stem is horizontal. Many valves in production facilities are installed in this orientation.

Two valves should be tested, one with the OEM packing "as delivered," the other with whatever spool packing is likely to be

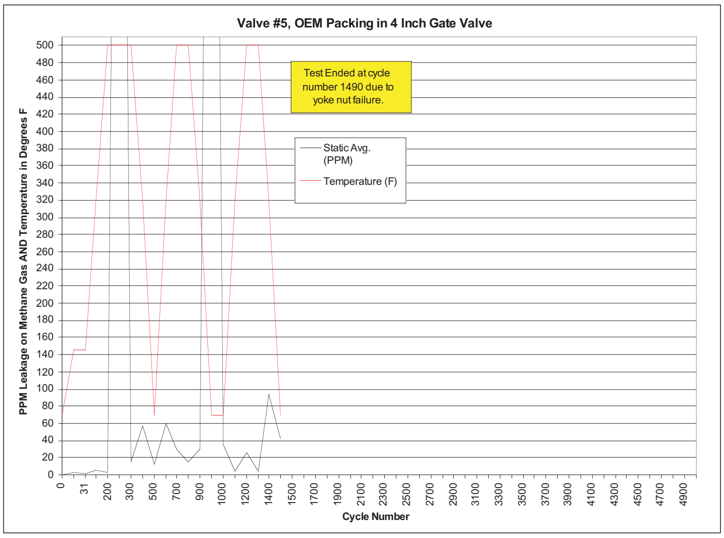

Fig. 10: Test valve #5

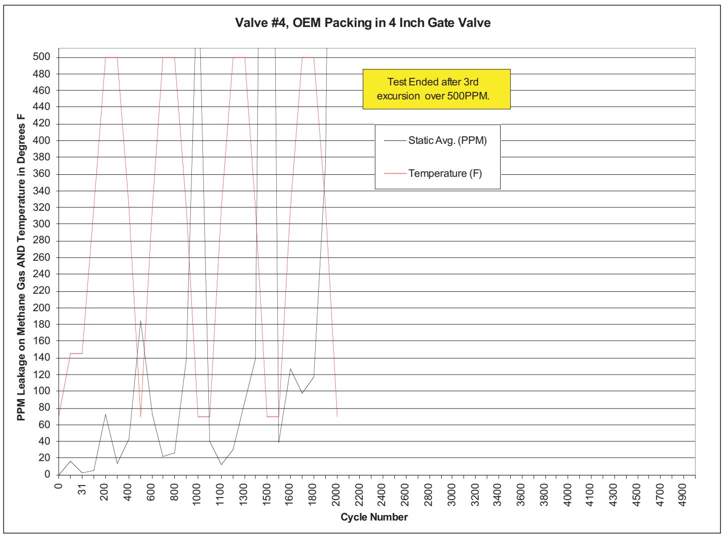

Fig. 11: Test valve #4

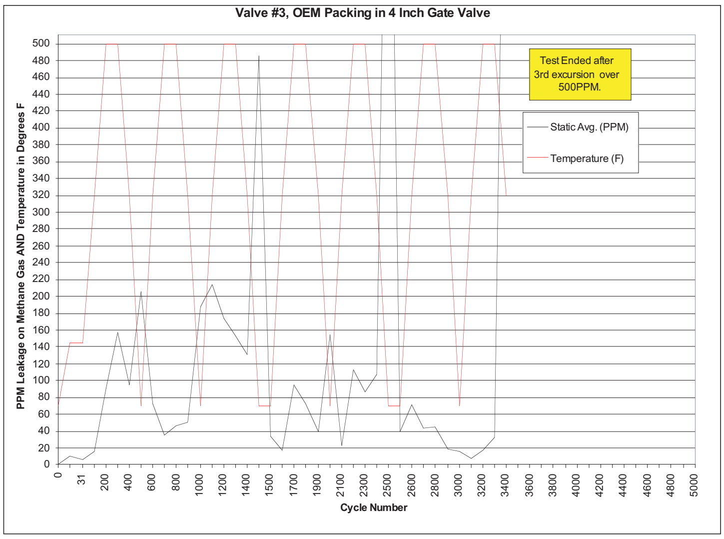

Fig. 12: Test valve #3

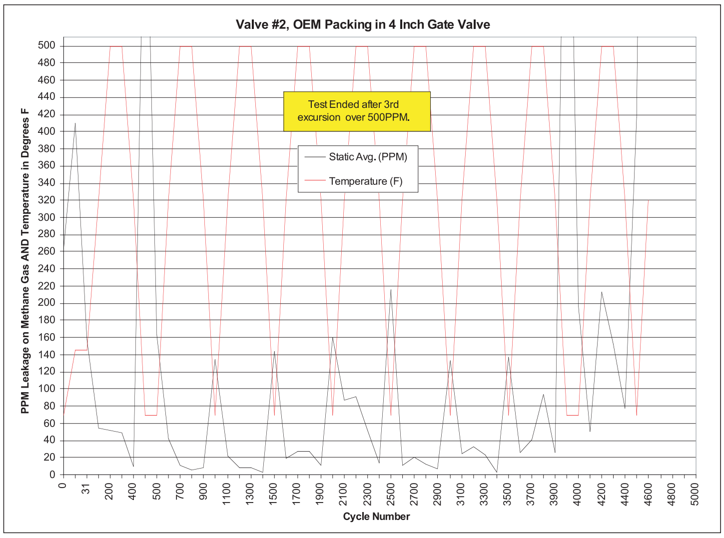

Fig. 13: Test valve #2

used during servicing in the field. A valve needs to provide low VOC emissions with both materials and be serviceable in the field. This second test has provided a wealth of comparative data that in many cases has shown that VOC performance in a new valve can be greatly improved by changing packing materials.
The test fixture should be simple to construct and relatively inexpensive to operate. This will provide the greatest value to manufacturers in the development and screening of packing materials, as well as to end users who wish to do their own testing. The drive mechanism that connects to the hand wheel must not induce side loads on the stem shaft.
Packing gland studs should be retightened early in the test back to the manufactures recommended torque value. All graphite materials relax, especially when heated. This will provide each packing with the best possible opportunity to perform at its highest level. When the maximum allowable ppm level is reached, the gland studs should be tightened to lower ppm levels back to an acceptable level (less than 100 ppm). In the field, retightening the gland nuts is generally the first attempt that is made to bring valves back into compliance. A good packing will have the resiliency to reseal against the stem and will continue to provide excellent long term emissions performance.

The entire test procedure that was used is included at the end of this paper (see Appendix: Testing procedure).
Figures 6 through 9 show the test setup. Figure 6 shows the valve bolted to the bench with blind flanges installed prior to testing. The valve is pressurized with methane through the top blind flange. The next picture (Figure 7) shows a close-up of the collection tube. In a deviation of Method 21*(EPA Method 21 does not require bag method testing), the entire packing glad area is wrapped with aluminium foil. This gives very consistent and accurate readings, while holding the area at a consistent temperature, without having to disturb the heaters and insulation while the valve is cycling. The aluminium foil also provides some protection against air movements that can affect readings.
Figure 8 shows one method of connecting the motor driven shaft to the valve's handwheel. Finally, Figure 9 shows the complete test setup. Note that two valves can be tested at the same time, both opened and closed with the same drive motor. The valves in this test have already been wrapped with insulation.

Valve test data and results

Valves were tested from five different major suppliers of outside stem and yoke (OS&Y) valves. These valves were randomly se-

