Application Note

Using SKF Microlog for Leak Detection

By Dr. Robert M. Jones • SKF

Abstract

Every plant has hundreds, or even thousands, of valves. If leakage occurs in these valves, the results are always bad; lost product, contamination, safety violations, etc. In addition, one of the higher cost plant operating systems, plant air, is typically one of the systems with the highest leakage. By applying the SKF Microlog for valve leakage measurements, leaks can be detected without disassembling the valve.

Figure 1. SKF Micrologs – portable data collectors / analyzers.

Discussion

Following are three case studies that illustrate SKF Microlog use for detection of valve leakage.

In the first application, we review data from tests conducted for the U.S. Navy's submarine service. In every boat, there is always some leakage from various valves that penetrate the hull.

In 1993, the U.S. Navy, looking for an off-the-shelf leak detector, asked if the SKF Microlog was capable of detecting a leak of one-eighth gallon per minute (GPM). In a Navy lab, SKF placed an accelerometer on a valve that could be visually observed. There was no leak through the valve. **Fig. 2** displays a spectrum of that condition.

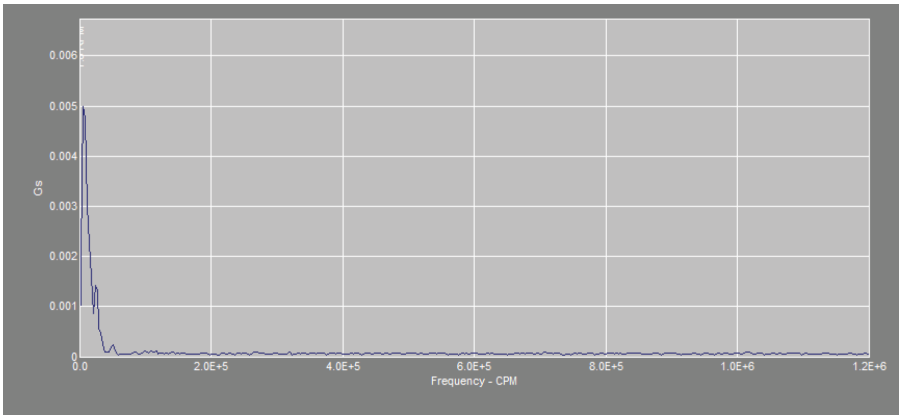

Figure 2. Valve closed, no leak.

For the next spectrum, the valve was opened to allow a measured flow of one-eighth of a gallon per minute. This proved that we could detect a very small leakage with an SKF Microlog and accelerometer. However, the question remained: what could be done in the field, where valve leakage could not be easily measured?

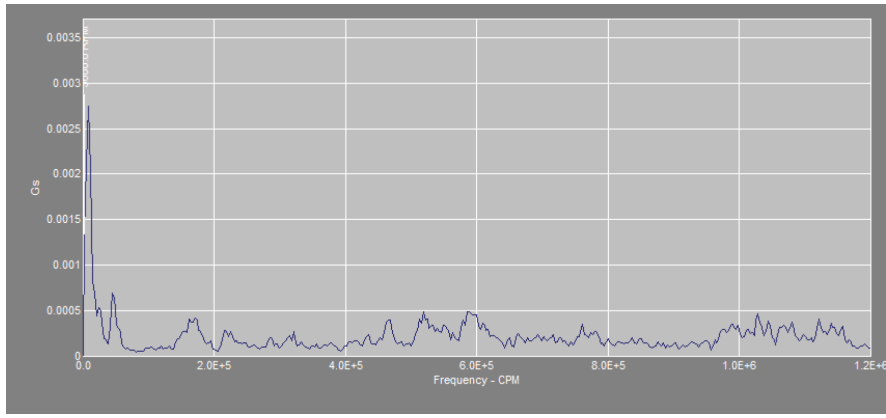

Figure 3. One-eighth gallon per minute leak.

The second application is used when the system remains in a constant state.

In a nuclear power plant, it is critical to monitor valve leakage inside containment. Of course, no one can be inside containment when the plant is operating, so how does one conduct the monitoring?

