Application Note

FESTO

Flushability of media separated valves

Flushability of media separated valves describes the performance of flushing liquid out of a valve with another liquid with as less volume as possible. A good valve design with little dead volume and therefore a good flushability is important when using media separated valves in laboratory applications e.g. for cleaning processes or with expensive liquids. A flushability test with two different liquids refers as an indicator of good valve design.

VYKA
VABS
NLFA
VAVN
PGVA

This application note covers the following topics:

- Description of a test setup to make the small internal volume and the flow-optimized design visible.
- Comparison of the flushability performance of different media separated valves.

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1 The importance of flushability of media separated valves in laboratory automation

Laboratory automation is used to increase the efficiency of labs. However, biological and chemical results must continue to be reliable. Therefore, the flushability performance of media separated valves is crucial especially for the following topics:

- Avoiding cross-contamination: whenever different liquids were used with the same components, some level of cleaning in between is necessary. Products with direct contact with the liquids need to be able to be cleaned.
- Reducing consumption of expensive media: sometimes reagents cost a lot of money and it is important to waste as little media as possible when flushing the components.

There are two main characteristics of media separated valves to influence these topics:

1. low internal volume, especially small dead volumes
2. flow optimized design

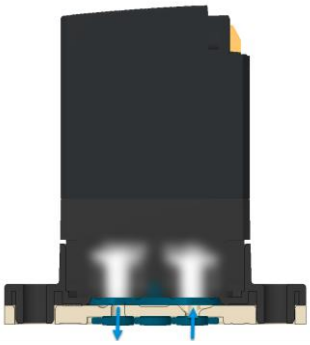

Figure 1: Intersection of the fluidic part of a VYKA 2/2-way valve

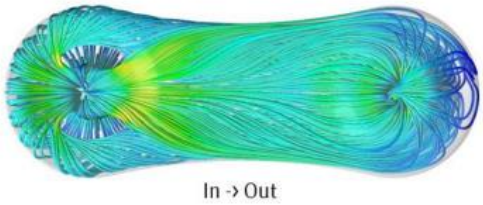

Figure 2: Simulation of turbulent flow of a VYKA 2/2-way valve

*Festo catalogue value **how competition measures. We have added this information in our catalogue, too.

Figure 3: Different views of internal volume of VYKA

Regarding to the internal volume, various manufacturers on the market provide different information. Figure 3 shows the different views of the internal volume and the information provided by Festo in its catalog.
Small dead volumes and a flow optimized design of the fluid chamber are important for a good flushability of the valve and a precondition to receive good cleaning results. Additionally, there are different other requirements to receive the application specific cleanability-level such as material compatibility against cleaning reagents and others (Figure 4).
This application note focusses on flushability and a procedure to make the dead volume and flow optimized design visible. A test setup was defined that compares the valves under the same conditions.

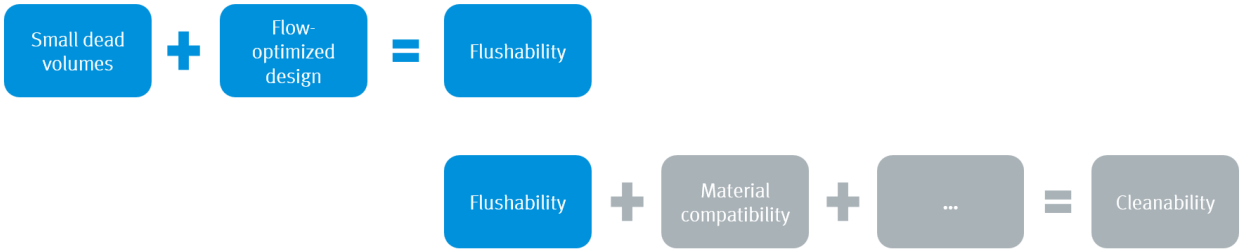

Figure 4: The difference between flushability and cleanability

2 Test setup

The whole test system was controlled via sequences with a Festo PLC. A PGVA pressure generator was used to set the bottles with the liquids inside under pressure. One VYKA valve for each bottle was used to trigger the dispense shots. As devices under test (DUTs), several 3/2-way valves from Festo and competitors were used. The tested 3/2-way valves were connected after the VYKA valves to be able to switch from one liquid to the other. The needle outlet on the 3/2-way valves dispensed directly in a 384 micro well plate. After filling the well plate with the liquids, the absorption of each well was measured with a plate reader.