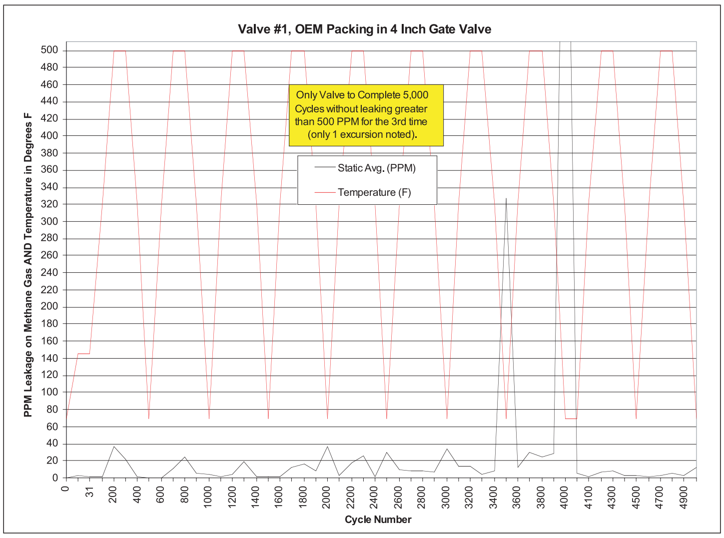

Fig. 14: Test valve # 1

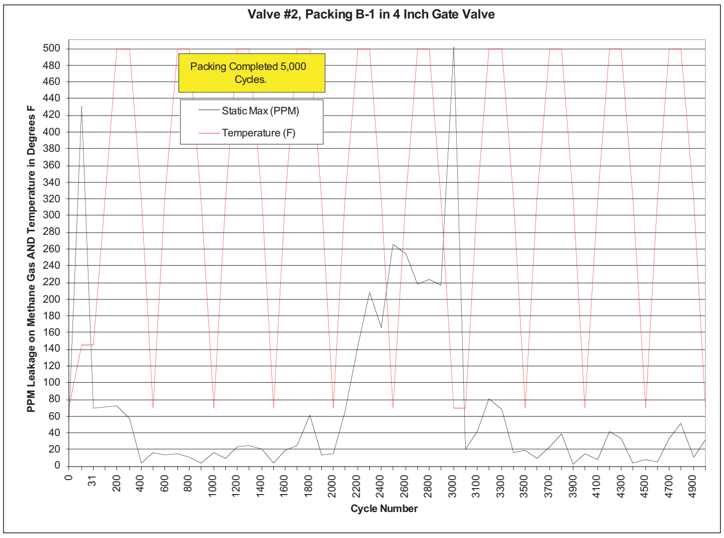

Fig. 16: Test valve #2 with packing B-1

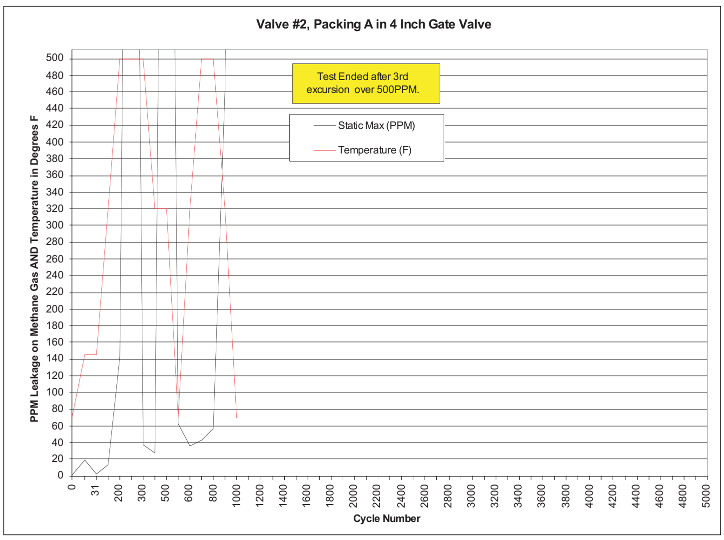

Fig. 15: Test valve #2 with packing A

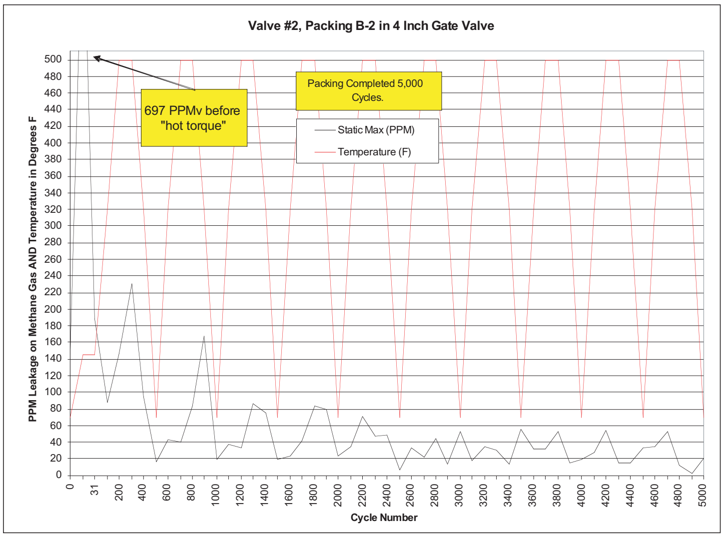

Fig. 17: Test valve #2 with packing B-2

lected off the distributor's shelves and sent directly to Yarmouth Research, in Yarmouth Maine, where the testing was conducted. For this report, the valves have been numbered 1 through 5, in the order of their relative performance. See Figures 10 through 14.

Packing tests were then conducted using "Valve #2" from the original screening tests above. A standard spool packing, generally considered to provide excellent performance in the field was tested first (see Figure 15). The end user, among others, was surprised by the results. The low initial ppm readings are a plus, given that most valves will not operate 100 times over the period of their lives. However, the long term performance of this packing is questionable, given its inability to withstand multiple mechanical and thermal cycles.

Two tests were then conducted with a competing spool packing (Figures 16 and 17). The results were equally surprising, given that this spool packing has been on the market for some time. The problem with the packing is the high initial ppm levels. The impressive result is that once the packing seems to fully seat, it has the ability to complete the entire 5,000 cycle test with relatively low ppm levels. Comparing the two sets of results will give the reader some idea as to the reproducibility of the testing.

Up to this point we found one packing that seals well initially, and another that has the ability to accommodate multiple mechanical and thermal cycles. Wouldn't it be nice to find a packing combination that could do both?

This was successfully accomplished in the next test by combining the two packings into the same stuffing box (Figure 18). The results are the best to date for any OEM or spool packing that has been tested. When compared to the initial OEM valve test results, they also challenge the notion that die-formed rings will provide a better seal than spool packing in new valves. Each of the OEM valve sets contained die-formed inner rings with some kind of braided end rings from various manufacturers. The data tends to suggest that these dieformed rings lack the resiliency to accommodate temperature changes and numerous mechanical cycles.

The results in Figures 13, 15, 16, 17 and 18 are all from the same valve (new valves or stems and bonnets for each test). This dramatically shows the impact that packing systems have on a valve's VOC performance.

Figures 19, 20 and 21 cover the inexpensive small bore forged API 602 gate valves from three major suppliers. The results show that the valves did not make it past one temperature cycle. ▶

