ANSI N13.1-2011 Stack Sampling Considerations

Background

Nuclear facilities are required to follow industry standards for sampling stack effluents. Exposure of the general public to released radionuclides must be monitored as specified in US governmental regulations. The United States Environmental Protection Agency (USEPA) and the United States Nuclear Regulatory Commission (USNRC) have the authority over the monitoring of these releases. The licensing criteria for each nuclear facility specify the industry standard to be used for stack and duct sampling. Current licensing criteria establish **ANSI/HPS N13.1-2011** as the standard to be used in designing the sampling systems.

ANSI/HPS N13.1-2011 Requirements

The design goal of the sampling system is to extract a representative sample from the vent or duct under normal operating conditions. ANSI N13.1-2011 requires that the sampling system extract a representative sample of all particle sizes with the acceptance criteria based on the ability of sampling system to extract and transport the large particles up to 10 micron (10 µm) aerodynamic diameter (AD) particles from the stack to the filter media. 10 µm AD radioactive particles are the largest particles that can be inhaled and accumulate in the respiratory system, and are considered a public health hazard. The representative sampling of 10 µm radioactive particles in a nuclear facility vent stack is considered to be more difficult than for radioactive iodines and noble gases. A representative sample of 10 µm particles will also ensure representative sampling of radioactive iodines and noble gases.

ANSI N13.1 requires that the flow conditions inside the vent or duct at the extraction point be well known and understood and establishes criteria for acceptable flow conditions in the flow stream. In addition, the deposition loses along the transport path must be evaluated.

In particle sampling, the following design criteria must be considered;

1. Draw a representative quantity of particles from the stack flow into a sample probe

2. Minimize the particle losses on the inner surfaces of the probe and from the probe outlet through the sample transport line to a particulate sampler or monitor.

   ANSI N13.1-2011 requires that the particle concentration at the sampler or monitor must be at least 50% of the 10 µm AD size particles of the stack free stream concentration at the sample extraction location

3. Accurately analyze the particulate sample as required by the US regulations, e.g., for record-keeping and/or alarm annunciation.

ANSI/HPS N13.1-2011 Sample Extraction Location Qualification

To verify that a representative sample of particulates, iodines and gases are extracted from the stack, a series of empirical tests are conducted to confirm that particulates and gases are well mixed with a uniform velocity profile and minimum swirl.

The following table (extracted from ANSI/HPS N13.1-2011) provides the flow characteristics to be measured, the test methodology to be used, and the acceptance criteria for qualifying the sample extraction location.

ANSI/HPS N13.1-2011 Sampling Location Acceptance Criteria

Characteristic	Methodology	Acceptance Criteria
Measurement to determine if flow in a stack or duct is cyclonic.	40CFR60, Appendix A, Method 1	The average resultant angle shall be less than 20°.
Velocity profile in a large duct (>about 0.3 m diameter) and small stacks and ducts (< about 0.3 m).	Select traverse points from 40CFR60, Appendix A, Method 1 (Figure 1-2) for the center 2/3 of the area of the stack or duct. Additional points or area may be needed to adequately cover the region.	Coefficient of Variation[1] (COV) shall not exceed 20% over the center region of the stack that encompasses at least 2/3 of the stack area.
Tracer gas concentration profiles in large and small stacks and ducts.	Select traverse points from 40CFR60, Appendix A, Method 1 (Figure 1-2) for the center 2/3 of the area of the stack or duct. Additional points or area may be needed to adequately cover the region.	COV shall not exceed 20% over the center region of the stack that encompasses at least 2/3 of the stack area.
Maximum tracer gas concentration in large and small stacks and ducts.	Select traverse points from 40CFR60, Appendix A, Method 1 (Figure 1-2) for the entire cross sectional area.	The maximum value of tracer gas concentration shall not exceed the mean value by more than 30% of the mean value at any point on a complete Method 1 set of velocity traverse points.
Aerosol particle concentration profile in large and small ducts.	Select traverse points from 40CFR60, Appendix A, Method 1 (figure 1-2). Additional points or area may be needed to adequately cover the region.	COV shall not exceed 20% over the center region of the stack that encompasses at least 2/3 of the stack area.

[1] Coefficient of Variation is defined as the ratio of the standard deviation of a variable to the mean value of that variable expressed as a percentage.

Sample Probe Design Considerations

The sample probe located at the qualified sample location is the heart of the sampling system. Sample probe designs must take into consideration the aspiration efficiency[2] and wall losses[3] of the design. ANSI/HPS N13.1-2011 requires that sample nozzles must have an aerosol transmission ratio within the range of 0.80 to 1.30 over the expected stack flow rate range for 10 µm AD particles; which includes the aspiration efficiency and wall losses.

Either a multi-point sample assembly with unshrouded sharp-edged nozzles operated isokinetically or a single shrouded probe operated isokinetically or at a constant sample flow rate can be used. Studies have shown that constant diameter sample nozzles typically used in multi-point sample assemblies may have large wall losses. This is especially true for small diameter nozzles and low sample nozzle flow rates needed for designs used in large stacks. For multi-point sample assemblies, ANSI/HPS N13.1-2011 requires testing to confirm that the multi-point sample assembly will satisfy the above criteria for transmission efficiency. Shrouded probe designs have been proven to have better performance than the constant diameter nozzle designs used in multi-point sample assemblies. Shrouded probe designs have much higher aspiration efficiency and lower wall losses than equivalent multi-point sample assemblies. Shrouded probes also have acceptable transmission losses when operated at a constant sample flow rate over a wide range of stack flow rates.

Sample Transport Line Design Considerations

The sample transport line from the sample probe to the filter media also must be designed to maximize the transmission efficiency for the complete sample system. Minimal horizontal line runs, minimum changes in direction, minimum changes in flow cross sectional area, and an optimum line size (based on sample flow rate) are the critical parameters for the transport system design.

Analysis can be performed on the transport line configuration to confirm that the transmission efficiency of the sample transport system is greater than 50%.

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[2] Aspiration efficiency is the particle concentration at a nozzle inlet plane divided by the particle concentration in the undisturbed stream at the point where the nozzle is located represented as a percentage.

[3] Wall losses are the particle losses of the sample on the internal walls of the sample nozzle from the nozzle inlet to the nozzle outlet.