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# Study on the Measurement of Valve Leak Rate Using Acoustic Emission Technology

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## 1. Introduction

This study is to estimate the feasibility of acoustic emission(AE) method for the internal leak from the valves. In this study, 4 inch ball water valve leak tests using three different leak path and various leak rates were performed in order to analyze AE properties when leaks arise in valve seat. As a result of leak test for specimens simulated valve seat, we conformed that leak sound amplitude increased in proportion to the increase of leak rate, and leak rates were plotted versus peak acoustic amplitudes recorded within those two narrow frequency bands on each spectrum plot. The resulting plots of leak rate versus peak AE amplitude were the primary basis for determining the feasibility of quantifying leak acoustically. The large amount of data attained also allowed a favorable investigation of the effects of different leak paths, leak rates, pressure differentials and AE sensors on the AE amplitude spectrum. From the experimental results, it was suggested that the AE method for monitoring of leak was feasible.

This paper describes quantitative measurements of fluid valve leak rates by the analysis of AE. Experimental apparatus were fabricated to accept a variety of leaking water valves in order to determine what characteristics of AE signal change with leak rate. The data for each valve were generated by varying the leak rate and recording the time averaged amplitude of AE versus frequency. Leak rates were varied by modifying the valve seating surfaces in ways designed to simulate actual defects observed in service. Most of the data analysis involved plotting the leak rate versus signal amplitude at a specific frequency to determine how well the two variables correlate in terms of accuracy, resolution, and repeatability.

## 2. Methods and Results

A used, 4 in. ball valve of the type found in nuclear power plant was acquired and installed in a test system. The test system was normally operated in an open loop configuration with a tap water source, however for some tests (e.g., with degassed water) it was necessary to re-circulate the water in a closed loop. For some tests, a clear plastic blank flange was used to replace the pipe downstream of the test valve to permit visual observation of the flow, bubble entrainment, air pocket formation, and so on. Tests were run on a variety of valve ball and seat combinations and conditions. The instrumentation was similar to that used in the other tests, except that a high-pass filter was used to eliminate the background noise caused by making vibrations being transmitted through the test system to the AE sensor. The differential pressures across the valve were in the range of 5 to 8 psi. It was noted that there were several types of acoustic emission that were apparently unrelated to leak rate. It was tentatively confirmed that some of the observed AE signal was due to air coming out of solution and that some was related to the existence of air pockets in the leak flow path immediately downstream from the ball of the test valve.

Figure 1 is a plot of AE amplitude versus frequency for three differential pressures across the test valve. Leak of approximately 2000 ml per min was obtained using the rough ball with new seats in the test valve. The sensor was attached to the valve flange and data were collected with the signal averager and x-y plotter. The data show that under the test conditions there is an adequate SN(signal-to-noise) ratio only below frequencies of about 70 kHz. This figure also shows a powerful increase of AE amplitude with increasing differential pressure at similar leak rates. This suggests that the use of higher differential pressures might produce AE signals related to leak rate that are stronger than the observed signal fluctuations not related to leak rate. This corresponds to a previous observation that the 5 to 8 psi range is threshold of differential pressure for leak detection by AE. Most of the investigation was restricted to low differential pressures across the valve because in practical applications higher differential pressures are difficult and costly to obtain.

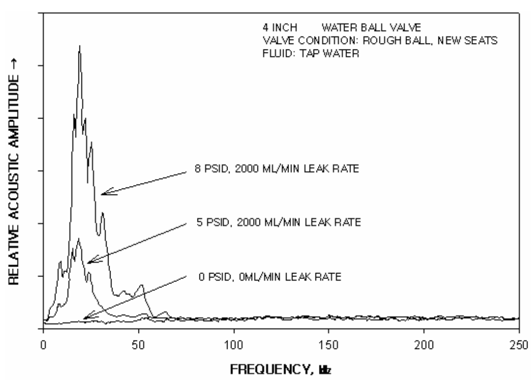


Figure 1. Typical spectrum of AE amplitude from leak through a 4 inch water valve

The data in Figure 1 is typical AE signal associated with leak through large ball valves. There was found to be a somewhat nonlinear correlation between the amplitude of this signal and leak rate at constant pressure even for a single valve. When the valve was cycled (opened and then re-shut) the leak rate and the signal both changed, and the changes were not exactly consistent with each other.

Large increases in signature as tap water is slowly added to previously degassed water are explained in Figure 2. The open-loop test stand with a fine (secondary) pressure regulator added was used. The smooth ball and a damaged upstream seat were installed in the test valve. The downstream seat was smooth, with a square channel leak at the bottom (6 o'clock position). The backpressure was zero and the leak rate was 790 ml per min to 800 ml per min. The AE amplitude increased slowly, but significantly, as the previously degassed water was replaced by fresh tap water-this despite the virtually constant leak rate of 790 ml per min to 800 ml per min. The data, partially illustrated by Figure 2, all tend to support the hypothesis that large variations in AE amplitude, within the useful spectrum and at constant leak rates, can be caused by air coming out of solution from water that has become supersaturated with air, due to the pressure drop across the leaking valve.

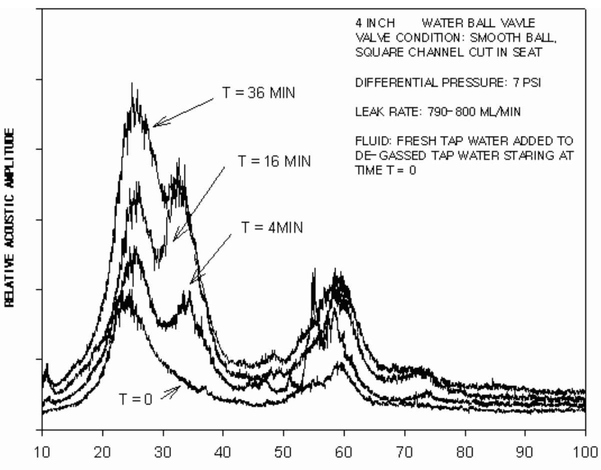


Figure 2. Leak associated AE amplitude increase

## 3. Conclusion

Experimental data reported herein show that there are detectable acoustic signals associated with water valve leak, and that the signals increase with increasing leak rate. From the experimental results for water valve leak detection, it may be reasonably concluded that the development of an instrument capable of quantifying water valve leak rates acoustically with useful accuracy, resolution, and repeatability is feasible. And also, all tend to support the hypothesis that large variations in AE amplitude, within the useful spectrum and at constant leak rates, can be caused by air coming out of solution from water that has become supersaturated with air, due to the pressure drop across the leaking valve. Since the resultant variations in AE amplitude are so large, means must be found to predict, measure, or control this phenomenon before AE can be used to measure leak rate through water ball valves.

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