Flow Rate Consistency of Peristaltic Pump Tubing Materials

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In any dispensing application, it is critical that the volume dispensed is predictable and consistent over time. Dispensing systems are typically calibrated prior to initial use, but over time components may experience wear or changes related to chemical exposure that can affect their performance. Unanticipated changes in dispensing volume can affect product quality, leading to failures in the field. As the leading global manufacturer of peristaltic pump tubing, Saint-Gobain elected to examine this issue in depth by testing the performance of a wide range of tubing materials in response to chemical exposure and long term use. The results of this study, described below, will help guide users in selecting the appropriate tubing for their dispensing application, and provide direction for new product development internally at Saint-Gobain.

Materials and Methods

This study examined the performance of seven different tubing materials:

- EPDM
- Fluoroelastomer
- Silicone
- Composite fluoroelastomer (multi-layered)
- Polyolefin elastomer
- Thermoplastic vulcanizate (TPV)
- Thermoplastic vulcanizate lined with a polyolefin

The experiments were conducted using Cole-Parmer L/S pump drives with EZ Load II pump heads. A back pressure of 15 PSI was applied and the pumps were operated at 100 RPM intermittently, with 10 minutes of down time (off) alternated with 5 minutes of pumping (on). The EZ Load II pump heads (Figure 1) have a slight bend and employ three rollers.

Figure 1: EZ Load II Peristaltic Pump Head

In this work, samples of each tubing material were subjected to chemical exposure and accelerated aging. Tubing samples were cut to 7" lengths for testing. Samples of each tubing material were then filled with either an acidic rinse additive with a pH of approximately 3 (Ultra Dry®) or an alkaline ware washing detergent with a pH of approximately 13 (Super Trump®) which were obtained from Ecolab. These samples were then tested for performance after one month of chemical exposure and after being subjected to an accelerated aging protocol that simulated one year of chemical exposure. The accelerated aging protocol involved placing the samples in a temperature controlled oven in accordance with a modified ASTM F1980 method. This method uses the temperature coefficient Q_{10} and the Arrhenius equation to relate temperature changes to time intervals, allowing researchers to use relatively short term exposure to heat to accurately simulate long term aging. In this work, samples were held at 50^{o}C and ambient humidity for 56 days to simulate one year of aging.

Results

EPDM:

The one-month aged EPDM samples exhibited between 10%-20% decrease in flow rate over a 3-week period. The EPDM samples aged with Ultra Dry® appeared to experience the most significant change in performance over time indicating that the material is more sensitive towards acidity. The EPDM samples subjected to one-year accelerated aging however, demonstrated a more stable trend overall with a slight flow rate deviation towards the end of testing. While the reason behind this observation was not investigated in detail at this time, we speculate that this could be attributed to a conditioning phenomenon by the chemicals on the material.

Figure 2: Effect of chemical exposure and time on EPDM tubing performance

Fluoroelastomer:

The one-month aged fluoroelastomer samples that were exposed to Ultra Dry® failed between the 96-and 144-hour interval while samples that were exposed to Super Trump® demonstrated erratic performance particularly towards the end of the testing reaching up to a 20% decrease in flow rate. Similarly, the fluoroelastomer samples that were subjected to the one-year accelerated aging process exhibited more consistent performance similar to that observed with the EPDM samples.

