NOT
MEASUREMENT
SENSITIVE

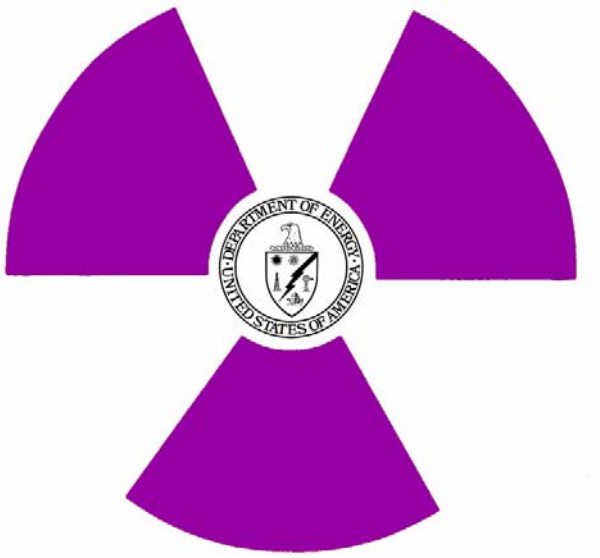
DOE G 441.1-1B
3-1-07

RADIATION PROTECTION PROGRAMS GUIDE

for Use with

Title 10, Code of Federal Regulations, Part 835,
Occupational Radiation Protection

[This Guide describes nonmandatory approaches for meeting requirements. Guides are not requirements documents and are not to be construed as requirements in any audit or appraisal for compliance with the parent Rule, Policy, Order, Notice, or Manual.]



Department of Energy
Office of Health, Safety and Security

TABLE OF CONTENTS

RADIATION PROTECTION PROGRAMS

1.0 PURPOSE AND APPLICABILITY

In 1999 the U.S. Department of Energy (DOE) published a set of 13 Implementation Guides for use with Title 10, Code of Federal Regulations (CFR), Part 835, Occupational Radiation Protection (DOE 1998a), hereinafter referred to as 10 CFR 835. That series of guides discussed acceptable methods for ensuring that the functional elements of radiological activities will be managed and administered in accordance with 10 CFR 835. As part of DOE's efforts to consolidate redundant requirements and guidance, this Guide is a compilation of the guidance provided in the set of 13 Implementation Guides and continues to provide cross-references to other Guides, DOE-STD-1098-99, RADIOLOGICAL CONTROL (DOE 1999a), hereinafter referred to as the RCS, DOE directives, and industry consensus standards that provide detailed guidance for implementing specific requirements in 10 CFR 835. Accordingly, this Guide cancels and supersedes the following guides:

- DOE G 441.1-1A, *Management and Administration of Radiation Protection Programs Guide,* dated 10-20-03
- DOE G 441.1-2, *Occupational ALARA Program Guide,* dated 3-17-99
- DOE G 441.1-3A, *Internal Dosimetry Program Guide,* dated 6-11-05
- DOE G 441.1-4A, *External Dosimetry Program Guide,* dated 6-11-05
- DOE G 441.1-5, *Radiation-Generating Devices Guide,* dated 4-15-99
- DOE G 441.1-6, *Evaluation and Control of Radiation Dose to the Embryo/Fetus Guide,* dated 4-29-99
- DOE G 441.1-7, *Portable Monitoring Instrument Calibration Guide,* dated 6-17-99
- DOE G 441.1-8, *Air Monitoring Guide,* dated 3-17-99
- DOE G 441.1-9, *Radioactive Contamination Control Guide,* 6-17-99
- DOE G 441.1-10, *Posting and Labeling for Radiological Control Guide,* dated 5-24-99
- DOE G 441.1-11, *Occupational Radiation Protection Record-Keeping and Reporting Guide,* dated 5-20-99
- DOE G 441.1-12, *Radiation Safety Training Guide,* dated 3-17-99
- DOE G 441.1-13, *Radioactive Sealed Source Accountability Guide*, dated 4-15-99

This Guide provides guidance with respect to implementing the provisions of all the functional areas contained in 10 CFR 835. These are listed in Chapter 3 of this Guide. Specific regulatory citations are provided in the body of the Guide.

This Guide amplifies the regulatory requirements of 10 CFR 835 and provides explanations and examples of the basic requirements for implementing the requirements of 10 CFR 835. The requirements of 10 CFR 835 are enforceable under the provisions of Sections 223(c) and 234A of the Atomic Energy Act of 1954, as amended (AEC 1954).

This Guide was developed consistent with DOE M 251.1-1B, *Departmental Directives Program Manual*, (DOE 2006a) which states that guides: (1) Provide preferred, nonmandatory, supplemental information about acceptable methods for implementing requirements, including lessons learned, suggested practices, instructions, and suggested performance measures; (2) Do not impose requirements but may quote requirements if the sources are adequately cited; and (3) Provide alternate methods that may be used if it can be demonstrated that they provide an equivalent or better level of performance.

Except for requirements established by a regulation, contract, or administrative means, the provisions in this Guide are DOE's views on acceptable methods of program implementation and are not mandatory. Conformance with this Guide will, however, create an inference of compliance with the related regulatory requirements. Alternate methods that are demonstrated to provide an equivalent or better level of protection are acceptable. DOE encourages its contractors to go beyond the minimum regulatory requirements and to pursue excellence in their programs.