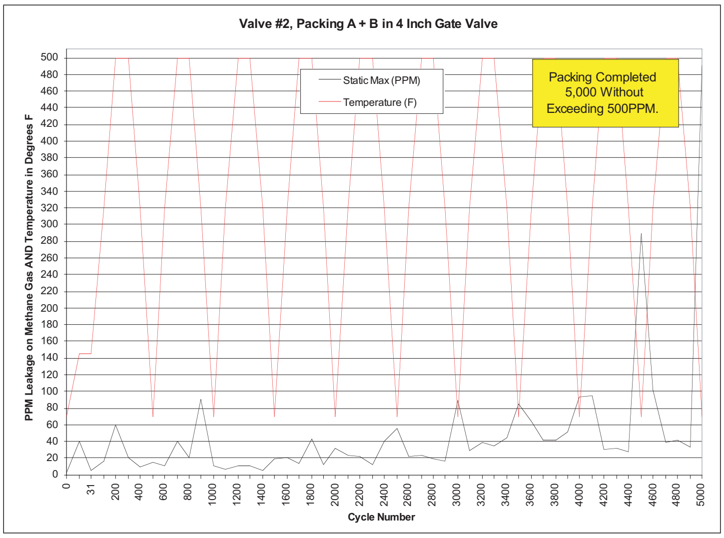

Fig. 18: Test valve #2 with A plus B packing

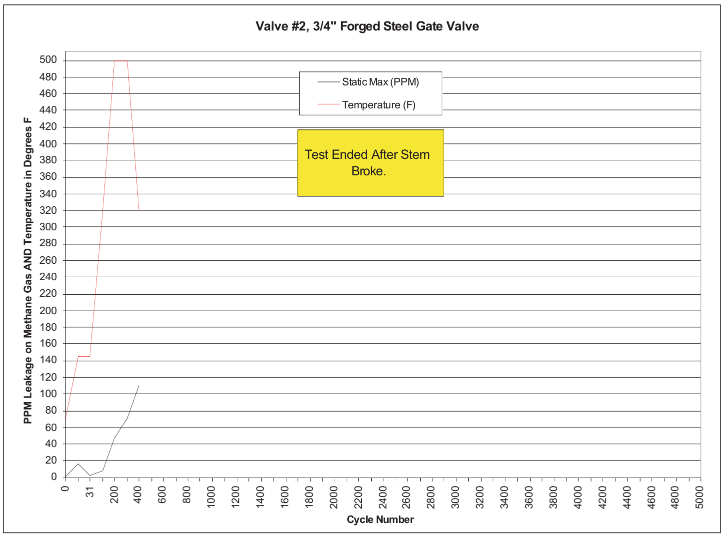

Fig. 20: Valve #2, 3/4 inch forged valve

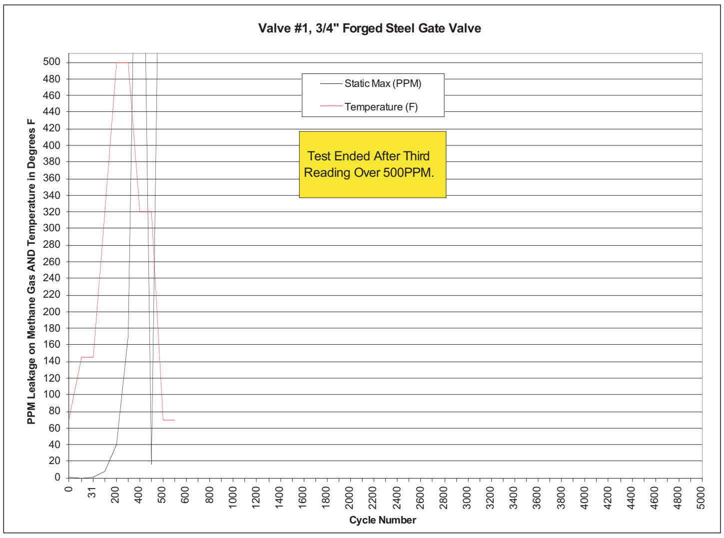

Fig. 19: Valve #1, 3/4 inch forged valve

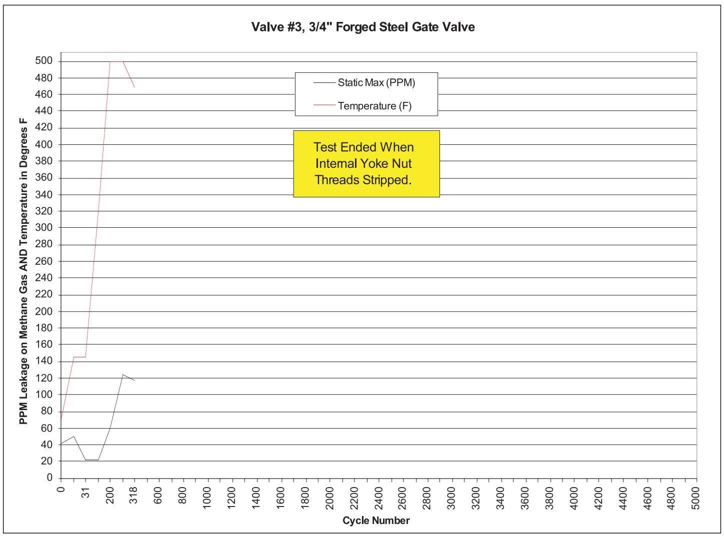

Fig. 21: Valve #3, 3/4 inch forged valve

The alternative is to use small bore bellow seal valves (Figures 22, 23 and 24). While these cost a little more, and care has to be taken to obtain a quality valve, the performance of these in VOC service is good. Note, however, that the valves do not obtain zero leakage over the 5,000 cycle test.

For comparison, a four inch bellow seal gate valve was also tested (Figure 25). While the performance during this test is good, these valves are not without their own disadvantages. Initial costs are about three times or more than the cost of a standard gate valve. Long term, the bellows can fail from vibration, stress corrosion cracking and debris that can get caught in the bellows, causing them to crack when the valve is operated. Once the bellows fails the initial ppm level is usually extremely high. Valves can be left in service as long as the packing gland can keep the valve in compliance. The bellows cannot be repaired in the field so the valves generally have to be replaced. There are also space problems when installing the valves. The bonnets are very tall to accommodate the bellows, so extra room is generally needed.

