C. REGULATORY POSITION

1. Methods of Sampling Analysis

The licensee should choose the sampling and analysis methods used in the effluent monitoring programs to provide information on the quantity and concentration of radionuclides in gaseous and liquid effluents. The bibliography in this guide provides useful references on sampling, analysis, statistical analysis, and preparation and maintenance of effluent monitoring programs.

2. Sampling Program

The sampling program should be sufficient to permit a determination of the quantities of radionuclides and the average concentration of radionuclides being discharged from the facility.

For most effluents, releases should either be batch controlled and released or continuous composite samplers should be employed. Licensees should only use periodic grab sampling at continuous release points to confirm the absence or negligible amount of radioactive materials in the effluent. When grab samples are collected in lieu of the use of continuous samplers, the licensee should ensure that the time, location, and frequency of such sampling is representative of the effluent. Licensees should take replicate grab samples periodically to determine the reproducibility of sampling. Interdispersed samples, spatially or temporally or both, should be collected periodically to verify their representativeness.

Licensees should use appropriate sampling equipment, proper locations of sampling points, and proper procedures for collection and storage of samples to ensure that they obtain representative samples.

2.1 Gaseous Effluents

The NRC recognizes the guidance developed in American National Standards Institute (ANSI)/Health Physics Society (HPS) N13.1-1999, "Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities," issued 1999 (Ref. 1). Licensees should use this guidance to establish sampling and monitoring methods for those gaseous effluent points that cumulatively emit 90 percent or more of the total radioactivity released from the facility, as well as those points that cumulatively contribute 90 percent or more of the total estimated offsite exposure from facility releases. Licensees may sample and monitor other gaseous effluent points in a manner consistent with the test methods outlined in Appendices A-1 through A-8 to 40 CFR Part 60, "Standards of Performance for New Stationary Sources," as applicable.

Licensees should consider gaseous effluents from all operations associated with the facility, including, but not limited to, such nonprocessing areas as laboratories, experimental areas, storage areas, and fuel element assembly areas, for inclusion in a sampling program. Licensees may use a graded approach to determine sampling and monitoring methods and frequencies. For example, a review of process information and the potential for offsite doses to members of the public could lead the licensee to implement continuous monitoring of emissions from particular points of release, continuous sampling of emissions for most other release points, and only periodic sampling or periodic administrative reviews for release points where material has little potential to be released.

Continuous monitoring is the appropriate method for determining released quantities of gaseous effluents from process systems that use materials that may be easily dispersed (in either gaseous or fine powder form) and that have a potential for exposures to the public above the limits found in Table 2 of Appendix B, "Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) for Radionuclides

for Occupational Exposures, Effluent Concentrations, Concentrations for Release to Sewerage," to 10 CFR Part 20, "Standards for Protection against Radiation," or when rapid detection of accidental releases is necessary.

If a particular point of release could be expected to emit radionulides that have a potential for exposures to the public above 10 percent, but less than 100 percent, of the effluent concentrations listed in Table 2 of Appendix B to 10 CFR Part 20, the licensee should conduct continuous sampling and review the data to identify trends.

For an individual point of release that could be expected to emit radionuclides that have a potential for exposures to the public less than 10 percent of the effluent concentrations listed in Table 2 of Appendix B to 10 CFR Part 20, the licensee may use periodic sampling (e.g., weekly). However, the licensee should perform periodic sampling in such a manner that significant batch releases or other releases that contain significantly elevated concentrations of radionuclides (also called "irregular" releases) are sampled appropriately.

If no radiological source can contaminate an effluent, sampling of the effluent for radionuclide concentrations is not necessary (e.g., a nonradiological stack). However, licensees should evaluate each effluent point periodically (e.g., annually) to verify that its radiological status has not changed.

Licensees may combine gaseous samples for analysis if they are collected at the same location and if they represent a sampling period of 1 week or less. Licensees should not combine samples from different locations.

2.2 Liquid Effluents

Licensees should collect representative samples at each liquid release point to determine the quantities and average concentrations of radionuclides discharged in any liquid effluents that could reach an unrestricted area. For continuous releases, licensees should continuously collect representative samples at each release point. For batch releases, licensees should collect a representative sample of each batch.

For some liquid effluents, the licensee may establish, by periodic sampling or by other means, that radioactivity in the effluent from a particular release point poses minimal risk and does not require continuous sampling. In such cases, licensees should periodically sample the particular effluent stream at least quarterly. However, the licensee should perform periodic sampling in such a manner that significant batch releases or other releases that contain significantly elevated concentrations of radionuclides (i.e., off-normal releases) are sampled appropriately. The licensee should provide supplemental information documenting that these samples are representative of actual releases. For the purposes of this guide, a liquid effluent release is considered to pose minimal risk if the concentration averaged over a calendar quarter is no more than 10 percent of the appropriate concentration listed in Table 2 of Appendix B to 10 CFR Part 20.

The sampling program should be sufficient to determine the quantities and the average concentration of radionuclides being discharged from the facility. The sampling rate at each release point should ensure that a representative sample of the effluent is collected. Licensees should report the volume of liquid effluents and should calculate and report the quantities of radionuclides discharged and the potential exposure to a member of the public.

