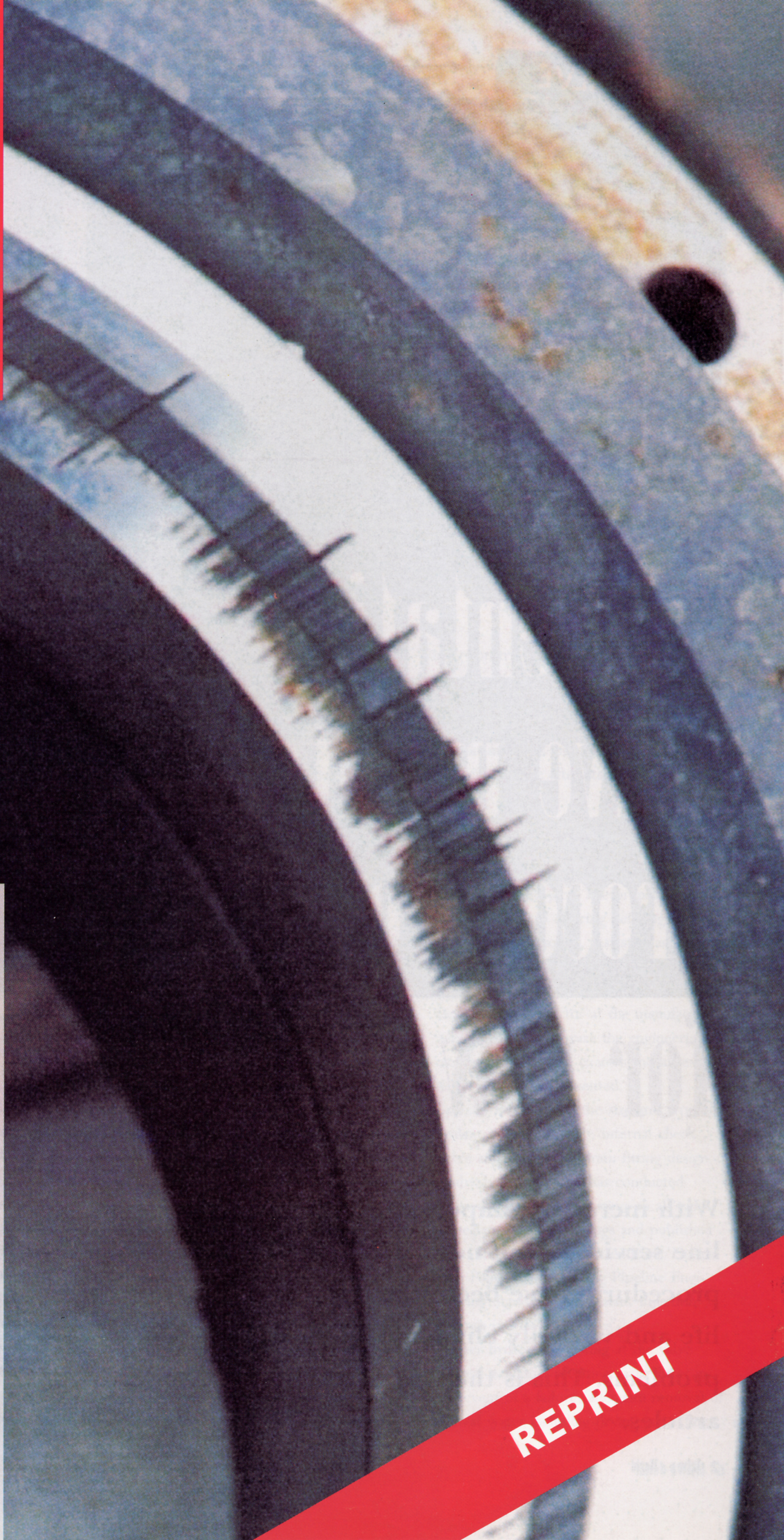
Valve World



Preventive procedure

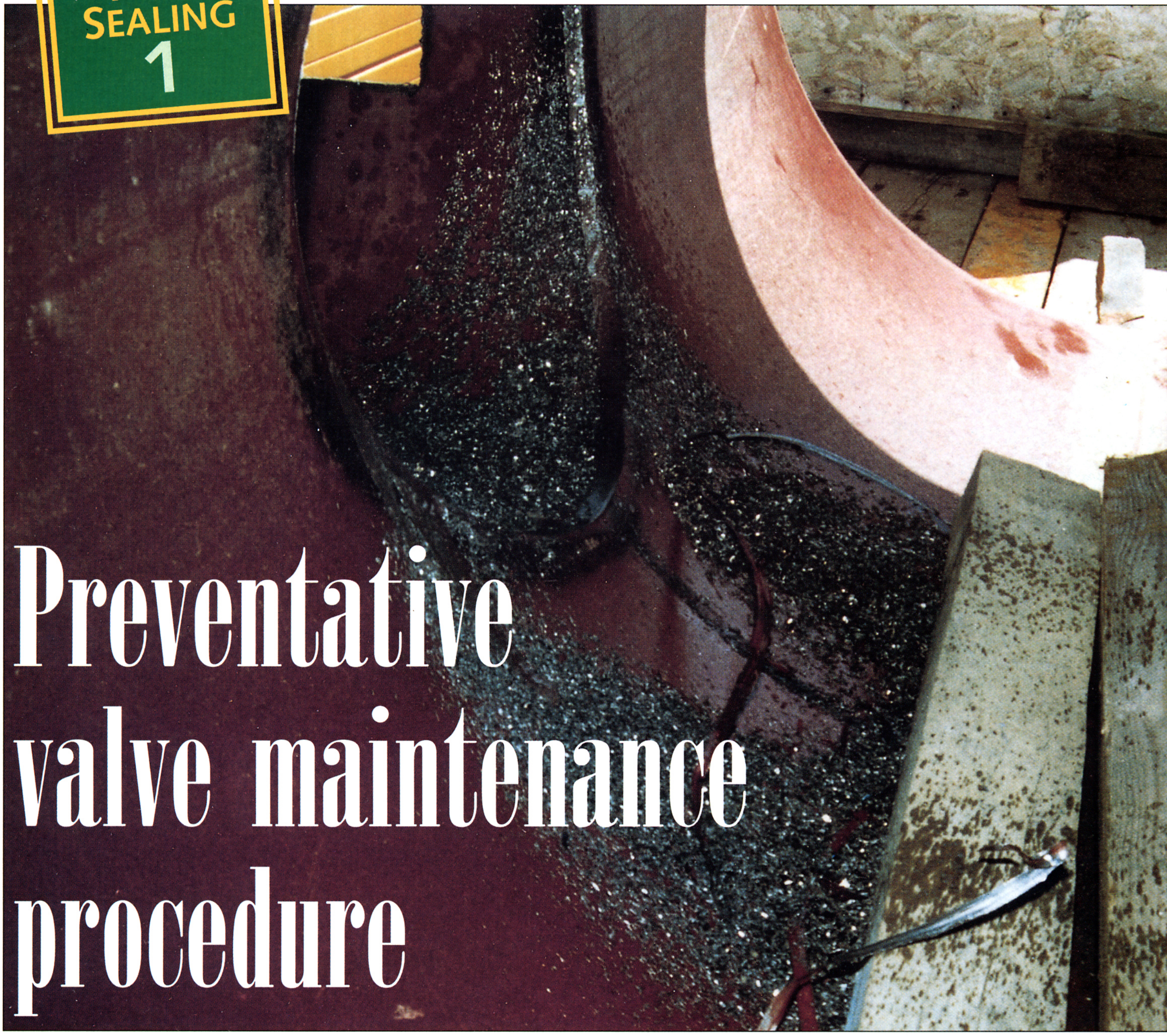
Audit and rehabilitation

Destructive ball valve seat testing

by Dean Chisholm,
Sealweld Corporation

REPRINT

VALVE SEALING 1

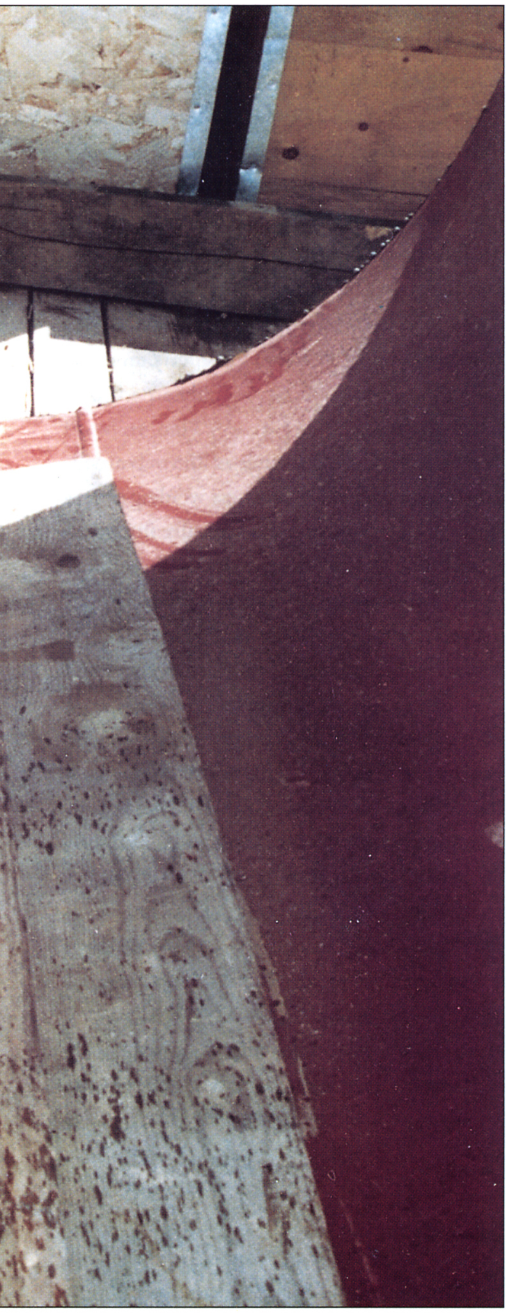


Preventative valve maintenance procedure for new valves

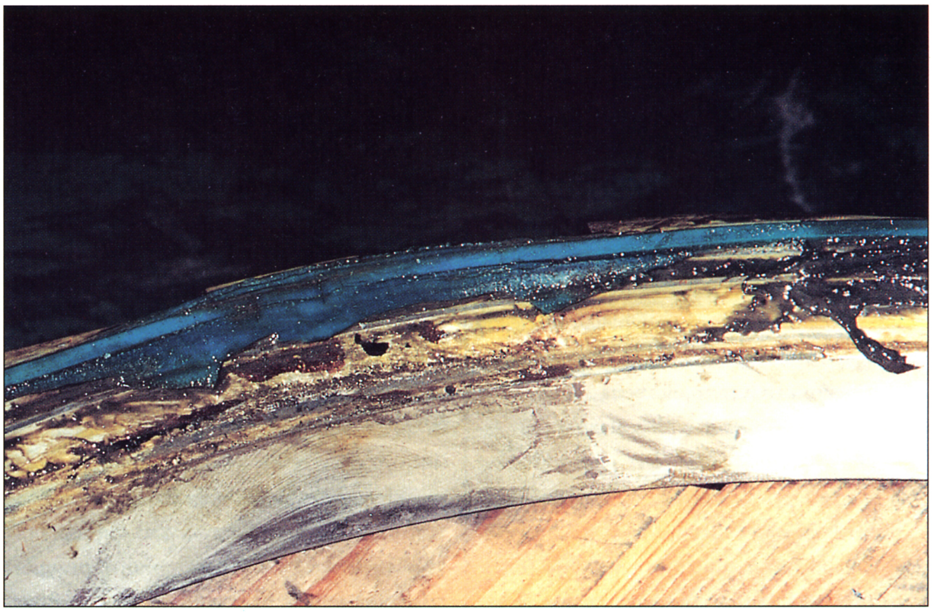
With increasing importance on extending the in-line service life of new valves, the following procedures have been found to extend valve seal life and virtually eliminate all minor seat leakage problems. This is the first of a three-part series of articles.

by Dean Chisholm (Sealweld Corporation Ltd, Canada)

Seal integrity becomes particularly important when performing pipeline rehabilitation work, looping or extending an existing pipeline. The cost of shutting down, evacuating, draining, excavating and new valve replacement costs are typically many times more than just the cost of a new valve. Factor in the lost revenue from down-time and the costs can climb into the hundreds of thousands of dollars per valve. There is also an important environmental concern related to the release of pipeline contents to atmosphere when valves fail to seal properly.



Large-diameter hot tapping test performed on large-diameter line pipe. Notice the quantity of metal shavings and cuttings being introduced into the pipeline. This is suspected as being one of the leading causes of seat seal damage resulting in valve seat leakage.



Photograph of a seat ring from a large-diameter welded body ball valve. The seat ring insert has obviously melted. This damage occurred during construction when the valve pup was pre-heated prior to welding the valve into the pipeline. Notice what appears to be metal shavings embedded into the insert. The shavings may have been introduced as a result of a hot tapping exercise some distance upstream of the valve site.