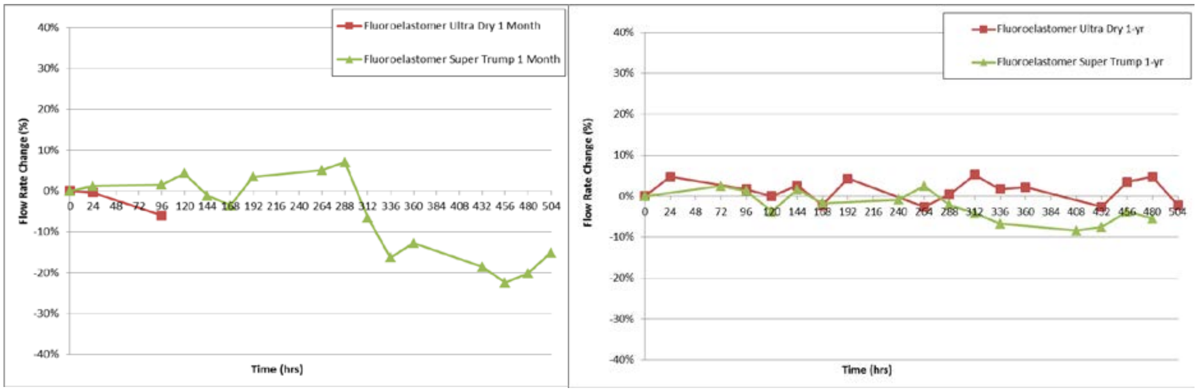

Figure 3: Effect of chemical exposure and time on fluoroelastomer tubing performance

Silicone:

The silicone samples that were subjected to chemical exposure for one month displayed very erratic performance after 192 and 408 hours of pumping post exposure to Super Trump® and Ultra Dry® respectively. As observed separately with other materials, silicone samples that were subjected to accelerated aging displayed more stable performance particularly when exposed to the more alkaline solution.

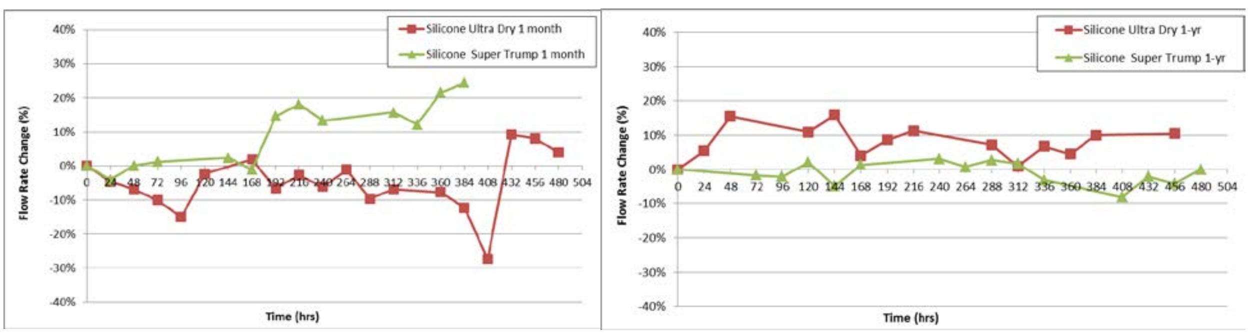

Figure 4: Effect of chemical exposure and time on silicone tubing performance

Composite Fluoroelastomer:

The composite fluoroelastomer samples exhibited the highest degree of flow rate variability of all the materials tested. The composite fluoroelastomer sample exposed to Ultra Dry® for one month exhibited up to a 35% increase in flow rate while similar exposure to Super Trump® saw a reverse trend with flow rates decreasing by up to 20%. The performance of the composite fluoroelastomer samples after one-year accelerated aging also exhibited erratic behavior whereby samples exposed to Ultra Dry® being impacted the most with a drop of over 30% in flow rate.