The word "shall" is used in this Guide in reference to requirements from 10 CFR 835. Compliance with 10 CFR 835 is mandatory except to the extent an exemption has been granted pursuant to 10 CFR 820, Procedural Rules for DOE Nuclear Activities (DOE 1997a). The words "should" and "may" are used to denote optional program recommendations and allowable alternatives, respectively.

This Guide may be used by all DOE activities that are subject to the requirements of 10 CFR 835. The Administrator of the National Nuclear Security Administration (NNSA) will assure that NNSA employees and contractors comply with their respective responsibilities under this Guide.

1.1 USE OF CONSENSUS STANDARDS

As discussed in the Department of Energy's Radiological Health and Safety Policy DOE P 441.1, (DOE 1996), DOE has established a system of regulatory policy and guidance reflective of national and international radiation protection standards and recommendations. Consistent with this policy, this Guide endorses the use of several national and international recommendations and standards, including several from the International Commission on Radiological Protection, the National Council on Radiation Protection and Measurements, the American National Standards Institute. In regards to national consensus standards, to the extent possible, this guidance document endorses and

is written to be consistent with following non-governmental national consensus standard standards for radiation protection:

- ANSI N13.3, Dosimetry for Criticality Accidents
- ANSI N43.3-1993, General Radiation Safety -Installations Using Non-Medical X-Ray and Sealed Gamma-Ray Sources, Energies up to 10 MeV
- ANSI N323A-1997, American National Standard Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments
- ANSI N13.5-R1989, American National Standard Performance Specifications for Direct Reading and Indirect Reading Pocket Dosimeters
- ANSI N42.17A-1989, Performance Specifications for Health Physics Instrumentation - Portable Instrumentation for Use in Normal Environmental Conditions
- ANSI N42.17C-1989, Performance Specifications for Health Physics Instrumentation - Portable Instrumentation for Use in Extreme Environmental Conditions
- ANSI N42.17B, Performance Specifications for Health Physics Instrumentation - Occupational Airborne Radioactivity Monitoring Instrumentation
- ANSI N2.1-1971(R1989), Radiation Symbol
- ANSI N13.27, Performance Specifications for Pocket-sized Alarming Dosimeter/Ratemeters
- ANSI Z88.2-1992, Practices for Respiratory Protection
- ANSI/HPS N13.30-1996, Performance Criteria for Radiobioassay
- ANSI/HPS N13.41-1997, Criteria for Performing Multiple Dosimetry
- ANSI/HPS N43.6-1997, Sealed Radioactive Sources Classification
- ANSI /HPS N13.6-1999, Practice for Occupational Radiation Exposure Records Systems
- ANSI/HPS N43.2-2001, Radiation Safety for X-Ray Diffraction and Fluorescence Analysis Equipment
- ANSI/HPS N13.49-2001, Performance and Documentation of Radiological Surveys

- ANSI/HPS N43.5-2005, Radiological Safety Standard for the Design of Radiographic and Fluoroscopic Industrial X-Ray Equipment
- ANSI/NCSL Z540-1-1994, American National Standard for Calibration - Calibration Laboratories and Measuring and Test Equipment -General Requirements
- ANSI N322, American National Standard Inspection, Test, Construction, and Performance Requirements for Direct Reading Electrostatic/Electroscope Type Dosimeters
- ANSI N320, American National Standard Performance Specifications for Reactor Emergency Radiological Monitoring Instrumentation

1.2 ACRONYMS

AEC	U.S. Atomic Energy Commission
ALARA	Low As Is Reasonably Achievable
AL	Annual Limit on Intake
ANS	American Nuclear Society
ANSI	American National Standards Institute
BEIR	Biological Effects of Ionizing Radiations
BRH	Bureau of Radiological Health
BZ	Breathing Zone
CAM	Continuous Air Monitor
CEDE	Committed Effective Dose Equivalent
CFR	Code of Federal Regulations
CSO	Cognizant Secretarial Officer
CTEDE	Cumulative Total Effective Dose Equivalent
DAC	Derived Air Concentration
DIL	Derived Investigation Level
DL	Decision Level
DOE	Department of Energy
DOE G	DOE Guide
DOE O	DOE Order
DOE P	DOE Policy
DOELAP	Department of Energy Laboratory Accreditation Program
DOE-STD	DOE Standard
DPM	Disintegrations per Minute
EPA	Environmental Protection Agency
FOIA	Freedom of Information Act

FR	Federal Register
GERT	General Employee Radiological Training
HEPA	High Efficiency Particulate Air (filter)
HPS	Health Physics Society
ICRP	International Commission on Radiological Protection
ICRU	International Commission on Radiation Units and Measurements
IL	Investigation Level
ISO	International Organization for Standardization
MDA	Minimum Detectable Amount/Activity
NCRP	National Council on Radiation Protection and Measurements
NCSL	National Conference of Standards Laboratories
NIST	National Institute of Standards and Technologies
NRC	Nuclear Regulatory Commission
PNL	Pacific Northwest Laboratory
PSE	Planned Special Exposure
PSO	Program Secretarial Office
RCO	Radiological Control Organization
RCS	DOE-STD-1098-99, RADIOLOGICAL CONTROL
RCT	Radiological Control Technician
RGD	Radiation-Generating Device
RMA	Radioactive Material Area
RPP	Radiation Protection Program
RWP	Radiological Work Permit
RWT	Radiological Worker Training
SLAC	Stanford Linear Accelerator Center
TEDE	Total Effective Dose Equivalent
TLD	Thermo Luminescent Dosimeter
TWD	Technical Work Document
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
USLW	United States Law Week

2.0 DEFINITIONS

Acceptance testing: Evaluation or measurement of performance characteristics to verify that certain stated specifications and contractual requirements are met.

