THE NEED FOR TESTING AND UPGRADING THE STACK MONITORING SYSTEMS AT U.S. NUCLEAR POWER PLANTS

Alfred C. Schmidt

Schmidt Instrument Co., P.O. Box 111, San Carlos, CA 94070; mschmidt@silcon.com
Phone 650-591-5347, or if no answer 650-343-2613

2003 RETS-REMP Workshop
June 23-25, 2003

Abstract

Stack monitoring systems are an essential part of the risk management strategy for nuclear power plants, and are the first place where radioactive releases to the atmosphere can be detected. Unfortunately, the largest part of these systems is hidden from view inside the stack where it cannot be examined easily, and few, if any, of these systems have been tested under simulated accident conditions where performance problems would show up. This paper cites numerous reasons why unmonitored releases may occur, and urges that these systems be tested and upgraded to meet the new ANSI/HPS Standard N13.1-1999.

Introduction

Stack monitoring systems serve the same purpose at nuclear power plants as smoke detectors do in buildings. If they are working properly, they provide information to the plant operators that radioactive substances are being released to the atmosphere, enabling the operators to institute appropriate control measures and to notify public safety officials that a problem exists. They are an essential part of the risk management strategy for these plants and are the first place where radioactive releases to the atmosphere can be detected. They also are required by law [1, 2].

The Need for Performance Testing

Unlike smoke detectors, the largest part of a stack monitoring system is hidden from view inside the stack, where it cannot be examined easily, or be tested by simply pressing a button [See Figure 1]. Secondly, most, if not all, of the existing systems were designed in accordance with ANSI Standard N13.1-1969 [3] which is now obsolete. That standard advocated the use of multiple inlet probes for sampling from all parts of the flow stream, but overlooked transmission losses that could prevent particles and condensable vapors from reaching the collection media where the radioactivity is measured. Thirdly, the Nuclear Regulatory Commission left "activities

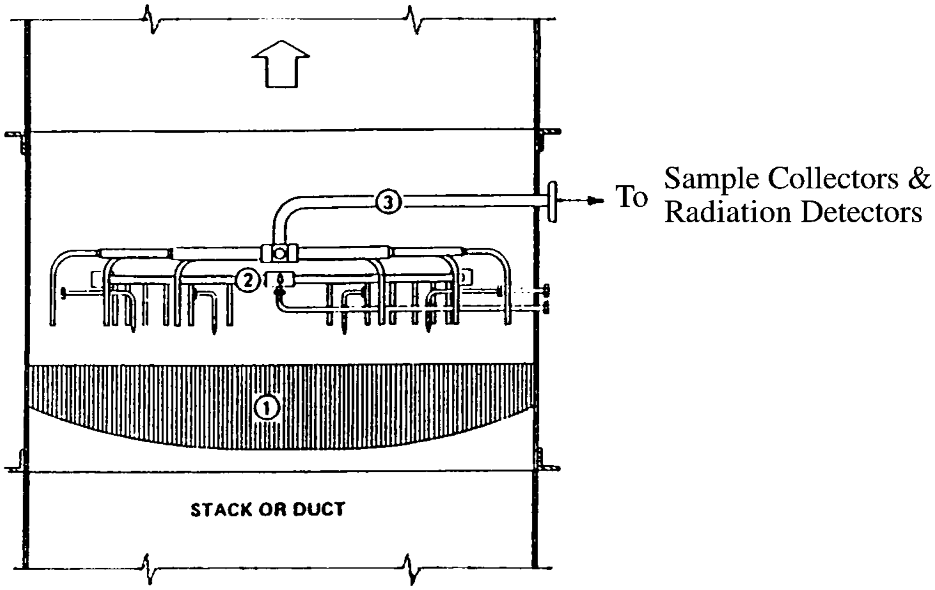

Fig. 1. The hidden portion of a typical stack monitoring system: (1) Flow profiling station; (2) Velocity sensing station; (3) Sample withdrawal section. This one at the Limerick Station has 64 1/8" diameter inlet nozzles. [5]

that can affect the quality of the monitoring results" up to its licensees and their contractors [4]. This was unfortunate because few of the contractors knew about transmission losses or had the expertise to conduct performance tests.

Numerous laboratory studies that have been made since 1969 [6-9] have raised doubts about the ability of existing stack monitoring systems to detect releases of radioactive particles and radioiodine in a timely manner. These doubts were substantiated by an event that occurred in 1986 at the Muehleberg nuclear power plant in Switzerland [10] when the stack monitoring system failed to detect some radioactive resin particles that had gone through breaks in the high efficiency [HEPA] filters and been discharged to the atmosphere. As a result the operators in the control room had no knowledge that anything was wrong until radioactive fallout was discovered downwind from the plant. Then an examination showed that the stack was massively contaminated and that resin particles had entered the inlets of the sampling probe but had barely gone past the first bends.