These factors are not always adequately considered when deciding valve selection. It is often in the long-term best interest of the pipeline operator to choose the best valve design for a particular application with less emphasis on simply getting the lowest price. A plant or process facility enjoys the opportunity to shut down periodically for maintenance including valve repair and replacement. Large-diameter pipelines are rarely, if ever, shut down. Proper attention must also be paid to selecting a premium brand of sealant injection fitting and body vent valve as these components can also determine the ultimate longevity of the in-line service life of the valve.

Valve seals, like any moving mechanical part, perform better and last longer when lubricated on a regular basis. Periodic routine maintenance will reduce valve torque requirements, this puts less strain on valve stems, gear sets and actuators resulting in a longer service life for these related components.

During the installation, construction and commissioning phases of the project is the time when valve seals are subjected to the greatest wear and damage, usually as a result of construction debris found inside the pipeline. Materials such as welding slag and splatter, welding rod tips, metal shavings, line scale, hand tools, timbers, dirt, sand and small stones are commonly found inside the pipeline after start-up. The damage caused to critical valve seals by these contaminants includes scratches and gouges to the metal seal face and/or nicks and cuts to soft elastomeric seals resulting in minor to severe seat leakage. One pipeline operator now claims that over 70% of their new valves now experience seat leakage problems after only two years of operation due to copper slag (sand blasting grit) that was introduced into the pipeline at some time during construction.

