HIGH PERFORMANCE KEY VALVE TESTING RESULTS

TEST REPORT **17.02.2016**

FALCON REPORT NUMBER **RE160217_HPKV001**

SCOPE OF TESTING: Field testing of High Performance Key-Valve® (HPKV) prototypes under real conditions:

- Test robustness, tightness and flow performance over time.

Lab testing of final HPKV product:

- Compare flow rate of HPKV with the existing Key-Valve® and additional competitor products (Urimat (Switzerland), Whiffaway (UK) and Helvex (Mexico)).

SAMPLES: 5 HPKV prototypes and 5 HPKV final products with bell-shaped membrane composed of LSR silicone and polypropylene valve tubing.

TEST PERIOD: 10.2.2015 – 27.7.2015 (5 month and 17 days)

TEST LOCATION: Swiss Federal Institute of Technology in Zurich (ETH Zurich), in the electro-technics department.

CLEANING: ETH uses in-house cleaning personnel, not external services. The cleaning personnel was instructed to not use acidic or alkaline cleaners, as recommended to all of our customers. Although workers clean autonomously, so we have conducted further trainings for the ETH cleaning staff.

TEST LOCATION:

LOCATION: ETH Zurich, electro technics department. Mostly male students.

INSTALLATION: 5 Urinals (Model 7000), 50 mm drain hole size in the bowl, Key-Adapter SE000 (long) installed (same size as SE037, Ideal Standard).

USERS: Users include students, professors, gamete of campus workers and external visitors. The restroom location is in a public space and is accessible to anyone.

USAGES: Approximately an average of 60 uses per urinal per day.

- Given 7500 usages lifetime the valve should be changed after 125 days (approx. 4 months) which is roughly three times a year.

KIND OF SEWER: The test installation is particularly suitable for tightness tests since the sewer gases in the pipes at this location are very concentrated and aggressive, enough so that any leakage can easily be detected immediately by human scent.

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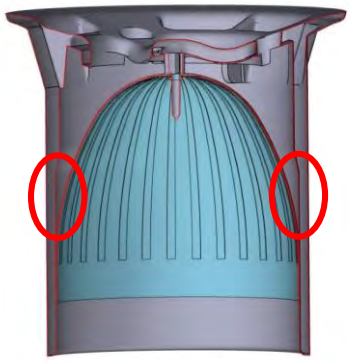
Ammonia® concentration was measured 20 cm above the urinal drain and was found to be far above 300 ppm (measured with a handheld ammonia measurement device, Dräger Pac® 7000, detection limit 300 ppm).

INSTALLATION TESTING LOCATION:

HPKV FEATURES:

THE VALVE: The valve consists of a silicone bell-shaped membrane valve which is mounted into polypropylene tubing. The silicone bell valve seals against the inner wall of the tubing which is shown in the following picture:



Picture: The silicone bell (pale blue) is in a radial contact with the inner wall of the PP tubing (grey).

The red circles indicate the sealing location between valve and tubing.

The valve rib technology allows a very high throughput of liquid volume and is therefore be suitable to retrofit water flushed urinals to waterfree.

THE RING: The Key-Ring is an indicator which shows when the valve has to be changed. After approx. 7500 uses the Key-Ring mass completely dissolves, signaling it is time to change the valve.

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TEST PROCEDURE FOR FIELD TESTING:
Five (5) HPKV prototypes were installed in five urinals at the ETH of Zurich using a Key-Adapter SE000 (long), Art.Nr. 107100. IMPORTANT The previously installed Key-Rings were reused as their condition does not affect the HPKV lifespan or performance. The overall goal is to measure both the sealing robustness of the technology and the flow performance over time.

TEST CRITERIA:
Odor Testing: Odor testing was measured by scent, 20–30 cm above the valve opening. The smell was judged with a rating scale of 0 – 3 (0 = no smell, 1 = weak smell, 2 = moderate smell, 3 = strong smell). Since sewer gases in this specific test location are very concentrated, a clear leakage falls into the 2 or 3 scale range. The rating of 1 can be attributed mostly to other contaminations, such as a dirty bowl surface or build-up in the system. In addition to the initial odor test conducted via scent, an image was taken of the bell-shaped membrane to visually document tightness and robustness against debris like hair, tobacco, or chewing gum.

