



REGULATORY GUIDE

OFFICE OF NUCLEAR REGULATORY RESEARCH

REGULATORY GUIDE 4.1

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RADIOLOGICAL ENVIRONMENTAL MONITORING FOR NUCLEAR POWER PLANTS

A. INTRODUCTION

This guide describes a method that the staff of the U.S. Nuclear Regulatory Commission (NRC) considers acceptable for use in establishing and conducting an environmental monitoring program at nuclear power plants. The guide describes programs for preoperational and operational environmental monitoring.

The regulatory framework for the radiological environmental monitoring program (REMP) derives from the following:

- plant-specific technical specifications that establish a requirement for radiological environmental monitoring activities;
- Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," Appendix I, "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion 'As Low As Is Reasonably Achievable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents" (Ref. 1);

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This guide was issued after consideration of comments received from the public.

Regulatory guides are issued in 10 broad divisions: 1, Power Reactors; 2, Research and Test Reactors; 3, Fuels and Materials Facilities; 4, Environmental and Siting; 5, Materials and Plant Protection; 6, Products; 7, Transportation; 8, Occupational Health; 9, Antitrust and Financial Review; and 10, General.

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- 10 CFR 20.1302, “Compliance with Dose Limits for Individual Members of the Public” (Ref. 2), which requires surveys of radiation levels in the unrestricted areas and radioactive materials in effluents to demonstrate compliance with the dose limits for individual members of the public; and
- 10 CFR 72.44, “License Conditions,” paragraph 44(d)(2), which requires establishment of an environmental monitoring program to ensure compliance with technical specifications (for those facilities with a specific license under 10 CFR Part 72, “Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Waste, High-Level Radioactive Waste, and Reactor-Related Greater Than Class C Waste” (Ref. 3)).
- General Design Criterion 64, “Monitoring radioactivity releases,” of Appendix A, “General Design Criteria for Nuclear Power Plants,” to Title 10, Part 50, of the Code of Federal Regulations (10 CFR Part 50), “Domestic Licensing of Production and Utilization Facilities”

Collectively, these regulations require that an environmental monitoring program be established and implemented to obtain data on measurable levels of radiation and radioactive materials. The Annual Radiological Environmental Operating Report provides summaries of the data, interpretations, and analyses of trends of the results. The licensee may submit the annual report required by 10 CFR 72.44 as part of the Annual Radiological Environmental Operating Report at the licensee’s discretion (if the reporting dates, as outlined in the licensee’s regulatory bases, are coincident).

This regulatory guide contains information collection requirements covered by 10 CFR Part 20, “Standards for Protection Against Radiation,” and 10 CFR Part 50 that the Office of Management and Budget (OMB) approved under OMB control numbers 3150-0014 and 3150-0011. The NRC may neither conduct nor sponsor, and a person is not required to respond to, an information collection request or requirement unless the requesting document displays a currently valid OMB control number.

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B. DISCUSSION

Regulatory Guidance

Six basic documents contain the regulatory guidance for implementing the 10 CFR Part 20 regulatory requirements and plant technical specifications related to monitoring and reporting of radioactive material in effluents and environmental media, solid radioactive waste disposal, and resultant public dose:

1. Regulatory Guide 1.21, “Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants” (Ref. 4);
2. Regulatory Guide 4.1, “Radiological Environmental Monitoring For Nuclear Power Plants,”
3. Regulatory Guide 4.15, “Quality Assurance for Radiological Monitoring Programs (Inception Through Normal Operations to License Termination)—Effluent Streams and the Environment” (Ref. 5);
4. NUREG-1301, “Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors,” (Ref. 6); and
5. NUREG-1302, “Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Boiling Water Reactors,” (Ref. 7).
6. Regulatory Guide 1.109, “Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Demonstrating Compliance with 10 CFR Part 50, Appendix I,” (Ref. 8)

The above documents, when used in an integrated manner, provide the basic principles and implementation details for developing and maintaining effluent and environmental monitoring programs at nuclear power plants. The three regulatory guides specify the guidance for radiological monitoring programs, whereas the two NUREGs present specific implementation details for effluent and environmental monitoring programs.

Regulatory Guide 1.21 addresses the measuring, evaluating, and reporting of effluent releases, solid radioactive waste, and public dose from nuclear power plants. The guide describes the important concepts in planning and implementing an effluent and solid radioactive waste program. Concepts covered include meteorology, hydrology, release points, monitoring methods, subsurface monitoring, identification of principal radionuclides, unrestricted area boundaries, continuous and batch release methods, representative sampling, composite sampling, radioactivity measurements, decay corrections, quality assurance, solid radioactive waste shipments, and public dose assessments.