An effective preventative valve maintenance procedure has been found to virtually eliminate the damage caused by these contaminants, thus ensuring a 'bubble-tight' seal in every valve after start-up.

Procedure summary

- Proper valve selection depending on application during the design/engineering phase of the project. The preparation of a written standard clearing defining the materials, accessories, test standards and retesting procedures in case of failure. The presence of an experienced, independent on-site inspector at the manufacturing facility to ensure the engineering standard is followed exactly and all exceptions are fully documented.
- Specific reference to the size and type of sealant injection fitting, internal check valve and body vent/drain fitting design. Sealweld Corporation has conducted extensive destructive testing on all types of sealant injection fittings and published their findings in a report entitled 'Discussion Paper for Modifying Pipeline Engineering Standards for Sealant Injection Fittings in Pipeline Valves'.
- Proper hydrostatic testing at the valve factory including retesting procedures in the event of a failure, adequate removal of all test water including drying procedures. ☞

After a successful test is completed, filling the seat sealant system is an effective means of purging the water from the pocket at the back of the seat ring. Use a light grade synthetic lubricant/sealant to purge any test water from that area of the valve before corrosion begins. Sealweld Equa-Lube Eighty or Total-Lube #911 are the recommended seat lubricant/sealant for valves in hydrocarbon pipeline service such as natural gas, crude oil and refined petroleum product applications. In the case of buried valves with sealant extensions, filling the sealant riser pipe with a light grade synthetic lubricant/sealant to displace any water from this area.

- Attach adequate end covers at the factory to prevent intrusion of contaminants such as dirt, sand, water and salt spray during transport and storage. Applying a waterproof coating or cover all exposed components such as valve stems.
- Special attention must be paid to palletizing or crating each valve to ensure the valve is handled properly at all stages of the transportation process. The lift points for each crate must be clearly marked on the outside of the container.
- Attach a copy of all relevant documentation including installation and maintenance manuals directly to the valve so that the construction crew and on-site Valve Commissioning Technician (VCT) know exactly how to unload, store, install and properly hydrotest each valve.

Valve preparation

The construction contractor's main consideration is completing the pipe laying, valve installation and hydrostatic testing as quickly as possible. The valve is often handled as 'just another piece of pipe' without consideration for the mechanical significance or the sealing ability of the valve. The pipeline is hydrostatically tested with the valve in place, the valves' sealing ability is not normally part of the test procedure. Valve seat leakage is not often discovered until after the pipeline has been placed in service.

In order to ensure that the valve is handled, stored, unloaded and installed properly, an independent Valve Commissioning Technician (VCT) should be appointed. The person can be an experienced independent contractor or someone from the pipeline operator's maintenance department.

The VCT's responsibilities include overseeing the handling of the valve to make sure it is loaded and unloaded properly. That it is equipped with the proper seat sealant fittings and body vent fittings and that these components were not damaged during transportation. That all relevant paperwork is attached and accurate.

A checklist is prepared, every valve must be clearly identified and all relevant information collected at every stage of the installation procedure. A sample check list is available from the Sealweld web-site (http://www.sealweld.ca).

When the valve is unloaded at the valve site it is critically important that the proper handling procedures are followed. If unsupervised, the on-site personnel have been known to sling hoisting ropes around the valve stem or actuator. This can bend the stem or gear set or break the seal in the stem extension. There have even been instances where the valve was simply dumped off the back of the truck where it sits 1/2 submerged in a mud hole for weeks and even months.

The valve must always be set on a pallet or onto timbers and not directly on the ground. Make sure the external fittings are not bent or damaged during this procedure. Verify that the end covers are firmly attached to prevent rain, dirt and sand from entering the valve bore. The valve stem should always be pointing up.

The VCT must test the seat sealant injection system prior to installation. Attach a sealant injection pump to the fitting, remove the protective end covers then watch the sealant enter the valve bore. Excess sealant is then smeared into the groove between the ball (or gate) and the seat rings and the small groove at the back of the seat ring. This will prevent the possibility of any pipeline contaminants becoming trapped in these areas where they can do the most damage or impede seat travel. In the event that contaminants become stuck in the sealant they will do considerably less damage as a result of being lubricated than they would if the valve was left in a dry condition. The end covers are re-attached until just prior to installation, the VCT's check list is marked according to the work completed.

Valve installation

Prior to installation, it is critically important that the valve is not turned or cycled in a dry condition. It is not unusual for unsupervised personnel to want to turn the valve handle or wheel just to see what happens. It is very important that the valve remains in the full open position at all times. Therefore, the VCT needs to instruct the on-site supervisor to watch that the valve is not turned. In some cases a lock and chain may be required. The VCT should be on location during the installation procedure to ensure the valve is hoisted and set properly.

Preheating

In some cases the pup ends of the valve will need to be preheated prior to welding the valve to the linepipe. It is critically important that the valve body, specially the elastomers in the seat ring, does not become overheated as a result of the preheating procedure. Overheating may cause permanent damage to the seat seals, the damage may not be realised until after the pipeline has been commissioned. A tempil stick should be used to ensure the valve body is not overheated. When using an open flame burner, never pre-heat inside the valve, apply the heat to the outside of the pup only. In the case that temperature exceeds the manufacturers specification, injecting additional sealant can often lower the seat ring temperature sufficiently to eliminate damage or distortion. More radical steps can be taken such as cooling the valve body with water.

Topping up

The seat sealant system should be topped up at various stages of the installation procedure. Injecting top-up quantities will push fresh sealant into the seat pocket between the ball and seat ring. In the event that the contaminants come in contact with the sealant, injecting additional sealant will force the contamination away from the seal face before it can create scratches or similar damage.

Top-up schedule

1 Top up every time **before** cycling the valve.
2 Top up immediately **after** the welding procedure is complete.
3 Top up immediately **after** the hydrotest is complete.
4 Top up immediately **after** commissioning.

5 Top up **quarterly** for the first year of operation.
6 Top up **bi-annually** for the second year of operation.
7 Top up **annually** for the third year of operation, annually thereafter.

The important consideration is not the quantity of sealant injected, only a small amount of fresh sealant is required to push contaminants away from critical seals and into the pipeline. Typically, top-up quantities are only 1/4 to 1/3 of the quantity required to fill each seat ring. After the seat sealant system has been filled, any additional sealant that is injected will enter the pipeline bore immediately upstream of the seal face on each seat ring. The greatest quantity of contaminants are present when the pipeline is new – when the pipeline is put into service the contaminants are washed downstream. As the pipeline matures, the maintenance interval can be extended as seen in steps 5 through 7. Note, this example is intended for mainline block valves that may only turn once per year. Other valves that cycle or turn more often will generally require a more frequent maintenance interval.

The VCT shall ensure that proper hydrostatic testing procedures take place. In many cases the contractors are rushed at this stage of construction so that pipeline operation can commence; shortcuts are often taken. The VCT shall ensure that every valve remains in the full open position while the pipeline is filled with water. This will push most contaminants downstream where they can be collected instead of accumulating in the bottom of the valves' body cavity. After the line is filled, but before building water pressure, the pumps are to be shut down and each valve in the test section is topped up then turned towards the ½ closed position. This will allow the water to fill the entire body cavity thus eliminating the risk of damaging the valve seals due to excess pressure differential.

