INVESTIGATION OF ACOUSTIC LEAK MONITORING
for
NUCLEAR REGULATORY COMMISSION
REGION III

by
W. DON JOLLY
Institute Scientist
Southwest Research Institute

1. SUMMARY

As a member of the Nuclear Regulatory Commission (NRC) investigation team led by Duane Danielson of Region III, I was responsible for reviewing the instrumented inspection technique (IIT) acoustic leak monitoring methods and procedures employed by H.A.F.A at the Palisades and the Davis-Besse nuclear power plants in 1988. The IIT method was approved by the NRC as a substitute for the required Section XI ten-year hydrotest. However, allegations that the IIT method was not properly implemented caused the subject investigation to be initiated by the NRC.

I reviewed the test reports and analyzed data from both plants. The test reports listed sources of leakage internal to the piping system, but no external leakage was reported. In the Palisades test report, a noise source thought to be a leak, but not confirmed visually, was indicated by a cautionary note suggesting that the utility perform further investigations when convenient.

I participated in interviews with the alleger and an individual who had previously been employed by H.A.F.A. and who had knowledge of implementation problems. I participated in meetings at H.A.F.A offices and specifically interviewed the acoustic leak detection engineers. The opinions expressed in this report are based on my experience in acoustic emission research, my understanding of the acoustic leak testing that was recorded in the test records from the two plants, and the reports of experimental work at H.A.F.A in support of the H.A.F.A acoustic leak monitoring methodology.

2. CONCLUSIONS AND RECOMMENDATIONS

2.1 CONCLUSIONS

The acoustic leak monitoring method was not adequately qualified by prior experimental testing for use on steam systems in Palisades or Davis-Besse. The acoustic leak monitoring method, represented by experiments described in Topical Report H.A.F.A. 135 P for water-filled piping was not fully implemented at Palisades or Davis-Besse. The IIT system, as used on water-filled piping, was not capable of locating external leaks in the long runs of piping between valves as claimed in the Topical Report. The acoustic leak monitor used on steam generators and piping could not quantify leakage, could not specify a minimum detectable leak size, and could not specify the effect of background noise on leak detectability. Calibration of the mounted AE sensors was not performed. A functional check using the pencil-lead break as a simulated AE source was performed after installation, but no interim or post-test functional checks were performed. The functional check was insufficient for calibration of channel-to-channel sensitivity. No attenuation measurements were made to determine the adequacy of sensor spacing on the installed system.

The pencil-lead break is not a satisfactory simulation of a leak signal because the signal produced is a fast rise/fast decay transient as opposed to the continuous signal produced by a leak.

2.2 RECOMMENDATIONS

The acoustic leak monitoring system may be qualifiable for steam system leak tests. This would require as a minimum:

- Demonstration of the threshold of leak detectability over a range of background noise, leak types, leak rates, and operating conditions.

- Demonstration of long-term stability of the installed AE system over a typical range of in-plant ambient temperatures.

- Demonstration of the relative nature of the leak signal interpretation to show that the method applies over a range of background noise, sensor-to-leak distance, and leak signal amplitudes.

- Use of pretest, interim, and post-test calibrations by means of a well characterized simulated leak signal.

- Compliance with the guidelines of ASTM E 1211 "Standard Practice for Leak Detection and Location Using Surface-Mounted Acoustic Emission Sensors," and E 976 "Standard Guide for Determining the Reproducibility of Acoustic Emission Sensors".

3. REVIEW OF TOPICAL

3.1 COMMENTS ON THE IIT METHOD

The IIT methodology provides a means of quickly detecting and locating leaks by monitoring the acoustic noise of the highly turbulent leakage across a pressure boundary. Leakage noise is usually wide-band, continuous noise that increases with pressure drop across the pressure boundary. Given a system free of other noise sources with sufficient density of sensors, the detection of very small leaks is possible. If the pressure changes and the RMS AE responses are recorded at frequent intervals, the leak response to pressure change may be used to separate leak noise from other continuous noise sources that do not change with pressure.

The IIT approach uses total leakage measurement in connection with acoustic monitoring to detect and locate leaks internally and externally.

This approach is sound if, and only if, the system being tested is free of leaks, or all sources of leakage are repaired to make the system free of leaks before the test is completed.

When any leakage is detected, the responsibility under the H.A.F.A procedure reverts to the VT-2 test. The VT-2 test cannot be carried out on an insulated or inaccessible pressure boundary without the full hold time at pressure to make the leakage visually detectable.