Regulatory Guide 4.1 addresses the environmental monitoring program. The guide discusses principles and concepts important to environmental monitoring at nuclear power plants. The regulatory guide addresses the need for preoperational and background characterization of radioactivity. The guide also addresses offsite monitoring, including the those exposure pathways that are important to a site. The guide defines exposure pathways, the program scope of sampling media and sampling frequency, and the methods of comparing environmental measurements to effluent releases in the annual environmental report.

Regulatory Guide 4.15 provides the basic principles of quality assurance in all types of radiological monitoring programs for effluent streams and the environment. The guide does not specifically address nuclear power plants but covers all types of licenses and licensees. It provides the guidance for structuring organizational lines of communication and responsibility, using qualified personnel, implementing standard operating procedures, defining data quality objectives, performing quality control checking for sampling and analysis, auditing the process, and taking corrective actions.

NUREG-1301 and NUREG-1302 provide the detailed implementation guidance by describing effluent and environmental monitoring programs. The NUREGs specify effluent monitoring and environmental sampling requirements, surveillance requirements for effluent monitors, types of monitors and samplers, sampling and analysis frequencies, types of analysis and radionuclides analyzed, lower limits of detection (LLDs), specific environmental media to be sampled, and reporting and program evaluation and revision.

Regulatory Guide 1.109 provides the detailed implementation guidance for demonstrating that radioactive effluents conform to the “As Low As Is Reasonably Achievable” (ALARA) design objectives of 10 CFR 50, Appendix I. The regulatory guide describes calculational models and parameters for estimating dose from effluent releases, including the dispersion of the effluent in the atmosphere and different water bodies.

Objectives of the Radiological Environmental Monitoring Program (REMP)

The regulatory positions described in this document provide guidance on the establishment of the REMP. The REMP has the following basic objectives:

1. Survey the radiological conditions in the vicinity of the facility before initial reactor operation to establish the baseline radiological conditions in the local environment.
2. Measure the levels of radiation and radioactive materials in the local environment during the lifetime of the facility.
3. Determine if any measurable levels of radiation or radioactive materials in the local environment are attributable to plant operation.
4. Determine if measurable levels of plant-related radiation and radioactive materials in the local environment are commensurate with the radioactive effluents and plant design objectives (e.g., as low as reasonably achievable).
5. Report measurement results, summaries, and trends regarding radiation and radioactive materials in the local environment.
6. Maintain the REMP by identifying changes in land use (e.g., agricultural land use in unrestricted areas) that may impact the measurements or measurement results associated with exposure pathways identified in the REMP.

C. REGULATORY POSITION

1. Preoperational Radiological Environmental Monitoring Program

- a. A REMP should be established and implemented at least 2 years before initial facility operation. The program will contain the routine surveillances necessary to adequately characterize the radiological conditions in the vicinity of the reactor site. Once initiated, the collection of samples and analysis of data should follow the sampling and analyses schedule and should continue for the first 3 years of commercial operation. For new reactor sites that are collocated with currently operating nuclear power plants (or previously operating nuclear power plants with a currently operating REMP program), the existing operational REMP associated with the operating (or previously operating) facility will normally meet the requirements for a preoperational REMP, given that the monitoring data is relevant to the time period .
- b. The preoperational REMP should be conducted so that the preoperational radiological conditions are understood in sufficient detail to allow future reasonable, direct comparison with data collected after power operation of the facility. The preoperational REMP should be updated when the land use census identifies new exposure pathways or receptor locations.

2. Operational Radiological Environmental Monitoring Program

- a. Although all operating facilities will have a REMP associated with the operating reactors, some licensees may have other REMPs to satisfy other needs. An operational radiological environmental monitoring program may consist of several different parts. For example, a licensee may have (1) a REMP that is associated with the 10 CFR Part 50 licensed facility, (2) a REMP that is associated with the 10 CFR Part 72 specific-licensed facility, and (3) a REMP not explicitly required by NRC regulations (e.g., environmental samples of local community interest or samples deemed important for continuity with the preoperational REMP). This regulatory guide addresses only those REMPs required by NRC regulations, but licensees may, at their discretion, apply this information to any aspect of a REMP conducted for purposes of local community interest.
- b. If a licensee has a REMP as part of a 10 CFR Part 50 license and another REMP as part of a 10 CFR Part 72 specific license, the licensee may choose to establish totally separate REMPs, or it may choose to collocate surveillance equipment where practical. In all cases, the licensee shall conduct the REMPs in accordance with the applicable regulations and the licensing bases at the site.
- c. The REMP is sometimes conceptualized as an offsite monitoring program. However, some portions of the REMP may be conducted on site. For example, NUREG-1301/1302 states that the inner ring of thermoluminescent dosimeters (TLDs) may be located “in the general area of the site boundary.” The same is true for radioiodine and particulate sampling. NUREG-1301/1302 also describes ground water monitoring if ground water is “likely to be affected” and describes the monitoring of drinking water supplies if they “could be affected.” Licensees should consider this when implementing a REMP (especially if the facility obtains drinking water from wells located down gradient from the site). In some situations, licensees should consider onsite