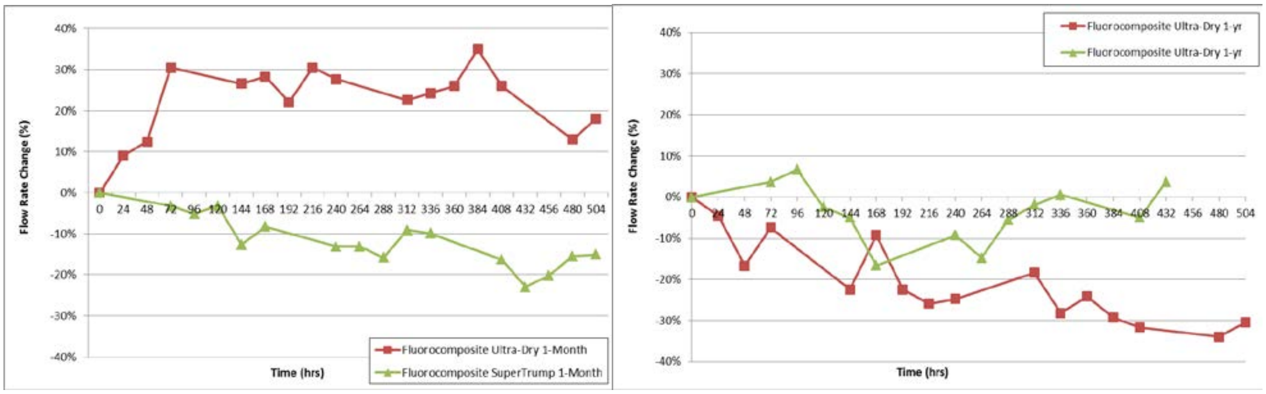

Figure 5: Effect of chemical exposure and time on composite fluoroelastomer tubing performance

Polyolefin Elastomer (TPO):

The one-month aged TPO samples that were exposed to Ultra Dry® failed after 24 hours while samples exposed to Super Trump® exhibited a steady downward trend in flow rate approaching a delta of close to 20% at the end of the testing period. The one-year accelerated-aged TPO samples did exhibit slightly more flow rate consistency but had a truncated lifespan even though exposure to Ultra Dry® did appear to prolong the lifespan slightly over the one-month aged analog.

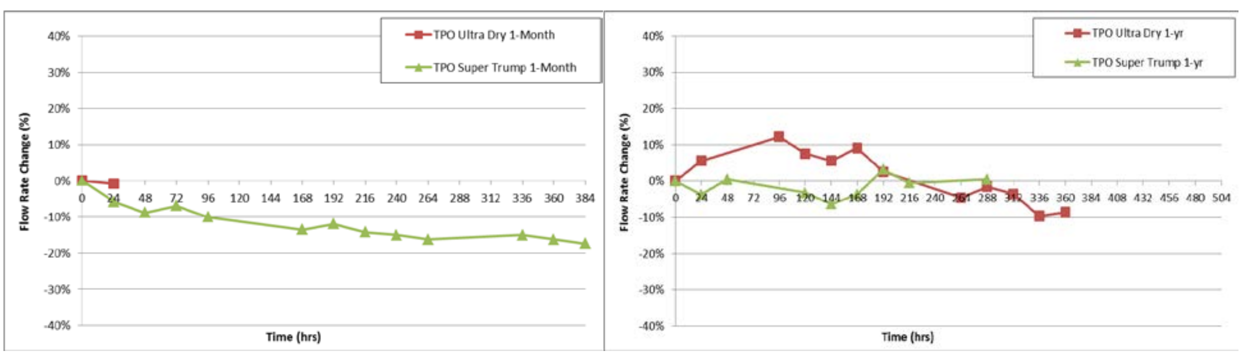

Figure 6: Effect of chemical exposure and time on polyolefin elastomer (TPO) tubing performance

TPV:

The one-month aged TPV samples that were exposed to Ultra Dry® and Super Trump® exhibited consistent performance overall with occasional deviations in flow rate. The performance of the one-year accelerated-aged TPV samples were similar in performance with the exception of the a slight increase in flow rate towards the end of the testing period when exposed to Ultra Dry®