Unlike Muehleberg, where all of the containment air is supposed to be HEPA filtered, a number of U.S. nuclear power plants discharge the air from the reactor containment building directly to the stack, and divert it through HEPA filters and charcoal beds only when the stack monitoring system indicates that a release of radioactive substances is occurring. This places great importance on the reliability of their stack monitoring systems.

In other instances the stack is used for both filtered containment air and unfiltered air from the rest of the plant. The latter contains construction and maintenance dust that can plug the flow straighteners and the inlets of the stack monitoring system. A situation like this occurred at the Susquehanna Nuclear Power Station that was reported by Daniel Dunn at the 2000 RETS-REMP Workshop [11] . The dust deposits on the upstream side of the flow straighteners were so bad that they caused a low airflow problem in the power station. After cutting access doors in the stack and cleaning the flow straighteners with vacuum cleaner brushes, the station airflow increased by 40%.

The Wipp Controversy

The first challenge to ANSI Standard N13.1-1969 occurred in 1986 when the State of New Mexico, through its Environmental Evaluation Group [EEG] refused to accept a stack monitoring system with a multiple inlet sampling probe for the main exhaust shaft of the Waste Isolation Pilot Plant [WIPP]. This plant was being built near Carlsbad, New Mexico for the storage of transuranic wastes in an underground salt deposit, and continuous monitoring was required in the event of an accident that released radioactivity to the atmosphere. Bechtel, the contractor, argued that multiple inlet sampling probes had the de facto approval of the U.S. Nuclear Regulatory Commission as a result of their use at many U.S. nuclear power plants. EEG argued that airborne particles from the underground mining and storage operations would be trapped in the inlet nozzles and connecting arms of a multiple inlet sampling probe and not reach the collection filters where the radioactivity is measured.

To settle the controversy EEG assembled a peer review panel from three prominent aerosol research organizations and invited representatives of the Department of Energy and the WIPP Project Office to participate. The ensuing discussions make interesting reading and are recounted in a comprehensive report published by the State of New Mexico [12]. The conclusions of this historic meeting were (a) that a large single-inlet sampling probe is better than a multiple inlet array providing that it is located where it will receive a representative sample of the contaminants in the stack; (b) that the collector/detector should be located as close to the probe as possible to minimize transport losses; (c) that straightening vanes and multiple velocity sensors are not desirable; and (d) that the monitoring system for this application must be able to deliver 10 μm particles from the free stream to the collection filters with better than 50% efficiency under all operating conditions.

Subsequently the probe design contract was awarded to the Aerosol Technology Laboratory of Texas A & M University, which made a further improvement by installing a tubular shroud ahead of the inlet, that serves to calm the air and reduce the inlet velocity. The resulting probe exceeded the performance requirements by a comfortable margin. [See Figure 2.]

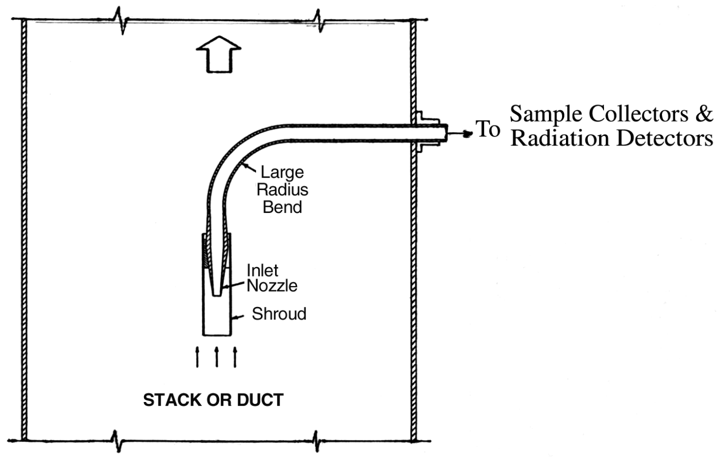

Fig. 2. A 2" diameter single-inlet sampling probe designed for continuous monitoring of the exhaust air at WIPP. The inlet nozzle is 1.18" I.D. and is surrounded by a 4" diameter tubular shroud. [13]

The Nature of Deposition Losses

Deposition losses in tubing systems are primarily a function of particle size and secondarily a function of system geometry. Thus submicron particles act like gases and can go through small diameter nozzles and tubing without losses; while larger particles, because of their mass and inertia, may be stopped by the first 90° bend. This is illustrated in Figure 3, which shows (A) the anticipated performance of multiple inlet sampling probes; (B) the minimum acceptable performance of new single inlet probes per ANSI/HPS N13.1-1999; and (C) the goal of future development. For each curve the larger the particles the smaller the percentages that reach the collection media. It would be a mistake to use submicron particles like DOP smoke for testing stack monitoring systems because they would provide no indication of the performance when larger particles are present.