monitoring with respect to NUREG-1301/1302, Section 3/4.12.2, “Land Use Census,” Control 3.12.2. Action “a” of that control specifies that new locations be reported in the Annual Radioactive Effluent Release Report when the doses are higher than those at the current location.

Action “b” of that control requires revising the REMP (and reporting to the NRC) if the licensee identifies a location yielding a dose or dose commitment that is 20 percent larger than the dose at locations from which samples are currently being taken. For example, where liquid effluents are stored in onsite ponds, and evaporation from those ponds may contribute to the inhalation pathway for residents at locations not currently identified in the REMP, licensees may need to evaluate the potential impact on the REMP. This could also apply in situations in which ground water transports seepage containing radionuclides from such onsite ponds to an offsite surface water body where commercial or recreational fishing is allowed. In addition, sites that contain onsite independent spent fuel storage installations (ISFSIs) may include onsite REMP samples.

3. Routinely Monitored Exposure Pathways

- a. Figure 1 shows the three exposure pathways (i.e., inhalation, ingestion, and direct radiation) that are routinely monitored, along with some related characteristics. Each of the three exposure pathways consists of one or more routes of exposure. For example, inspection of Figure 1 for “liquid effluents” reveals three types of sample media associated with the ingestion exposure pathway. Each of these media is involved in a different route by which radioactive material may be transferred from the environment to an individual (causing an exposure). These routes of exposure are identified based on site-specific information (e.g., receptors, receptor locations, distances, directions, and water usage) identified during the land use census.
- b. Using the results of the land use census, each site should develop, implement, and maintain a site-specific REMP as outlined in NUREG-1301/1302. Some exposure pathways (e.g., inhalation) are considered to exist at all sites (because air, the transfer media, exists at all sites). Therefore, the REMP should always include air samples (e.g., particulate filters and charcoal cartridges). Other exposure pathways and routes of exposure do not exist at all sites. For example, the REMP includes drinking water samples only if drinking water sources are present and are likely to be affected by effluents.

Figure 1. Routinely Monitored Exposure Pathways

#	Type of Effluent	RG 1.109	Exposure Pathway	Potential Sample Media	Critical Receptor
1	Liquid Effluent (Waterborne)	C.1.a	Ingestion	Drinking Water	Organ ⁽¹⁾
2		C.1.b	Ingestion	Aquatic Foods	Organ ⁽¹⁾
3		C.1.c	Direct Radiation— Ground Plane	Shoreline Deposits	Organ ⁽²⁾
4		C.1.d	Ingestion	Irrigated Foods	Organ ⁽¹⁾
5	Noble Gases Discharged to Atmosphere (Airborne)	C.2.a	Gamma Air ⁽³⁾	Air (only if stack >80 m)	Air
6		C.2.b	Gamma Air and Beta Air ⁽³⁾	Air	Air
7		C.2.c	Direct Radiation— Submersion	Air (only if stack >80 m)	Total Body ⁽¹⁾
8		C.2.d		Air (only if stack >80 m)	Skin
9		C.2.e		Air	Total Body ⁽¹⁾
10		C.2.f		Air	Skin
11	Iodines, Particulates, and Tritium Discharged to Atmosphere (Airborne)	C.3.a	Direct Radiation— Ground Plane	Surface Soil	Organ ⁽²⁾
12		C.3.b	Inhalation	Air (particulate, iodine, tritium)	Organ ⁽¹⁾
13		C.3.c	Ingestion	Food (produce, milk, leafy vegetables, meat)	Organ ⁽¹⁾
14	N/A ⁽⁴⁾	N/A	Direct Radiation— Shine	TLDs (or other measurement device)	Total Body ⁽¹⁾

¹ The total body is considered as a critical organ in the 1959 International Commission on Radiological Protection (ICRP)-2, “Report of ICRP Committee II on Permissible Dose for Internal Radiation.”