Air monitoring: Actions to detect and quantify airborne radiological conditions by the collection of an air sample and the subsequent analysis, either in real-time or offline laboratory analysis, of the amount and type of radioactive material present in the atmosphere.

Air sampling: A form of air monitoring in which an air sample is collected and analyzed at a later time, sometimes referred to as retrospective air monitoring.

ALARA committee: The multi-disciplined forum that reviews and advises management on improving progress towards minimizing radiation dose and radiological releases.

ALARA design review: A systematic review to ensure that ALARA considerations are evaluated, incorporated if reasonable, and documented for the design of new facilities and modifications to existing facilities that involve the potential for exposure to ionizing radiation.

ALARA job/task/experiment review: A systematic pre- and post-job review of high-dose and potentially high-dose activities to ensure that ALARA controls are planned, evaluated, implemented where reasonable, and documented.

Alarm set point: The count rate or concentration at which a real-time air monitor will alarm, usually set to correspond to a specific airborne radioactive material concentration averaged over time (e.g., DAC-hour alarm equivalent) by calculating the sample buildup rate on the collection medium.

Alpha (α): The probability (not to be confused with an alpha particle) of a *Type I error* or *false positive*. Also called the false positive probability.

Analyte: The particular radionuclide to be determined in a sample of interest.

Baseline bioassay: An appropriate bioassay measurement obtained from a radiobioassay program participant prior to beginning or resuming work with radioactive material.

Beta (β): The probability (not to be confused with a beta particle) of a *Type II error* or *false negative*. Also called the non-detection probability.

Boundary identifier: A hazard identifier that is used to define the boundary of an area.

Boundary: The line that defines the transition from one specified area to another.

Breathing zone air monitoring: A form of air monitoring that is used to detect and quantify the radiological conditions of air from the general volume of air breathed by the individual, usually at a height of 1 to 2 meters. See "personal air monitoring."

Cabinet X-ray system: An X-ray system with the X-ray tube installed in an enclosure (hereinafter termed "cabinet") which, independently of existing architectural structures except the floor on which it may be placed, is intended to contain at least that portion of a material being irradiated, provide radiation attenuation, and exclude individuals from its interior during generation of X-radiation. Included are all the X-ray systems designed primarily for inspection of carry-on baggage at airline, railroad, and bus terminals, and in similar facilities. An X-ray tube used within a shielded part of a building or X-ray equipment which may temporarily or occasionally incorporate portable shielding is not considered a cabinet X-ray system.

Challenge examination: An examination administered to ascertain the knowledge of a worker with respect to radiation safety and provide an exception to the required training.

Check source: A radioactive source, not necessarily calibrated, that is used to confirm the continuing satisfactory operation of an instrument.

Confirmed intake: An intake confirmed by follow-up radiobioassay, by association with a known incident, or by investigation.

Contaminated area: Any area meeting the definition of "contamination area," "high contamination area," or "airborne radioactivity area" provided in 10 CFR 835.2(a).

Continuous air monitor (CAM): An instrument that continuously samples and measures the levels of airborne radioactive material on a "real-time" basis and has alarm capabilities at preset alarm set points.

Decision level (L_c): The amount of a count (L_c or L'_c) as final instrument measurement of a quantity of analyte (D_c or D'_c) at or above which a decision is made that the analyte is definitely present.

Derived investigation level (*DIL*): A value of a radiobioassay or air monitoring measurement that indicates an intake resulting in a dose exceeding an Investigation Level *(IL)*.

Detector: A device or component designed to produce a quantifiable response to ionizing radiation, normally measured electronically.

Direct (in vivo) radiobioassay: The measurement of radioactive material in the human body utilizing instrumentation that detects radiation emitted from the radioactive material in the body.

DOELAP: The Department of Energy Laboratory Accreditation Program. This program defines a set of reference performance tests and provides a description of the minimum levels of acceptable performance for personnel dosimetry systems and radiobioassay programs under either DOE STD-1111-98, THE DEPARTMENT OF ENERGY LABORATORY ACCREDITATION PROGRAM ADMINISTRATION (DOE 1998b), or

DOE STD-1112-98, THE DEPARTMENT OF ENERGY LABORATORY ACCREDITATION PROGRAM FOR RADIOBIOASSAY (DOE 1998c).

Dose assessment: The process of determining radiological dose and uncertainty included in the dose estimate, through the use of exposure scenarios, bioassay results, monitoring data, source term information, and pathway analysis.

Elimination: The biological removal of a radionuclide from the body by excretion, perspiration, exhalation, secretion (e.g., breast milk), exfoliation (sloughing of dead tissue), or excision.

Embryo/fetus: A developing human organism from conception until birth.

Escort: An individual with the prerequisite training necessary for unescorted access to the area(s) where the escort activities will be performed and who is authorized to accompany and ensure the safety of individuals who lack such training.

Evaluation: The process of arriving at a value for intake or dose that uses, among other inputs, measurement results.

Excretion: The biological removal of a radionuclide from the body via one or more excretion pathways: urine and feces.

Exempt sealed radioactive source: A sealed radioactive source that does not meet the accountability criteria established in the definition of the term "accountable sealed radioactive source" provided in 10 CFR 835.2(a).

Exposure: The general condition of being subjected to ionizing radiation, such as by proximity to external sources of ionizing radiation or through intake of radioactive material into the body. In this document, exposure does not refer to the radiological physics concept of charge liberated per unit mass of air.

