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Study on the Leak Detection for Power Plant Steam Valve Using Acoustic Emission

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1. Introduction

The AE method has the capability of locating the leak, continuous leak surveillance and monitoring hard-to-access locations. Feasibility of leak detection by AE depends on three factors: the sound radiated from the leak, the attenuation between leak and sensor, and the background noise. This paper discusses the first and of these factor from a fundamental viewpoint, and gives possibility of the practical capabilities of the AE leak detection method for actual nuclear power plant.

In this study, 8 inch globe steam valve leak tests were performed in order to analyze AE signals when leaks arise in valve inside. As a result of leak test for valve seat in a secondary system of power plant, we conformed that leak sound level increased in proportion to the increase of leak rate, and leak rates were compared to simulated tests. The resulting plots of leak rate versus FFT(fast fourier transform) spectrum and AE signal level were the primary basis for determining the feasibility of quantifying leak acoustically. Previously, the large amount of data attained also allowed a favorable investigation of the effects of different leak paths, leak rates, pressure differentials through simulated test. All results of application tests are compared with results of simulated test. From the application tests, it was suggested that the AE method for diagnosis of steam leak was applicable.

This paper presents quantitative measurements of steam valve leak conditions by the analysis of AE parameter, FFT and RMS(root mean square) level. Test apparatus were fabricated to accept a variety of leaking steam valves in order to determine what characteristics of AE signal change with leak conditions. The data for each valve were generated by varying the leak rate and recording the averaged RMS level versus time and frequency versus amplitude(FFT). Leak rates were varied by the valve differential pressure and valve size and leaking valves were observed in service. Most of the data analysis involved plotting the leak rate versus RMS level at a specific frequency to determine how well the two variables correlate in terms of accuracy, resolution, and repeatability.

2. Methods and Results

A test valve is 8 inch globe valve operated by air pressure and operated as condition of high temperature and high differential pressure to purify feeder water system in secondary system of nuclear power plant. Tests were performed on a globe valve in operating using portable AE leak detector. 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 sensors. The differential pressures across the valve were in the range of about 60 kg/cm^2. Figure 1 is a block diagram for the detection of AE signal radiated from the leak in valves and background noise in near valves.

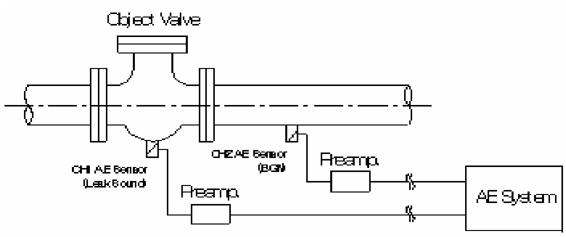

Figure 1. Detection method of AE signal and background noise in site

Figure 2 is a plot of leak sound level(RMS level) versus leak rate(flow rate) for three types of valve test in simulated test. Leak of approximately 60 ml/sec was obtained using the slit hole by inserting foreign objects in the test valve. Results of application tests are compared with results of simulated test of Figure 2. The sensor was attached to the valve flange by two types of method, direct contact method and indirect method using waveguide, and data were collected with the signal acquisition board. The data show that under the test conditions there is an adequate SN(signal-to-noise) ratio only upper frequencies of about 25 kHz and below frequencies of 530 kHz. This figure also shows a powerful increase of AE sound level with increasing leak rates in all size valves. 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.

The data in Figure 2 is FFT spectrum of AE signal associated with leak through 8 inch globe valves in simulated test. There was found to be a somewhat linear correlation between the sound level and leak rate at constant pressure 60 kg/cm^2.

FFT analysis results on background noise during detecting leak for 8 inch globe valve are explained in Figure 3. AE rms level is 24.5~25.0 mVrms and represents peak component at both 20~25 kHz and 100 kHz. Especially, line spectrum of part near 18 kHz had a large amplitude is the noise component in system itself. Figure 4 represents waveform and FFT analysis results graph. From this graph, acoustic signal shows a typical continuous type AE signal and it is confirmed that constant size amplitude is received to system continuously.

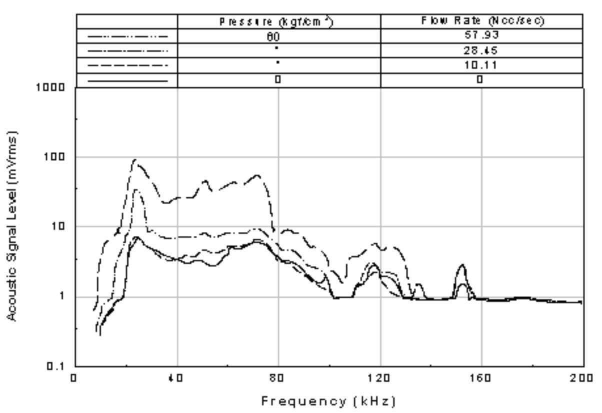

Figure 2. FFT spectrum of AE signal from leak through a 8 inch globe valve in simulated test

And also, AE rms level is 42 mVrms and represents peak component at both 20~25 kHz and 100 kHz. As the test valve in site is 8 inch, glove and operated in condition of 60 kg/cm^2, it can be compared with results of simulated test results of the same condition showed in Figure 2.