The complete IIT procedure cannot be performed on a steam- or gas-filled system because the compressibility of gases makes it impossible to use make up flow as a measure of total leakage. Without a method to verify the absence of leakage, interpretation of the AE response requires visual verification.

A case in point is the treatment of AE response of sensor No. 6 on main steam line A at Palisades. [redacted] The responsibility was shifted to "an additional VT-2" which found no sign of leakage. Based on the VT-2 result, a cautionary suggestion of other NDE when convenient was made. The conclusion was that no through-wall leakage was apparent from any other section of either main steam line. *

If a leak-like noise is present, but judged to be a non-rejectable condition, the detection of additional leaks in the same area is not possible. If visual inspection must be invoked to detect leakage, then the reduced hold-time and reduced pressure allowed the IIT method should be revoked.

* Proprietary Information Deleted

4. SITE VISITS

4.1 PALISADES

The IIT test records at Palisades Nuclear Power Plant were reviewed. The steam supply system tests were of particular interest because only acoustic leak monitoring was used to detect leakage in these tests. The pretest calibration using lead breaks was inadequate because a pencil-lead break does not simulate a continuous leak signal. No interim calibrations or post-test calibrations were performed. In an effort to discover failed sensors or faulty channels, the RMS data were plotted from the test log. No anomalous conditions were found by examination of the plots. No indication of failed sensors or faulty channels was observed. Internal system leakage could not be quantified by the acoustic monitor and the noise produced by internal system leakage would mask the signal from other smaller leaks.

The IIT method of monitoring the inlet and outlet flow was used in tests performed on water-filled insulated piping systems. The monitoring of the outlet flow did not cover the entire boundary of the system being tested. Acoustic monitoring was performed only on selected boundary valves. Maximum sensor-to-sensor spacing to detect leaks was found by H.A.F.A experiments to be 20 feet ("Experimental Final Report - Sensor Spacing," August 18, 1988, by R. P. Milke). On the water-filled piping tests sensor spacing was over 100 feet in some instances. The insulated piping was not adequately monitored by the acoustic leak detection instruments.

4.2 DAVIS-BESSE

The IIT performed at Davis-Besse did not include the steam generators, but the steam system was tested by acoustic leak monitoring following the same procedure as the testing at Palisades. The Davis-Besse staff exercised a tight control over the test performance and compliance with procedures. The water-filled systems were tested by the IIT method using LMD and acoustic valve monitors.

Review of the test logs indicated that the same discrepancies in calibration were present as found at Palisades. The pencil-lead break functional check was performed, but no detailed calibration of the mounted sensors was done. No interim calibration checks were performed and no post test calibration was done. The test report indicated no external leakage in the piping of both the water tests and the steam tests.

4.3 ANALYSIS OF ACOUSTIC LEAK TESTS

The discrepancies found at both test sites were calibration, sensor coverage, and test records.

The calibration consisted of a pencil-lead break check at each channel sensor performed after installation of the waveguide/sensors. This pretest functional check using the pencil-lead break does not show specific values on each sensor, but indicates that each sensor was checked and found to be within a specified range of response. No post-test functional test was performed. No attenuation measurements were made on the installed system to determine the appropriate sensor spacing. The guide of 20 feet between sensors was not used on the water-filled piping. The rule of 20 dB attenuation of signal between neighboring sensors was not followed on the steam system tests.

Since the measurement of leakage depends on a change in the response of sensors during the pressurization and the return to the original background level upon depressurization, absolute calibration is not critical. The critical condition is that the system must not change sensitivity during the course of the test. (This was one of Hamstad's main points.)[1] This condition was not verified during the test.

Normally a serious failure, such as the debonding of a sensor or loss of continuity in a coaxial cable, will be apparent when the leak data is plotted against pressure for every sensor. Data from Palisades was plotted, but no indication of system failure was apparent. A similar review of Davis-Besse data plots did not expose any channels that appeared to fail during the test. This analysis does not rule out channels that failed before the pressurization began or channels that changed sensitivity gradually.

The only way to be sure is through pretest, interim, and post-test calibration using a simulated leak representative of the maximum allowed undetected leak.