False negative: A *Type II (β) error,* that is, concluding that *analyte* is not present when in fact it is.

False positive: A *Type I (α) error*, that is, concluding that there is *analyte* present when it is not.

Fixed contamination: Radioactive material that cannot be readily removed from surfaces by nondestructive means, such as casual contact, wiping, or brushing.

Fixed-location sampler: An air sampler located at a fixed location in the workplace.

Frisk or frisking: Process of monitoring individuals or surfaces for contamination by directly scanning the surface with a suitable radiation detector.

Functional tests: Tests (often qualitative) to determine that an instrument is operational and capable of performing its intended function. Such tests may include, for example, battery check, zero setting, or source response checks.

Geotropism: A change in an instrument's reading as its orientation changes, due to gravitational effects.

Gestation period: The time from conception to birth; usually 40 weeks or approximately 9 months.

Grab sampling: A single sample removed from the air over a short time interval, typically a few minutes for high volume air samplers and less than one hour for low volume air samplers.

Hot particles: Small, discrete, highly radioactive particles that can cause extremely high dose rates to a localized area.

Indirect (in vitro) radiobioassay: The measurement or analysis of radionuclides in excreta or other biological samples removed from the body.

Instrument (radiation detection): A complete system consisting of one or more subassemblies (e.g., detector, readout, etc.) designed to quantify one or more characteristics of ionizing radiation or radioactive material.

Intake: The amount of radionuclide taken into the body by inhalation, absorption through intact skin, injection, ingestion, or through wounds. Depending on the radionuclide involved, intakes may be reported in mass (e.g., μg, mg), activity (e.g., μCi, Bq), or potential alpha energy (e.g., MeV, J) units.

Interlock: A device for precluding access to an area of radiation hazard by either preventing entry or by automatically removing the hazard. One example is an electro-mechanical control mechanism that interrupts the beam of ionizing radiation or shuts down the radiation installation whenever the interlock is challenged.

Internal audits: Reviews and evaluations of the content and implementation of the documented radiation protection program conducted by an organization neither responsible nor accountable for developing program content or implementing the program.

Investigation level (*IL*): The value of the committed effective dose equivalent from an intake(s) of a radioactive material by a worker at or above which, for regulatory purposes, is regarded as sufficiently important to justify further investigation

Irradiator: Any gamma- or neutron-emitting sealed radioactive material that has the potential to create a radiation level exceeding 500 rads (5 grays) in 1 hour at 1 meter and is operated within the requirements of an RGD installation.

Minimum detectable amount (*MDA*): The smallest amount (activity or mass) of an analyte in a sample that will be detected with a probability, β, of non-detection (*Type II error*) while accepting a probability, α, of erroneously deciding that a positive (non-zero) quantity of analyte is present in an appropriate blank sample (*Type I error*). The *MDA* is computed using the same value of α as used for the L_c. The *MDA* depends on both α and β. Measurement results are compared to the L_c, not the *MDA*; the *MDA* is used to determine whether a program has adequate detection capability. The *MDA* will be greater than or equal to the L_c.

Modification: Any alteration of the shielding configuration, device or installation operating practices, or the replacement of the original RGD (or component part thereof) with another that has not been previously evaluated, inspected, monitored, and documented by the radiological control organization. This definition also includes the collocation of additional or multiple unevaluated RGDs within a previously evaluated installation.

Normal operation: Operation under conditions as recommended by the manufacturer of the RGD with recommended shielding and barriers in place, and as specified in the operating procedures and requirements for the RGD installation.

Occupied (occupiable) area: An area or location that may be physically accessible by individuals (or body parts thereof) while a radiation-generating device is in operation.

Off-normal operation: An event or condition that adversely affects, potentially affects, or indicates degradation in the safety, security, environmental, or health-protection performance or operation of an RGD installation.

Optimization methodology: A documented methodology which describes how the factors affecting a protection decision, i.e., social, technical, economic, practical, and public policy, are assigned values to compare detriment and benefits.

Performance demonstration: A demonstration by a student of the skills required to perform certain designated activities.

Performance tests: Tests performed periodically over the life of an instrument to verify that it continues to meet operational requirements. Examples of performance tests are response time and geotropism.

Personal air monitoring: A form of breathing zone air monitoring that involves the sampling of air in the immediate vicinity (typically within one foot) of an individual's nose and mouth, usually by a portable sampling pump and collection tube (e.g., a lapel sampler) worn on the body.

Physical barrier: A bounding physical obstruction that prevents unimpeded access to an area.

Portable air sampler: An air sampler designed to be moved from area to area.

Portable monitoring instrument: An instrument intended to be operated while being carried by an individual.

Qualified expert: An individual having the knowledge, training, and recognition of such by management to measure ionizing radiation, to evaluate safety techniques, to design RGD installations, and to provide advice on radiation protection requirements.

Radiation protection program (RPP): The documented program, approved by DOE, including, but not limited to, the plans, schedules, and other measures developed and implemented to achieve and ensure continuing compliance with 10 CFR 835 and to apply the as low as is reasonably achievable (ALARA) process to occupational dose.

Radiation-generating device (RGD): Collective term for devices which produce ionizing radiation, including, certain sealed radioactive sources, small particle accelerators used for *single purpose* applications which produce ionizing radiation (e.g., radiography), and electron generating devices that produce X-rays incidentally.