Flow Rate Testing: Different water volumes (250 ml (waterless urinal volume), 1L (low flush urinal) and 2L) were tested against time. The time measurement started from the moment water hit the bowl surface and stopped when all water had completed flowing through the valve. IMPORTANT Water was never poured directly into the valve, as this would significantly increase flow rate (due to the weight of the falling water) and skew results positively. Instead, water was poured on the ceramic surface in front of the valve.

TEST PROCEDURE FOR FLOW RATE TESTING IN THE LAB:
Five (5) HPKV units were tested for flow rate, with the water volumes noted above, in a standardized bowl (Key-One, see picture on the right). For comparison, the same procedure was followed with our existing Key-Valve and competitor mechanical valves, including: Whiffaway, Urimat and Helvex.

250 ml, 1L and 2L volumes of water were used in testing and the time for drainage was measured following the same steps noted above in the field testing. IMPORTANT Water was never poured directly into the valve, as this would significantly increase flow rate (due to the weight of the falling water) and skew results positively. Instead, water was poured on the ceramic surface in front of the valve.

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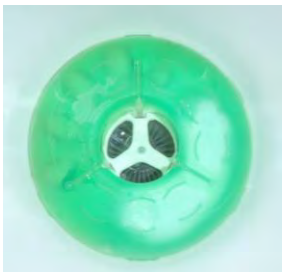
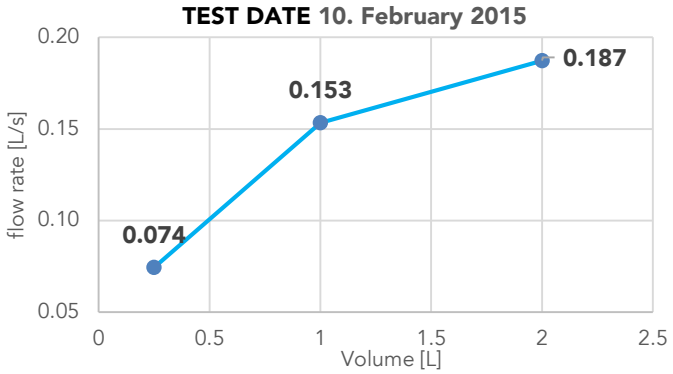
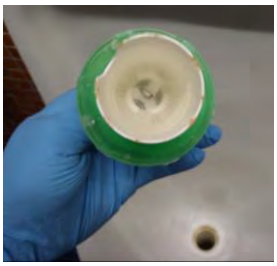
TEST RESULTS:
FLOW RATE TEST RESULTS WITH HPKV PROTOTYPE (FIELD):

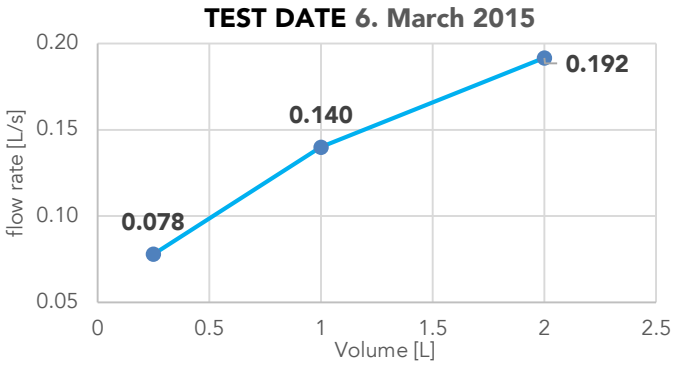
At The Start (10.2.2015)



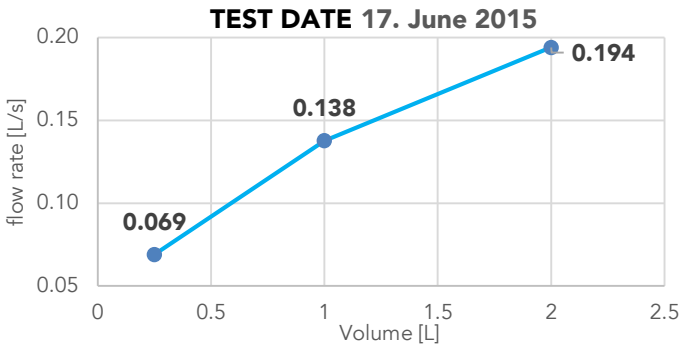


After 1 Month (6.3.2015)