Conclusion

Selecting the correct valve for an application can have a major impact on fugitive emission levels, environmental performance and costs. Without good data, end users are left guessing as to how a valve will likely perform in the field over extended run cycles in demanding conditions. If end users require testing to be performed by manufacturers that can highlight performance differences, manufacturers will meet the demand and find ways to improve VOC performance. Without data, end users are left making educated guesses as to which valve or packing to specify. If you have to purchase valves and packing, why not purchase the ones with the best VOC performance, especially when the cost difference is insignificant and will reduce your total cost of ownership after you factor in the cost for correcting non-compliant valves and environmental fines? With today's technology, it is possible to significantly reduce fugitive emissions to the point where almost all valves should remain in compliance. It is up to all of use to do what we can to protect the environment. Give a hoot, don't pollute! ■

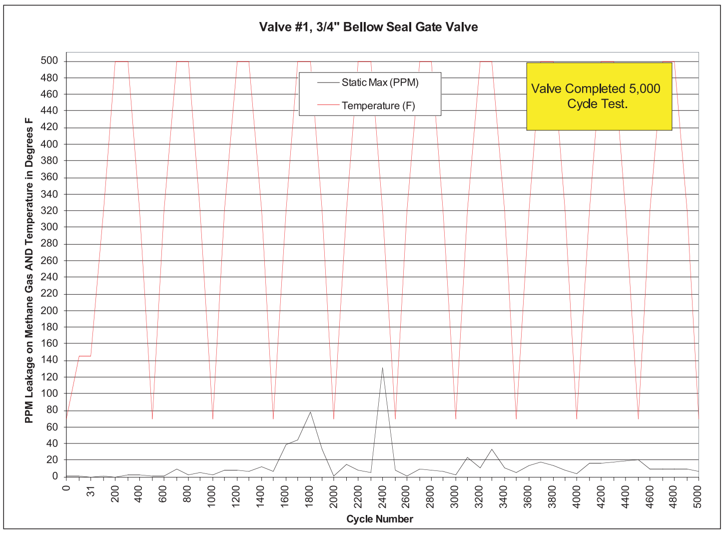

Fig. 22: Valve #1, 3/4 inch bellow seal valve

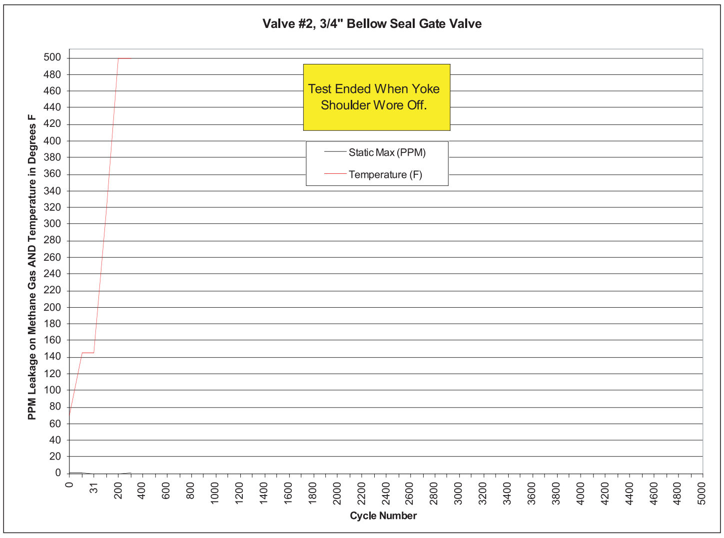

Fig. 23: Valve #2, 3/4 inch bellow seal valve

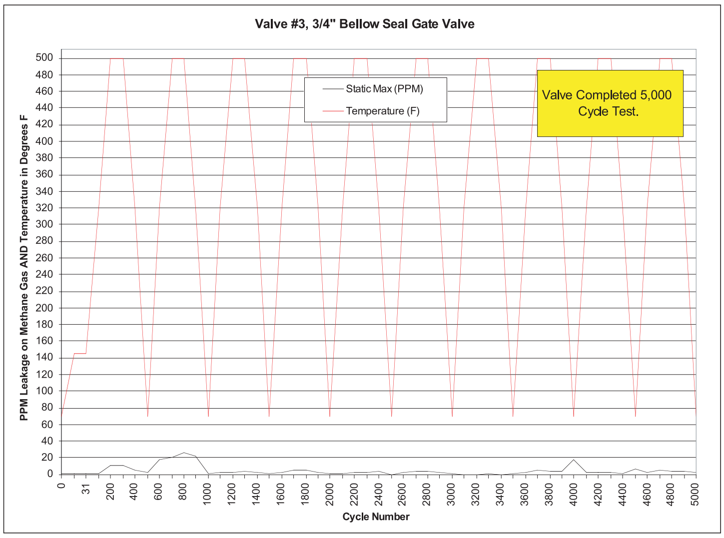

Fig. 24: Valve #3, 3/4 inch bellow seal valve

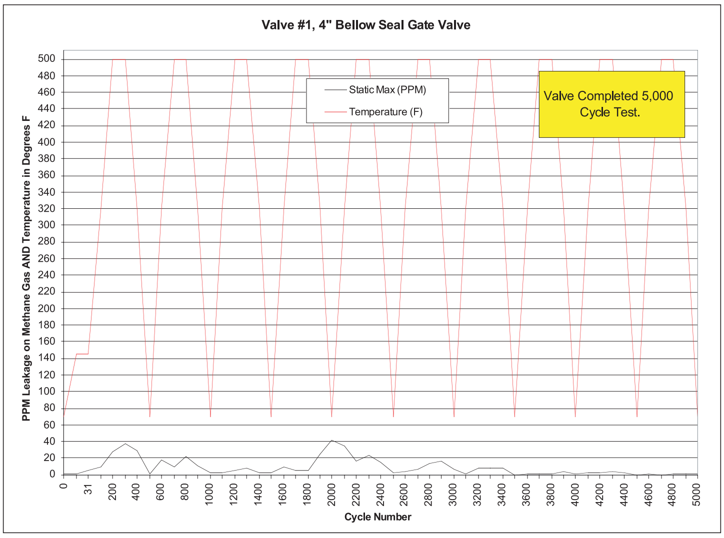

Fig. 25: Valve #1, 4 inch bellow seal valve

About the authors

David Reeves has been with ChevronTexaco for 28 years. For the past 11 years has been a Reliability Analyst at the El Segundo Refining in California where he has been conducting research on bolting technology, sealing materials and fugitive emissions using the 250,000 barrel per day refinery as his laboratory. David has developed special measurement technology for field applications and is the holder of several patents. He is currently the Corporate Bolting and Sealing expert and is responsible for the elimination of leaks on tube and shell heat exchangers, high pressure breech lock exchangers, reactors, piping systems, and packing glands.

Matthew Wasielewski is the owner of Yarmouth Research and Technology located in Maine, USA. Matt started the laboratory in 1992 to provide quality valve, seal and gasket testing services. These services include fugitive emission, fire, cryogenic and flow testing. Prior to 1992, Matt was a Design Engineer at a major US valve manufacturer. Matt can be contacted by email at yrt-lab@maine.rr.com or through the company website at www.yarmouthresearch.com.

Bill Ross has been a Senior Design Engineer with ChevronTexaco for the past five years. Bill has worked in CT's Richmond, CA refinery for 22 years and led the effort to develop new refining wide piping classes. Bill is considered a piping and valve expert throughout the company. After receiving a BS degree in Mechanical Engineering, Bill joined Bechtel Corp. as a piping and project engineer working on projects from around the world. Bill is also a licensed Professional Engineer, Mechanical, in the state of California.

Appendix: Testing procedure

1 Scope and purpose

This is a mandatory test of "off the shelf valves" (meaning out of general stock) for any valve manufacturer interested in being on the approved valve list for ChevronTexaco. Results are subject to review and approval by ChevronTexaco before any valve will be put onto the approved list. Costs for the tests are the responsibility of the valve and/or packing manufacturers. Testing Facilities must be reviewed and approved by ChevronTexaco.