Radiography: Examination of the structure of materials by nondestructive methods, using a RGD.

Radiological control organization (RCO): An organization responsible for radiation protection activities.

Radiological engineer: An individual who is responsible for providing technical support and assistance to supervisors, planners, schedulers, principal investigators, and design engineers to reduce occupational doses and the spread of radioactive materials.

Radiological work permit (RWP): The document that identifies radiological conditions, establishes worker protection and monitoring requirements, and contains specific approvals for radiological work activities. The RWP serves as an administrative process for planning and controlling radiological work and informing the worker of the radiological conditions.

Radon: Unless otherwise specified, the isotope ^{222}Rn.

Real time air monitor: An instrument that measures the levels of airborne radioactive material on a "real-time" basis.

Refresher training: Periodic (usually annual) training that provides current information on changes to radiation protection policies and procedures or changes in facility conditions, or to promote awareness of infrequently encountered radiological safety matters.

Removable contamination: Radioactive material that can be removed from surfaces by nondestructive means, such as casual contact, wiping, or brushing.

Representative air sampling: The sampling of airborne radioactive material in a manner such that the sample collected closely approximates both the amount of activity

and the physical and chemical properties (e.g., particle size and solubility) of the contaminant to which the individuals may be exposed.

Retention: The amount of material which, after being taken into the body by inhalation, ingestion, entry through an open wound, or absorption through the skin, exists in the whole body, a compartment, an organ, or a tissue at a specified time.

RGD Custodian: An individual who is trained and designated to maintain cognizance over accountability control of radiation-generating devices assigned to him or her.

RGD installation: The sum of the radiation source (e.g., sealed radioactive material or x-ray tube), the associated equipment and component items, and the space in which they are operated.

Five types of installations are defined as follows:

(1) **Shielded installations** are those designed to use the room-within-a-room concept to limit access to the RGD beam and to place more emphasis on distance as opposed to shielding for radiation protection and include shielded, exempt shielded, and cabinet x-ray installations;

(2) **Unattended installations** are those designed for a specific purpose and that do not require personnel in attendance for operation and include unattended gauge and other unattended installations;

(3) **Open installations** are those designed to accommodate a specimen that is so large as to make an exempt shielded installation impractical;

(4) **X-ray diffraction & fluorescence analysis equipment**, including both open and closed beam installations; and

(5) **Incidental**, including devices that emit low levels of ionizing radiation as a byproduct of their normal function, such as electron beam welders, electronic microscopes, and pulse generators.

RGD Operator: An individual who is trained and deemed qualified to use a radiation-generating device.

Routine radiobioassay monitoring: Any radiobioassay measurement made on a predetermined, periodic schedule, to establish whether a worker has had any intake of radioactive material since previous radiobioassay measurements.

Source custodian: An individual who is trained and designated to maintain cognizance over accountability and control of assigned sealed radioactive sources.

Source response check: A functional test that includes the observation of the response of an instrument to a check source.

Source user: An individual who is trained and authorized to use sealed radioactive sources.

Source-specific air sampling: Collection of an air sample near an actual or likely release point.

Special radiobioassay monitoring: Any radiobioassay measurement that is required for confirmation of a suspected intake of radionuclides, or is required for follow-up evaluation of confirmed intakes.

State-of-the-art: The most advanced technology that is commercially available and successfully field tested.

Technical work document (TWD): A term used to generically identify formally approved documents that direct work, such as procedures, work packages, or job or research plans. TWDs provide radiological and ALARA controls applicable to the task.

Technology shortfall: A technology shortfall for routine radiobioassay exists when the derived investigation level (*DIL*) for a well-designed and appropriate routine radiobioassay program, using current or state-of-the-art methods and equipment, is less than the minimum detectable amount/activity of the routine monitoring method (e.g., the *DIL* is less than the *MDA*).

Termination radiobioassay: A radiobioassay measurement performed for the purpose of documenting the retention of radioactive materials in the body due to occupational exposure either upon termination of employment or upon the cessation of potential exposure to a specific nuclide.

Test: A procedure whereby an instrument, component, or circuit is evaluated against certain criteria for satisfactory operation.

Thoron: Unless otherwise specified, the isotope ^{220}Rn.

Traceability: The ability to show, through documentation, that a particular instrument or radiation source has been calibrated using either the national standard or a transfer standard in a chain or echelon of calibrations, ultimately leading to a comparison with the national standard.

Type test: An initial test of one or more production instruments made to a specific design to show that the design meets certain specifications.

Type I error: Incorrectly concluding from a result that there is analyte present; the probability (α) of a *Type I error* is usually taken as 0.05. The *decision level* is determined on the basis of an acceptable level of *Type I errors*.

Type II error: Incorrectly concluding from a result that there is no analyte present; its probability (β) is usually taken as 0.05.

Uniform exposure: Hypothetical radiation field in which the fluence and its angular and energy distributions are the same throughout the volume of interest.

Useful beam: That part of the primary and secondary radiation beam that passes through the aperture, cone, or other device used for collimation.

3.0 RADIATION PROTECTION PROGRAMS

10 CFR 835 establishes specific requirements for the development, content, revision, and approval of the documented RPP for a DOE activity. These requirements include identifying existing and/or anticipated operational tasks and formal plans and measures for maintaining occupational radiation doses ALARA. Guidance provided in this Guide, in combination with the provisions of site radiological control manuals developed and implemented consistent with guidance provided by the RCS for those regulatory provisions not addressed by the this Guide, provide reasonable assurance that a site RPP will meet the requirements of 10 CFR 835.