² Regulatory Guide 1.109, “Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Demonstrating Compliance with 10 CFR Part 50, Appendix I,” specifies factors for two organs: the total body and the skin.

³ This is dose to air, and it is not considered a pathway for exposure to man.

⁴ While no type of effluent is associated with it, direct radiation is included here because it is an exposure pathway.

4. New Routes of Exposure

- a. If the facility is modified or otherwise changed in a manner that results in the creation of a new point of release for radioactive material, the new release point could potentially impact a receptor or receptor location associated with the existing REMP. Alternatively, plant modifications may result in the discovery of a previously unidentified effluent release point that could impact the REMP. For example, installation of a new liquid effluent settling pond located some distance away from the center of the facility may create a new release point and cause a change to the nearest maximum exposed individual identified in the most recent land use census. This change to the maximum exposed individual may be associated with (1) the receptor, (2) the receptor location, (3) the distance to the receptor, or (4) the direction of the receptor. New routes of exposure, new sample locations, or new receptor locations may result from a radioactive leak or spill. If conditions at a site create a new route of exposure, or alter the parameters associated with an existing route of exposure, the REMP may recognize such changes after the change has occurred through environmental sample results that are different than expected (or different than those identified in the preoperational REMP). With REMP sample results different than expected (or different than those identified in the preoperational REMP), licensees may refer to the actions in NUREG-1301/1302, Controls 3.12.1 and 3.12.2. This reactive approach is an appropriate and acceptable manner to conduct a REMP and, historically has been the basis of the REMP. At the same time, operating experience indicates that, if licensees take a more proactive approach to the REMP, they may realize program improvements and reduce regulatory involvement, including regulatory actions. Such a proactive approach includes recognizing how changes, modifications, or operational occurrences at the facility could affect the REMP with respect to actions described in NUREG-1301/1302, Controls 3.12.1 and 3.12.2.

5. Sample Media

- a. Figure 1 lists some common sample media associated with various exposure pathways. In general, sample media should be selected for environmental monitoring as outlined in NUREG-1301/1302. The REMP need only include sample media that actually exists at a site and are utilized in sufficient quantities (consider availability and usage/consumption factors). However, if the site-specific land use census identifies a new important route of exposure that contributes more than 20% to the calculated individual dose as determined by Regulatory Guide 1.109, then sample media associated with the route of exposure should be added to the REMP
- b. TLDs or other equivalent devices should be used to monitor direct radiation exposure as outlined in NUREG-1301/1302. These results may be used, as outlined in the offsite dose calculation manual (ODCM), in demonstrating compliance with the 40 CFR Part 190, “Environmental Radiation Protection Standards for Nuclear Power Operations” (Ref. 9), dose limits for members of the public in the unrestricted area.
- c. The sample media associated with the inhalation exposure pathway should be monitored as outlined in NUREG-1301/1302.

- d. The sample media associated with the ingestion and ground plane exposure pathways for liquid effluents should be monitored as outlined in NUREG-1301/1302. Because Table 3.12-1 in NUREG-1301/1302 specifies ground water and drinking water separately, the REMP should include separate sampling and analysis for ground water and drinking water if they are likely to be affected by liquid releases. For example, if liquid effluents are discharged to a local pond, the licensee should evaluate whether ground water is likely to be affected and take the appropriate action.
- e. The sample media associated with the ingestion pathway for gaseous releases should be monitored as outlined in NUREG-1301/1302. This includes sampling and analyzing sample media (i.e., milk, or if milk is not available, broad leaf vegetation) and other sample media if identified in accordance with Section 5.a above. For example, sampling of domesticated meat may be needed if the land use census shows that a significant amount of meat is raised locally, and an evaluation shows that meat consumption contributes a 20% dose increment to the total individual dose. Similarly, sampling meat from game animals may be necessary if hunting accounts for a significant amount of meat obtained for consumption (see usage factors in Regulatory Guide 1.109). If goat milk is produced locally (e.g., within 5 miles or 8 km) for human consumption, then sampling and analysis may be required if sufficient quantities are available for sampling purposes. However, if sufficient quantities are not available for sampling, then an alternate sample media should be sampled such as broad leaf vegetation.
- f. Sample media other than those identified in Figure 1 that have special local interest or are otherwise locally important should be evaluated for inclusion in the REMP. In these instances, from a regulatory perspective, the licensee need demonstrate only that the sample media and receptor location associated with the route(s) of exposure are appropriately evaluated (e.g., by using the criteria of NUREG-1301/1302, Control 3.12.2).
- g. Control stations should be established and clearly distinguished from indicator stations for use in correlating control and indicator station results as specified in NUREG-1301/1302.