This procedure is designed to be the standard by which all valve and valve packing systems will evaluated by ChevronTexaco. The objective of this test is to allow direct comparisons between packing and valve manufacturers so the best performing products can be selected that will provide the lowest level of VOC emissions. The issue of fugitive emissions has and will continue to be a major factor in valve and packing system selections.

Once test results are available for a valve and packing type, these results will stand as the official results and the test will not need to be repeated unless packing changes are made, or any changes are made to the valve that effects the bonnet seal, packing or other sealing component that can result in leakage of the valve contents to the atmosphere. If improvements are made to a valve or packing, new test results that reflect that change will become official once those changes are included in the valves that are being produced for the open market.

2 Basic test parameters

Test media	Methane gas
Test pressure	600 psig
Test temperature	500°F at the stuffing box
Heating rate	70°F to 350°F, 115 degrees per hour, 350°F to 500°F, 83 degrees an hour
Time for open/close cycle	60 seconds, 15 second rest between cycles
Number of cycles	5,000 fully open to fully close, or until 500ppmv is reached the third time
Number of cycles per day	500
Test valve	ANSI Class 300, API 600, NPS 4, carbon steel gate valve
Leak detection method	EPA Method 21
Maximum emission (ppm)	500 ppmv static with data provided on dynamic measurement
Leak detection frequency	Every 100 cycles after valve has set for 2 minutes (static) and upon the resumption of cycling (dynamic)
Torque to open and close	Every 100 cycles, either by hand or electronically
Minimum number of tests	Two for each valve manufacturer, one on the valve's OEM packing, one on an approved spool packing used for field repacks (Repack Test). Testing with two rings of Garlock 1303FEP above and below a single ring of JM Clipper CW-2000 packing will be required at this time. Other packings or packing systems may be approved or requested in writing by ChevronTexaco. Two tests are required to evaluate a packing or packing system (Re-pack Test on a new valve, specified by ChevronTexaco).

3 Test apparatus

3.1 Testing shall be performed in a test fixture that will retain the valve during multiple cycling while under pressure. There shall be no modifications/alterations of the valve from its original design and mode of operation.

3.2 The test valve shall be installed in the orientation which causes maximum displacement of the stem to occur. For this test the stem shall be in the horizontal position and the port vertical. To facilitate testing, a power (motor or pneumatic) actuator may be used to open and close the valve. The actuator shall be supported independently from the valve and connected to the valve using a flexible shaft and clamp on assembly to the hand wheel.

3.3 The shop performing the test shall prepare a schematic diagram of the test system and submit it to ChevronTexaco for review prior to the test. It shall show the test valve and piping system, methane source and heater, pressure gauges and regulators, thermocouples and placements, safety devices, etc. Digital pictures of the test stand shall also be submitted.

3.4 The piping or tubing that supplies the methane gas shall include a flow restrictor that will limit the leakage rate to a ppm below that which will support combustion. Other flow restricting methods may be used with ChevronTexaco approval.

3.5 Testing facility will ensure that proper fire protection systems are in place and that proper procedures are in place to mitigate the risk of a fire or other mishap.

