Experimental Comparison of Opening Characteristics between Swing and Lift Check Valves

Dae-woong Kim, Yang-seok Kim, Sung-geun Park, Sung-yull Hong
Korea Electric Power Research Institude, 103-16 Muji-dong, Yusung-ku, Taejon, Korea
kimdw@kepri.re.kr

1. Introduction

Since swing and lift check valves are most commonly used in nuclear power plants, considerable data are available describing their flow characteristics. The most basic data needed for evaluating check valve performance is the disc position versus flow velocity. Such data provides information on the disc stability and the velocity required opening and holding disc firmly against stop. Generally, The normal procedure for selecting check valves is to choose the size so that the velocity at the valve inlet is high enough to have the disc fully open and held firmly against the stop when operating in the design flow range.

The velocity required to fully open the disc is defined as Vopen and the velocity required holding disc firmly against the stop is defined as Vmin. Test on swing check valve has shown that the velocity to hold disc firmly against the stop(Vmin) is about 20% higher than that of Vopen. If system does not provided the required velocity, check valve will be operated under the unstable condition and expected to experience some degradation due to wear and impact. The degradation leads to the unsuitable valve operation and the fracture of valve parts.

In this paper, The opening characteristics of 3-inch swing and lift check valves are compared using the check test loop. The tests were performed under the flow condition with upstream elbow at various distances from both check valves. The experimental results are presented herein.

2. Test Loop and Method

2.1 Test Loop

As shown in figure 1, a check valve performance test loop has two horizontal 3-inch and 6-inch test pipelines. The main components of the test loop are two water storage tanks, one centrifugal pump with rated capacity of 5.4m^3/min at 71.4m, two flow meters, test section, and flow control valve, including the several pipe segments. The test section consists of two instrumented check valves to be tested, 3-inch and 6-inch pipe segments with the length of 2D, 4D, and 6D, and the pressure transmitters. The two downstream remote control valves (2-inch and 6-inch) control the water flow rate. Flow measurement is made with both of the turbine flow meter and electromagnetic flow meter. The range of the turbine flow meter is 80 ~ 800m^3/hr with an accuracy of ±1.0% full scale. Electromagnetic flow meter provided more accurate flow measurements with the range and accuracy of 5 ~ 180m^3/hr and ±0.5% full scale. 3-inch swing check valve has a disc diameter of 82mm, a disc full open angle of 61.3-degree, and the weight of the disc assembly in air of 1.3kg. The technique used to measure disc motion is illustrated schematically in figure 2. As can be seen, the physical connection from the displacement transducer is made to the hinge arm, which moves, with the disc in response to the fluid flow.

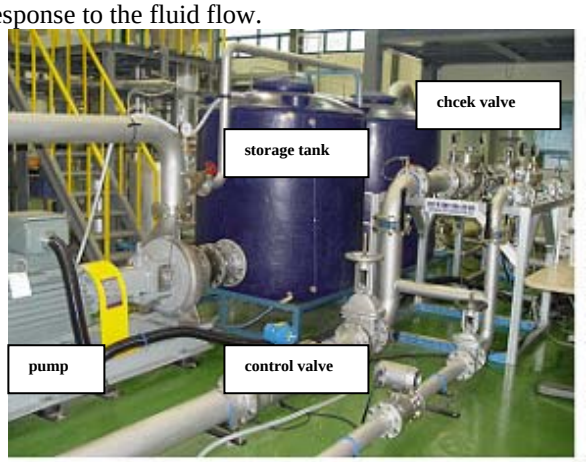

Figure 1. Check Valve Test Loop

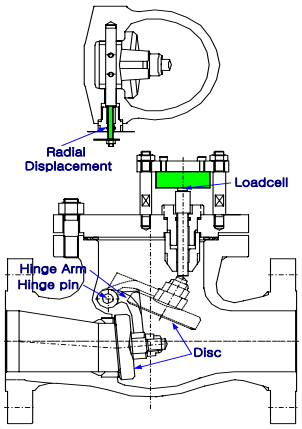

Figure 2. Swing Check Valve & Radial Displacement

2.2 Test Method

Tests were performed for the swing check valve with the elbow as an upstream disturbance. The swing check valve in the test section was moved to change the distance from the elbow. Using the control valve, flow rate was increased slowly. If the steady flow was established, the disc position, flow rate and pressure drop were measured using data acquisition system.

Similarly, the tests of lift check valve were also performed.

3. Test Results and Discussion

3.1 Disc Opening Characteristics of Swing Check Valve

Figure 3 shows a set of three curves of the measured disc positions according to the average flow velocities for 3-inch swing check valve. Each curve is associated with three flow conditions such as elbows being 2, 6, 10 diameters upstream of the check valve. According to the increase the flow velocity, disc opening angle is enlarged. And finally the disc is reached full open angle. From this figure, it seems that there is negligible effect of upstream flow conditions on the opening characteristics of the valve, because the curves are almost collapsed into one, However, a plot to compare the disc fluctuations with the average flow velocity, shows that the highest disc fluctuation is 6-diameter case. And the 10- diameter case shows the most stable condition of the disc. In addition, it can be seen that the disc is unstable near the full open position and the velocity to hold disc firmly against the stop(Vmin ≒ 4m/s) is higher than the velocity required to just fully open the disc(Vopen ≒ 3m/s).