6. Sampling and Analysis Schedule

- a. The environmental sampling and analysis program should be conducted at the frequencies specified in NUREG-1301/1302, unless otherwise evaluated and justified. The justification for deleting samples from the REMP should be based on the results of the local land use census (e.g., the census indicates the absence or unavailability of the sample media) or as otherwise justified. The deletion of sample media from the REMP should be rare. Reduction in sample frequency may be appropriate if it is shown that the reduction does not impact the effectiveness of the REMP. Advances in remote telemetry of some air samplers may provide sufficient justification for reducing the frequency of air samples. For example, it may be appropriate to reduce the frequency of analysis associated with an air sampler (from once per week to once per 2 weeks) if the licensee can demonstrate that the new equipment is more reliable and results in fewer “missed samples” Changes to the sampling and analyses program can also be made based on operational experience.
- b. In all cases where sample or analysis frequencies are reduced, the changes should not reduce the overall effectiveness of the environmental monitoring program. If sample or analysis frequencies are reduced, the justification should also include an evaluation showing that the increased

sampling interval does not impact the ability to detect radionuclides (e.g., because of half-life considerations). The licensee should document and report the basis for changes to the environmental monitoring program in the Annual Radiological Environmental Operating Report.

7. Analytical Detection Capabilities

- a. Sample analysis should employ analytical techniques so that an appropriate analytical sensitivity (e.g., *a priori* LLD) is achieved, as specified in NUREG-1301/1302. Alternately, licensees may use the analytical detection sensitivities as determined by the licensee based on the “Multi-Agency Radiological Laboratory Analytical Protocols Manual” (MARLAP) (Ref. 10). Selection of values different from those in NUREG-1301/1302 should be justified and documented.
- b. The specified detection capabilities are normally achievable for routine environmental measurements. Deviations from the *a priori* analytical sensitivity levels are anticipated during actual sample analyses because of interference from other radionuclides or other factors but should be evaluated and documented. Licensees should report the analytical sensitivity capabilities of the REMP in the Annual Radiological Environmental Operating Report.
- c. If a licensee has reduced a sample frequency as outlined in Position 6 above, the licensee should evaluate the impact on the analytical detection capability.
- d. Analyses for C-14 in environmental media are not required since the plant produced component is a small fraction of the naturally occurring C-14.

8. Deviations from the Radiological Environmental Monitoring Program

- a. Deviations from the sampling schedule are permitted if samples are unobtainable because of hazardous conditions, seasonal unavailability, malfunction of automatic sampling equipment, and other legitimate reasons. Legitimate reasons with respect to seasonal unavailability may include consideration of the migratory routes of species or the growing season of crops but should generally not include unavailability which is within the control of the licensee. Similarly, sample pump failures that occur at an unacceptably high rate or pump failure that continues to occur because of ineffective corrective actions would not be legitimate reasons for sample unavailability. Hurricanes, tornadoes, or floods may qualify as legitimate reasons for temporary sample unavailability.
- b. If samples are unobtainable because of sampling equipment malfunction, reasonable effort under the circumstances should be made to complete corrective action before the end of the next sampling period, or else compensatory sampling and analysis are required. The Annual Radiological Environmental Operating Report should document deviations from the sampling schedule. Deviations that should be reported include loss of sample media, inability of the sample to meet the analytical sensitivity (e.g., the sample volume was too low to provide adequately sensitive analysis results), or invalid analyses results. Minor deviations, such as use of alternate sampling media and short periods of missed collection time, do not need to be reported.

9. Land Use Census

- a. Land use, exposure pathways, and the mechanisms of exposure may change over the operating life of the plant. The REMP should contain provisions to identify changes in land use, and based on this information, the licensee should revise the REMP as necessary to identify and evaluate the site-specific parameters identified in NUREG-1301/1302 (e.g., receptors and receptor locations). Licensees should refer to NUREG-1301/1302, Section 3/4.12.2, "Land Use Census," for additional information, including the distance over which the land use census is conducted.
- b. In accordance with NUREG-1301/1302, a land use census should be conducted, typically annually during the growing season, to identify (1) changes in land use, (2) receptor locations, and (3) new exposure pathways (or route of exposure). Monitoring of vegetation at the site boundary can be performed in lieu of the garden census as identified in NUREG-1301/1302. The frequency of the land use census may be reduced provided that (1) the frequency is outlined in the procedures (e.g., the ODCM and related procedures), (2) the licensee can demonstrate that there is no reduction in the effectiveness of the REMP, and (3) persons knowledgeable in land use census monitor usage characteristics based on knowledge gained during routine sample collection.