The RPP for a specific DOE activity is approved by the cognizant DOE Headquarters Program Office. The RPP is intended to provide DOE reasonable assurance that the DOE activity will be conducted in compliance with the provisions of 10 CFR 835. The RPP also satisfies the requirement for an Implementation Plan found in other DOE directives. Guidance concerning the specific documentation required for DOE approval of RPPs as required in 10 CFR 835.101(f), (g), and (h) is provided in Appendix 3.A, PREPARATION, REVIEW AND APPROVAL OF RADIATION PROTECTION PROGRAMS. Appendix 3.A is based on guidance which previously was provided in DOE-STD-1082-94, PREPARATION, REVIEW, AND APPROVAL OF IMPLEMENTATION PLANS FOR NUCLEAR SAFETY REQUIREMENTS. Guidance is also provided by the cognizant DOE Headquarters Program Office.

Program Offices will also provide guidance should DOE need to direct or make modifications to an RPP as provided under 10 CFR 835.101(b). 10 CFR 835 permits changes, additions, or updates to an RPP to become effective without prior DOE approval only if the changes do not decrease the effectiveness of the RPP and the RPP, as changed, continues to meet the requirements of the rule. Proposed changes that decrease the effectiveness of the RPP shall not be implemented without submittal to and approval by DOE [10 CFR 835.101(h)]. Guidance regarding the process for submitting and approving changes will be provided by the appropriate DOE Headquarters Program Office.

The RPP is the basis for implementing operational radiation protection program requirements for a DOE activity. A combination of various methods which can be used to achieve regulatory compliance is discussed in this Guide. DOE recognizes that many of the requirements of 10 CFR 835 are not new. Equivalent requirements were previously promulgated in DOE Orders and the DOE Radiological Control Manual, which were implemented under contractual obligations for most DOE activities. Therefore, much of the RPP documentation required to ensure compliance with 10 CFR 835 has already been developed to ensure compliance with contractually-imposed radiation protection standards. DOE recognizes that significant effort was expended in upgrading radiation protection of the work force and does not intend for its contractors to expend significant additional effort to develop and implement a separate, redundant program to satisfy the RPP requirements of 10 CFR 835. The RPP should rely on existing documents, such as the site radiological control manual, contractual agreements, procedures, and memoranda, to effectively administer and

manage regulatory commitments. However, the completeness of these existing documents should be verified to ensure that all 10 CFR 835 requirements are satisfied. This chapter of this Guide provides guidance on the management and administrative aspects of the RPP to achieve and maintain compliance with specific requirements in 10 CFR 835.

Internal audits of the radiation protection program, including examination of program content and implementation, shall be conducted through a process that ensures that all functional elements of the program are reviewed no less frequently than every 36 months (10 CFR 835.102). This Guide discusses the role of an internal audit program in effectively managing and administering an RPP that complies with 10 CFR 835. These internal audits may also be incorporated into quality assurance programs developed under 10 CFR 830 Subpart A, Quality Assurance Requirements (DOE 2001a) and/or DOE Order 414.1C, *Quality Assurance* (DOE 2005a). Functional elements of a comprehensive RPP are identified and discussed throughout Section 3.2 of this Guide. The specific functional elements for a DOE activity will depend upon the types of radiological work being performed and the radiological hazards present. Other functional elements necessary for an integrated worker health and safety program are not addressed in this Guide, but should be integrated with a radiological control program. These other functional elements include: respiratory protection, radioactive material shipment and receipt, radioactive waste management, and emergency response.

3.1 Implementation Guidance

The approved RPP details how a DOE activity shall be in compliance with 10 CFR 835 and should identify the functional elements appropriate for that activity. Additional documentation should be developed and maintained to supplement the approved RPP to demonstrate that an RPP can be effectively managed and administered to achieve compliance with 10 CFR 835. This documentation typically includes a site radiological control manual developed to the guidance contained in the RCS, as well as detailed implementing procedures, appropriate management policy statements, and technical basis documentation. While this documentation need not be part of the RPP, it should be clearly linked to the compliance commitments contained in the RPP.

DOE has developed technical guidance to support effective implementation of programs to ensure compliance with 10 CFR 835. The RCS was developed to provide detailed guidance on and best practices for line management implementation of DOE's radiation protection requirements. DOE has also developed a set of technical standards and handbooks addressing radiation protection issues, such as training, internal dosimetry, or plutonium operations. Additionally, DOE has developed a set of Radiological Control Technical Positions (RCTPs). The RCTPs provide acceptable approaches to implementing specific provisions, or otherwise address specific issues, of the Rule (available at http://www.hss.energy.gov/radiation). In addition, this Guide provides acceptable methods for achieving compliance with a variety of technical and administrative requirements.

RPP changes may be implemented without prior DOE approval only if the RPP continues to meet 10 CFR 835 requirements and the changes do not reduce program effectiveness [10 CFR 835.101(h)]. Due to the wide range of activities subject to 10 CFR 835 and the variety of methods used by these activities to ensure compliance, no specific criteria exist by which DOE may predetermine whether an RPP change results in a reduction in program effectiveness. Factors that should be considered include the impact of the proposed change(s) on:

- radiological conditions in occupied areas;
- individual and collective doses;
- worker awareness of radiological conditions and controls;
- management oversight and control of routine and non-routine radiological work activities;
- sufficiency of area and personnel monitoring programs;
- completeness and irretrievability of records;
- radiological control performance indicators;
- adherence to consensus standards; and
- other factors that ensure full implementation of the RPP.