4.4 OTHER SUPPORTING TESTS BY H.A.F.A

H.A.F.A conducted a series of tests and contracted with Dr. Hamstad to review the IIT Acoustic Leak Test Method.[1] Dr. Hamstad found that the pencil-lead break test is adequate for calibration of sensor sensitivity. This approach is not supported by ASTM E 1211 which requires a continuous leak simulator signal. Dr. Hamstad recommends reasonable sensor spacing, which was not followed in water-filled tests. He also recommends interim calibration and indicates that H.A.F.A methods for tracking interim sensitivity only find gross changes in sensitivity. Hamstad expressed concern over possible temperature drift effects on interim sensitivity. In my opinion, both interim and post-test calibration are absolutely necessary to the proper analysis of acoustic leak test data.

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1 Review of H.A.F.A. International, Inc. Instrumented Inspection Technique by Dr. M. A. Hamstad, Professor of Mechanical Engineering, University of Denver, February, 1989.

A question on the seemingly high instrumentation case temperature measured at Davis-Besse (DB1) was addressed by an elevated temperature test. The test showed that the channel sensitivity changed by 1-2 dB when the temperature of the air was raised from 90 to 110 degrees F. The instrumentation was enclosed by polyethylene film and the air temperature inside the enclosure was allowed to rise to more than 110 degrees F. The change in sensitivity of 1-2 dB due to equipment heating during a test is not a serious problem if periodic calibrations are performed. However, the procedure used by H.A.F.A. relies on initial sensitivity checks with no interim or post test calibration. Under this procedure, the heating effect increases the error in data interpretation. Small leaks could be missed because gradual heating has the inverse effect of gradual pressure rise on the sensor signal. The effect would show-up as a 1-2 dB change in leak detection threshold.

H.A.F.A also conducted laboratory studies to determine that the sensor spacing should be nominally 20 feet. Other tests showed that in a quiet laboratory environment very small air or water leakage could be detected by the acoustic sensors. The effects of background noise or noise from other leaks was not considered in this study. Tests must be performed in the plant environment to determine the actual leak detection sensitivity.

5. INTERVIEWS

Interviews of the allegers were conducted by the NRC team at the Royce Hotel in West Palm Beach, Florida, on September 12-13, 1989.

My impression from the two interviews was that H.A.F.A began to cut corners and change acoustic leak monitoring equipment against the urging of alleger. Alleger had developed an acoustic leak test procedure using Hartford Steam & Boiler (HS&B) staff and equipment. Alleger had confidence in his procedure, but Herb Askwith redirected the program to use PAC equipment. The PAC equipment included the 5120 valve leak monitor designed by the Navy for detection of internal valve leakage and the Spartan multichannel system which was designed for acoustic emission testing where the signal source is primarily transient crack growth signals. Alleger was taken off the team and eventually laid off for economic reasons.

After on-site review of the data from Palisades and DB1 and detailed review of the Palisades test data, it was found that questions needed to be addressed to alleger and to the H.A.F.A. inspection team in connection with the recording of data and the absence of a large portion of data during the pressure ramp from 50 to 900 psig.

5.1 QUESTIONS FOR ALLEGER

Review of the allegations and the leak test reports from Palisades and Davis Besse raised the following questions. The questions listed here cover the subject of the acoustic leak monitor instruments, how the instruments were used and problems in testing that were pointed out by the alleger. Two individuals were interviewed; both are called alleger in this report.

Comments by the writer were inserted after some answers where clarification or evaluation of the answer was appropriate.

1. In your letter, you mention that you were Level III on recently developed leak testing methods. In what NDE methods were you classified Level III?

A1. IIT leak monitoring and IIT acoustics.

2. You referred to a method which you demonstrated at BV1 for leak testing steam lines. Can you give us a copy of that procedure?

A2. Procedure not available. Hartford Steam & Boiler equipment and staff were used to conduct the tests at BV1.

3. The changes in the test engineer requirements in the H.A.F.A QA manual. Did these changes reduce the technical proficiency requirements for test engineers? Less experience required? Less training?

A3. Change of equipment to EARS prompted changes. Training was given.

4. Did the changes introduce training for the new equipment you mentioned?

A4. Yes.

COMMENT - WDJ: The training for new equipment is properly introduced and the change in test engineer requirements in the QA manual were warranted to cover new equipment.

5. Did the H.A.F.A qualifications for Levels I, II, and III in AE testing use the standard SNT-TC-1A test questions supplied by American Society for Nondestructive Testing (ASNT)?

A5. SNT-TC-1A does not supply AE questions. Guidelines are provided for developing training and examinations.

6. No. 2: Please clarify your statement that experience shows that leaks are most likely to be below 100 kHz.

A6. The 5120 valve leak monitor used 10-100 kHz range with 30 kHz sensors. Hartford Steam & Boiler used frequency range below 100 kHz.

