Rotary Shear Valves

Competitive Study

- Ultra Long-life Valves -
  - Up to 24 times the life of competing valves
- Compatible with -
  - Tecan/Cavro® XP Syringe Pumps
  - TCS C3000 3cm Stroke Pumps
  - TCS C12000 & C24000 3cm Stroke Pumps
  - TCS MC6000 Multi-Channel Pumps
- Proprietary designs & processes
- Available in a variety of inert materials -
  - PCTFE
  - PEEK
  - PTFE
  - UHMWPE

- Custom OEM options available
- Available in numerous porting configurations
- 2 year warranty against defects in materials and workmanship

TRICONTINENT™
HANDLING LIQUIDS...PRECISELY

Summary

#	Competitor Valve Tested/compared	Competitor - Average Cycles until Leak	TCS - Average Cycles until Leak	TCS Advantage (X Times Longer)
1	TCS Cat. # 10092 compared to XP 3-Port 120° Y	519,300 [1]	4,089,000 [2]	**8X**
2	TCS Cat. # 10062 compared to XCalibur - 4-Port 90° Distribution	327305 [3]	7,939,258 [4]	**24X**

1. The five Tecan/Cavro® XP Valves exhibited first measurable leaks ranging from a low of 65,573 to a high of 1,076,912. Average cycle count across all 5 valves was 519,288.
2. **Test stopped before measurable leak encountered.**
3. The two Tecan/Cavro® XC/XLP Valves exhibited first measurable leak at the 327,305 cycles
4. The two TCS Valves exhibited first measurable leaks ranging from a low of 6,507,224 cycles to a high of 9,371,293. Average cycle count for the two valves was 7,939,258.

TCS Rotary Shear Valves manufactured with our proprietary processes and using proven engineering polymers such as PCTFE, PEEK, UHMWPE & PTFE provide cost effective and unparalleled longevity in syringe pump applications. The life provided by TCS valves is typically a minimum of 1 million cycles even in more demanding applications and routinely several times the life of competing polymer valves. In many cases, the life far exceeds ceramic valves at a fraction of the price. These claims are backed up by extensive testing and real life applications/data provided by TCS customers.

Background

Rotary Shear Valves have long been the standard design for flow control used in precision syringe pumps. Although unmatched in providing fluidic performance, they have historically experienced relatively poor longevity, sometimes lasting as little as 50,000 cycles.

In recent years some manufacturers have pursued alternate materials and designs in an effort to reduce their high failure rates. Commonly the materials now used for "long-life" valves are ceramic rotors and/or stators with a face seal configuration. Compared to previous Rotary Shear valve designs this approach offers promise of longer life but at significant expense. Ceramic is also prone to seizing when crystallizing reagents, such as commonly used saline buffers, are being used and the valves sit idle for a even a short period of time, resulting in very costly replacements.

TriContinent accepted the challenge from key instrument manufacturers to develop a better alternative, providing relief from the early failure versus extreme cost dilemma. TriContinent embarked on an exhaustive R&D program to satisfy industry demand for a long-life cost-effective valve.

TCS Findings

TCS engineers ultimately discovered that previous longevity limits using polymers were largely related to the materials used, how they are processed by the raw materials suppliers, how they are machined and how parts are handled after machining:

- Although the chemical makeup of the PCTFE, PEEK, PTFE and UHMWPE used in TCS valves are industry standard, it was discovered that not all raw material suppliers process the materials the same way. Consequently TCS worked with the best material suppliers to develop unique and stringent specifications to which the materials must adhere.

- Outdated manufacturing processes were not ideally suited to these materials for this application. TCS invested heavily in the proper equipment required and developed proprietary manufacturing processes to realize their full potential. Additionally TCS engineers had to make special modifications to the CNC machine tools in order to achieve the exceptional finishes and tolerances needed to achieve superior longevity.

- Valve components are 100% visually inspected to ensure the parts are free of burrs and potentially harmful contaminants. Parts are also dimensionally inspected using fully automated coordinate measuring machines (CMM). Finally the components are assembled and 100% tested for leaks using extremely sensitive automated leak check instrumentation.