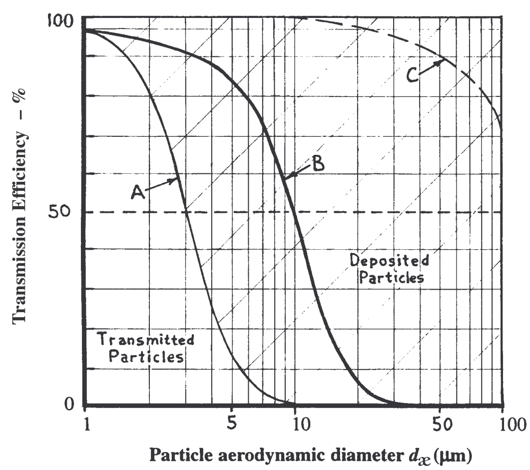

Fig. 3. The effect of particle size on deposition losses in (A) multiple inlet sampling probes (anticipated performance), (B) single inlet probes per ANSI/HPS N13.1-1999, and (C) the goal of future development.

Standards for Performance Testing

The second challenge to ANSI Standard N13.1-1969 occurred in 1999 when the Health Physics Society replaced it with ANSI/HPS N13.1-1999 [14]. This standard follows the lessons learned at WIPP and specifies that "Total transport of 10 μm particles and vaporous contaminants shall be greater than 50% from the free stream to the collector/analyzer" (under all operating conditions). The 10 μm particle size was selected on the basis that it would serve the majority of anticipated events and was achievable in practice. It should be noted, however, that 10 μm does not cover all recorded events, including Muehleberg where the estimated size of the radioactive resin particles was 50 μm.

Testing the existing stack monitoring systems for compliance with the 1999 standard can be done inexpensively by qualified experts. There will be some initial expense to develop equipment and techniques for simulating releases of 10 μm radioactive particles and for measuring the proportion that reaches the collector/analyzer. Since many of the existing monitoring systems are similar, it will be necessary to test only representatives of each design.

Additional tests are needed at the collector/analyzer to make sure that the flow resistance will not exceed the limit of the flow control system; to make sure that all of the collected radioactivity is viewed by the radiation detectors; and to make sure that all components are free of air leaks that could reduce the accuracy of the measurements.

Upgrading the existing stack monitoring systems to the 1999 ANSI/HPS standard also can be done inexpensively. Costly multi-inlet sampling probes are no longer required since better measurements can be achieved with single-inlet shrouded probes that are located where they will receive representative samples of the contaminants in the stack. (See Figures 1 and 2.) Here again there will be some initial expense for developing equipment and techniques for determining the best locations for representative sampling.

Risk Management Considerations

From a risk management perspective the more timely the information, and the more accurate it is, the better the decisions that can be made. Thus it will be to the benefit of the owners and managers of nuclear power plants to not only test and upgrade their stack monitoring systems to the 1999 ANSI/HPS standard, but to also sponsor research on how to increase the size of the particles that reach the collector/analyzer, and how to increase the sampling flow rate in order to reduce the time required for detecting radioactive releases. Some work has been started in this direction, and both of these goals appear to be achievable.

Conclusions

1. There is a definite need for testing the stack monitoring systems at U.S. nuclear power plants, and for upgrading any that do not meet the minimum performance requirements of ANSI/HPS N13.1-1999.

2. This is a matter of risk management, creditability, and public safety and deserves to be given a high priority by the owners and managers of the nuclear power plants, and by the U.S. Nuclear Regulatory Commission.

3. Testing is especially important for plants that discharge the containment air directly to the stack and divert it through HEPA filters and charcoal beds only when the stack monitoring system indicates that a release of radioactive substances is occurring.

4. Testing also is very important for plants that use the same stack for dust-laden air that can plug the flow straighteners and the inlets of the stack monitoring system.

5. Because this is an industry-wide problem, it is best handled on an industry-wide basis through cost sharing arrangements with organizations like the Electric Power Research Institute (EPRI) and the Department of Energy (DOE), which will reduce the cost to each plant.

Acknowledgments

The author is indebted to Bill Wendland of American Nuclear Insurers for encouraging him to write this paper.

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