COMMENT - WDJ: Leaks usually produce a wide spectrum of sound. The pressure drop, the viscosity of the fluid, and the area of the leak opening determine the frequency range and the intensity of a leak. Water leaks usually induce frequencies greater than 100 kHz in the pipe or structure. The leak noise coupled to the air surrounding the leak is usually below 100 kHz. Typical airborne leak detectors use a 30-40 kHz sensor.

7. No. 3: Could RMS data be recorded manually from RMS voltmeters?

A7. Voltmeters were used to record "RMS" from a point in the EARS instrument.

COMMENT - WDJ: "RMS" means the root mean square voltage. Instruments such as the Hewlett Packard 3400A measure RMS voltage. Electronic circuits such as the one in the PAC Spartan (EARS) produce an analog DC voltage representative of the RMS voltage. This voltage may be displayed on an inexpensive multimeter or voltmeter.

8. No. 5: Do you refer to the ramp-up to pressure from 50 to 900 psi?

A8. There were data points where the data was taken at the wrong time or not taken.

COMMENT - WDJ: Power failure on systems in containment at Palisades caused loss of data after the first data point and before the final data point.

9. No. 5: Were test personnel allowed in containment during pressurization?

A9. Yes.

10. No. 6: What specific discrepancies in background measurement practice prompted this question?

A10. Alleger felt that the floating threshold interfered with proper measurement of background.

COMMENT - WDJ: Floating threshold did not apply to RMS measurements. Background is the ambient noise detected by the sensor before and during a test that is not caused by leakage. Background measurements at Palisades and Davis-Besse were appropriate, judging from the test reports.

11. No. 7: Are you aware of the tests performed by H.A.F.A to verify the functionality of the instrument at elevated temperature? If so, was this test adequate?

A11. Alleger had no confidence in the elevated temperature test.

COMMENT - WDJ: Test result seemed to show that an ambient temperature of 110 degrees F did not significantly affect the function of the EARS system.

12. No. 8: Do you refer to graphs of manually recorded RMS data from DB1 such as this example?

A12. Alleger agreed that the manually plotted data on computer forms was the condition he questioned.

COMMENT - WDJ: The computer form in question provides a border and a format that is the same as the computer generated plots. The data from the test log were checked and the accuracy of the plots was verified. Deception is not suspected.

13. No. 9: What was the ratio of crosstalk between channels on the equipment you handled?

A13. Alleger had no specific data, but said that when 70 dB was measured from an active channel, an unused channel would also report 70 dB.

COMMENT - WDJ: Crosstalk between channels can be a problem in poorly designed multichannel instrument bins and this could have been the case in early prototype Spartan instruments. The problem can be aggravated by poor ground contact in the board connectors or by unterminated inputs on unused channels.

14. No. 9: Was this the same equipment used at Palisades and DB1?

A14. Yes.

COMMENT - WDJ: The equipment discussed is the PAC Spartan system which was designated by H.A.F.A. as the EARS system.

15. No. 10: Can you give specific examples of malfunctioning channels on this equipment?

A15. Alleger had no specifics.

COMMENT - WDJ: Wehrmeister confirmed that channel 6 of EARS 1 on Palisades failed during the test. Alleger's complaint included malfunctions that were corrected before start of testing.

16. No. 10: Can you explain the nature of the malfunction?

A16. Continuous lockout. LED indicator on constantly.

COMMENT - WDJ: Wehrmeister and Milke explained that such problems were corrected before test start. The "LED indicator on" condition meant that the signal level was constantly above the preset threshold level. This did not affect the RMS measurements.

17. No. 11: Can you identify debonded sensors as to channel number or location during the test?

A17. No specific data.

COMMENT - WDJ: Wehrmeister and Milke explained that pre-test evaluation detected bad channels which were repaired before test start.

18. No. 12: Do you have specific examples of loose or failed coaxial cables?

A18. No specifics given.

COMMENT - WDJ: See answer to Question 17.

19. No. 13: At what stage of the DB1 test were the containment air blowers in operation?

A19. At different times.

COMMENT - WDJ: The alleger used an LD 180 to monitor noise during test. The low frequency range of the LD 180 made it possible to hear valves open and close as the pressure was increased. The LD 180 was probably much more sensitive to the containment air blowers than was the higher frequency EARS system.