TEST 1 - SET UP AND SUMMARY RESULTS
CAVRO® XP VALVES vs. TCS C3000 VALVES
3-PORT 120° Y VALVES

04 Aug, 2009 HFS
7682-REV-EE

Test 1 - AVTF Auto Test Fixture Sample Size 5 each	
TCS XP Style - 120° 3-port PCTFE body, UHMWPE Plug (TCS Cat. # 10092)	**Tecan® XP Style - 120° 3-port PCTFE body, PTFE Plug (Tecan® PN 20725587)**
	

Test Description

A comparitive analysis of valve life from testing on the automated valve test fixture is presented below. V1 through V5 are XP valves and V6 through V10 are TCS valves. Shown in the columns from left to right are leak rate verses cycle count for each valve as determined from the fixture data. At the bottom is the actual (off-line) measured leak rate for each valve. The XP valves exhibited the leak rate criteria (3 consecutive detected leaks of 0.7 microliters in less than 15 seconds = 0.047 microliters/sec) starting as low as 65,573 cycles for V3 and as high as 1,076,912 cycles for V5. The TCS valves did not exhibit the leak rate criteria through the end of testing (4,089,230 cycles).

While the fixture is capable of detecting low leak rates, at very low leak rates (less than approximately 0.2 micro-liters/sec.), the fixture will record a leak rate that, while a measurable air leak rate, is essentially a zero fluid leak rate.

Test 1 Set Up

For Test 1, the TCS proprietary Automated Valve Test Fixture (AVTF) was used. The AVTF has been extensively engineered and is the only fixture in existence that can rapidly life cycle and automatically leak check rotary valves without ever removing them from the apparatus. The device can test up to 10 valves of varying configurations simultaneously. The AVTF cycles valves at an accelerated rate, up to 80,000 cycles per day. The AVTF is driven and managed via a sophisticated LabView software system that controls all test timing, valve motions, logging and data acquisition.

Test 1 Conditions

Automated Valve Test Fixture (AVTF)

- Cycling test fluid was filtered distilled water.
- Cycling pressures were 30 PSIG and Leak Test Pressures were 60 PSIG water. Offline leak test pressures were 100 PSIG water.
- Leak Criteria –
  - 0.047 microliters of water per second (tested online by the AVTF).
  - 0.010 microliters of water per second offline and/or an increasing leak rate of air from a port with an increasing number of cycles.

Test 1 Summary

The five Tecan/Cavro® XP Valves had cycle counts at first indication of leakage ranging from a low of 65,573 to a high of 1,076,912. Average cycle count across all 5 valves was 519,288. None of the TCS valves provided indication of leakage throughout the duration of the test. The five TCS valves were allowed to cycle beyond 4 million cycles before it was decided to end the test. The test fixture would be utilized to perform additional tests and further enhancements would be made. At "end of test" the TCS valves were once again leak checked. When determining a ratio of expected life improvement over the Tecan/Cavro® valves, the cycle count at end of test was used even though there was no measured leakage. This yields a value of 7.9 so **an advantage statement of "greater than 8X" is justified**. If the TCS valves were allowed to cycle until leakage was measured, it is expected the advantage ratio would be considerably higher, potentially 24X or greater since the valves are manufactured in the same manner as those used in Test 2.