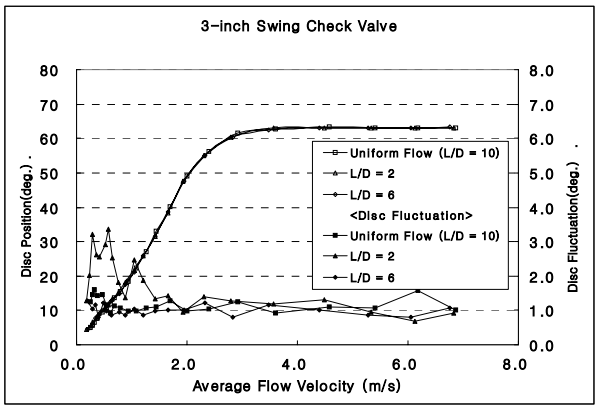

Figure 3. Disc position and Disc Fluctuation with Average Flow Velocity for 3-inch Swing Check Valve

3.2 Disc Opening Characteristics of Lift Check Valve

Figure 4 shows the disc opening characteristics of lift check valve. As shown in the figure, the opening characteristics can be divided into four regions. In linear region, the valve disc is just opened and lifted slowly as increasing the flow rate. Fluctuation region is the condition of the valve disc lifting remarkably. Although the increase of flow rate is very slow, the disc is moved to upward position. In this region, the disc is very unstable. Sudden rise region is the region just prior to the disc full open. This region is very important for the opening stroke of lift check valve. Compared with swing check valve, the full open phenomenon of lift check valve is appeared suddenly. The velocity at that time is called Vopen. Fully open region is the condition of disc fully open and maintains stable condition. Figure 5 shows a set of three curves of the measured disc positions according to the average flow velocities for 3-inch lift check valve. Test conditions are similar to these of the swing check valve such as elbow at 2-diameter, 6-diameter and 10-diameter locations from the valve. While 10-diameter location is required the shortest time for reaching the full open position, 2-diameter location is appeared the most unstable situation.

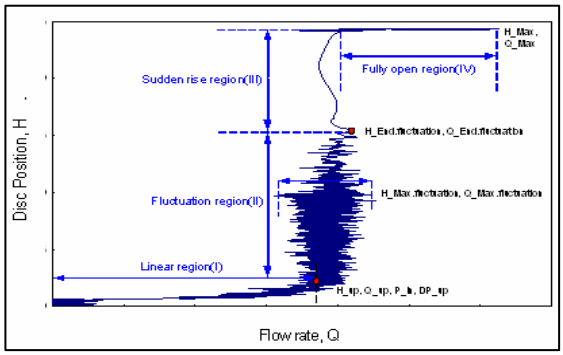

Figure 4. Opening Disc Characteristic of Lift Check Valve

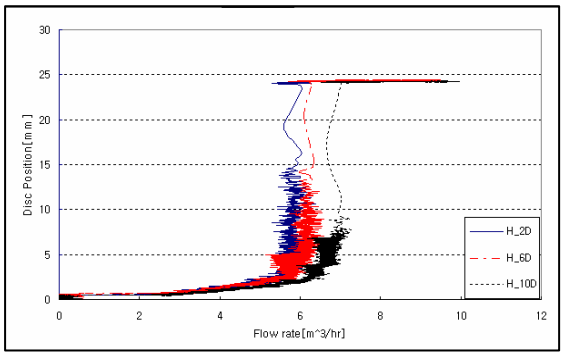

Figure 5. Comparison of the Opening Characteristics for 3-inch Lift Check Valve

4. Conclusion

To compare the opening characteristics between the swing and lift check valves, the tests were performed under the flow disturbances due to elbow at 2~10 diameters upstream of the valves. From the tests, it can be found that while there is little difference between the measured positions of the swing check valve, those data of the lift check valve show more distinct difference. In addition, the maximum disc motion of the lift check valve occurs just before the disc is fully open but the disc of the swing check valve experiences the maximum fluctuation at relatively low velocities. Additional tests with the other disturbance source, such as orifice and globe valve, may be needed to refine and confirm the present results.

REFERENCES

[1] EPRI, Application Guidelines for Check Valves in Nuclear Power Plants, EPRI NP-5479, Rev. 1, 1993.

[2] Chong Chiu & M. S. Kalsi 1986, “Plant Availability Improvement by Eliminating Disc Vibrations in Swing Check Valves,” ASME Paper 86-JPGC-NE-6