After a successful hydrostatic test is complete, the valves are turned back to the full open position so that the water can be drained from the pipeline. Test water must also be drained from the body cavity of each valve, this can be done by opening the body vent or drain fitting on the body of the valve. It may be necessary to turn the valve partially to open the seat seal to allow all water to be drained out. The VCT must ensure that all water has been removed and that the body vent or drain valve is closed prior to commissioning.

The VCT is responsible for checking the set stops on the valve gear set or actuator to ensure that both the full open and full closed positions are clearly identified. The checklist is marked accordingly. The VCT shall be present during actuator installation, hooking up and setting of the line break control system and all valve-related accessories.

The VCT is the person accountable to make sure every valve, even small-diameter valves, turns easy and seals properly before the construction contractor is released from the site. Every valve shall be clearly identified and fully documented. A copy of all documentation is presented to the construction superintendent upon completion of each segment of pipeline.

These procedures have been proven effective by ensuring every valve seals perfectly during three years of field trials in several new pipelines around the world. Sealweld has published numerous technical papers researching common valve problems and troubleshooting techniques. To obtain copies of these procedures including the complete report this article is based on you are invited to visit our valve maintenance web site: http://www.sealweld.ca. ■

About the author

Dean Chisholm is the President of Sealweld Corporation Ltd. Sealweld Corporation is a manufacturer of valve care products with offices in Calgary, Canada, and Houston, Texas, USA.

VALVE SEALING 2

Figure 1. Ball valve with seat damage. This valve was not equipped with a sealant injection system. Sand in the crude oil created scratches on the sealing surfaces. The continued leakage resulted in progressively larger leak paths.

Natural gas pipeline valve performance audit and valve seal rehabilitation

With increasing importance on extending the in-line service life of new valves, the following procedures have been found to extend valve seal life and virtually eliminate all minor seat leakage problems. This is the second of a three-part series of articles.

by Dean Chisholm (Sealweld Corporation Ltd, Canada)

In response to the international concern regarding reducing methane emissions to atmosphere, many pipeline operators are instituting a much more aggressive and systematic approach to eliminate all sources of gas leakage. Through proper coordination by the training, environmental, loss control and engineering departments, the costs and benefits of performing a comprehensive valve performance audit can be evenly distributed. In many cases, the cost of training and performing a system-wide valve audit will cost significantly less than the cost of replacing only one mainline block valve.

The first step should be to ensure all maintenance personnel receive specific training for performing on-line valve maintenance routines safely. On-line valve maintenance can be extremely dangerous when performed by inexperienced personnel. The high-pressure sealant injection guns and pumps being used are capable of generating injection pressures many times greater than the maximum rated valve body pressure. Many of the sealant injection fittings currently installed into valves are substandard and potentially dangerous. Providing teams of experienced valve maintenance technicians who can respond rapidly to any valve leakage emergency, is essential to the safety and confidence of everyone working on and living near the pipeline.

The second step should be to perform a comprehensive valve performance audit. A well-planned audit can provide accurate data that will quantify the net gas loss reduction. Reducing valve leakage will improve

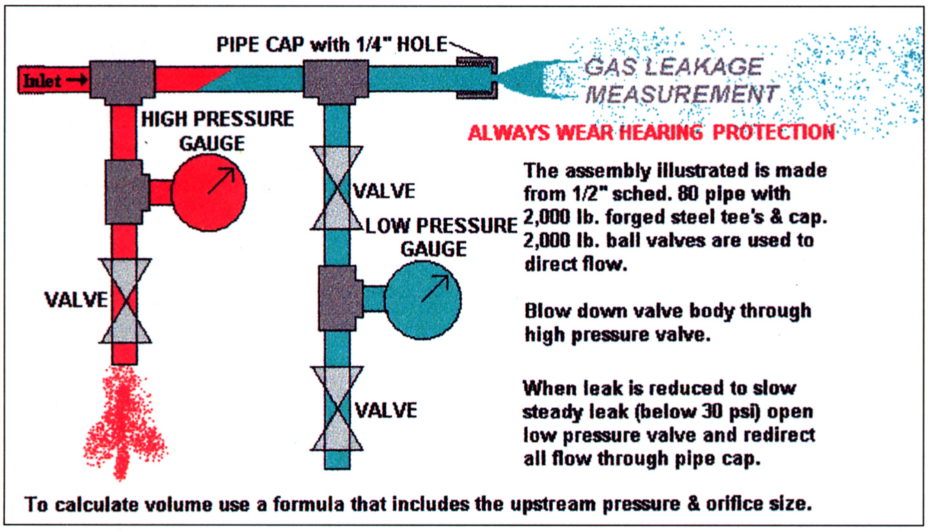


Figure 2. Gas leakage orifice fitting device for measuring valve seat leakage. Connect to the valve body or drain fitting. Vent high-pressure gas through past the high-pressure side (red). When the leakage rate slows, close the high-pressure valve and open the low-pressure gauge valve (blue) and watch gauge closely.

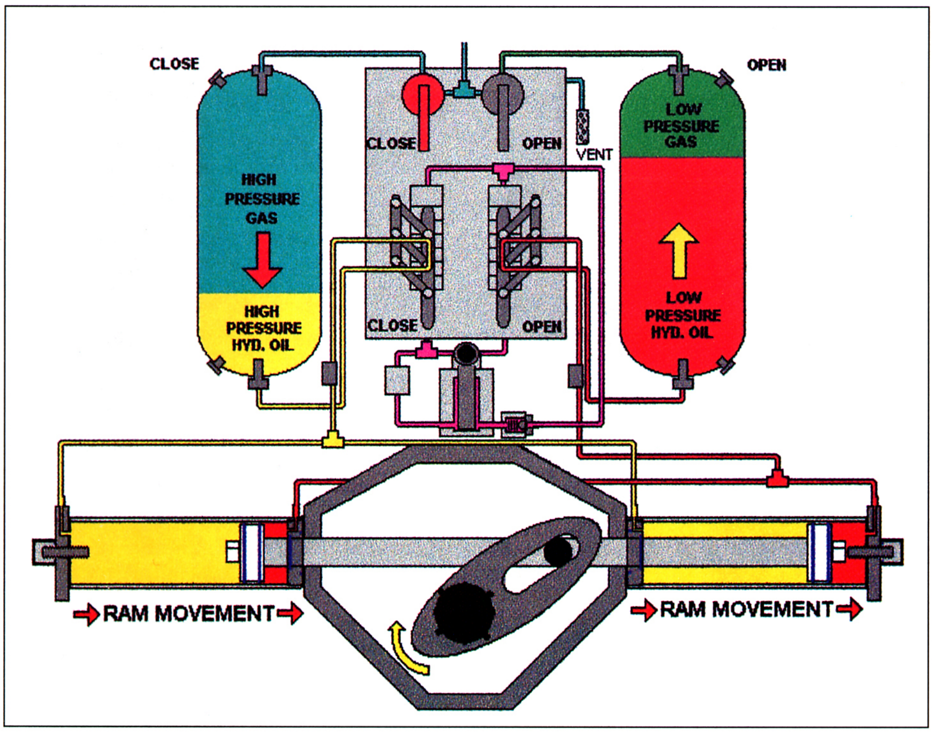


Figure 3. Bettis gas/hydraulic valve operator. This illustration details the hydraulic control system and scotch yoke mechanism.

overall pipeline efficiency and performance. The majority of valves will exhibit only minor leakage problems and can be sealed bubble-tight with conventional maintenance procedures. Problem valves can be identified and a more aggressive sealing procedure applied. In the event that all maintenance efforts are unsuccessful, these valves can be clearly identified and repaired or replaced during the next scheduled outage. A permanent record of valve performance will be created for the benefit of future pipeline expansions, tie-ins, inspections and rehabilitation projects.