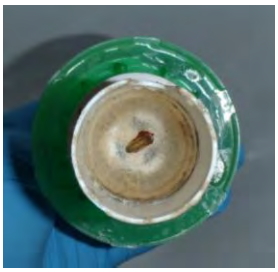


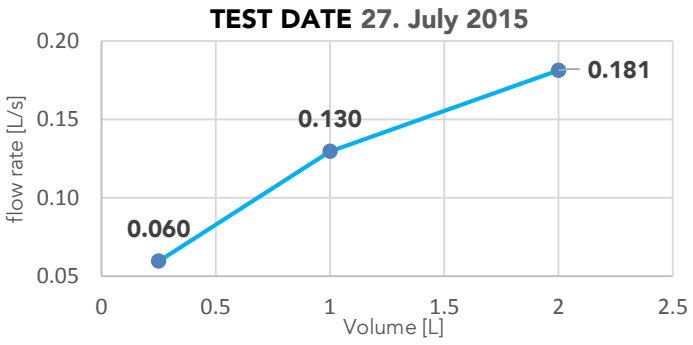


After 4 Months (17.6.2015)



After 5 Months (27.7.2015)





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CONCLUSION FROM FLOW RATE TESTS:
After over 5 months of testing the flow rate for low and high volumes of water, the HPKV proved to be very stable and showed no statistically significant detected reduction in flow rate. The formation of debris on the bell-shaped membrane did not lead to any leakage and hair, or any other debris, was flushed out easily during everyday usage.

This flow rate testing shows that the new bell valve membrane is capable of handling large volumes of water (commonly found in flushing urinals), unlike the blue Key-Membrane valve. The bell valve contains a larger flow rate radius which is more than double, from 235.13 mm^2 to 501.17 mm^2. This increased radius consequently increased the flow rate substantially.

ODOR TEST RESULTS WITH HPKV PROTOTYPE (FIELD):

ODOR RATING TABLE (HPKV):

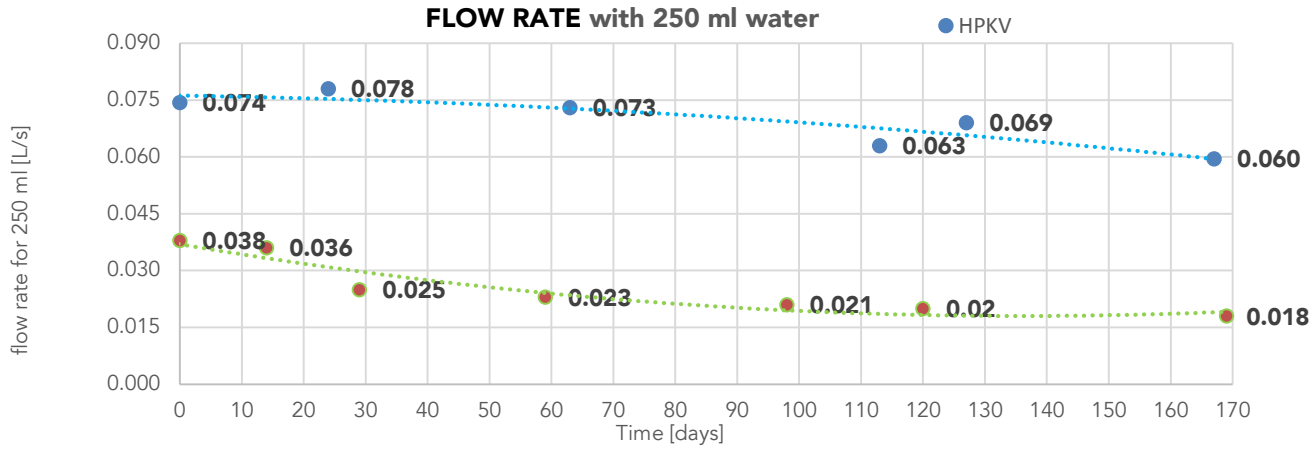
URINAL	10.2.15	11.2.15	19.2.15	6.3.15	24.3.15	14.4.15	3.6.15	17.6.15	27.7.15
U1	0	0	0	0	2*	1	0	0	1
U2	0	0	0	0	0	0	0	0	0
U3	0	0	0	0	1	0	0	0	0
U4	0	0	0	0	0	0	0	1	0
U5	1	0	0	0	0	1	0	0	1

