Designation: E1167 – 15 (Reapproved 2021)

Standard Guide for Radiation Protection Program for Decommissioning Operations[1]

This standard is issued under the fixed designation E1167; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide provides instruction to the individual charged with the responsibility for developing and implementing the radiation protection program for decommissioning operations.

1.2 This guide provides a basis for the user to develop radiation protection program documentation that will support both the radiological engineering and radiation safety aspects of the decommissioning project.

1.3 This guide presents a description of those elements that should be addressed in a specific radiation protection plan for each decommissioning project. The plan would, in turn, form the basis for development of the implementation procedures that execute the intent of the plan.

1.4 This guide applies to the development of radiation protection programs established to control exposures to radiation and radioactive materials associated with the decommissioning of nuclear facilities. The intent of this guide is to supplement existing radiation protection programs as they may pertain to decommissioning workers, members of the general public and the environment by describing the basic elements of a radiation protection program for decommissioning operations.

1.5 This guide defines the elements of a radiation protection program that will ensure that the goals and objectives of a decommissioning activity are attained within the radiological limits and restrictions imposed by applicable governing and regulating agencies. The implementation of such a program will provide radiological protection to personnel and the environment. This guide should be used for developing the documentation that defines the intent and implementation of the radiation protection program for a specific decommissioning project.

1.6 The Radiation Protection Program should address the following elements (see Note 1). This program shall be developed and maintained such that it satisfies all applicable Quality Assurance requirements developed for the decommissioning project.

NOTE 1—If the site to be decommissioned is adjacent to an operating site, the radiological impact of the operating site must be considered in the development of the Radiation Protection Program for the decommissioning site.

1.7 This guide does not address the subjects of emergency preparedness, safeguards, accountability, waste handling, storage, and transportation. Each of these issues has a direct interface with the radiation protection program. However, each constitutes a program in and of itself from program definition through implementation.

1.8 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.9 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E181 Test Methods for Detector Calibration and Analysis of Radionuclides

E1134 Specification for Source-Separated Steel Cans (Withdrawn 2001)[3]

E1168 Guide for Radiological Protection Training for Nuclear Facility Workers

E1893 Guide for Selection and Use of Portable Radiological Survey Instruments for Performing In Situ Radiological

[1] This guide is under the jurisdiction of ASTM Committee E10 on Nuclear Technology and Applicationsand is the direct responsibility of Subcommittee E10.03 on Radiological Protection for Decontamination and Decommissioning of Nuclear Facilities and Components.

Current edition approved Feb. 1, 2021. Published February 2021. Last previous edition approved in 2015 as D1167–15. DOI: 10.1520/E1167-15R21.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

Assessments to Support Unrestricted Release from Further Regulatory Controls

2.2 *ANSI Standards:*

ANSI N13.6 Practice for Occupational Radiation Exposure Records System[4]

ANSI N323AB American National Standard for Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments[4]

2.3 *NRC Documents:*

USNRC Regulatory Guide 8.8 Information Relevant to Insuring that Occupational Radiation Exposure at Nuclear Power Stations will be as Low as is Reasonably Achievable[5]

USNRC Regulatory Guide 8.10 Operating Philosophy for Maintaining Occupational Radiation Exposures as Low as Reasonably Achievable[5]

USNRC Regulatory Guide 8.13 Instruction Concerning Prenatal Radiation Exposure[5]

USNRC Regulatory Guide 8.15 Acceptable Programs for Respiratory Protection[5]

USNRC Regulatory Guide 8.29 Instruction Concerning Risk from Occupational Radiation Exposure[5]

2.4 *DOE Document:*

DOE/EV/1830-T5 Guide to Reducing Radiation Exposure to as Low as Reasonably Achievable (ALARA)[6]

DOE/IG G-10CFR835/E1 Implementation Guide, Instrument Calibration for Portable Survey Instruments

DOE Standard 1070-94 Guidelines for Evaluation of Nuclear Facility Training Programs

2.5 *INPO Document:*

INPO 82-004 General Employee Training[7]

2.6 *USEPA Document:*

U.S. Environmental Protection Agency (EPA), 1972 Environmental Radioactivity Surveillance Guide, ORP/SID 72-2[8]

2.7 *ICRP Document:*

ICRP Publication 43 Principles of Monitoring for the Radiation Protection of the Public; Annals of the ICRP Volume 15/1, December 1984[9]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *audit, n*—formal systematic examination to verify adequate implementation.