Licensees may combine liquid samples collected at the same location if they represent a sampling period of 1 month or less. Licensees should not combine samples from different locations.

3 Quality Assurance and Quality Control

3.1 Regulatory Guidance

Licensees should develop a Quality Assurance (QA) program applicable to monitoring effluents. Regulatory Guide 4.15, Revision 2, "Quality Assurance for Radiological Monitoring Programs (Inception through Normal Operations to License Termination)—Effluent Streams and the Environment," issued July 2007 (Ref. 2), describes the quality assurance program activities for ensuring that radioactive effluent monitoring systems and operational programs meet their intended purpose. Regulatory Guide 4.15 contains guidance for determining the appropriate sensitivity levels for analytical instrumentation based on data quality objectives (DQOs). The NRC staff believes that the use of DQOs provides a better technical basis for determining sensitivity levels (minimum detectable concentration [MDC]) than the previously used prescriptive approach, which specified MDCs of less than 10 percent of the applicable value given in Appendix B to 10 CFR Part 20. ANSI/American Society for Quality (ASQ) E4-2004, "Quality Systems for Environmental Data and Technology Programs—Requirements with Guidance for Use," issued 2004 (Ref. 3), includes additional guidance pertinent to quality assurance of effluent monitoring.

3.2 Minimum Detectable Concentrations

The MDCs for any sampling and analysis method should be consistent with developed DQOs for the sampling and analysis program. In the prior revision to this guidance, the NRC staff considered MDCs to be acceptable if they were less than 10 percent of the concentration limits listed in Table 2 of Appendix B to 10 CFR Part 20. For example, the NRC staff considered the MDC for soluble uranium-238 to be acceptable if less than 1×10^{-11} kilobecquerel per milliliter (kBq/mL) (3×10^{-13} microcurie per milliliter [μCi/mL]) for gaseous effluents and 1×10^{-6} kBq/mL (3×10^{-8} μCi/mL) for liquid effluents. If the actual concentrations of the sampled radionuclides are known to be elevated in comparison to the MDC requirements, DQOs should establish that the sampling and analysis procedures need only be adequate to measure the actual concentrations. However, in such cases, the MDCs should be low enough to accommodate fluctuations in the concentrations of the effluent.

Appendix A to this regulatory guide describes an acceptable method for calculating the MDC.

3.3 Quality Control Checks

Licensees should conduct QC checks of laboratory instrumentation either daily or before use and monitor background variations at regular intervals to demonstrate that a given instrument is in working condition and functioning properly. QC records should include results of routine tests and checks, background data, calibrations, and all routine maintenance and service. Tests should be applied to analytical processes, including duplicate analysis of selected effluent samples and periodic cross-check analysis with independent laboratories.

Because many of the data to be reported may be based on gross radioactivity measurements, the program should include periodic tests to ensure that such measurements represent actual quantities of individual radionuclides in samples. For example, in facilities handling uranium, the licensee should perform a chemical or isotopic analysis for uranium at least quarterly on selected samples for comparison with the gross radioactivity analyses. The use of supplemental analysis for comparison to gross activity analyses has several QC applications: to independently verify the gross activity analytical method; to identify biases developing in the analytical methodologies; and to verify the mixture of materials present (e.g., if gross analytical results change significantly relative to isotopic results, additional investigation is warranted as the mixture of materials may have changed).

3.4 Functional Checks

Licensees may perform routine qualitative tests and checks (e.g., channel operational tests, channel checks, or source checks to demonstrate that a given instrument is in working condition and functioning properly) using radioactive sources that are not traceable by the National Institute of Standards and Technology (NIST). The schedule for source checks, channel checks, channel calibrations, and channel operational tests should be consistent with developed DQOs.

3.5 Procedures

Licensees should use individual written procedures to establish specific methods of calibrating installed radiological monitoring systems and grab sampling equipment. Written procedures should document calibration practices used for ancillary equipment and systems (e.g., meteorological equipment, airflow measuring equipment, in-stack monitoring pitot tubes). Calibration procedures may be compilations of published standard practices or manufacturers' instructions that accompany purchased equipment, or they may be specially written in-house to include special methods or items of equipment not covered elsewhere.

Calibration procedures should identify the specific equipment or group of instruments to which they apply. Licensees should use written procedures to maintain counting room instrument accuracy, including maintenance, storage, and use of radioactive reference standards; instrumentation calibration methods; and QC activities, such as collection, reduction, evaluation, and reporting of QC data.

Licensees should also establish procedures to ensure that the samples are not affected by improper handling or storage before analysis. For example, liquid samples may require chemical treatment to prevent losses to the walls of storage containers, and samples containing solids should either be made homogeneous or the liquid and solid portions should be analyzed and reported separately.