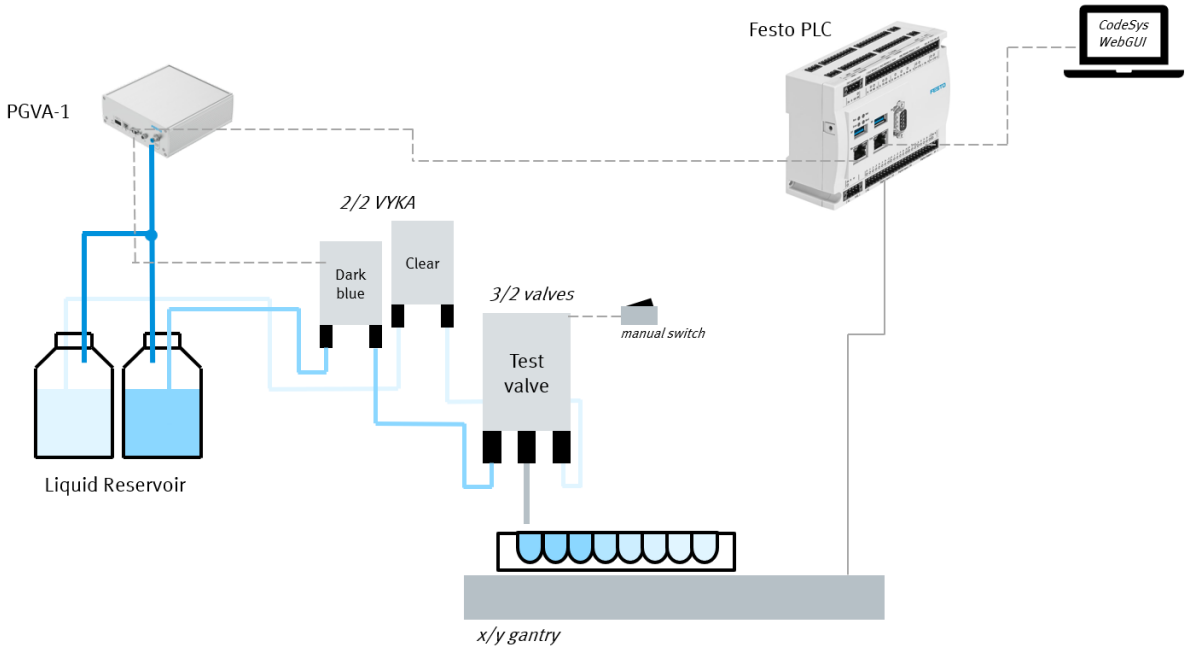

Figure 5: Technical scheme of test setup

The VYKA with its subbase was compared to two different competitor valves with its subbases.

Table 1: Devices under test (DUTs)

picture	Valve	Part. No. / description	Sealing material
	VYKA	8170085: VYKA-F7-M32-12-PE-5YQ7	EPDM
		8047063: VABS-K1-7B-12-U14-P	-
	Competitor 1	n.n.	EPDM
	Competitor 2	n.n.	FPM

Different concentrations of base acid blue liquid were used to operate the plate reader in the required absorption range during the entire measurement series. To eliminate effects due to varying volumes, the volume of the dispensed shots was kept stable.

Table 2: different concentrations of blue

Description	Concentration	Use case
Light blue	60% of 90 mg/L Basacid Blue 762, liquid	offset to prepare the well plates
Dark blue	90 mg/L Basacid Blue 762, liquid	for 100 % absorption value
Clear	Clear DI water (0% blue)	flush the valve after primed with dark blue

3 Test Procedure

To measure the flushability of the 3/2-way valves, one port was connected to a defined concentration of blue water and the other port to clear DI water. For measurement purposes, a third concentration was used to prefill the micro well plate.