3.1.2 *certified radioactivity standard source, n*—calibrated radioactive source, with stated accuracy, whose calibration is certified by the source supplier, as traceable to the National Radioactivity Measurements System (see Test Methods E181).

3.1.3 *decommission, vt*—to remove nuclear facilities safely from service and reduce residual radioactivity to a level that permits release of the property for unrestricted use and termination of any applicable licenses.

3.1.4 *decontamination, n*—those activities employed to reduce the levels of (radioactive) contamination in or on structures, equipment, materials and personnel. Five levels of decontamination are defined as follows:

3.1.5 *decontamination for decommissioning, n*—at facilities such as nuclear reactors or accelerators, where high radiation fluxes have been present, structural materials may have become radioactive through activation. Removal of such radioactive material (such as a reactor vessel or internals) constitutes "decontamination." Removal of intact equipment or structures containing radioactive material (such as internally contaminated pipes, valves, pumps, tanks, etc.) also constitutes" decontamination."

3.1.6 *decontamination to reduce radiation levels, n*—examples of this type of decontamination would be the use of chemicals to dissolve radioactive corrosion product deposits from the inside of a piping system or the removal of the top layer of a concrete floor into which contaminants had been embedded and had become a part of the concrete matrix.

3.1.7 *decontamination supporting radiological protection, n*—this category includes the" housekeeping" type of decontamination intended to reduce the spread of contamination, to reduce the amount of protective clothing required, or to reduce the probability or amount of airborne contamination.

3.1.8 *decontamination for unrestricted release, n*—involves reducing radioactive contamination from material, tools, or equipment to levels that satisfy "Radiological Release Criteria" (see section 3.1.18).

3.1.9 *personnel decontamination, n*—removal of radioactive material from workers.

3.1.10 *nuclear facility, n*—facility whose operations involve (or involved) radioactive materials in such form and quantity that a radiological hazard potentially exists (or existed) to the employees and the general public.

3.1.10.1 *Discussion*—Included are facilities that are (or were) used to produce, process, or store radioactive materials. Some examples are as follows:

(1) Nuclear reactor (power or research),
(2) Fuel fabrication plant,
(3) Fuel reprocessing plant,
(4) Uranium or thorium mill,
(5) UF_6 production plant,
(6) Radiochemical laboratory, and
(7) Radioactive waste processing or disposal site, or both.

3.1.11 *review, n*—critical evaluation to ensure inclusion of appropriate principles.

3.1.12 *survey plan, n*—document that describes the techniques and procedures to be used to provide sufficient radiation measurements to describe the radiation source present within a predefined area.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[5] Available from Nuclear Regulatory Commission, Public Document Room, 1717 H St. NW, Washington, DC 20555.

[6] Available from Department of Energy, National Technical Information Service, U.S. Dept. of Commerce, Springfield, VA 22161.

[7] Available from Institute of Nuclear Power Operations, 1100 Circle, 75 Parkway, Atlanta, GA 30339-3064.

[8] Available from Office of Radiation Programs, 401 M St., SW, Washington, DC 20460.

[9] Available from Comitato Nazionale Per L'Energia Nucleare, Rome, Italy.

3.1.13 *radiation protection plan, n*—document developed for a specific decommissioning project that describes the goals and intent of the radiation protection program.

3.1.13.1 *Discussion*—The radiation protection plan is an element of the radiation protection program and shall become an integral part of the decommissioning plan.

3.1.14 *radiation protection procedures, n*— documents used to implement the radiation protection plan.

3.1.15 *Radiation Protection Program, n*—actions applied to a decommissioning project whose intent is to limit the exposure of workers, members of the general public, and the environment from radiation or radioactive materials, or both, and the written documentation supporting these actions.

3.1.16 *radiation work procedure, n*—documentation used to specify protective measures and to specify personnel access requirements to radiation or radioactive materials, or both.

3.1.16.1 *Discussion*—Control may be achieved through use of a single document such as a Radiation Work Permit, which specifies the protective measures for particular work tasks, or it may be achieved through application of generic procedures and instructions.

