

PACKING CONFIGURATION PERFORMANCE FOR SMALL STEM DIAMETERS

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ABSTRACT

The extensive use of graphite packing and its excellent track record for large isolating valves in CANDU, Primary Heat Transfer (PHT) systems has resulted in an increased application of graphite packing on the conventional side. Many of these applications are in air operated valves (AOVs) where the packing sets are used on small stem diameters (< 1 inch) with frequent short-cycling strokes ($\pm 10\%$ of full stroke). The direct application of the proven packing configurations for large isolating valves to control valve application has generated problems such as stiction, packing wear and, in isolated cases, stem stall.

To address this issue, a test program was conducted at AECL, CRL by MED branch. The testing showed that by reconfiguring the packing sets and using PTFE wafers reductions in stem friction of 50% at ambient conditions, and 3 fold at hot conditions are achievable. The test program also demonstrated benefits gained in packing wear with different stem roughness finishes and the potential need to exercise small stems valves that see less than full stroke cycling. The paper describes the tests results and provides field support experience.

INTRODUCTION

The extensive use and excellent performance of graphite valve stem packing configurations for large isolating valves in CANDU[®] Primary Heat Transport (PHT) systems has resulted in an increased use of these configurations on the conventional side. Many of these applications are in air operated valves (AOVs) with stem diameters less than 1 inch and frequent short cycling strokes. Problems with packing wear, unstable stem actuation due to high static friction relative to dynamic friction, and stem stall have been noted.

Limited experience indicated that the application of PTFE wafers would reduce stem friction and increase packing wear. Little research has been done with PTFE wafers and previous testing of the effects of different stem finishes on stem friction gave mixed results. Tests at CRL at elevated temperature and pressure show 10 % less stem friction for an 8 RMS stem compared to a 32 RMS stem, while ambient temperature tests showed no difference between 4 and 12 RMS stems. For marginal actuators,

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even small reductions in friction are desirable. At the same time, leakage must be maintained below acceptable levels.

Air operated valves are often used on a control loop where they stroke frequently to maintain the desired loop conditions. While each actuation may be very short, the total stem travel seen by the valve packing may reach several hundred thousand inches in a few months. The packing must be capable of performing reliably over the entire period.

To address these issues, a three-phase test program was funded by COG WP#1 and conducted at AECL-CRL by the Mechanical Equipment Development (MED) branch. In Phase 1, packing configurations containing PTFE wafers were tested at simulated PHT conditions to obtain hot friction test data. In Phase 2, selected packing configurations were tested at room temperature and 150 psig water on instrument air operated valves to determine leakage and friction performance. Phase 3 testing investigated wear and friction characteristics of selected configurations in dry, ambient operating conditions at room temperature. The following presents an overview of the findings from this program and its field application.

PACKING PRODUCTS

The test program used Argo 6000, composite end rings, "C", Argo 6300J, die-formed graphite, full height, "D" and reduced height, "d" (50% of the width), and PTFE wafers, "t". The packing sets were tested in various configurations, from the standard 5-ring set of CCDDC, to sandwich style sets such as CtdCtdC, Figure 1.

NOTE:

The chemical composition of PTFE is 20% carbon and 80% fluorine. Exposure of PTFE to high levels of ionizing radiation can cause it to break down and release leachable fluorides. Use of packing materials containing PTFE in nuclear power stations raises the following concerns:

- reduced packing life and performance due to radiation exposure;

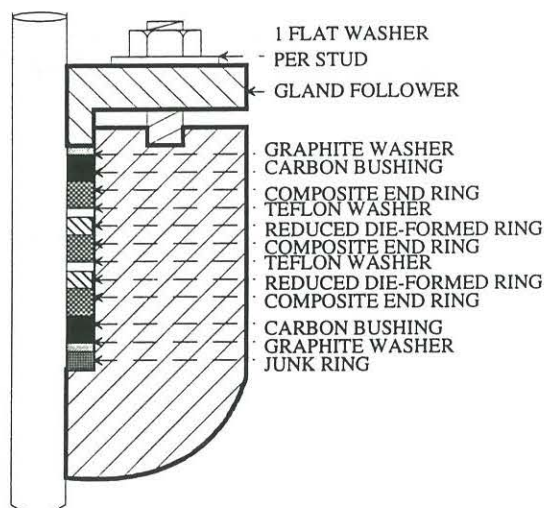


FIGURE 1
Reduced Height Sandwich Configuration

- release of leachable fluorides into the system fluid;
- release of small amounts of PTFE into the system due to "skirting".

The first two concerns have been addressed in various qualification tests. Sample packing material were irradiated to 10 MRads gamma in a simulated stuffing box. Irradiation had no detrimental effect on the sealing properties of the packing or operability of the valve. Both, prior to and after irradiation, the level of leachable fluorides in the packing was within limits set in specifications..