3.1 Preparation of the test

The volume was calibrated for each test valve in the mentioned dispensing setup gravimetrically with the help of a scale. Therefore, pressure and opening times of the valves were varied to receive 5mg and 10 mg, which is for water at room temperature approximately equivalent to the needed 5 µl and 10 µl.

Table 3: Opening time and pressure for the needed volumes

	VYKA EPDM 8170085		Competitor 1		Competitor 2	
	5µl	10 µl	5µl	10 µl	5µl	10 µl
Opening time [ms]	15	23	16	23	16	26
Pressure [mbar]	200	200	200	200	200	200

The plate reader needs a certain volume of liquid in the wells and a certain concentration to measure linear absorption values. The wells were prefilled with 10 µl of light blue liquid. This prefill plus 5 µl of clear water refers to an absorption value of the plate reader that is still in measurement range.

3.2 Test execution

With the setup a few rows of a micro well plate were filled. First with the dark blue liquid and after a few shots the 3/2-way valve was switched to the clear water port. This allows to see a gradient of the dark blue color in the water with the resolution of the volume of one well.

Test protocol flushability:

- dispense 10 shots of 5 µl dark blue in A1-10 to get the mean adsorption rate for this liquid
- switch the 3/2-way test valve to clear water port
- dispense shots of 5 µl clear water to A11-C24
- measure absorption values of the plate with plate reader

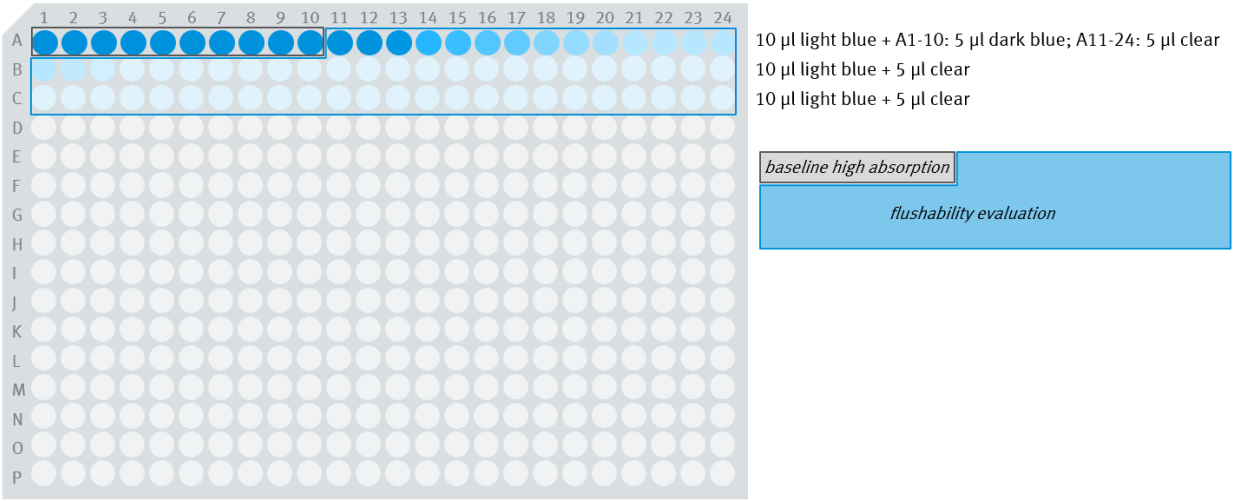

Figure 6: graph of liquids in well plate

4 Results

The measured values from the plate reader were put in an excel sheet where they were further processed for better comparison. The absorption values in this test represent the concentration of blue color in the water. As the absorption values defer from plate to plate it was necessary to norm the max and min values for every valve to be able to compare the different valves and plates with each other. Therefore, 100 % absorption value and 0 % absorption value were defined, and the other values were calculated in percentage. After the calibration the absorption values could be compared in one graph of concentration of blue color.