3.1.17 *radiological control areas (RCA), n*— area of a nuclear facility or area being decommissioned where access is controlled for purposes of radiological protection.

3.1.18 *radiological release criteria, n*— levels of residual radioactivity at the completion of a decommissioning activity below which the object of the decommissioning may be released for unrestricted use to the general public.

4. Significance and Use

4.1 A program based on this guide will provide assurance to all concerned that the appropriate elements of radiation safety have been included to protect workers, the general public, and the environment in proximity to the decommissioning activities.

4.2 Implementation of such a program will provide assurance to those agencies responsible for review or audit of the decommissioning project that the requirements for radiation protection have been addressed.

RADIATION PROTECTION PROGRAM

5. Radiation Safety Organization and Responsibilities

5.1 The radiation protection plan should include a description of the radiological protection organization and the radiation safety responsibilities of each level of the decommissioning project organization from the individual worker to the project manager. This description should show the radiation safety organization interfaces and reporting responsibilities at all levels of the project (see Note 2).

6. Radiological Control Areas (RCA)

6.1 The Radiation Protection Program should define the conditions for designation of an RCA, the physical barriers and administrative methods to control the spread of radioactive material, and the requirements to restrict personnel access for purposes of radiation exposure control. Access to these areas shall require a radiation work procedure. The Radiation Protection Program should include procedures to determine the radiological conditions within the area, that identify the anti-contamination clothing, dosimetry, and respiratory protection required for RCA entry and that define the limitations for working within the RCA. These procedures should include any restrictions for workers whose physical condition may limit entry into or ability to operate within an RCA. The procedures should describe the requirements for egress and checkout from the RCA.

NOTE 2—USNRC Regulatory Guides 8.8 and 8.10 provide guidance on describing the relationships that should exist between radiation safety and the operating function and the importance of high level management support of the radiation safety program.

7. Sources and Types of Radiation

7.1 The radiation sources, to be encountered during decommissioning activities, shall be defined. Reviews of the operating history of the facility (including interviews with past and present employees), coupled with nuclear analysis and detailed radiological characterization surveys (see Section 9), should be used to provide this information. This description of radiation sources should include the type of radiation such as alpha, beta, gamma, or neutron; the isotopic composition, the physical and chemical form of the radioactive material, and the magnitude and location of the radiation sources. This information is necessary for developing the instructions relating to radiation instrumentation selection, radiation measurement techniques, shielding requirements, selection of decontamination methods, contamination control methods, and personnel dosimetry systems.

8. Radiological Release Criteria

8.1 The radiation protection plan should include a discussion of the radiological criteria that will be used as the basis for determining the completion of decommissioning. These criteria should be based upon applicable limits for unrestricted release. Decontamination for unrestricted release, if needed, should consider the specific radionuclides present, the material contaminated such as soil or facility, and the potential end uses of the item or area being decontaminated. The development of the criteria should consider the type of measurement to be performed, such as surface versus volume, and the medium to be measured, such as air or water.

9. Radiological Survey Plans

9.1 There are many phases of a decommissioning project that require a radiological survey plan. Surveys generally fall into three categories: planning surveys, operational surveys, and release surveys. The survey plan for each should include the description of where the measurements are made, how they are made (direct measurement or samples), and what is to be measured (examples include soil samples, vegetation samples, air samples, surfaces, and bore hole logging). The survey plans should emphasize any unique features requiring special procedures.

9.2 An environmental monitoring plan should also be prepared to support the decommissioning project. This plan

should be an independent document covering the environmental protection program from predecommissioning through unrestricted release of the facility or conclusion of the decommissioning project. The environmental monitoring plan should become an integral part of the radiation protection plan.

9.3 Since there are many factors that may influence the method and procedures to be used in support of an environmental monitoring plan, a detailed description of the environmental monitoring plan content is outside the scope of this guide (see Note 3).

9.3.1 *Planning Surveys:*

9.3.1.1 The primary objective of the planning surveys is to define the radiation source terms with respect to isotopic identification, location, physical and chemical configuration, and radiation level.