Release of PTFE into PHT and Moderator systems is a system chemistry issue. Small particles of PTFE could be carried into the reactor core where intense radiation would break them down and release fluorides into the system fluid. Where packing materials containing PTFE are used in PHT and Moderator system valves, provisions should be made to ensure that fluoride levels in system fluids do not exceed the acceptable limit of 0.1 parts per million established by AECL.

EQUIPMENT

Endurance Test Rig (ETR)

The Valve Packing Endurance Test Rig (ETR), is a fully instrumented valve packing test rig that monitors and measures system operating

conditions, packing leakage, consolidation and stem thrust. Hydraulic actuators move the stem, with control through a hydraulic circuit and test monitoring by data acquisition unit.

Six combination die-formed graphite packing sets were evaluated at cold and CANDU PHT conditions of 565° F and 1,450 psig. The configurations were tested through 400 stem cycles, with a static shut down period after 200 stem cycles.

All the packing sets used solid rings on a 1 inch diameter stem. Gland stress was 4,000 psi without live loading. Two packing cross-sections and stem finishes were used: 5/16 inch with a 32 RMS stem finish and 1/4 inch with a 4-6 RMS stem finish.

Air Operated Valve Test Facility (AOV)

Two instrumented AOVs were used for this test program (Fisher Controls, Type EZ, Size 2, with Type 667, Size 50 actuators). AOV1 had a 4 RMS stem, while AOV2 ran the first test with a 32 RMS stem and the second test with a 12 RMS stem. Each valve used a 0.75 inch diameter stem and a 1.25 inch diameter stuffing box and each was pressurized to 150 psig water. For the majority of the test period, the stem travel was 0.31 in. for a full cycle at a stroke rate of approximately 7.5 strokes per minute. Depending on the test plan, full stem stroking was done to monitor changes in packing friction and the effects of stem wiping.

SuperCycle Jigs (SCJ)

Three test jigs, each consisting of a stem and stuffing box, were used for the long-term wear tests. Each SuperCycle Jig (SCJ) used a 0.75 inch stem diameter and a 1.25 inch stuffing box inside diameter. Stem finishes used were 32, 12 or 4 RMS. The three valve stems were connected to a variable speed motor which exercised them at a stroke rate of 14 cycles / minute. A cam shaft with three different offsets provides valve stem stroke lengths of 0.8 inches, 0.33 inches, and 0.75 inches.

SUMMARY OF RESULTS

The following is an overall summary of the findings. For additional detail see the referenced COG reports.

Hot Testing (ETR)

Stem friction using sandwich-style configurations at ambient conditions was reduced about 50% compared to the standard 5-ring set.

Use of PTFE at elevated temperature reduced stem friction 3-fold compared to ambient conditions.

PTFE extrusion past the in-board composite ring was observed with all PTFE configurations used with the 32 RMS stem. Therefore, stems with 32 RMS finish are not recommended for use in this type of application.

Little to no PTFE extrusion was observed using the 4-6 RMS stem.

AOV Testing

A 32 RMS stem exhibits packing leakage well before a 4 RMS stem, and is not recommended for use in any CANDU valves where total stem travel will be above 10,000 inches and low leakage is important.

Packing configurations with PTFE wafers allow about twice as much total stem travel before failure as those without PTFE wafers.

Increased friction due to packing build-up on the stem can occur within 70 inches of total stem travel when the stroke length is short relative to the packing ring height. The build-up can lead to a doubling of stem thrust after 850 inches of travel. A few full strokes at this point can reduce the thrust by half.

There are no obvious effects of PTFE wafers or reduced height die-formed rings on stem thrust.

SuperCycle Jig

Composite/die-formed configurations without PTFE wafers show extensive wear after 400,000 inches of stem travel.

PTFE wafers reduce packing wear but increase stem thrust at ambient conditions.

Increasing stem travel increases packing wear but has no effect on stem thrust.

There is no evidence that changes in stem speed affect packing wear or stem thrust.

FIELD CONFIGURATIONS

Based on the above test results and lessons observed in the field, the following configurations are being used to reduce friction and improve the operability of AOVs and MOVs.

Bruce-B (Contact Dean Cumming)

Re-heater drains system, units 5-8-41850-LCV's (level control valves) are using a reduced height sandwich style with PTFE wafers inserted between the rings (Figure 2). By adding the PTFE wafers, the gland stress can be increased from 3000 to 4000 psi. At gland stresses of 3000 psi there were problems with the packing leaking a few months after a repack. This was attributed to a loss of gland load caused by packing wear which resulted in increased packing consolidation.