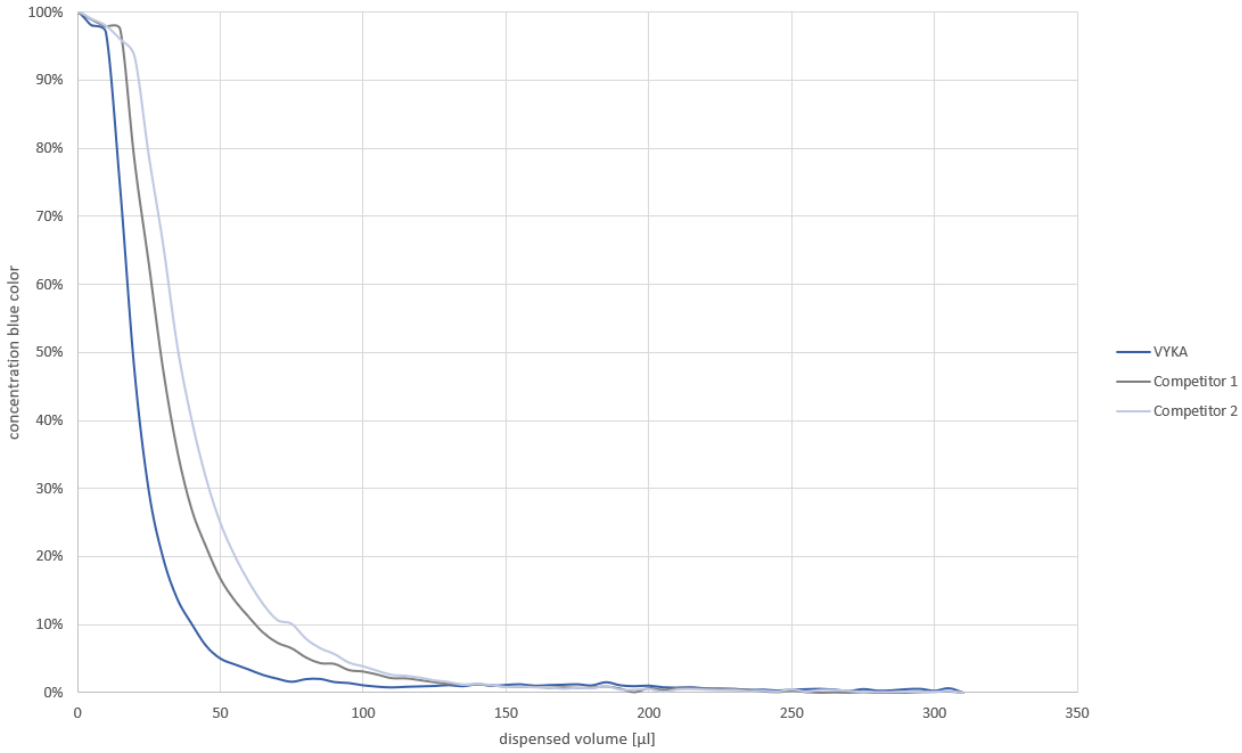

Figure 7: Flushability of VYKA in comparison with competitor valves

This test setup allows to compare the flushability of different valves with their subbases under the same condition. All three valves show similar declining gradients to flush out the blue color. In general, the blue color could be flushed out with little volume up to less than a hundred microliters. Different internal volumes lead to different flushability curves. The steeper the gradient the better the design and therefore the flushability of the valve.

The VYKA valve shows the highest change in absorption values in the first shots which means it has the best flushability performance out of these three tested valves. It outperforms similar competitor valves in direct comparison. Based on the optimized hygienic design, it offers an easily flushable solution.

This test only shows the flushability of valves with blue colored water. This works well as an indicator for dead volume and valve design. However, it can only serve as a precondition for the cleanability of a valve. The cleanability of a valve is also affected by membrane materials, surface conditions and others. For the evaluation of cleanability of these valves, a different approach was used.
This could be found in the following paper:
ApplicationNoteCleanability of media-separated solenoid valves100703V1.pdf (festo.com).