4 Test valve

4.1 The test valve shall be a standard production valve made in accordance with API 600. Valve shall be a NPS 4, ANSI Class 300 gate valve and shall be new. The valve shall be selected from vendor "off-the-shelf" inventory by a ChevronTexaco representative.

4.2 Stem diameter and stem finish measurements shall be taken before cycling is started, from the area of the stem that is in the center of the packing stack and above the follower when the valve is normally closed, by opening the valve to expose the stem. (Two measurements are required so they can be compared.) The test valve shall be disassembled and the valve stem and stuffing box shall be dimensionally checked as outlined below after the initial test on the valve's OEM packing has been completed. The following information shall be recorded and provided in the final report.

Stem: Measure stem circularity and taper in the area in contact with the packing, and above and below the area of the stem that has contacted the packing. Record how the stem is attached to the gate and the amount of side to side play in the stem after the packing has been removed and when the valve is half open. Stem side to side measurements should be made at the top of the packing gland with the follower pulled up. Count the number of full turns on the hand wheel to open the valve from fully closed to fully open. Measure stem straightness and surface finish.

Stuffing box: Measure stuffing box depth, ID, and surface finish.

Follower: Check to see how high the packing has extruded up the stem between the stem and follower. Measure the follower ID, OD and height.

Packing Gland Follower Studs: Record the stud size and threads per inch.

Diametrical clearance: Measure the diametrical clearances between the stem diameter and stuffing box ID, stem diameter and gland follower ID, gland follower OD and stuffing box ID.

Pictures: Provide at least three digital pictures, one before the valve is opened up, one of the top of the bonnet, stem, hand wheel and packing gland, and one of the inside of the bonnet showing where the stem comes through, the gate and the attachment between the stem and gate.

5 Packing installation

5.1 For the Repack Test using spool packing or other requested packing system, the stuffing box shall be prepared for a maximum of 5 rings. Unless specified otherwise by the packing manufacturer, all 5 rings should be the same material. If the second test will include the use of die-formed rings, a maximum of 2 wiper rings (top and bottom) and not more than 3 middle die-formed rings shall be used. If the stuffing box is deeper than a 5 ring set, a split bushing made of carbon steel and having the same ID and OD as the gland follower shall be installed to fill the excess depth of the stuffing box. Record the depth of the stuffing box with and without the split bushing. The bushing should be placed in the bottom of the stuffing box.

5.2 The test packing shall be procured from normal distribution. If braided packing is used, the packing rings shall be cut from a spool. The ends shall be cut at a 45° angle, or as recommended by the packing manufacturer, and the cut ends shall be at least 90 degrees apart.

5.3 The test facility shall install the packing in accordance with the manufacturer's written instructions. The packing manufacturer may not verbally or otherwise assist the test facility personnel in installing the packing.

5.4 Install the packing rings one at a time in the stuffing box and then compress each ring with the gland follower.

5.5 Record the packing size, quantity of each type of packing, packing material, manufacturer and brand name, 45∞ or square cut ends, and ease of cutting and installation. If die-formed rings are used, note in the test documentation whether the rings are endless or split and the density. After the packing is completely installed per the written instructions, record the follower height. This will be used to measure the packing gland movement later if adjustments are made to stop a leak during pressurization and cycle tests. Refer to paragraph 6.3.5. Stoke the valve 5 times and re-record the follower height.

6 Test procedure

6.1 Test Set-up

6.1.1 Verify that the valve stem is not backseated when the valve is in the open position. It can be up to 3/8" off the backseat position. In the close position, the valve wedge can be up to 3/8" from the full close position.

6.1.2 Verify that the cycle counter is operating properly.

6.1.3 Ensure that the valve stem nut is lubricated properly. Lubricate the yoke with high temperature grease, and re-lubricate it every 500 cycles.

6.1.4 Ensure that the heaters, thermocouples, and temperature controller are operating properly.

6.1.5 Any adjustment to the test set-up after cycling is started shall be recorded.

6.1.6 Record the packing gland nut torque and follower height, then remove the nuts and lubricate the threads with Jet-Lube 550 anti-seize. Make sure the nuts can be completely run down using only the fingers. Clean the OD of the follower to ensure it will slide smoothly into the stuffing box. Then re-torque the nuts to the value given in the manufacturers written instructions. If the nuts can't be run down with the fingers, clear the threads or chase them with a die or tap until the nuts run freely.

6.1.7 Operate the value for 5 pre-cycling strokes and then verify that the gland nuts are still at their required torque as defined in the step above. Tighten if needed. Record the follower height and the torque to open and close the valve.

6.2 Pressurization

6.2.1 Prior to opening the methane supply valve, with the supply system de-pressured and sealed up, zero out the ppmv background by zeroing out the measurement instrument. The ppmv readings that are recorded should be above the background reading.

6.2.2 Pull a vacuum on the valve body and cavities before pressurizing the valve with methane. Then pressurized the valve with methane gas, 98% to 100% methane gas by volume, per EPA Method 21. The test pressure and temperature shall not exceed the pressure/temperature charts for standard class valves as shown in ASME B16.34.

6.2.3 Check for leaks in the test apparatus and valve body joints and eliminate any leaks that are found.

6.2.4 Prior to cycling the valve, a sniff test in accordance with EPA Method 21 shall be performed in the stem and stuffing box area. The packing nut torque reading shall be taken and recorded at this time.