Valve Test 1 - Life Testing Results, Indication of Leak Summary*

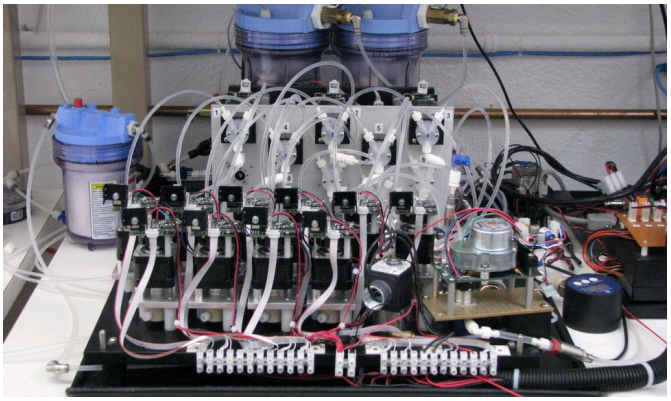
	First Indication of Leak			End of Test
Valve #	**Leak Rate/ # Cycles**	**Leak Rate/ # Cycles**	**Leak Rate/ # Cycles**	**Leak Rate/ # Cycles**
COMPETITOR VALVES				
V1 (XP)	**.064 µL/s 892,803**	.047 µL/s 1,052,995	.239 µL/s 1,060,729	2.136 µL/s (a) 4,089,230
V2 (XP)	**.495 µL/s 230,767**	1.278 µL/s 296,760	.050 µL/s 329,757	3.064 µL/s (b) 4,089,230
V3 (XP)	**.473 µL/s 65,573**	.153 µL/s 98,360	.076 µL/s 131,147	3.082 µL/s (c) 4,089,230
V4 (XP)	**.095 µL/s 330,387**	.051 µL/s 364,266	.086 µL/s 401,634	4.080 µL/s (d) 4,089,230
V5 (XP)	**.053 µL/s 1,076,912**	.079 µL/s 1,141,350	.048 µL/s 1,203,224	.823 µL/s (e) 4,089,230
TRICONTINENT VALVES				
V6 (TCS)				**.028 µL/s (f) 4,089,230**
V7 (TCS)				**.034 µL/s (f) 4,089,230**
V8 (TCS)				**.028 µL/s (f) 4,089,230**
V9 (TCS)				**.027 µL/s (f) 4,089,230**
V10 (TCS)				**.006 µL/s (f) 4,089,230**
Average Cycles :	**519,288**			**4,089,230**

a) Actual leak rate: 3.162 µL/s (extrapolated from 100 to 60 PSIG)
b) Actual leak rate: 1.338 µL/s (extrapolated from 100 to 60 PSIG)
c) Actual leak rate: 6.324 µL/s (extrapolated from 100 to 60 PSIG)
d) Actual leak rate: 2.232 µL/s (extrapolated from 100 to 60 PSIG)
e) Actual leak rate: 1.122 µL/s (extrapolated from 100 to 60 PSIG)
f) Actual leak rate: 0 leak detected in 120 seconds, leak = 5 picoliters/sec

*: all cycle counts until first indication of leakage were recorded and then averaged.

TriContinent Scientific, Inc.
Toll Free: (800) 937-4738
Email: liquidhandling@tricontinent.com
www.tricontinent.com

Test 1 Set up
Automated Valve Test Fixture



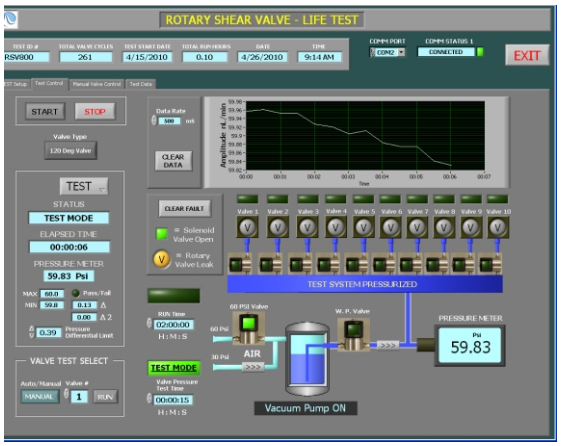
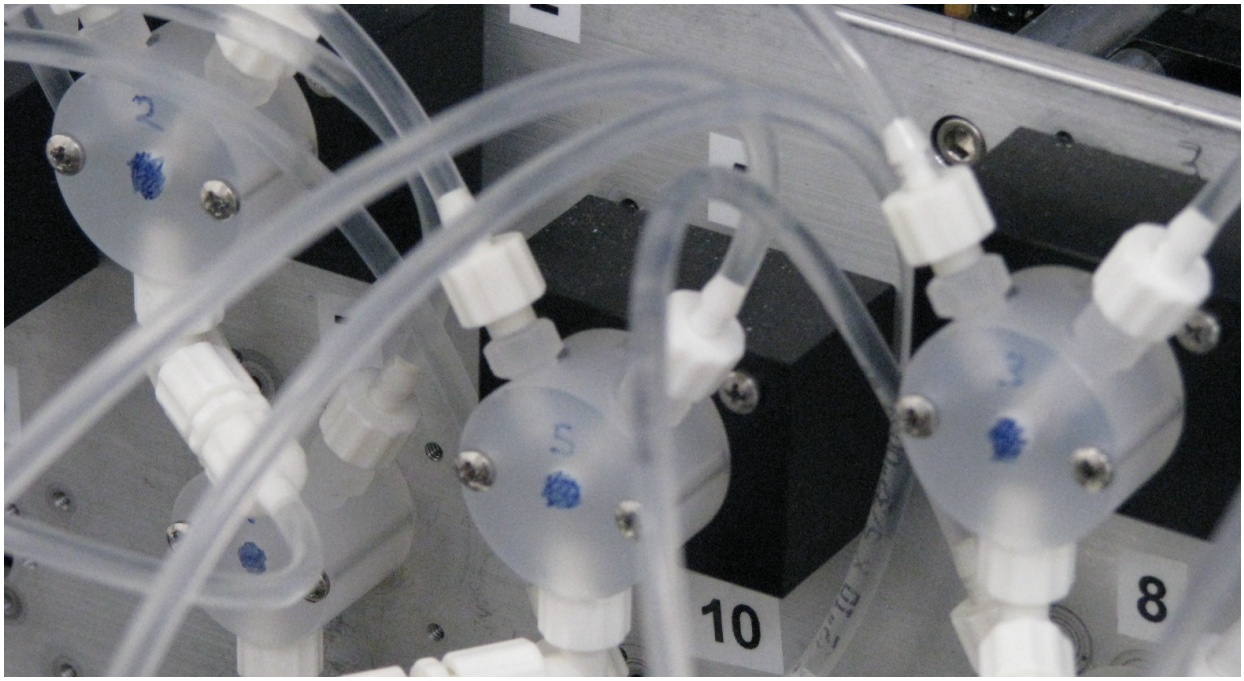
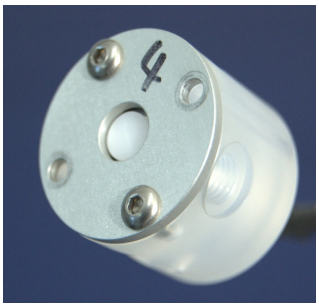