The third step is to integrate the knowledge acquired through the auditing process into all new valve purchases and planned pipeline expansions. A safe and effective valve maintenance schedule can be implemented based on actual field conditions.

Why do valves leak?

Natural gas pipeline valves are typically subject to a greater number of leakage problems than identical valves in crude oil or hydrocarbon liquid service. This is because dehydrated natural gas offers little, if any, lubrication. The internal elastomeric seals tend to dry out, harden and then stick to the sealing surfaces. Solid contaminants such as pipe scale, welding slag, hot tap cuttings, sand and dirt create tiny scratches on the mated sealing surfaces. These scratches erode into progressively larger leak passageways, resulting in larger leak rates over time. The routine application of a high-quality synthetic lubricant/sealant will eliminate all minor leakage problems and will extend the service life of every valve considerably.

The personnel assigned to perform valve maintenance often have no prior training or experience. An inexperienced technician may not realise the danger of removing a sealant fitting under pressure and may sustain disabling injuries or even death from the impact. Understanding the sealant pumping equipment is required to ensure injection of the proper amount of lubricant/sealant. A malfunction with the pressure gauge on the pump is a potentially dangerous situation.

Proper valve maintenance is essential to the reliability and integrity of the entire pipeline system. The common presumption is that because the valve was tested in the factory, the valve should seal perfectly for many years into the future. Like any moving mechanical component, a pipeline valve will only seal properly when proper maintenance and lubrication routines are practised on a regularly scheduled basis.

Certification program

Sealweld Corporation, in association with the University of Calgary and the world's leading valve and actuator manufacturers has developed a comprehensive training and qualification program for the people responsible for maintenance of pipeline valves. The program consists of a combination of classroom instruction with models, cutaway valves, computer animations, video tapes, written and computer-based training manuals, specific job task lessons, practical field experience under the direct supervision of experienced personnel and written exams.

Each student is provided with a written training manual and software-based training program. The interactive computer software package offers the form and function of common features found in any Windows® based help menu. Full of colour illustrations, fully indexed for easy reference. Includes the Grove® Glossary of Valve Terms for easy on-screen reference to many industry specific terms.

There is no substitute for experience. A comprehensive training program must include supervised hands-on experience provided by professional instructors. The work experience and skill level of any employee can only be determined by a combination of written and oral testing in conjunction with practical exams by a senior supervisor *(table 1)*.

Pipeline valve performance audit

Due to operational considerations, it is not always possible to interrupt line flow conditions by cycling the valve to the closed position in order to test its sealing ability.

Many types of gate and ball valves allow for the body cavity to be evacuated in either the open or closed positions. In that most seal damage occurs to the soft Teflon® or nylon seat insert, it is reasonable to assume that if the valve will seal in the open position, it will also seal in the closed position. In the event that the valve will not seal in the open position, it is reasonable to assume that it will also leak in the closed position.

An experienced technician can determine the reason for seat leakage by following proven step by step procedures. In cases where it is determined that the ball and not the seat ring is damaged, there may be an advantage to rotating the ball 180 degrees so the valve is sealing on the opposite side of the ball.

The technician must document the valve position and the leakage rate in that position during the initial audit. Then, at some time in the future when line flow conditions permit, the leakage rate of that valve may be recorded in the closed position.

GUIDELINES FOR ELIMINATING VALVE SEAT LEAKAGE

The valve body will not blow down in the open and/or closed positions.

1 Some valve designs do not allow for the valve body to blown down in the open position. Read the original owner's manual supplied with the valve and/or consult with the specific manufacturer or service specialist.

2 Inspect the valve position indicator and external valve stops to make sure the valve is fully open/closed. Misalignment by even 2 or 3 degrees will often result in continuous seat leakage.

3 Inspect the internal valve stops; in some cases debris can collect between the stops, preventing full travel and resulting in continuous seat leakage. This is most likely on buried valves with stem extensions.

4 Top up the seat sealant system with a quality lubricant/sealant. Many types of manual injection equipment have a very low rate of discharge. In many cases the seat sealant system may not be full. An insufficient quantity of sealant may be the cause of continuous seat leakage. Verify that all sealant injection equipment is working properly and every gun is equipped with a working high-pressure gauge.

5 Clean the entire seat sealant system by injecting a valve cleaner compound directly into the seat sealant system. Over time a film of old sealant and/or compressor oil can build up on the sealing surfaces. Tiny leak paths are cut through the build-up resulting in continuous seat leakage. Allow the cleaner to soak inside the valve from several hours to several days. Always make sure the cleaning compound is compatible with the many types of elastomer seals inside the valve.

6 Refill the seat sealant system with fresh synthetic lubricant/sealant. In many cases the lubricant/sealant will create a thin sealing membrane and result in a perfect seal of the mated metal surfaces.

7 Cycle the valve repeatedly; this will often dislodge solid contaminants that may have become trapped between the seating surfaces.

8 Drain and flush the body cavity. In many gate valve designs, pipeline contaminants will collect in the bottom of the body cavity and will prevent full gate travel.

9 Inject a heavier valve sealant compound. Open the valves body vent fitting to create a pressure differential. This will draw the sealant into the leak path resulting in a reliable high-pressure seal.

10 Inspect the limit switch setting. In some cases the actuator may trip out prior to end of stroke resulting in the valve not reaching the full closed position. In other cases the switch may be set to trip too late and the valve may be turning past full closed.

11 Examine the original 'as-built' drawings or step back and study the piping systems on either side of the valve. Could gas be entering through some other smaller valve or leaking check valve?

For additional information regarding valve technician training, valve performance auditing and on-line valve maintenance procedures, please visit our website: http://www.sealweld.ca.

Valve identification/verification

The creation of an accurate database is essential to a successful audit. Do not rely on old drawings or records; go to each valve to determine what is actually installed. Locate the nameplate on each valve and record all information stencilled onto the name plate. It is very time consuming to properly remove all the many layers of paint that may have been applied. The technician must be very careful not to ruin the stencilling on the name plate during paint removal and cleaning. Create a coding system that uniquely identifies each valve by type and function. Record the location information, where and how to find each valve. Make a sketch of the valve site layout; this is particularly important for buried valves and piping systems. Identify the manual gear set or power actuator and its related accessories and record all name plate information.