20. No. 14: Have you met Dr. Hamstad? Are you familiar with his research work in acoustic emission at Lawrence Livermore Labs and more recently at University of Denver?

A20. Alleger had not met Hamstad before and was not aware of Hamstad's AE research experience.

6. H.A.F.A FACILITY VISIT

6.1 GENERAL DISCUSSION

General discussions with most of H.A.F.A management and engineering staff were led by Duane Danielson.

6.2 ACOUSTIC LEAK MONITORING QUESTIONS

My effort was concentrated on the question of the validity of the acoustic leak testing used on steam systems and water-pressurized piping at Palisades and Davis-Besse. The records of testing at both plants were examined in detail. Some data were re-plotted from the logs to determine the validity of acoustic leak test analysis on Palisades. Questions about the method of recording RMS data [redacted] were discussed with Allen Wehrmeister and Rick Milke at H.A.F.A. Questions and answers are listed below. *

1. Why was no data recorded on EARS 1, 2 and 3 while the pressure was increasing from less than 50 psi to 900 psi?

A1. The power was off in containment where the three systems were located.

2. On ears 1, channel 6, the RMS millivolts is recorded as 14.32, 14.28, 14.28, 14300, 14300, 14.35, 14.30, 14.30, 14.35, 14.30, 14.30, 14.30, 14.30, 1430, 8000, 8000, 8000, 7.82, 7.85, 7.88, 5.02, 4.36, 4.01, 60, 110, 300, 350, 800. Is it possible that the underlined values all represent the same reading with the decimal misplaced?

* Proprietary Information Deleted

A2. Yes, some data takers recorded volts others recorded millivolts. This was not unusual.

COMMENT - WDJ: The values shown above were entered in the log in error. The error is easily recognized but the values could not be correctly interpreted without explanation by the test engineer.

3. Why was no simulated leak test done on EARS 1, 2 and 3, as was recorded on EARS 4 and 5?

A3. The leak simulator was not portable and, therefore, was too difficult to set up in containment.

COMMENT - WDJ: The use of a leak simulator is necessary to the proper calibration of a leak monitor system. Initial, interim and post-test calibration by leak simulator are needed for accurate interpretation of leak type signals.

4. Each data run includes three sets of RMS values. How were the three sets of RMS data used in deciding whether a leak existed?

A4. The three data sets were recorded to bracket the pressure reading. RMS data were used in connection with the leak analysis criteria to decide on the presence of a leak.

5. Can you provide test data to justify the use of AE monitoring without the leak monitoring instrumentation to test steam lines and steam generators under steam pressurization?

A5. The H.A.F.A laboratory study on "Real-Time Acoustic Analysis," Report No. 1009-88, shows that air leaks and water leaks can be detected by the H.A.F.A procedure.

COMMENT - WDJ: These experiments did not include detection in the presence of background noise such as found in a nuclear power plant. The detection threshold and the interpretation of leak type signals are strongly affected by background intensity and frequency content.

6. On the AE testing at the Palisades plant, was a return to baseline verified at the end of the test?

A6. Validation of baseline was not possible because plant was at start-up condition.

7. Was any post-test calibration check performed on the installed system?

A7. No. A post-test was not considered necessary.

COMMENT - WDJ: The assumption that the AE leak detection system did not change and that the sensor coupling or sensitivity was constant throughout the test is unrealistic. Interim and post-test calibration are very important to the validation of test data.

8. How were the pressure changes and the valve operations documented for use in interpretation of the RMS data?

A8. These conditions were entered in the chronological log.

9. The chronological log indicates that the pressure levels were not maintained for very long. How was the RMS data related to pressure under such conditions?

A9. The three data sets taken on RMS logs bracketed the time at which each pressure plateau was reached.

10. When some noise sources cannot be stopped during pressurization (e.g. "high acoustic activity as a result of blowdown operations," and "sensor 138 yielded indications of leakage") how can an absence of leakage in the system be verified by IIT when AE is used alone?

A10. The four leak analysis criteria help to separate other noises from leak noises.

COMMENT - WDJ: The leak analysis criteria (discussed in 7.) were developed without experimental evaluation of the effect of different background noise conditions. The minimum detectable leak size should be determined as a function of background noise conditions.

11. When the complete IIT system is used and some leakage is measured by the leak monitors, how do you verify that no external leakage is present?

A11. (From General Discussion): Acoustic sensors would detect leaks and show the region of leakage.