Figure 2 - LabView Control Screen



TEST 2 - SET UP AND SUMMARY RESULTS
TECAN/CAVRO® XC/XLP VALVES vs. TCS C3000 VALVES
4-PORT DISTRIBUTION VALVES

20 MAY, 2010 HFS
7688-REV-A

Test 2 - C3000 & XCalibur Pumps Sample size 2 each	
C3000 Style - 90° 4-port Distribution PCTFE body, UHMWPE Plug (TCS Cat. # 10020)	**XCalibur Style - 90° 4-port Distribution PCTFE body, PTFE Plug (Tecan® PN 20736615)**
	

Test 2 Description

A comparison analysis of valve life from testing on Tecan® XCalibur Pumps and TCS C3000 Pumps is presented below. V1 & V2 are TCS 4-port Distribution Valves and V3 & V4 are Tecan/Cavro® XC/XLP valves. Shown in the columns from left to right are leak rate verses cycle count for each valve as determined from the offline leak test data.

The XCalibur valves exhibited measurable leakage starting as low as 327,305 cycles. The TCS valves continued cycling and were checked for leaks periodically until 6.5 million cycles when Valve 2 was noticed to have developed a leak. It maintained this leak rate until 7.25 million cycles when the leak rate became moderate and the valve was removed from test.

Valve 1 was allowed to cycle beyond 10 million cycles and finally developed a leak of .018 µL/s at 10,323,829. The test was ended at this count.

TriContinent Scientific, Inc.
Toll Free: (800) 937-4738
Email: liquidhandling@tricontinent.com
www.tricontinent.com

Test 2 Set Up

For Test 2, the distribution valves were tested on the physical pumps they were designed to work with. This was necessary because the sealing surface area available on standard distribution style rotary shear valves is significantly less than non-distribution valves such as those used in Test 1. This can result in over-heating of the materials when run in an accelerated mode and can lead to skewed test results. Consequently the XCalibur Distribution valves were tested on XCalibur pumps alongside the C3000 Distribution valves tested on C3000 Pumps.

Test 2 Conditions

3 cm Stroke Pumps

- Cycling test fluid was filtered distilled water.
- Cycling pressures were 30 PSIG and Leak Test Pressures were 100 PSIG.
- Leak Criteria – 0.010 microliters of water per second offline and/or an increasing leak rate of air from a port with an increasing number of cycles.