At the time these tests were conducted, the allowable leakage from an unknown source for a boiling water reactor was 1,5 gallons per minute. This is measured as the leakage comes out of the containment into a closed collection system. However, if the leakage source is identifiable, the limit was 2,5 gallons per minute. If able to use the higher figure, the plant could be operated longer and more efficiently between shutdowns.

A test lab was set up to identify various types of leakage. A variety of potential leakages and their amplitude points were collected using constant operating temperatures and pressures. When results were plotted, they showed a linear relationship between the noted amplitude and the observed leakage. This data was submitted to the Nuclear Regulatory Commission (NRC), who validated and accepted the test results.

There were 26 valves inside the containment. An accelerometer was mounted on each valve body and connected to a data collector outside containment. This allowed each valve to be monitored and its leakage measured. Thereafter, the plant was allowed to continue operations to the higher limit of 2,5 gallons per minute.

It must be noted again, for this second application the pressures and temperatures must remain constant. Any variations would change the results and invalidate the linear relationship established under constant conditions.

The third application is used when the system pressures and temperatures may vary.

This application takes place in various plant systems: air, nitrogen, instrument air, natural gas supply lines, etc. Acoustical energy is generated when any product, liquid or gas, is emitted through an orifice. Sometimes it can be heard with the human ear, but often no sound is heard because the frequency is too high. When mounted on the valve body, a standard accelerometer has the ability to detect this high frequency energy.

By placing the accelerometer on the valve stem, a direct vibration measurement path is established to the ball or flapper on the end of the stem. A spectrum is collected at this position. Another characteristic of high frequency energy is that it will attenuate over distance. Testing by others has determined that the distance range of this energy from the valve body is approximately 10 pipe diameters. Therefore, a second measurement (background reading) is then taken 10 pipe diameters from the valve body, upstream or downstream. If the valve is not leaking, the amplitudes of the background reading and the reading on the valve body will be approximately equal. However, if the amplitude on the valve body is 20 to 25% higher than that of the background, the valve is probably leaking. The greater the amplitude difference, the greater the probability that a leak exists.

Note that if the pipe is wrapped, it is necessary to open it so the accelerometer can be placed directly on the pipe. If a standoff must be used on the pipe, then the standoff must also be used when collecting data on the valve stem. Otherwise, you are comparing dissimilar conditions.

If you are working in a noisy environment, the numbers may be large. If it is quiet, as the examples below, the numbers will be small.

At 10 pipe diameters, the overall amplitude was 0,018 gE, the spectrum is shown in **fig. 4**.

The reading on the valve, without a leak, is shown in **fig. 5**. The overall amplitude was 0,017 gE. Since this data was collected in a lab, we knew the valve wasn't leaking.

When plotting spectrums, be sure to set the "X" and "Y" axes to the same scale for each plot. This will not affect the amplitudes, but the visual impact can be deceiving if the settings are not the same.

Fig. 6 shows the spectrum for the measurement taken on a valve that was leaking. On the leaking valve, the overall amplitude was 0,037 gE, well over the 25% target.

Note that the data for the Navy was in acceleration, "G's", and data on the second valve is in enveloped acceleration, "gE". Both methods of measurement are valid.

The author worked nine years in a pressurized water nuclear plant. One of the systems that had over 20 valves used borated water for safety purposes. If any of these valves leaked, the storage tanks would show a decrease in volume. It seemed that there was always some leakage. The only time the valves could be accessed was during a shutdown when the boron system was shut down. There was no way of knowing which valves needed to be rebuilt, which meant that every valve was internally inspected, a process usually taking four to six days. Mounting an accelerometer on each valve was not practical from a cost and time standpoint, since the valves were in scattered locations and it would take years to get Nuclear Regulatory Commission approval for the cable installation and routing.