COMMENT - WDJ: The acoustic monitoring was done only on selected boundary valves where the full IIT was used. Therefore, leakage could only be detected within 20 feet of the selected valves. Most of the uninstrumented piping could contain external leakage which could not be detected acoustically.

12. Except for the steam seal leak at the turbine overspeed trip valve, you reported no apparent external leaks on the Palisades main steam system. You did report "acoustic activity typical of steam leakage" near sensor No. 6 on the main steam lines. How long was the pressure held before attempting to visually locate the source of the acoustic activity?

A12. (From General Discussion): Usually pressure was up for much longer than the 10 minutes required because of scheduling constraints.

COMMENT - WDJ: The leakage in question was in a penetration section of piping where VT-2 could not be performed. It should be noted here that the acoustic leak indication was not sufficient cause for the plant engineer to initiate a repair activity.

13. Was this region of the steam line insulated?

A13. (From General Discussion): Yes.

14. Was insulation removed for the visual examination?

A14. (From General Discussion): We assume not.

7. DESCRIPTION OF METHOD

I was shown how the RMS was taken from an analog output connected by a rotary switch to the 32 channels of the EARS (H.A.F.A's name for the Spartan). This output was a DC voltage representative of the RMS voltage. A standard DVM was used for the readout. The DC output was derived from a differential circuit which could have a negative output when the DC voltage dropped below an internal reference value.

Allen Wehrmeister explained to me how the interpretation of the Spartan recorded data was used to determine the presence of a leak. [redacted] *

[redacted]

[redacted]

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[redacted] *

7.1 DEMONSTRATION OF IIT

A laboratory demonstration of the IIT method was performed. A 20-foot length of 2-3 inch diameter pipe was outfitted with an inlet LMD and an outlet LMD to monitor the leakage from a throttle valve at the outlet. Acoustic sensors were connected to an EARS unit where the RMS output from each sensor could be monitored. At the suggestion of John Jacobson, a small valve near the inlet end was used as a simulated external leak. The outlet valve simulated an internal leak. We found that the RMS output from the sensor mounted on the throttle valve increased sharply when the external leak rate was increased to about 120 ml/min (0.03 gpm). These measurements were made while the simulated internal leak from the valve at the opposite end of the pipe was at 0.44 gpm indicated by the two LMDs. The LMD was not sensitive enough to detect the loss of 0.03 gpm through the simulated external leak while measuring 0.44 gpm flow through the pipe.

The demonstration showed that leaks could be detected when the leak signal exceeded the uncertainty of the ambient noise signal. [redacted] *

* Proprietary Information Deleted

8. ANALYSIS OF METHOD

It is clear that the signal-to-noise ratio must be very high for Wehrmeister's leak identification criteria. [redacted] * Therefore, the sensitivity of the leak detection process depends on the background noise.

* No qualification testing was reported that defines the relation between noise and leak detection sensitivity.

* The sensor spacing on water filled system tests where LMDs were used was usually too great for acoustic leak detection.

The leak detection and location system described in Topical Report H.A.F.A. 135 P measures the input-output flow to determine amount of leakage and uses acoustic leak monitoring to locate the region or component that is leaking. This process would facilitate the rapid inspection of a pressure boundary.

The acoustic leak monitor technique was not fully or properly implemented at Palisades or Davis-Besse. The tests included in the topical report were not adequate to qualify the acoustic leak monitor technique because no calibration of the acoustic leak detection sensitivity was performed. A functional check using simulated leak was sometimes used. Another functional check using a pencil-lead break technique was performed. These tests give no evidence as to the leak detection sensitivity or the distance over which a leak may be detected. Further, the degradation of leak detection sensitivity with increasing background noise is not addressed.

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The acoustic leak monitoring process described to me by Allen Wehrmeister has not been qualified by testing to prove the range of detectable leak sizes or to show the effects of increasing background noise or the detectability of multiple leaks. Testing to date consists of finding a noise signal and a visible leak in the same area. Laboratory demonstrations (H.A.F.A report 1009-88) showing detectability of leaks did not include the operating noise usually found in a power plant.

The application of acoustic leak detection to water-filled piping was applied to some of the boundary valves. The valves in most cases were too far apart to afford acoustic detection of leaks in piping or interior components. H.A.F.A supplied a report of sensor spacing evaluation ("Steam Leak Simulation Project," April 1987, Jim Pedersen) that indicated a spacing of 20 feet would provide some overlap of the sensor coverage. Some boundary valves that were acoustically monitored were not monitored by LMDs.