Bruce B has at least 4 - LCV's repacked with the new configuration live-loaded to 4000 psi. Flowcanner™ results have confirmed the lower friction using PTFE wafers. The reduced height graphite sets gave proportionally reduced friction at 3000 psi gland stress but due to increased friction at 4000 psi without PTFE wafers Bruce B does not plan to increase the live-loading to 4000 psi until the PTFE wafers are inserted into the configuration.

Another application of the reduced height graphite rings has been the boiler feed level control valves 7-43230-LCV9 and 8-43230-LCV5. To date, a reduced height graphite set with PTFE wafers has been installed in 2-LCV's to replace the PTFE Chevron™ sets.

Hot operating Flowscanning has been performed on 7-43230-LCV9. The intent was to document the effect of hot operating conditions on reducing friction as compared to the cold repack Flowscan. Depending on the results, the intent was to increase the gland stress to 4000 psi from 3000 psi. The original cold Flowscan friction value was in the 600 -650 lbf range after the original repack with composite/graphite

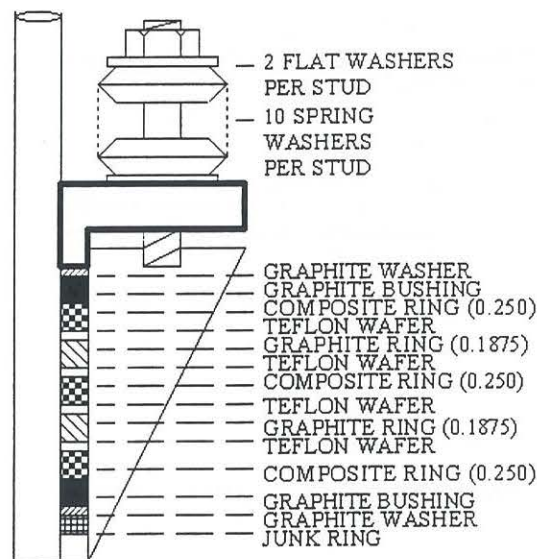


FIGURE 2
Bruce B Configuration Using PTFE Wafers in Level Control Valves

sandwich style with PTFE wafers, performed in Oct 1996. In 1997 May, system configuration provided an opportunity to Flowscan 7-43230-LCV9 under hot operating conditions without causing any upset conditions. The as-found hot Flowscan at 4000 psi gland stress showed that the friction had increased from 614 lbf to 627 lbf. That is the Flowscanning results showed an increase of 13 lbf in friction under hot conditions as a result of increasing the gland load from 3000 to 4000 psi. Based on as-left Flowscan data collected during the final setup following a repack, a conservative decision was made, to increasing the gland stress to 4000 psi for the identical material code or family of LCV's.

Cases of using reduced-height composite graphite without the PTFE wafers have been successful in reducing the friction, such as the boiler blow-off MV's. However, Bruce B are planning to have PTFE wafers installed during the next repacks. The decision to include PTFE wafers is based on the improved operating characteristics, reduced friction and increased packing life.

The boiler blow-off MV's 5-8-36410-MV's 9-24, 35, 36 (Rockwell Edward's valve with EIM actuators), have had friction problems because the actuators have limited torque thrust capabilities. The original configuration used a

5-ring set (1.125 in. ID x 2.535 in. OD x 11/16 in. cross-section). The packing configuration now being used is a 4-ring reduced height composite graphite set with upper and lower bushings (Figure 3). A gland stress of 4000 psi can now be used where before it was restricted to 3000 psi to maintain operability.

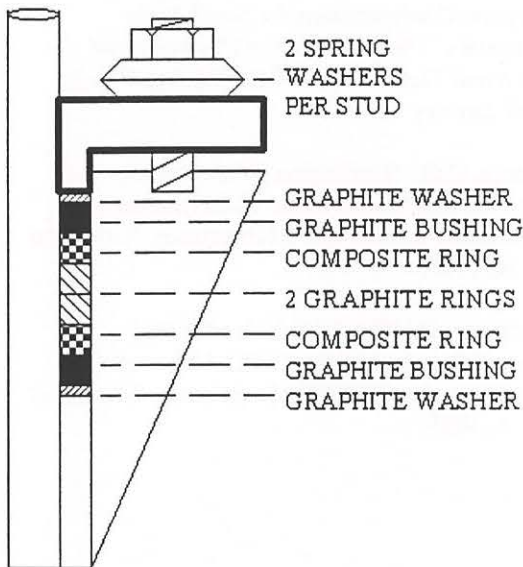


FIGURE 3
4-Ring Reduced Height Set -
Friction Reduction

Darlington (Contact Cameron Spence)

Darlington's work in the AOV packing program has resulted in a significant effort on gland follower and guide bushing/junk ring (stainless steel) changes. At this time any AOV re-packing for the first time, the following good practices are implemented: gland follower replacement, guide bushing removal, junk ring installation (bonnet removal required), stem polishing, installation of composite graphite set with PTFE wafers, and in many cases the addition of live loading. The intention of the stainless steel component change is to allow the graphite bushings to act as the guide mechanism instead of the stainless steel components to reduce galling risk and allow tighter tolerances with the stem.