Scale: 0 = no odor, 1 = slight odor, 2 = moderate odor, 3 = strong odor

* Build-up on adapter was identified to cause the smell. Adapter was cleaned an odor was gone. The valve proved to be fully sealed. The cleaning personnel was instructed to regularly clean the adapter surface to avoid build-up (cleaned once a week with a wet towel to wipe away any residual urine).

CONCLUSION:
The odor test showed that the HPKV prototype was properly sealing over the five month testing period. In addition to the odor rating, pictures from the bell-shaped membrane were taken and analyzed for each inspection day. The pictures showed a proper circular adhesion of the bell valve to adaptor walls for every inspection day. The pictures are not shown in this short report but are available upon request. We also observed a high robustness of the valve against common types of debris.

FLOW RATE COMPARISON WITH KEY-VALVE (FIELD):



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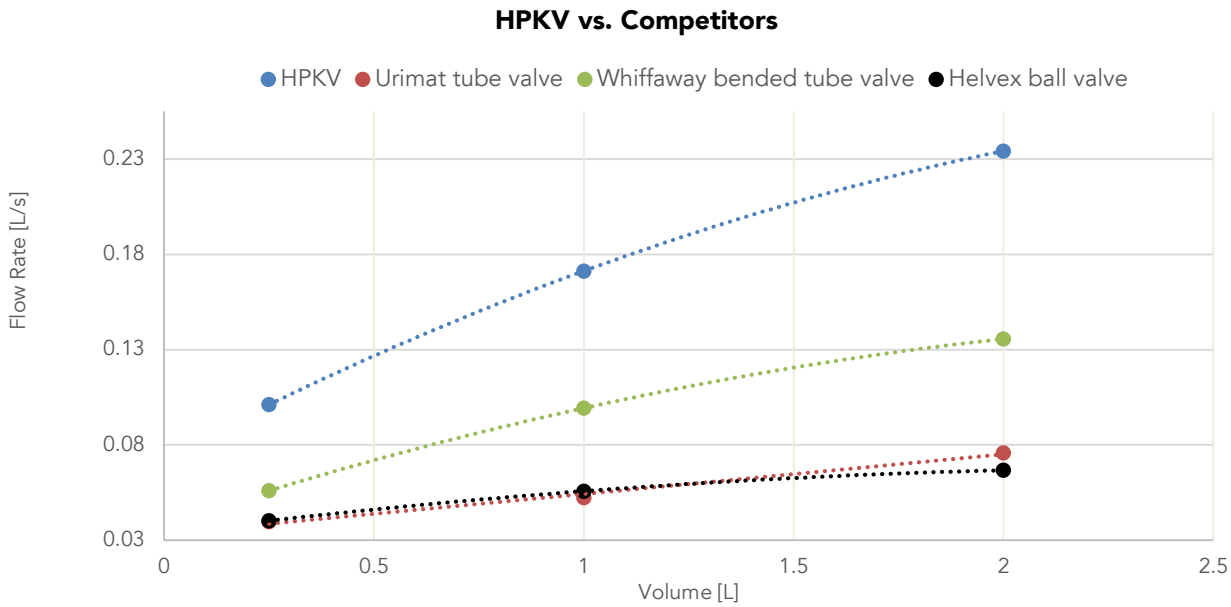
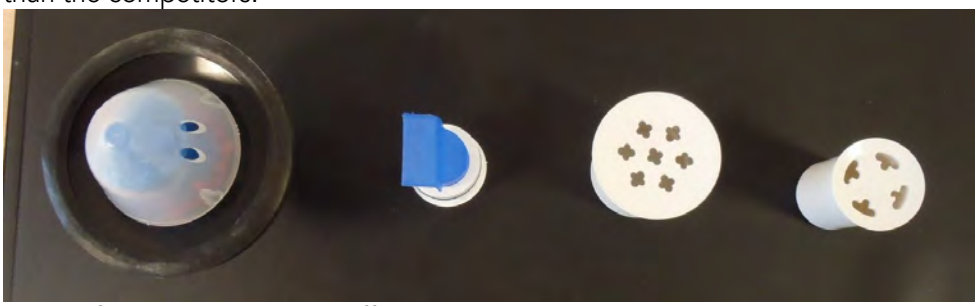
CONCLUSION:
From the comparison of the flow rate in the above figure you can see that the Key-Valve reduces its flow rate much faster during the usage phase than the HPKV. At the beginning of testing the HPKV was tested to show double the flow rate associated with the Key-Valve. 170 days after testing began, the flow rate of the HPKV tests more than three times higher than the Key-Valve. Showing that the peak performance of the HPKV is much higher for a much longer time.