Gas leakage survey

Use calibrated gas detection equipment to locate and identify all sources of gas leakage to atmosphere. There is a wide variety of detection devices available with varying levels of accuracy. Choose the equipment that best suits your application. Inspect for

Level	Job title	Years of experience
6	Junior Valve Technician	0
5	Assistant Valve Technician	1
4	Senior Valve Technician	2
3	Assistant VT Supervisor	3
2	Senior VT Supervisor	5
1	Valve Maintenance Specialist	8

Table 1. This table is to serve as a guideline only, the work experience and skill level of any employee can only be determined by a combination of written and oral testing in conjunction with practical exams by a senior supervisor.

leakage at all flanges, valve stems, sealant fittings, body vent fittings and every tube fitting connection. In the absence of sophisticated equipment, soapy water and/or tight fitting plastic bags will often provide adequate results in identifying and quantifying small gas leaks.

Valve seat leakage

Record the internal sealing ability of every valve in both the open and closed positions. If line flow conditions prevent the closing of a mainline valve, record the seat leakage rate in the open position. The body cavity should always be vented into a portable recovery tank in order to catch any liquids that may have collected in the valve body. Use a gas metering device to record the volume of seat leakage both before and after servicing. Depending on the size and location of the leak, the meter can be a simple orifice fitting type device, plastic bag with a known size or gas capacity, or turbine gas meter.

Manual gear set maintenance

Examine the stem and gear set closely for evidence of external corrosion. Clean and adjust the valve stops to full open/full close. Lubricate all bearings and gears. Drain water from inside gear set, replace any worn seals. Verify that the valve position indicator is in proper orientation.

Power actuator maintenance

Check for gas and hydraulic oil leakage at all seals and tube fittings. Verify that all gas and hydraulic pressure is drained from the system before disassembling any components. Inspect the quality of the hydraulic oil and the oil level in all tanks. Drain all water from the hydraulic tanks; change the oil and gas filters as required. Lubricate bearings, gears and seals as required. Test any manual hand pumps. Adjust external valve stops only if required. Test and calibrate all line break control equipment, limit switches and related accessories. Verify that the valve position indicator is in proper orientation.

General valve site care and appearance

Visually inspect all painted surfaces; look for evidence of external corrosion and oil leakage from the gas/hydraulic actuators. Inspect, clean and repaint as per company specification. Test the working condition of all chains and locks, lubricate or replace as required. Inspect the fence and gate for damage, repair as required. Remove all garbage and weeds from the site. Replace site gravel as required. Inspect all signs, replace all damaged or defective signs and verify that the emergency response phone number shown on the sign is correct.

The auditing procedure

Record all gas leakage rates prior to performing any maintenance procedure to determine the before and after leakage rate comparisons. Identify problem valves and common valve problems or patterns that emerge.

Inject valve cleaning compound into the seat sealant system. This will purge the old sealant out of the system and clean all sealing surfaces thoroughly. Cycle the valve to spread the cleaner. Refill the sealant system with a synthetic lubricant/sealant then test the seat sealing ability by opening the body vent/drain fitting. Record the type of lubricant/sealant used and the results achieved. Use a heavier synthetic seat sealant compound only as necessary.

Pipeline rehabilitation projects

Pipeline operators often plan their rehabilitation projects months or even years in advance. In many cases, severely leaking valves are not discovered until after the rehabilitation work commences. This often results in the need to evacuate adjacent sections of pipeline and the subsequent release of large gas volumes to atmosphere.

It is recommended to perform a valve performance audit well in advance of all rehabilitation work. Problem valves and actuators can be identified and properly serviced. This will eliminate the vast majority of leakage problems. This in turn reduces the volume of gas that must be evacuated from the pipeline when valve seat leakage is discovered.

In the event that a severely leaking valve is discovered and conventional valve sealing methods are not providing the desired results, there is a new emergency valve sealing technique that can provide a gas tight seal. Sealweld Corporation has developed a new emergency valve sealing product, Chameleon Seal. This new sealant and procedure has been proven effective in over 100 field applications on large-diameter ball and gate valves. Only after every routine and emergency valve sealing procedure has been tried and failed should consideration be given to evacuating the pipeline to replace the valve.

Designated valve maintenance employees

Many pipeline operators have discovered that experienced valve technicians are some of the most important people employed along the pipeline. These professionals must possess a combination of expert knowledge in a variety of specific fields.

The senior valve specialist must know the unique seat and stem sealing characteristics of every valve in the system. The specialist must be qualified to service many different types of power actuators, regulators, line break control systems, instrumentation and control systems with a background in gas compression, electrical, pneumatic and hydraulic systems troubleshooting.

About the author

Dean Chisholm is the President of Sealweld Corporation Ltd. Sealweld Corporation is a manufacturer of valve care products with offices in Calgary Canada, and Houston, Texas, USA.

Acknowledgements

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Grove® is the Registered Trademark of Grove Valve and Regulator Company. ■

VALVE SEALING 3

Destructive ball valve seat testing and effective sealing procedures

Scribing tool used for first series of tests.

Blowing down or draining long sections of large-diameter natural gas pipelines due to valve seat leakage can be an expensive proposition for the pipeline operator. The following tests prove that minor valve seat leakage can be reliably sealed through the use of valve sealing compounds injected through the seat sealant system. This is the last of a three-part series of articles. Part one and two were published in the April and June 1997 issues.

by Dean Chisholm (Sealweld Corporation Ltd, Canada)

Unique independent seat seals in the Grove B-4C and Grove B-5 trunnion-mounted ball valves can be utilised to achieve seat seals even in severe leakage situations. Ultra-heavy emergency sealing compounds, that may be injected directly into the body cavity of these valves, can provide a reliable temporary seal. Once a seal is obtained, in this manner, it will provide a bubble-tight seal until the valve is cycled from closed to open.

Pipeline valves in natural gas service are subject to a variety of contaminants that create minor scars on seating surfaces. Most minor damage occurs at start-up as a result of construction debris but can also be caused by such things as the normal erosion of internal pipe surfaces, coupons from hot-tapping operations and damaged pipeline pigging devices.

A series of destructive tests were performed on a pipeline ball valve typically used in high-pressure gas service. A variety of lubricant/sealants, sealants and emergency sealing compounds were utilised to seal the valve at various degrees of damage.

The tests performed concluded that most minor seat seal leakage can be sealed through the use of different valve sealing compounds.

Background

Many types of trunnion-mounted ball valves feature a downstream self-relieving seat ring. This prevents the over-pressuring the body when the ball is in the closed position and thermal expansion of liquid occurs.

To prevent the valve body from rupturing, a self-relieving downstream seat is used. When body pressure exceeds line pressure by more than the spring force applied to the seat ring, the spring's collapse and the pressure escapes out the side of the valve that has the lowest pressure typically the downstream side.

The Grove models B-4C and B-5 ball valves are designed so that if any leakage occurs past the upstream seat, in the closed position due to damage or wear, the resulting increase in body pressure (A2 > A1 by amount X) will activate the downstream seat. In this situation, the downstream seat produces a positive seal against the ball. This type of independent floating seat design, with the valve in the closed position and the body cavity pressure higher than line pressure, produces a closed body cavity. Because this design of seat does not self-relieve, a standard relief valve is supplied on the body of the Grove B-4C and B-5 ball valves. Any excess pressure (i.e. 1.65 × MOP) that develops in this situation is vented. This relief valve is not required for valves in gas service, due to the compressibility of gas.