6.3 Cycle test

6.3.1 The valve shall be cycled from fully closed to fully open (see paragraph 6.1.1). A full cycle shall consist of starting the valve from the closed position, opening the valve to open, and returning to the close position. The valve will be cycled starting at room temperature at the rate of one cycle every 75 seconds. The pause between open and close, and close and open operation, shall be distributed evenly. Record the amount of time it actually takes for the valve to cycle from closed to open.

6.3.2 Leak readings shall be taken in accordance with EPA Method 21, using a calibrated Foxboro OVA 128 instrument. Leak readings shall be taken according to the schedule published below. All readings shall be taken in still air with the ventilation fan off. Also leak check the bonnet gasket area to make sure this gasket is not leaking and record the measurement in ppmv. Testing at the end of each day will be stopped 10 cycles short of 500 cycles, so the final leakage measurement can be made at the start of the next day on the 500th cycle.

6.3.3 Two readings shall be taken at each leak test interval, when the valve stem is in the static position (not moving) and when the stem is in the dynamic (moving) position. The static reading shall be taken when the valve is in the closed position and the dynamic reading shall be taken when the stem is in motion during the opening stroke following the static reading. Readings shall be taken by positioning the probe on the topside of the stem against the follower. Wrap the area encompassing the follower with foil to capture any leakage from the seals OD and ID. Since the methane will rise, the probe is placed on the topside of the stem. Leakage is recorded 1 time per second for 60 seconds. The average and maximum values are then calculated and reported. The static reading shall be taken after the valve stem has been allowed to sit stationary for 2 minutes. Record both readings.

6.3.4 The stuffing box should be pre-heated to 90°F. Ten thermal cycles shall be performed over the 5,000 cycle test, with one every 500 cycles. A thermal cycle consist of heating the valve's packing gland to 500°F, holding the temperature at 500°F for approximately 100 cycles, and then cooling it back down to 70-90°F. The valve body should be heated and insulated enough that it does not act as a heat sink, but the critical temperature to monitor is the outside center of the packing gland.

6.3.5 When the static leak rate exceeds 500 ppm, adjust the packing to zero ppm reading, or as low as possible, and continue the cycle. Record the number of cycles and ppm reading at this point. The torque required to re-tighten the packing nuts shall be measured and recorded. If the static leakage does not drop below 50 ppmv using the manufacturer's recommended torque, the nut torque should be increased to 1.5 times the recommended level. If the static leakage is still above 50 ppmv, the nut torque shall be increased to 2 times the recommended level. The nut torque is limited to 200% of the original recommended torque. Record the follower height after the adjustment has been made. Continue the test until the 500 ppm leak level is reached the third time. At this time terminate the test. Record the static and dynamic leakage rates in ppm and the number of cycles.

6.3.6 Record operating torque on the valve every 100 cycles, for both the opening and closing cycles, and before and after any adjustments (if needed). Torque measurements can be made electronically with a stain gage or by hand with an appropriate torque wrench. Closing torques are limited to a 200 pound pull force on the handwheel. The allowable torque is calculated as 200 pounds times the radius of the handwheel in feet. If the allowable torque is exceeded, the test shall be ended.

6.3.7 After the first 30 cycles, when the valve is about 160°F, take the first leakage measurement, then adjust the packing gland nuts back to the original recommended torque level. Record the follower height after the original torque is reached.

6.3.8 The cycling test is designed to take 10 days, with each 500 cycle block taking approximately 11 hours. The chart below outlines an approximate schedule, showing elapsed time, temperatures and hold points. The controller should be set to stop cycling the valve every 100 cycles so leakage measurements can be made. The temperature should also be held until the measurements are completed. This way, if it takes slightly more time to complete leakage measurement, the schedule can be easily adjusted.

Approx. test time (hours)	Cycle number	Set temp (°F)
0.0	0	70
0.7	30	145
2.2	100	320
4.3	200	500
6.5	300	500
8.7	400	320
10.8	500	70

7 Test results

The test results, both static and dynamic readings, shall be plotted on a chart, leakage in ppm on the vertical axis and number of cycles in the horizontal axis. The number of cycles and ppm readings in each packing adjustment shall be shown on the chart. The chart must be in Microsoft Excel (XL) format (see below).

ChevronTexaco reserves the right to use the test results in any manner necessary in the conducting of its business. Data will not be released outside ChevronTexaco where the names of specific valve or packing manufacturers are tied to specific test results unless ChevronTexaco has paid for the test or the company purchasing the testing gives written permission. The testing facility shall not release any test results without the written approval of the company purchasing the testing.

8 Post-test valve and packing inspection

After the tests, the valve shall be disassembled and the parts inspected. The same measurements as previously taken on the stem, stuffing box, gland follower, etc, shall be taken again and compared to the previous measurements. Record any evidence of wearing on these parts, including digital pictures, especially on the stem. If no change in measurements can be detected, the same valve and stem can be used for the second test. If the stem is damaged or worn, it should be replaced prior to starting the next test.

9 Document submittal

Results of the leakage readings in graph form, measurements taken on the valve, packing torque readings and other information required by this procedure shall be placed in a Microsoft Excel file and submitted to ChevronTexaco at the address below. It is preferred that the documents be e-mailed.

Name: David W. Reeves E-Mail Address: dree@chevrontexaco.com
Street: 100 Chevron Way City: Richmond CA., 94802
Office Phone: 510-242-2241 Pager: 310-225-2084

■