10. Reporting Levels

- a. The results of the REMP must be evaluated using the reporting levels in NUREG-1301/1302. When applying reporting levels, licensees may use the average of the measured radionuclide concentrations during the quarterly period. The values selected for the reporting levels approximate the concentrations equivalent to the design objectives of Appendix I to 10 CFR Part 50 for the given pathway or media. If the reporting levels are exceeded, the licensee must submit a special report to the NRC.
- b. If a principal radionuclide (as determined in accordance with Regulatory Guide 1.21) is detected in an environmental sample and if NUREG-1301/1302 does not provide a corresponding reporting level, licensees should calculate a reporting level for that radionuclide. The basis for that calculation should be to approximate compliance with the numerical guides of Appendix I to 10 CFR Part 50.
- c. If it can be demonstrated that a detected radionuclide exceeding the reporting level is not the result of 10 CFR Part 50 licensed operation (e.g., from medical radioisotopes or by comparison with control station or preoperational data), a report need not be submitted. However, the licensee should describe this occurrence in the Annual Radiological Environmental Operating Report, as discussed in NUREG-1301/1302.

11. Annual Radiological Environmental Operating Report

- a. An Annual Radiological Environmental Operating Report must be prepared and must include measurement summaries and trends regarding radiation and radioactive materials in the local environment. The report should include a summary description of the REMP, a map of indicator locations keyed to a table giving distances and directions from the reactor or site centerline, any changes identified in the land use census, measurements (i.e., indicator, control, and quality control), and trends in the measurements of levels of radiation and radioactive materials in the

environment and other such information as NUREG-1301/1302 may specify. NUREG-1301/1302 provides more guidance on preparing the Annual Radiological Environmental Operating Report.

- b. This annual report should summarize the environmental data in the format specified in NUREG-1301/1302. Data should be evaluated to identify the levels of plant-related environmental radioactivity above background levels (i.e., plant-related contributions that are distinguishable from background). For data distinguishable from background levels, a comparison should be made of current environmental monitoring results with preoperational data as appropriate and previous operational measurements for the purpose of trending environmental radioactivity resulting from licensed plant operation.
- c. In addition, in cases where plant-related activity is detected in the environment (e.g., tritium discharged to lakes or ponds or subsurface ground water), a basic correlation should be made between predicted and measured environmental concentrations. The purpose is to determine the adequacy of the effluent measurements and dispersion modeling. In cases where plant-related activity in the environment is increasing, the impact of prior year effluent releases should be factored into the correlations to determine if the rate of increase is commensurate with plant effluents.
- d. For direct radiation, the direct measurement data (e.g., TLD data) should be evaluated to determine if there is a dose contribution from plant operation. For plants with onsite sources of radiation (e.g., ISFSI or low-level waste storage) that cause measurable changes in REMP TLDs, trend graphs may be appropriate to demonstrate the change in radiation levels from the preoperational (and previous operational) REMP results to current time periods.
- e. The Annual Radiological Environmental Operating Report for the previous calendar year should be submitted electronically or as a hard copy to the director of the NRC regional office (with a copy to the Director, Office of Nuclear Reactor Regulation) as a separate document by May 15 each year (unless otherwise specified in technical specifications or the ODCM). Note that the period of the first report should begin with the date of initial criticality and end on December 31.

12. Environmental Program Review

- a. A periodic environmental program review should be conducted to reexamine the adequacy and effectiveness of the REMP to achieve its objectives. The review can be performed during preparation of the Annual Radiological Environmental Operating Report.
- b. The program review should evaluate the need to expand (or reduce) the environmental monitoring program given the results of the environmental data and trends in environmental radioactivity. Note that any reductions must be thoroughly evaluated and justified, given that environmental data indicating the absence of plant-related radioactivity are important.
- c. The review should confirm exposure pathways and sampling media.
- d. The review should ensure that the principal radionuclides being discharged are the same nuclides being analyzed in the environmental program.

- e. The review should identify whether the land use census is able to identify potential changes in exposure pathways (e.g., new drinking water locations or irrigation systems in use).
- f. The review should examine 10 CFR 50.75(g) files to identify leaks, spills, or other events that could affect radioactivity levels in the unrestricted area.
- g. The review should identify any REMP changes or special studies that may be needed as a follow-up to evaluations made when comparing effluent and environmental program results.
- h. The review should evaluate whether the sampling and measurement techniques meet the objectives of the REMP.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC's plans for using this regulatory guide. The NRC does not intend or approve any imposition or backfit in connection with its issuance.