9.3.1.2 The results of this survey must also be in sufficient detail to permit an engineering evaluation for selecting an appropriate decommissioning option. These results then form the basis for input into the engineering plan for decommissioning and for defining elements of the radiation protection plan necessary to ensure that adequate environmental monitoring and radiation exposure management procedures are implemented for the isotopic and physical forms present. Elements of the engineering plan that have a direct bearing on the radiation protection plan include selection of the methods and extent of decontamination to reduce radiation and contamination levels, analysis and design of temporary and semipermanent radiation shielding, selection and evaluation of remote tooling techniques, and the performance of tradeoff studies among various radiation exposure reduction alternatives.

9.3.1.3 The survey plan must be developed to identify the proper instrumentation, the direct measurement techniques, and the sampling and laboratory analysis requirements. Surface and volume measurements should be made with an established grid pattern. Selection of grid dimensions should reflect expected variability in the residual dose rates and contamination from all source terms present. The grid would be used to locate positions for both direct measurements and samples on the surface and below the surface. For process equipment such as machinery or hardware, the survey plan should include provisions for measuring readily accessible surfaces and the methodology and criteria for determining potential contamination on surfaces not readily accessible.

NOTE 3—For additional guidance for environmental monitoring plan content, refer to ORP/SID72-2 and ICRP-43.

9.3.2 *Operational Surveys:*

9.3.2.1 The objectives of operational surveys are to provide input to the radiation exposure control program prior to initiating a task, to provide monitoring of the radiation environment during a particular task, and to assess the progress of the decommissioning project. The radiation surveys for exposure control must provide sufficient information, prior to starting a decommissioning task, to permit the health physicist to specify the proper dosimetry, anti-contamination clothing, respiratory protection, and radiation monitoring requirements. Environmental monitoring shall be performed during decommissioning activities to ensure that radiological material released from the decommissioning site are within project goals. The surveys will also be used by the health physicist and nuclear engineer to perform an engineering analysis of the tradeoffs among alternative methods of reducing exposure, to predict changes in radiological conditions that will occur during the decommissioning task, and to specify exposure management techniques for workers performing the task.

9.3.2.2 The radiation monitoring during a task must consider the isotopic composition, the physical and chemical forms, the radiation levels expected, and the activities of the task which may alter these parameters. The survey plan should include the monitoring techniques and the actions to be taken if the radiation environment changes unexpectedly during the task operation. At the completion of tasks involving changes to the radiation environment, a complete radiation survey should be conducted and the results compared to pre-task surveys to assess the effects of the operation.

9.3.3 *Release Surveys*—The objective of the release survey is to ensure that the goals and objectives of the decommissioning program have been met. The release survey plan would be implemented when operational surveys indicate that the objectives of the decommissioning operation have been achieved. The release survey would be similar to the planning survey and should use a grid system to locate the radiation measurement points. This survey may be sufficiently different to change the requirements on the instrument selection, measurement technique, and sampling analysis. The types of measurements and samples to be taken and the depth beneath the surfaces for sampling must take into account changes in the surfaces that resulted from the decontamination operation. The number and sensitivity of the measurements must be sufficient to evaluate the decommissioning activities against the criteria described in Section 8 (see Note 4). Additional guidance for selection and use of portable survey instruments for in situ measurements may be found in Guide E1893 and for isotopic analysis using spectroscopy measurement in Test Methods E181.

NOTE 4—Independent verification surveys are normally the responsibility of applicable state and federal agencies.

10. ALARA Program

10.1 Protecting workers from unwarranted radiation exposure and radioactive materials is basic to a radiation protection program. State and federal regulations provide limits for maximum internal and external exposure to radiation and radioactive materials. Further, the regulations require that persons engaged in activities involving radioactive materials should make every reasonable effort to maintain radiation exposures and releases of radioactive materials to unrestricted areas *as low as reasonably achievable* (ALARA). This means as low as is reasonably achievable taking into account the state of technology, and the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations.

10.2 Active support for implementation of the ALARA concept within the Radiation Protection Program at the highest management levels is essential to its successful implementation. In addition to establishing policies supporting the

ALARA concept, management must ensure the clear, explicit assignment of the ALARA concept at all levels of the decommissioning organization including the individual worker. Implementation of the ALARA concept is not limited to exposure aversion efforts following a decision to proceed with certain activity. To be effective, the ALARA concept must be applied at the earliest opportunity in the planning stages of a facility so that alternatives for accomplishing the purposes of the facility decommissioning may be considered with respect to radiation exposure and cost associated with the various alternatives.