Documentation of the rationale applied to RPP changes implemented without prior DOE approval should be retained for future reference and demonstration of compliance.

The terms "likely" and "potential" have been used judiciously throughout the rule to allow the use of professional judgment and experience in making decisions in specific circumstances and provide the flexibility necessary to implement the regulatory requirements under a broad range of activities. The technical bases and other considerations should be documented when professional judgment is exercised. This documentation should provide sufficient detail to permit individuals who are responsible for implementing and assessing the RPP to clearly understand how regulatory compliance is achieved and maintained. The RCS, Guides, and other DOE technical standards and handbooks are designed to facilitate development and implementation of a comprehensive RPP commensurate with the radiological hazards associated with the DOE activity. In addition, consensus standards, such as those developed by the American National Standards Institute (ANSI) and the Health Physics Society (HPS), may provide additional guidance concerning technical issues not specifically addressed by the Guides, RCS, DOE technical standards, or other DOE guidance documents.

3.2 Organization and Administration

The RPP shall include plans, schedules, and other measures for achieving compliance with 10 CFR 835 [10 CFR 835.101(f)]. Plans should include establishing the organization and administration of the RPP to ensure that the program is effectively implementing appropriate measures that ensure regulatory compliance can be achieved and sustained. The authority and responsibility for radiation protection should originate at the highest levels of line management and should be emphasized throughout the organization. Ultimately, workers should be aware of their individual responsibilities for radiation protection. Programmatic documentation should be developed to document the organizational and administrative aspects of the RPP.

3.2.0 Administrative Processes

The degree of formality and scope of the associated administrative processes should be commensurate with the radiological hazards encountered and complexity of the associated control measures. More rigorous administrative processes should be implemented for more complex or hazardous DOE activities. Administrative processes should include a hierarchy of documents that clearly and unambiguously delineate management policies, requirements, expectations, and objectives for the RPP. This documentation should typically include the following:

- Policy statement: The policy statement should articulate management's commitment to conduct radiological operations in a manner that will ensure the health and safety of all its employees, contractors, and the general public. This policy statement should be patterned after DOE P 441.1, *Department of Energy Radiological Health and Safety Policy*.

- Site-specific radiological control manual or handbook: This document should be issued and endorsed by senior management for a DOE activity. This manual or handbook should address all functional elements of the RPP for the DOE activity.

- Procedures: These documents should provide detailed instructions for implementing various functional elements of the RPP. Responsibilities and actions required of management and workers should be clearly and unambiguously stated. Written procedures shall be developed and implemented as necessary to ensure compliance with 10 CFR 835, commensurate with the radiological hazards created by the activity and consistent with the education, training, and skills of the individuals exposed to those hazards (10 CFR 835.104).

  It is not necessary for written procedures to be developed and implemented for all of the requirements of 10 CFR 835. Written procedures should be developed and employed under the following circumstances:

  – Worker health and safety are directly affected;

- the expected outcome for the process or operation requires that a specific method be followed;
- the process or operation is infrequently used and competence training cannot assure adequate implementation; or
- to document the approved method to implement specific processes or operations. In evaluating the need for written procedures, consideration shall be given to the level and extent of the radiological hazards, the complexity of the measures required to achieve compliance, and the education, training and skills of the individuals who must implement those measures (10 CFR 835.104). Under such a regimen, a low hazard activity employing a stable staff of highly educated and skilled workers having demonstrated an advanced knowledge of radiation protection principles and practices could have fewer and less detailed procedures than a higher hazard activity employing a transient workforce with less knowledge of radiation protection practices and principles. This Guide provides additional guidance regarding specific procedural aspects of the RPP.

- Technical basis documents: Document decisions and approaches used to achieve regulatory compliance, such as those decisions where professional judgment has been exercised. The document should include supporting analyses and justifications sufficient to demonstrate that regulatory compliance can be achieved and maintained. This Guide contains specific recommendations for documenting the technical basis for various RPP functional elements.

10 CFR 835 specifies the frequency for performing certain activities. Internal audits shall be conducted on a 36 month cycle (10 CFR 835.102); radiation safety training shall be conducted every twenty four months [10 CFR 835.901(e)]; and accountable sealed radioactive sources shall be inventoried and leak tested every six months [10 CFR 835.1202(a) and (b)]. DOE expects that those entities responsible for ensuring compliance with the rule will undertake those measures necessary to perform the required activities within the prescribed time frame (e.g., if a sealed radioactive source is leak tested on January 15, DOE would expect the subsequent leak test to be performed on or before July 15 of the same year). 10 CFR 835.3(e) allows a grace period of up to 30 days when operational or scheduling considerations preclude adherence to the required schedule (e.g., the leak test could be performed no later than August 14 of the same year). If the provisions of 10 CFR 835.3(e) are exercised, documentation of the schedule deviation should be developed and include a discussion of the specific activity involved and the reason for the schedule deviation. Schedule extensions beyond the 30 day grace period can only be granted through the regulatory exemption process under 10 CFR 820.62.

3.2.1 Radiological Control Organization

A radiological control organization should be established to support line managers and workers. To function effectively and be consistent, as necessary, with the requirements

in DOE Order 226.1, *Implementation of Department of Energy Oversight Policy* (DOE 2005b) the radiological control organization should be independent of the line organizational element responsible for production, operation, or research activities, and should have an equivalent reporting level. Radiological control organization function is discussed in detail in the RCS. Other organizational schemes that allow effective compliance with the standards set forth in 10 CFR 835 should be considered to address site- or facility-specific needs.