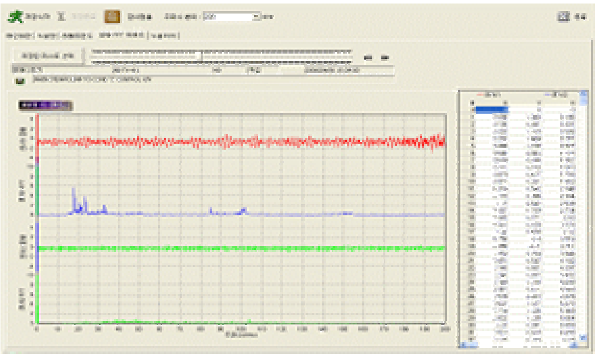

Figure 3. waveform and FFT analysis graph for background noise

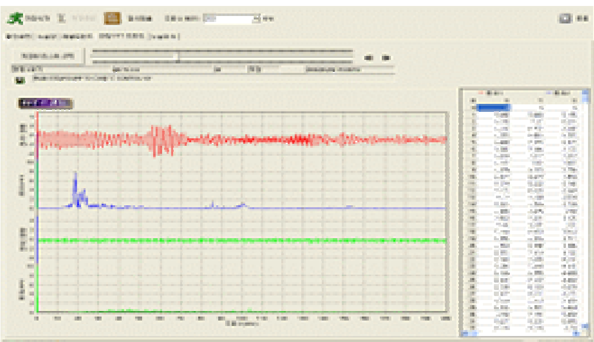

Figure 4. Waveform and FFT frequency analysis graph for leak signal

Background noise spectrum represents 25 kHz and 70 kHz around and acoustic sound level increases according as leak rate increases in simulated test. But peak frequency component is the same value regardless of increase of acoustic sound level according to increase of leak rate. And we conformed that all test results have the same peak components in condition of leak rate of 0(BGN)~57.93 cc/sec. Small leaking of about 51.0 cc/min/inch was expected in site test valve and represented the same peak frequency components regardless of increase of acoustic sound level according to increase of leak rate.

3. Conclusion

This paper presents quantitative measurements of fluid valve leak conditions by the analysis of AE parameter, FFT and RMS level. Test apparatus were fabricated to accept a variety of leaking steam valves in order to determine what characteristics of AE signal change with leak conditions. The data for each valve were generated by varying the leak rate and recording the averaged RMS(root mean square) level versus time and frequency versus amplitude(FFT). Leak rates were varied by the valve differential pressure and valve size and leaking valves were observed in service. Most of the data analysis involved plotting the leak rate versus RMS level at a specific frequency to determine how well the two variables correlate in terms of accuracy, resolution, and repeatability.

Background noise spectrum represents 25 kHz and 70 kHz around and acoustic sound level increases according as leak rate increases in simulated test in condition of 8 inch, steam globe valve and differential pressure 10 kg/cm^2. But peak frequency components represent the same value regardless of increase of acoustic sound level according to increase of leak rate.

REFERENCES

[1] W.F. Hartman and J.W. McElroy, Acoustic Emission Surveillance of Boiling Water Reactor piping Nozzles and Valves, Acoustic Emission Monitoring of Pressurized Systems, ASTM STP 697, ed. by Hartman and McElroy, ASTM, Philadelphia, p. 205-218, 1979.
[2] D.O. Harris, R.G. Brown, D. Dedhia and D.E. Leaver (1980), "Acoustic Emission Leak Detection and Location Systems Technology Review" Electric Power Research Institute Report, EPRI CS-1896, EPRI, Palo Alto, CA, 1980.
[3] Douglas E. MacDonald, Application Guide for Check Valves in Nuclear Power Plants, Final Report, NP-5479, Revison 1, Nuclear Maintenance Applications Center, 1993.
[4] Morse, P. M. and K. U. Ingard, Theoretical Acoustics, McGraw Hill, 1968.
[5] M. N. Hsu and S. C. Hardy, Experiments in Acoustic Emission Waveform Analysis for Characterization of AE Sources, Sensors and Structures, ASME, p. 85-106, 1978.