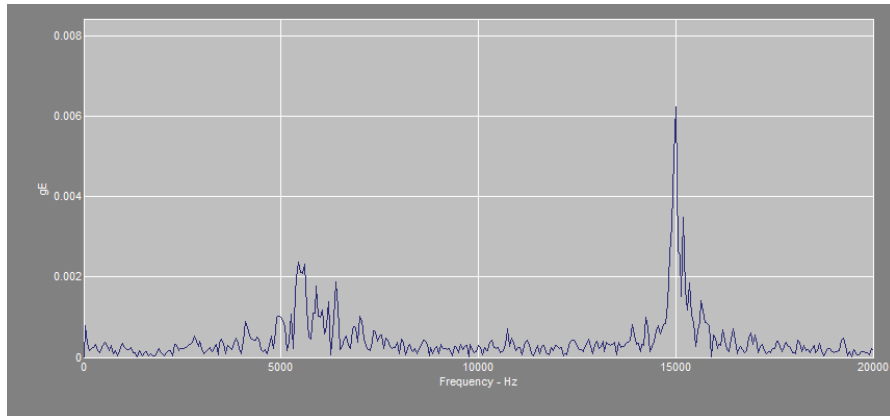

Figure 4. Measurement taken at a distance of 10 pipe diameters away from the valve.

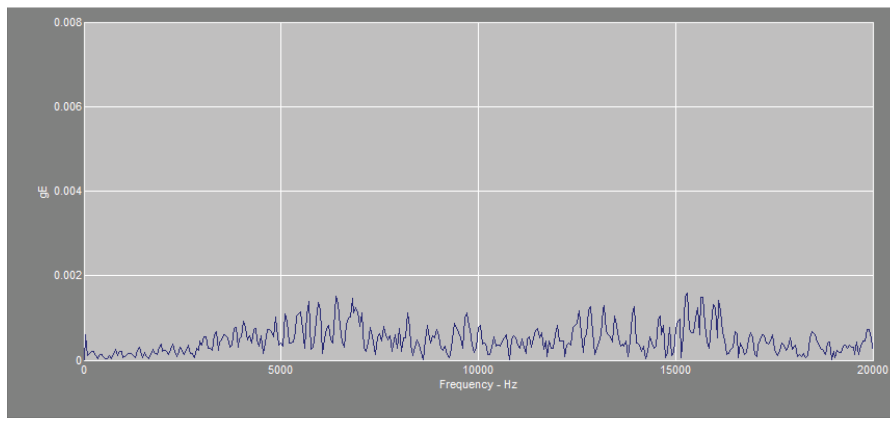

Figure 5. Measurement taken at the valve stem, with no leak.

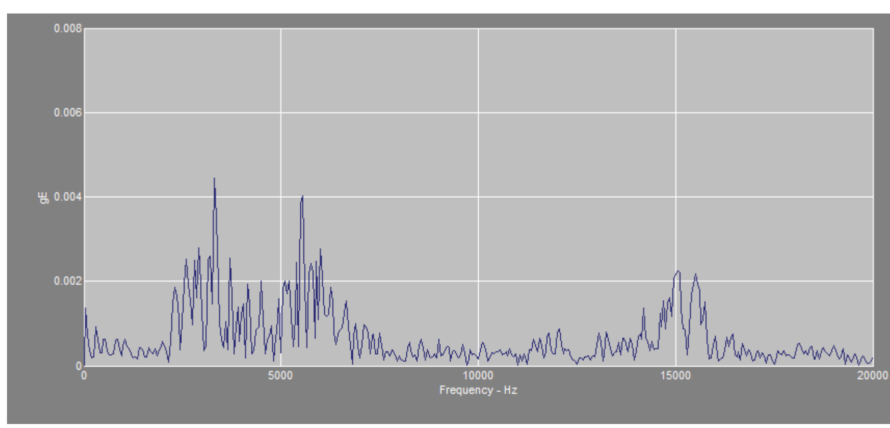

Figure 6. Spectrum of the leaking valve.

The solution was to pressurize the system with nitrogen and take an SKF Microlog reading on each valve. The amplitudes were then listed in descending order. When the variance between consecutive readings showed a sharp drop, only the valves above that line were inspected. Using this method, seven valves were inspected and repaired in two days.

When the system was again pressurized with borated water, the level in the storage tanks remained constant. The leaking valves had been located and repaired. The importance is that on the timeline for start-up, this system was prime. By saving two to four days of the shutdown, the cost savings was several million dollars.

Conclusion

The SKF Microlog can be successfully used to detect leaking valves for gas or liquid service. If operating conditions are constant, a linear relationship exists between the reading amplitude and the volume of leakage. This can be plotted and used to determine the volume of leakage based on observed amplitudes. Alternatively, in variable systems, measuring the amplitude difference of measurements taken on the valve and up or downstream on the pipe allows a logical determination to be made.

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