For these reasons it was theorised that, due to the unique Grove seat ring design in cases of severe leakage, that an ultra-heavy sealing compound could be injected directly into the body cavity to both close off leak paths and pressure energise the seat rings, thereby producing a reliable temporary seal.

	Damage type	Results
Test 1	No damage:	The valve sealed 100% bubble-tight. No sealant required.
Test 2	Ball Scars: .005''	The valve sealed 100% bubble-tight. No sealant required. The resilient seat seal o-ring conformed to the shape of the .005'' scars.
Test 3	Ball Scars: .010''	A leak rate of 6.76 CFM before injecting sealant. Injected Total-Lube #911 – sealed 100% bubble tight.
	Ball Scars: .015''-.020''	A leak rate of 40.0 CFM before injecting sealant. Injected Total-Lube #911 – appeared to hold for 10 minutes then started to leak, gradually increasing back to 40 cfm. Injected 5050 Sealant – sealed 100% bubble-tight.
Test 4	Ball Scars: .030''	Insufficient nitrogen supply to conduct flow test, leak rate estimated as severe. Injected 5050 Sealant, then applied 1000 psig N_2 pressure, sealed 100% bubble-tight.

Table 1. Ball scar test.

	Damage type	Results
Test 5	Seat o-ring – 1 nick	Leak rate 5.5 CFM. The intention was to simulate damage caused by pinching off a welding rod
Test 6	Seat o-ring – 4 nicks	Leak rate 18.0 CFM.
Test 7	- 2 scrapes	Leak rate 36.0 CFM Simulating the damage caused by pinching a pig off or pinching a coupon from hot tapping operations.
Test 8	Cut-out a 3/4'' section of O-ring completely	Insufficient nitrogen to conduct flow test. This is considered a worst case situation for o-ring damage

Table 2. O-ring damage test.

Sealant detail

Ball valves are designed not to require lubrication for normal operation. Use of lubricants and/or sealants during API hydrostatic testing at the factory is prohibited.

Minor damage may occur after the valve is shipped from the factory due to improper handling or because sand or dirt gets into the valve while sitting at the pipeline right-of-way waiting for installation. The valve is usually cycled during installation of actuators and during hydrostatic testing of the pipeline. The contaminants create tiny scratches on the polished seating surfaces causing minor leak paths. These minor leaks only become obvious after the introduction of high pressure gas into the pipeline.

Factory testing confirmed that minor seal leaks can be sealed through the introduction of light grade lubricants or sealants such as Sealweld Total-Lube #911, into the standard seat injection fittings provided on the Grove B-5 ball valve. More severe leak paths can be reliably sealed through the injection of Sealweld #5050 Ball Valve Sealant. The larger size and variety of PTFE particles used in regular grade 5050 can be safely injected through all types of sealant injection fittings and internal check valves without risk of plugging the check valve mechanism.

It should be stated that these sealing compounds are designed to provide a reliable temporary seal only. Valves with severe seat or ball damage should be repaired or replaced at the earliest opportunity.

The use of emergency sealants provides a temporary seal for the duration of the pipeline tie-in, pig launching or compressor repair. When the valve is cycled, the seal may be lost. In some cases, additional sealant will need to be injected in order to bridge-off the leak path the next time a bubble-tight seal is required. These types of sealants are commonly utilised in large-diameter gas pipelines where valve repair or replacement is impractical and/or prohibitively expensive.

Review of first tests

Objective

The objective was to intentionally damage the seating surfaces of the ball valve to simulate minor seat damage that may occur as a result

Scar Depth – Top Side

.073"	.080"	.070"	.090"	.075"	.080"
.045"	.067"	.066"	.085"	.075"	

Scar Depth – Bottom Side

.071"	.070"	.065"	.068"	.068"

Table 3. Re-measurement of scars.

Damage	Sealant
O-Ring Damage Only	Sealweld Total-Lube #911
Scar Damage -Minor to .010"	Sealweld Total-Lube #911
Scar Damage -.010" to .030"	Sealweld 5050 Sealant
Scar Damage -.030" to .047"	Sealweld XXXH 5050 Sealant
Scar Damage -.047" to .060"	Sealweld XXXXH 5050 Sealant
Scar Damage -.070" to .090"	Sealweld CHAMELEON Sealant

Table 4. Sealant summary.

of construction debris being left in the line at start-up and to demonstrate the effectiveness of sealants injected into the seat area.

Initially, at one end of the valve, the ball was deliberately scarred and at the opposite end the seat seal o-ring was deliberately damaged. A hand-held electric engraving tool was utilised to scar the ball. A depth gauge was utilised to measure the depth of the scars. A turbine gas meter was utilised to measure gas flow.

Leakage rates and bubble-tight seals were measured by using a small-diameter hose connected to the body vent fitting, through a turbine meter and into a container of soapy water. To be considered 100% bubble-tight there had to be zero leakage or bubbles passing by the seat seal, for a duration of 25 minutes. 1000 psig gaseous nitrogen was utilised as the test medium. A typical API 6D valve seat test in this size of valve is 5 minutes to each seat independently and 5 minutes to both seats simultaneously. The valve must seal with no visible pressure loss for the duration of the test.

Test procedure

The valve was assembled repeatedly, tested, disassembled, cleaned, seal damage worsened then reassembled until a 'worst case' leakage situation was realised.

See *table 1* for the ball scar test and *table 2* for the o-ring damage test.

In all 4 cases of seat seal o-ring damage, a bubble-tight seal was achieved with Total-Lube #911 through the injection fittings. The heavier 5050 sealant was not required.

We believe the turbine meter may be useful as an analytical tool, it will not be known if the leak path is one large scar or several smaller scars. By starting with a light grade sealant the smallest leak path may be sealed off first and a heavy sealant may not be required.

One may conclude as a result of the o-ring damage test, that just because the valve is leaking severely, application of heavy sealant may not be necessary.

Without the introduction of Sealweld sealants, in a typical pipeline application, the valve would have continued to leak, possibly eroding and enlarging the leak path size over time.

Second tests

The second tests verified the results of the first series of tests. The ball scar damage was again gradually worsened. Progressively heavier sealants were injected until the seat sealant system became inoperable. The body cavity was then filled with an ultra-heavy sealing compound.

As previously described the Grove B-5 ball valve has a unique seat ring design. Contrary to other trunnion-mounted ball valve designs that feature a downstream self-relieving seat ring, the Grove B-5 is designed so that any leakage past the upstream seat ring pushes the downstream seat ring harder against the ball.

It was theorised that due to the unique Grove seat seal design, filling the body cavity with an ultra-heavy sealant would accomplish two things:

1. The filled body cavity would apply hydrostatic pressure to both the upstream – and downstream seat seal rings, thereby forcing both seats against the ball.
2. The increased size and quantity of the PTFE particles in the ultra-heavy – sealing compound would seal even severe leak paths.

Upon disassembly the scars were re-measured for depth. Measurements were taken 1/2" from the balls' through bore, where the seat seal contacts the ball (*table 3*).

It was calculated that filling the body of the valve including the hole through the ball would require 9.4 gallons of sealant.