FLOW RATE COMPARISON OF FINAL PRODUCT WITH COMPETITORS (LAB):



CONCLUSION:
The flow rate comparison of the final HPKV product shows that the new HPKV performs much better than the competitors.


From left to right: Urimat, Whiffaway, large Helvex and small Helvex.

Whiffaway (green):

Flow rate was tested to show about half of that of the HPKV. Furthermore, the bended tube valve is very prone to sticking. When we initially tested the valves, the flaps stuck to each other and drainage time of 250 ml was longer than 30 seconds. In addition the pressed tube structure with the bend in the middle section of the membrane proved difficult to flush out common debris.

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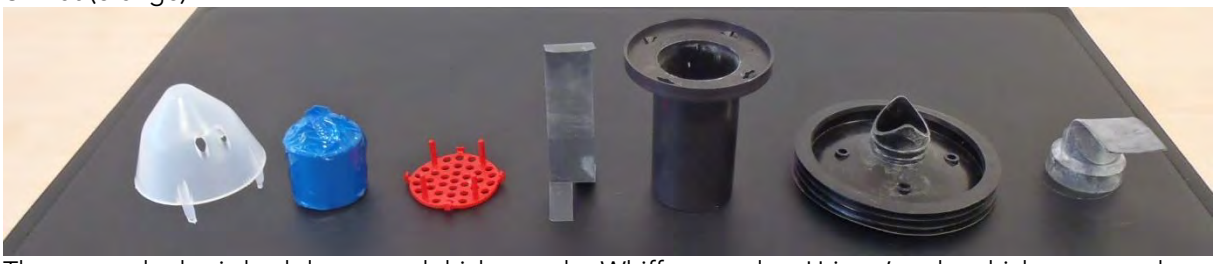
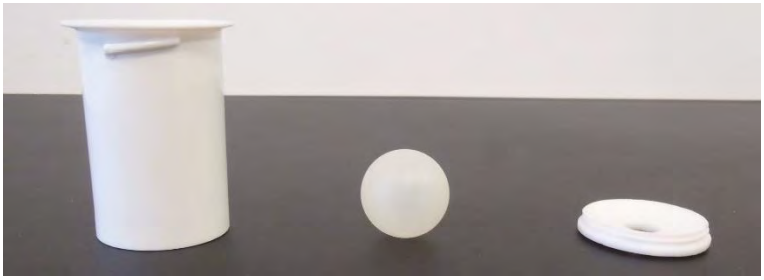
Urimat (orange):



The pressed tube is both larger and thicker to the Whiffaway valve. Urimat's valve thickness was shown to reduce liquid flow rate. This valve is commonly known to be prone to sticking, for which reason Urimat uses talcum powder to help mitigate. Due to the laterally closed tube, the Urimat valve was shown to be prone to blockage from common debris.

Helvex (black):



In testing, the liquid volume did not completely flow from the small Helvex container, leaving a certain amount of fluid in the container after the flow rate tests were completed. Throughout usage, testing showed inevitable sludge build up in the container, which resulted in continuous odor issues. The design of the Helvex container quickly gathered common types of debris, which created additional odor issues as well as leakage since the ball no longer fit the drain opening. Furthermore, the small size of the hole at the bottom of the Helvex container and the small drainage cross section compromised the Helvex cartridge's ability to drain quickly, ultimately resulting in flow rate issues and urine pooling.