Darlington is now in the process of installing this complete fix in several AOV's along with the use

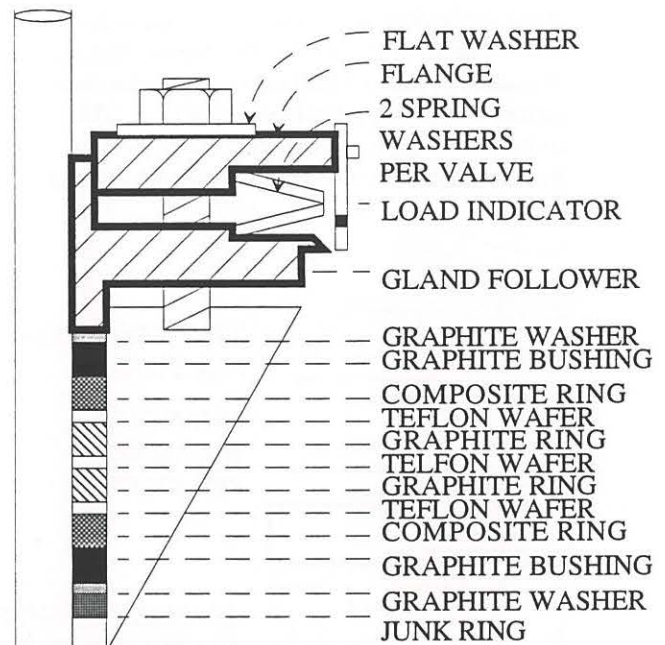


FIGURE 4
Configuration for Copes-Vulcan with
0.75 inch Stem Diameter

of reduced-height packing sets to assist with valve operability and packing life. Up to 50% reduction in friction, in some cases, has been seen by switching out the gland follower and guide bushing to graphite alone. This has been quite successful but there have been some operability, stiction, problems with some valves. It is expected, based on R&D testing and other field results, that the use of PTFE wafers when added to the configuration along with reduced height sandwich sets, operability will be further improved.

Figure 4 illustrates the configuration being used for Copes-Vulcan Valves with a 0.75 inch stem diameter.

Figure 5 shows the configuration used on AOV's with stem diameters primarily 1 inch and greater. There are some 0.75 inch valves that use this configuration as well. Some of Darlington's smaller Copes-Vulcan AOV's use 4-ring sets as shown in Figure 5 but with normal live load of 14 Belleville springs per stud.

REMARKS

The R&D support provided to the station to reduce stem friction and improve packing life is

being implemented. The success of the program is the combined effort from the station initiative to install specialized packing configuration and regular contact with R&D and suppliers. This co-operative approach has led to stem packing friction reductions along with improved packing life.

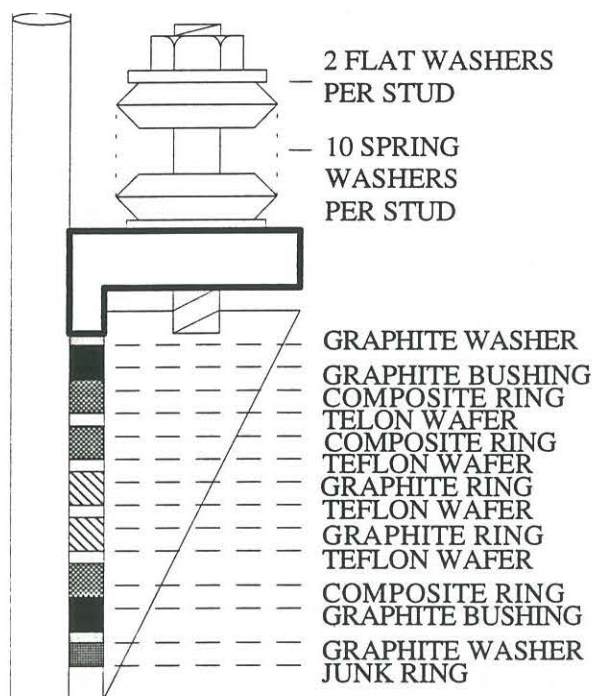


FIGURE 5
AOV Configuration for Stem Diameters
Greater Than 1 Inch

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