10.3 It must be realized that the avoidance of exposure to the workers should not be accomplished at the expense of exposure to the public. Exposure management decisions shall consider both worker and public exposures resulting from decommissioning activities.

10.4 ALARA involves both a philosophical approach to radiation protection and a defined set of technologies incorporating principles of time, distance, shielding, source reduction, and tradeoff assessment which minimize exposure at acceptable cost. The Radiation Protection Program should describe how radiation exposure management is achieved through proper training of workers, adequate work procedures, engineered support systems, good housekeeping practices, and, when required, use of protective equipment. The work procedures should be reviewed to identify those operations that may be completed in a cost-effective manner below the administrative limits and criteria set for the program. Radiological data collected during the decommissioning operations should be reviewed, evaluated, and trended to determine if improvements in the interest of ALARA can be made on future tasks yet to be completed (see Note 5).

NOTE 5—USNRC Regulatory Guide 8.10 and DOE/EV/1830-T5 provides additional guidance on ALARA.

11. External Radiation Exposure Control

11.1 *Techniques for Controlling External Exposure*—The Radiation Protection Program should include elements that provide guidance on the use of task planning, shielding, and extension and remote tooling to reduce exposure. The program should also provide guidance on the use of "low dose areas" for ALARA application to work tasks. The program should describe the use of access control logs to augment timekeeping to minimize stay times for the workers.

11.2 *Methods for Monitoring External Exposure:*

11.2.1 The Radiation Protection Program shall include use of personnel external dosimetry appropriate to the radiation environments to be encountered.

11.2.2 The Radiation Protection Program should incorporate elements for obtaining measurements of area radiological conditions during conduct of work to augment personnel dosimetry. The uses of supplemental dosimetry, for monitoring specific parts of the body where radiation fields may be localized, should be included.

11.3 *Dose Assessments for External Exposure*—The external radiation exposure control program should describe the methods and procedures used to perform dose assessments and reviews. These dose assessments should be performed for those tasks that contribute significantly to collective or individual doses from external exposure. The dose assessments should involve models that employ time-and-motion study data for the workers' actions in relation to spatial variations of the radiation field. The dose assessment models should also include consideration of operations that might change radiological conditions.

12. Internal Radiation Exposure Control

12.1 This portion of the Radiation Protection Program is an extension of the external control program. The primary elements of an internal exposure control program include operational techniques, monitoring, and dose assessment.

12.1.1 *Techniques for Controlling Internal Exposure*—The Radiation Protection Program should include procedures to minimize inhalation and ingestion of radioactive material. Program elements for internal exposure control include: continuous air sampling and monitoring, decontamination, surface stabilization (that is, fixing), fluid collection, use of containments, positive ventilation, HEPA and charcoal filtration, respiratory protection equipment, protective clothing, and task analysis to identify operations that might change radiological conditions.

12.1.2 *Methods of Monitoring Internal Exposure:*

12.1.2.1 The internal exposure monitoring and control program shall be based upon methods selected for the specific radionuclides to be measured and their physical and chemical form. For gamma emitting radionuclides, in vivo counting may be used. Other common techniques involve bioassay such as urinalysis, fecal samples, nasal smears, and air sampling using fixed equipment and lapel samplers.

12.1.2.2 It is recommended that for routine monitoring, a program of urinalysis or in vivo whole-body counting, or both, be considered as applicable. Techniques such as fecal sampling and nasal smears should be considered for providing additional information if uptake of radioactive material by an individual is suspected. The internal exposure monitoring program should describe the sampling/monitoring frequency to be used and it should define action levels, and a corresponding action.

12.1.3 *Models for Assessing Internal Exposure*—The internal exposure control program should describe and reference the analytical models used to assess the dose received. The models must be compatible with the monitoring technique used. This portion of the program should also describe the algorithms and associated references for combining the radiation dose from internal and external exposure if applicable. The radiation protection plan should discuss how the combined internal and external exposures are to be controlled to ensure that limits applicable to the program are not exceeded.

13. Decontamination

13.1 The Radiation Protection Program should include procedures that describe the decontamination techniques to be employed for the project. The procedures should describe action levels for decontamination and the actions to be taken when the levels are exceeded. Separate procedures should be developed for personnel decontamination and decontamination of surfaces and equipment used in decommissioning.