Test 2 Summary

The two Tecan/Cavro® XC/XLP Valves had cycle counts at first indication of leakage at the 327,305 cycle mark. The two TCS valves provided first indication of leakage at the cycle mark of 6,507,224 and 9,371,293 for Valve 2 and Valve 1 respectively. Valve 2 achieved what was deemed a moderate leak at the 7.2 million cycle mark and cycling was stopped. Valve 1 was allowed to cycle to the 10.3 million cycle mark at which time the test was ended. By the end of test Valve 1 had achieved a leak rate of 0.018 microliters/sec.

When determining a ratio of expected life improvement over the Tecan/Cavro® valves, the cycle counts at the first indication of leakage for all valves was used. The life for TCS valves was then 7,939,258 cycles and for Tecan/Cavro® 327,305 cycles. This yields a ratio of 24.26 so **an advantage statement of greater than 24X is justified**.

Valve Test 2 - Life Testing Results, Indication of Leak Summary

	First Indication of Leak - water			End of Test
Valve #	**Leak Rate/ # Cycles**	**Leak Rate/ # Cycles**	**Leak Rate/ # Cycles**	**Leak Rate/ # Cycles**
TRICONTINENT VALVES				
V1 (TCS)	**.014 µL/s 9,371,293**			.018 µL/s 10,323,829
V2 (TCS)				.104 µL/s 7,248,393
COMPETITOR VALVES				
V3 (XC/XLP)	**.012 µL/s 327,305**			.310 µL/s 1,190,963
V4 (XC/XLP)	**.046 µL/s 327,305**			0.564 µL/s 599,096

Average Cycles :	**(TCS) 7,939,258** **(XC/XLP) 327,305**			

Test 2 Set Up
3 cm Stroke Pump Test

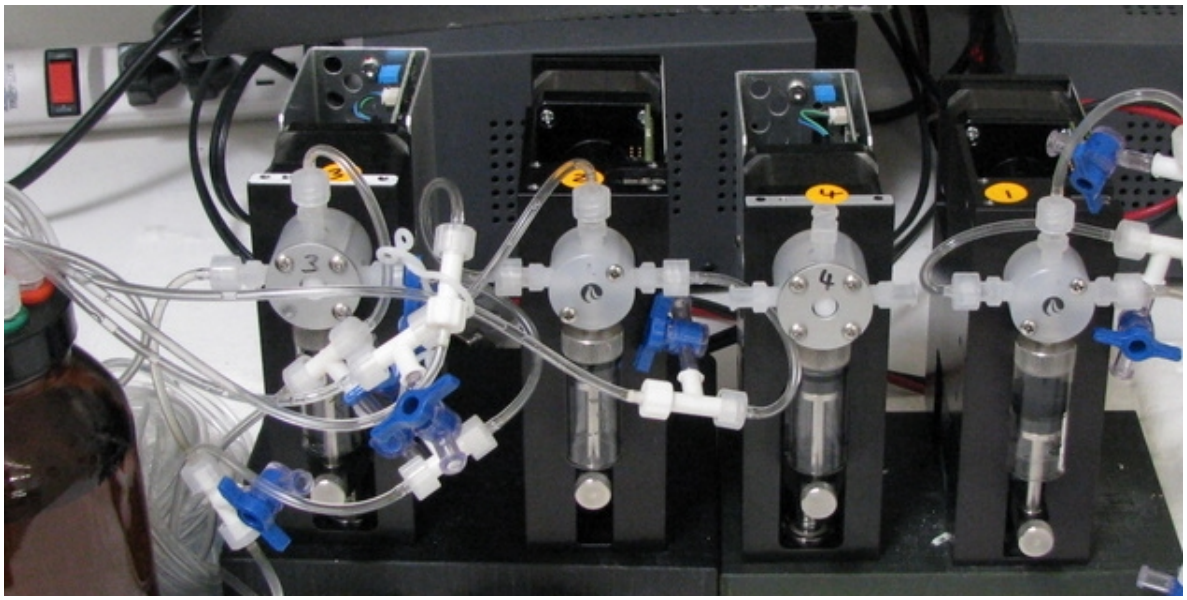


Figure 1- Distribution Valves, On-Pump Test

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Email: liquidhandling@tricontinent.com
www.tricontinent.com