3.6 Calibration of Laboratory Equipment and Radiation Monitors

Licensees should perform calibrations (e.g., of laboratory equipment and continuous radioactivity monitoring systems used to quantify radioactive effluents) using reference standards certified by NIST or secondary standards traceable to NIST. Calibration standards should have the necessary accuracy, stability, and range required for their intended use. The relationship between concentrations and monitor readings should be determined over the full range of the readout device.

Calibration standards should use radionuclides of appropriate radiation and energy. Calibration standards for natural or depleted uranium are typically fashioned from natural uranium. For enriched uranium, alpha calibration standards are commonly fashioned from thorium-230, whereas beta standards are commonly fashioned from technetium-99. Calibration standards may use other radionuclides, but their impact should be understood and appropriate for the radionuclides of interest in the analysis.

Licensees may apply NIST-traceable sources, combined with mathematical efficiency calibrations, to instrumentation used for radiochemical analysis (e.g., gamma spectroscopy systems), if employing a method provided by the instrument manufacturer.

The adequacy of the system should be judged on the basis of reproducibility, time stability, and sensitivity. Licensees should perform periodic inservice correlations that relate monitor readings to the concentrations or release rates (or both) of radioactive material in the monitored release path. This will validate the adequacy of the system. These correlations should be based on the results of analyses for specific radionuclides in grab samples from the release path.

3.7 Calibration of Measuring and Test Equipment

Licensees should calibrate measuring and testing equipment using reference standards certified by NIST or standards that have been calibrated against NIST-certified standards. The calibration standards should be representative of the sample types analyzed and have the necessary accuracy, stability, and range required for their intended use.

3.8 Calibration Frequency

Calibrations should generally be performed at regular intervals, in accordance with developed DQOs. A change in calibration frequency (either an increase or a decrease) should be based on the reproducibility and time stability characteristics of the system. For example, an instrument system that gives a relatively wide range of readings when calibrated against a given standard should be recalibrated at more frequent intervals than one that gives measurements within a more narrow range. Any monitoring system or individual measuring equipment should be recalibrated or replaced whenever it is suspected of being out of adjustment, excessively worn, or otherwise damaged and not operating properly.

3.9 Measurement Uncertainty

Licensees should estimate the measurement uncertainty (formerly called measurement error) associated with the measurement of radioactive materials in effluents. Counting statistics can provide an estimate of the statistical counting uncertainty involved in radioactivity analyses. Normally, the statistical counting uncertainty decreases as the amount (concentration) of radioactivity increases. Thus, for the radioactive effluent release report, the statistical counting uncertainty is typically a small component of the total uncertainty.

Because it may be difficult to assign error terms for each parameter affecting the final measurement, detailed statistical evaluations of error are not required. The sampling uncertainty is likely the largest component and includes uncertainties such as that in volumetric and flow rate measurements and the laboratory processing uncertainties. The total or expanded measurement uncertainty (also referred to as the systematic uncertainty) associated with the effluent measurement should include the cumulative uncertainties resulting from the total operation of sampling and measurement. Expanded uncertainty should be reported with measurement results. The objective should be to evaluate only the important contributors and to obtain a reasonable measure of the uncertainty associated with reported results. Detailed statistical and experimental evaluations are not required. The overarching objective should be to obtain an overall estimate of measurement uncertainty. The formula for calculating the total or expanded uncertainty classically includes the square root of the sum of the squares of each important contributor to the measurement uncertainty.

Licensees should round the uncertainty estimate to either one or two significant figures and the measured value to the same number of decimal places as its uncertainty.

4. Analysis of Gaseous and Liquid Samples

As required by 10 CFR 70.59 and 10 CFR 40.65, fuel cycle licensees must report, within 60 days after January 1 and July 1 of each year, the quantity of principal radionuclides released to unrestricted areas in liquid and gaseous effluents during the previous 6 months of operation.

Licensees should perform radionuclide analyses on selected samples unless: (1) the gross alpha and gross beta activities are so low that individual radionuclides could not be present in concentrations

APPENDIX A

MINIMUM DETECTABLE CONCENTRATION

This appendix provides information on calculating the minimum detectable concentration (MDC) for radioactive materials in environmental media based on detection of the radiation emitted from the materials.

$$MDC = \frac{3 + 4.65S_b}{1\,x\,10^3\ EVY\ e^{-\lambda\Delta t}}$$

where:

MDC	is the minimum detectable concentration (kilobecquerel per milliliter)
S_b	is the standard deviation of the instrument background counting rate (counts per second)
1×10^3	is the number of disintegrations per second per kilobecquerel
E	is the counting efficiency (counts per disintegration)
V	is the sample volume (milliliters)
Y	is the fractional radiochemical yield (when applicable)
λ	is the radioactive decay constant for the particular radionuclide
Δt	is the elapsed time between the midpoint of sample collection and the time of counting

The licensee should base the value of S_b used in the calculation of the MDC for a particular measurement system on the actual observed variance of the instrument background counting rate rather than on an unverified, theoretically predicted variance.

Since the MDC is a function of sample, volume, counting efficiency, radiochemical yield, and the like, it may vary for different sampling and analysis procedures. Whenever there is a significant change in the parameters of the measurement system, the licensee should recalculate the MDC.