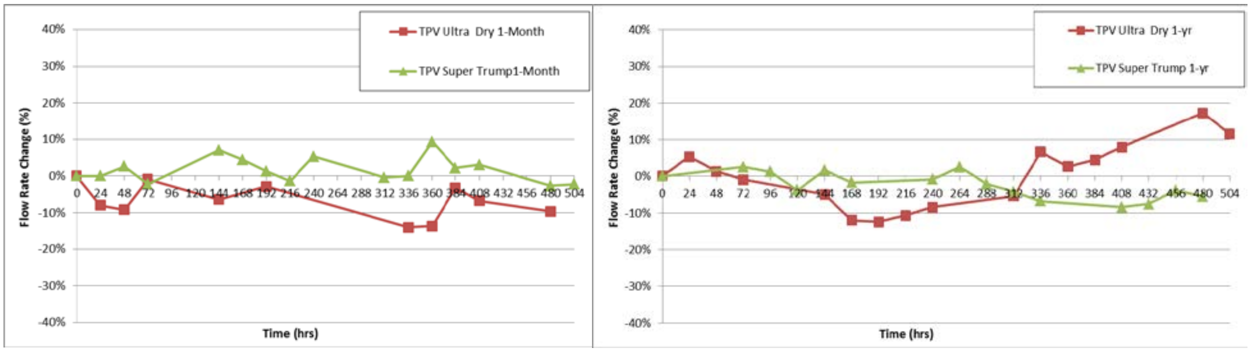

Figure 7: Effect of chemical exposure and time on thermoplastic vulcanizate (TPV) tubing performance

Lined TPV:

Both the one-month and accelerated-aged lined TPV samples that were exposed to Ultra Dry® and Super Trump® exhibited very stable performance over time with minimal change in flow rate. With the exception of a premature failure observed in the one-month aged sample in Ultra Dry®, the performance of the lined TPV samples was more consistent than the regular TPV sample.

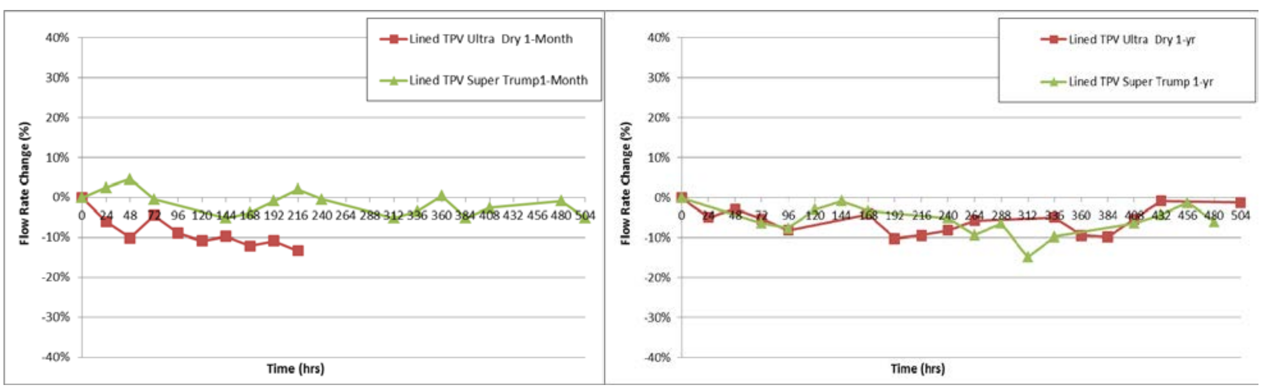

Figure 8: Effect of chemical exposure and time on lined thermoplastic vulcanizate (lined TPV) tubing performance

Conclusions:

The data generated in this work clearly shows that there is no one tubing material that is ideally suited to all applications. End users must consider multiple factors in selecting a final tubing material, including anticipated operating conditions (time, temperature, and fluid composition), pricing and availability, reliability, quality systems, customer support, as well as the tubing supplier's reputation. Saint-Gobain is committed to providing its customers with the highest quality products and best in class customer support while is constantly striving to develop new products that meet the evolving needs of end users in a wide range of industries. The results of this work will be used to guide new product development at Saint-Gobain as well as to support customers in selecting the right tubing material for their unique application.