Chameleon Seal was injected via 2 ea. Sealweld ACTIV-8® pumps into the body cavity. Total pumping time was 2.5 hours. With approximately 400 psig pressure head maintained, the small leak continued as we injected additional sealant. As we approached the estimated full capacity of the valve body (approximately 95 pounds), leakage across the valve stopped completely. After 2 minutes we noticed a small release of approximately 20 bubbles and then the valve sealed off 100% bubble-tight.

The gas pressure was increased to 820 psig and a 100% bubble-tight seal was maintained.

The gas pressure was increased to 1000 psig and a 100% bubble-tight seal was maintained.

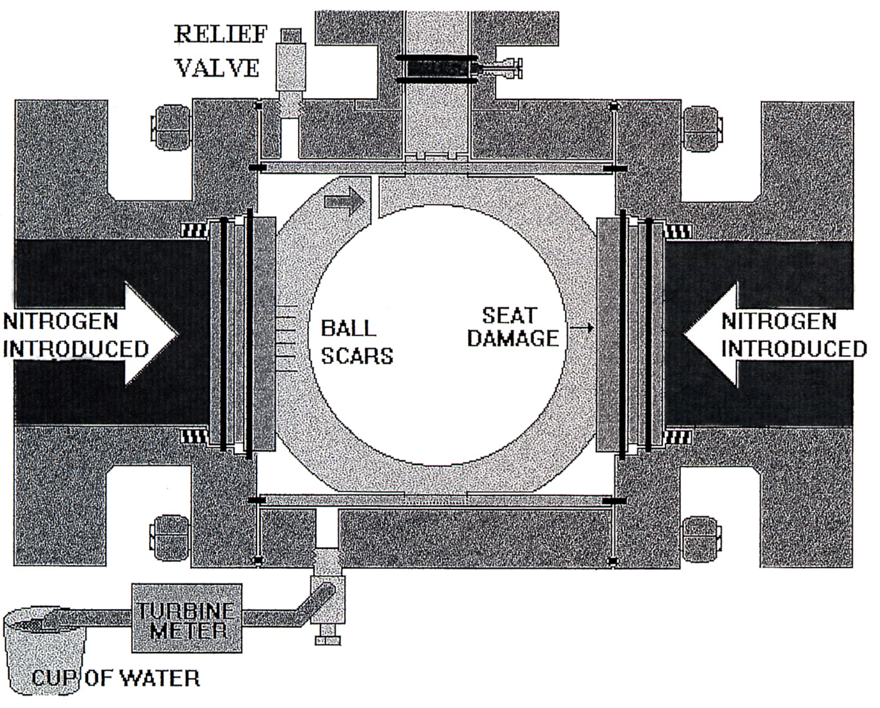
The nitrogen bottles were disconnected leaving 1000 psig nitrogen pressure in the top end of the valve. The 100% bubble-tight seal across the valve was then maintained for 17 hours.

The next morning the valve was still holding bubble-tight but had lost 20 psig pressure. All flanges and threaded connections were inspected with soapy water and a sealant fitting was found to be leaking very slightly by its threads. The fitting was tightened and no further leakage was observed.

Gas pressure was increased to 1440 psig and a 100% bubble-tight seal was maintained for 40 minutes. The testing was stopped.

Conclusion

We concluded that a 100% bubble-tight seal could be achieved in a worst-case leakage situation by utilising an ultra-heavy sealing compound in combination with the unique seat sealing characteristics of Grove B-4C and B-5 ball valves.



Ball valve test configuration.

Safety considerations

There is a considerable risk that rapid injection of sealant with high pressure injection pumps into the body cavity could cause the valve body to rupture when the body becomes completely full.

To prevent this from occurring we recommend this procedure be performed by experienced valve technicians only. Excess pressure can be avoided by attaching a pressure relief valve to the sealant injection hose leading from the pump or into the valve body. The pressure relief valve should be set to the rated maximum working pressure of the valve. The pressure relief valve should have sufficiently large internal orifices for large PTFE particles to pass safely through.

Other considerations

The valve body cavity should always be flushed with cleaning fluid before and after filling the body cavity to flush out all foreign contaminants and material that may have collected in the body cavity. The cleaning fluid should be approved by operations/engineers and should also be compatible with all elastomers in the valve. The recovered cleaning fluid should be disposed of using environmentally safe methods.

Summary

Minor seat damage can be reliably sealed by means of injecting Sealweld Total-Lube #911 and Sealweld 5050 Ball Valve Sealant with PTFE bridging agents without risk of plugging off the sealant fittings, insert check valves or sealant injection system.

The Ultra-heavy 'Chameleon' Seal compound can be utilised in Grove B-4C and B-5 ball valves, to seal severely damaged seating surfaces. These types of sealants have per cent concentrations of solids that are too high to be injected through conventional sealant injection fittings, but may be injected through Sealweld FLOW WOLF® Fittings or through full port ball valves. See *table 4* for a sealant summary.

The testing demonstrated that valves that utilise double acting seats, like Grove B-4C and B-5 ball valves, can be sealed 100% bubble-tight by utilising body filling techniques. The ultra-heavy sealant filling the body cavity activates both the upstream and downstream seats. With seats activated, the filled body volume is pumped up to higher than line pressure, creating a positive seal.

Most gate valve designs are also capable of sealing by utilising body filling techniques.

Gate valve design can vary greatly depending on the manufacturer and model. Some pipeline gate valves feature a self-relieving upstream seat ring while other types feature no relieving seat ring.

Gate valves that rely on a mechanical seal do not have any provision for internal pressure relief and extreme caution must be taken to prevent over pressuring and rupturing the valve body. Fatalities have been reported when the technician failed to relieve trapped body pressure in gate valves with mechanical seals. Valves in liquid service may over-pressure very rapidly therefore we recommend this procedure be performed by technicians with considerable experience.

Subsequent to the factory testing, field trials have been conducted on over 100 large-diameter ball and gate valves. In every case, a 100% bubble-tight downstream seal was obtained by filling the body cavity Sealweld Chameleon sealant.

Our testing and field trials have proven that it may not be necessary to blow down long sections of pipeline, depending on the type of valve and the nature of the leakage problem.

The technician should always verify that the valve is fully closed prior to injecting sealants into the seat sealant system and/or body cavity. ■

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We would like to thank the engineering department at Grove Valve & Regulator and their Canadian licensee Valgro Ltd for the 12" ball valve that was used for testing and the use of their facilities. The seat sealing design described in this article is standard in all Grove B-4C and B-5 ball valves, many other ball valve manufacturers now claim to offer a similar design, the effectiveness of which is unproven.

About the author

Dean Chisholm is the President of Sealweld Corporation Ltd. Sealweld Corporation is a manufacturer of valve care products with offices in Calgary Canada, and Houston, Texas, USA.

Sealweld Corporation

#106 – 4116 – 64TH Ave. S. E.

Calgary, Alberta, Canada T2C 2B3

Tel: + 1-403-236-0043

Fax: + 1-403-236-5487

Website: www.sealweld.ca

Sealweld Corporation Inc.

7240 Brittmoore, Suite 120

Houston, Texas 77041

Tel: + 1-713-937-9222

Fax: + 1-713-896-0821

Website: www.sealweld.com