In some cases, applicants or licensees may propose or use a previously established acceptable alternative method for complying with specified portions of the NRC's regulations. Otherwise, the methods described in this guide will be used in evaluating compliance with the applicable regulations for license applications, license amendment applications, and amendment requests.

Licensees who are committed in their licensing bases to Revision 1 of this regulatory guide may retain that commitment. In the 35 years since the NRC published Revision 1, the industry has gained important operating experience. The staff guidance contained in Revision 2 addresses that operating experience and clarifies some issues that Revision 1 addressed only broadly. Licensees may wish to review the guidance in this document and adopt those practices they determine are appropriate for use at their site. Licensees are encouraged to (1) review the guidance provided in this document and (2) consider supplementing their existing environmental monitoring program with the updated staff guidance.

GLOSSARY

ALARA — As Low As Is Reasonably Achievable

a priori — Before the fact limit representing the capability of a measurement system and not as an after the fact (*a posteriori*) limit for a particular measurement.

AREOR — Annual Radiological Environmental Operating Report

controlled area (10 CFR 20) — Means an area, outside of a restricted area but inside the site boundary, access to which is limited by the licensee for any reason.

controlled area (10 CFR 72) — Means that area immediately surrounding an ISFSI (Independent Spent Fuel Storage Installation) or MRS (Monitored Retrievable Storage Installation) for which the licensee exercises authority over its use and within which ISFSI or MRSI operations are performed.

control station — An environmental monitoring location (station) remote from the nuclear power plant beyond the influence from the plant's effluents or direct radiation.

determination — A quantitative evaluation of the release or presence of radioactive material under a specific set of conditions. A determination may be made by direct or indirect measurements (e.g., with the use of scaling factors).

drinking water — Water that does not contain an objectionable pollutant, contamination, minerals, or infective agent and is considered satisfactory for domestic consumption. This is sometimes called potable water. Potable water is water that is safe and satisfactory for drinking and cooking. Although EPA regulations only apply to public drinking water sources supplying 25 or more people (refer to EPA for more information), for purposes of the effluent and environmental monitoring programs, the term drinking water includes water from single-use residential drinking water wells.

effluent—Liquid or gaseous waste containing plant-related, licensed radioactive material, emitted at the boundary of the facility (e.g., buildings, end-of-pipe, stack, or container) as described in the FSAR.

effluent discharge (radioactive) — Any evolution in which plant-related, licensed radioactive material is released from a system, structure, or component and enters the unrestricted area.

exposure pathway — A mechanism by which radioactive material is transferred from the (local) environment to humans. There are three commonly recognized exposure pathways; inhalation, ingestion, and direct radiation. For example, ingestion is an exposure pathway, and it may include dose contributions from one or more routes of exposure. For example, one route of exposure that may contribute to the ingestion exposure pathway is often referred to as grass-cow-milk-infant-thyroid route of exposure.

ground water — All water in the surface soil, the subsurface soil, or any other subsurface water. Ground water is simply water in the ground regardless of its quality, including saline, brackish, or fresh water. Ground water can be moisture in the ground that is above the regional water table in the unsaturated (or vadose) zone, or ground water can be at and below the water table in the saturated zone.

ISFSI — Independent Spent Fuel Storage Installation

indicator station — An environmental monitoring location (station) near the nuclear power plant where there may be an influence from the plant's effluents or direct radiation.

licensed material — Means source material, special nuclear material, or byproduct material received, possessed, used, transferred, or disposed of under a general or specific license issued by the Commission.

lower limit of detection (LLD) — The *a priori* smallest concentration of radioactive material in a sample that will yield a net count, above system background, that will be detected with 95% probability with only a 5% probability of falsely concluding that a blank observation represents a real signal (see NUREG-1301, NUREG-1302).

member of the public (10 CFR 20) — Means any individual except when that individual is receiving an occupational dose.

member of the public (40 CFR 190) — Means any individual that can receive a radiation dose in the general environment, whether he may or may not also be exposed to radiation in an occupation associated with a nuclear fuel cycle. However, an individual is not considered a member of the public during any period in which the individual is engaged in carrying out any operation which is part of a nuclear fuel cycle.

monitoring — (Radiation monitoring, radiation protection monitoring) means the measurement of radiation levels, concentrations, surface area concentrations or quantities of radioactive material and the use of results of these measurements to evaluate potential exposures and doses.

pre-operational data — Environmental monitoring data collected prior to nuclear plant operation that is used to characterize the preoperational radiological conditions prior to influence from the plant's operation.

ODCM—The Offsite Dose Calculation Manual (ODCM) shall contain the methodology and parameters used in the calculation of the offsite doses resulting from radioactive gaseous and liquid effluents, in the calculation of gaseous and liquid effluent monitoring Alarm/Trip Setpoints, and in the conduct of the Radiological Environmental Monitoring Program. The ODCM shall also contain (1) the Radioactive Effluent Controls Program and Radiological Environmental Monitoring Program and (2) descriptions of the information that should be included in the Annual Radiological Environmental Operating and Annual Radioactive Effluent Release Reports required by Technical Specifications. (NUREG-1301/1302 has additional information related to ODCMs.)

principal radionuclide — A principal radionuclide is one of the principal gamma emitters listed in NUREG-1301 and NUREG-1302, Tables 4.11-1 and Table 4.11-2, or alternatively, from a risk-informed perspective, a radionuclide is considered a principal radionuclide if it contributes either

(1) greater than 1 percent of the 10 CFR Part 50, Appendix I, design objective dose when all radionuclides in the type of effluent are considered, or (2) greater than 1 percent of the activity of all nuclides in the type of effluent being considered. Regulatory Guide 1.109 lists the three types of effluents as (1) liquid effluents, (2) noble gases discharged to the atmosphere, and (3) all other nuclides discharged to the atmosphere. In this document, the terms “principal nuclide” and “principal nuclide” are synonymous since this document is only concerned with measuring, evaluating, and reporting radioactive materials in effluents.

release point — A location from which radioactive materials are released from a system, structure, or component (including evaporative releases and leaching from ponds in the controlled or restricted area before release under 10 CFR 20.2001). For release points monitored by plant process radiation monitoring systems, the release point is associated with the piping immediately downstream of the radiation monitor. (See also the definition for “significant release point.”) Several release sources may contribute to a common release point.

REMP — Radiological Environmental Monitoring Program

reporting levels — Levels of radioactivity in the unrestricted area from licensed operation that must be reported to the NRC within 30 days via a special report in accordance with 10 CFR 50.4, “Written Communications.” (See also NUREG-1301 and NUREG-1302.)

route of exposure — A specific path (or delivery mechanism) by which radioactive material, originally in the environment at a specified location, can eventually cause a radiation dose to an individual. The path typically includes a type of environmental medium (e.g., air, grass, meat, or water) as the starting point and a recipient’s organ or body as the end point. For example, the grass-cow-milk-infant-thyroid route of exposure may contribute to the ingestion exposure pathway. Additionally, several routes of exposure may contribute to a single exposure pathway.

site boundary — Site boundary means that line beyond which the land or property is not owned, leased, or otherwise controlled by the licensee.

site environs — Locations outside of the nuclear power plant systems, structures, or components as described in the final safety analysis report or the Off Site Dose Calculation Manual (ODCM).

surface water — Water on the land surface, whether intermittent or permanent (e.g., streams, rivers, lakes, and wetlands).

TLD — Thermoluminescent Dosimeter

unrestricted area — Unrestricted area means an area, access to which is neither limited nor controlled by the licensee.

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7. NUREG-1302, “Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Boiling Water Reactors,” U.S. Nuclear Regulatory Commission, Washington, DC, April 1991.
8. Regulatory Guide 1.109, “Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Demonstrating Compliance with 10 CFR Part 50, Appendix I,” U.S. Nuclear Regulatory Commission, Washington, DC.
9. 40 CFR Part 190, “Environmental Radiation Protection Standards for Nuclear Power Operations,” U.S. Environmental Protection Agency, Washington, DC.
10. EPA 402-B-04-001A, “Multi-Agency Radiological Laboratory Analytical Protocols Manual,” U.S. Environmental Protection Agency, Washington, DC, July 2004.²

¹ Publicly available NRC published documents such as regulations, regulatory guides, NUREGs, and generic letters listed herein are available electronically through the Electronic Reading Room on the NRC’s public Web site at: <http://www.nrc.gov/reading-rm/doc-collections/>. Copies are also available for inspection or copying for a fee from the NRC’s Public Document Room (PDR) at 11555 Rockville Pike, Rockville, MD; the mailing address is USNRC PDR, Washington, DC 20555; telephone 301-415-4737 or (800) 397-4209; fax (301) 415-3548; and e-mail PDR.Resource@nrc.gov.

² Copies of the non-NRC documents included in these references may be obtained directly from the publishing organization.

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