3.2.2 Education, Training, and Skills

Individuals responsible for developing and implementing measures necessary for ensuring compliance with the requirements of 10 CFR 835 shall have the appropriate education, training and skills to discharge these responsibilities (10 CFR 835.103). These individuals can include technical and management personnel within the radiological control organization, independent assessors, and line managers responsible for radiological work activities. In addition, 10 CFR 830.122(b), Quality Assurance Criteria, specifies that nuclear facility personnel shall be trained and qualified to ensure they are capable of performing their assigned work.

DOE previously issued requirements and guidance with regard to education, training, and skills for many categories of personnel, including individuals responsible for developing and implementing measures necessary for ensuring compliance with the requirements of 10 CFR 835. Some of these requirements are addressed in DOE 5480.20A, Ch. 1, *Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities* (DOE 2001b). This order establishes training and qualification requirements for technical professionals and management personnel operating defense nuclear facilities. While these requirements are not mandatory for all DOE facilities, this information may be useful for all DOE facilities in developing training programs and standards for the education, training, and skills appropriate for personnel to achieve compliance with the requirements of 10 CFR 835.103 and 10 CFR 830.122(b).

Key radiation protection positions are identified in DOE STD-1107-97, KNOWLEDGE, SKILLS AND ABILITIES FOR KEY RADIATION POSITIONS AT DOE FACILITIES (DOE 1997b). This document supplements the requirements discussed above by synthesizing guidance from several source documents into a single reference. DOE STD-1107-97 describes the level of knowledge, skills, and abilities for personnel in key radiation protection involved with DOE activities. The approach taken in DOE STD-1107-97 reinforces the DOE's emphasis on establishing a system of criteria for key radiation protection positions that reflects the increasing levels of education, training, and skills needed for positions of increasing responsibility. The information contained in this standard should be strongly considered when evaluating the education, training, and skills of personnel in key radiation protection positions.

The standards in DOE 5480.20A and DOE STD-1107-97 are based on DOE, Nuclear Regulatory Commission, and related industry standards and provide an acceptable method for achieving compliance with the requirements of 10 CFR 835.103.

DOE STD-1107-97 includes radiological control technicians (RCTs) in the list of key radiation protection positions. While 10 CFR 835 does not establish specific requirements for RCT training, DOE considers the typical job functions associated with RCTs to be critical in implementing an acceptable RPP. These typical job functions include: prescribing and implementing radiological work controls, performing radiological monitoring, responding to radiological incidents, or evaluating radiological conditions in the workplace. Individuals performing these functions shall meet the provisions of 10 CFR 835.103. Chapter 6, Part 4, of the RCS discusses the essential elements of RCT training and qualification, including qualification standards, oral examination boards, and continuing training. In support of these elements, DOE has developed and maintains the core course for RCTs. DOE considers the DOE-developed core course for RCTs, augmented with site specific training, an acceptable level of training for individuals performing the typical job functions associated with RCTs. As is the case with using any of the DOE-developed training courses, sites need to evaluate the individual's job functions and ensure the adequacy of the training provided.

To ensure that the work performed by RCTs receives the appropriate level of review and evaluation, it is important that RCT Supervisors receive a higher level of training and maintain a higher level of knowledge than those expected of RCTs. Chapter 6, Part 4 of the RCS also provides guidance on the essential elements of RCT Supervisor training and qualification, including continuing training and oral examination boards.

DOE developed and implemented core courses to enhance the content of training provided to general employees, radiological workers, and radiological control technicians across the DOE complex and bring these core training programs up to a standard consistent with the commercial industry. The use of the core courses is not mandatory. However, these courses should strongly be considered as a basis for developing and implementing radiation safety and radiological control technician training programs. Additional guidance regarding compliance with the Subpart J requirements is provided in Chapter 14 of this Guide.

DOE has also sponsored development of additional training courses and guidance. DOE strongly encourages its operating entities to implement these courses and guidance. These courses and guidance, when augmented with site specific information and appropriately revised to reflect the most current regulatory requirements, provide acceptable approaches for providing radiation safety training or training for individuals responsible for developing and implementing measures necessary for ensuring compliance with the rule. These courses include:

- DOE-HDBK-1143-2001; RADIOLOGICAL CONTROL TRAINING FOR SUPERVISORS (DOE 2001c)

- DOE-HDBK-1145-2001; RADIOLOGICAL SAFETY TRAINING FOR PLUTONIUM FACILITIES (DOE 2001d)

- DOE-HDBK-1141-2001;RADIOLOGICAL ASSESSOR TRAINING (DOE 2001e)

- DOE-HDBK-1105-2002; RADIOLOGICAL SAFETY TRAINING FOR TRITIUM FACILITIES (DOE 2002a)
- DOE-HDBK-1106-97; RADIOLOGICAL CONTAMINATION CONTROL TRAINING FOR LABORATORY RESEARCH (DOE 1997c)
- DOE-HDBK-1108-2002; RADIOLOGICAL SAFETY TRAINING FOR ACCELERATOR FACILITIES (DOE 2002b)
- DOE-HDBK-1109-97; RADIOLOGICAL SAFETY TRAINING FOR RADIATION-PRODUCING (X-RAY) DEVICES (DOE 1997d)
- DOE-HDBK 1110-97; ALARA TRAINING FOR TECHNICAL SUPPORT PERSONNEL (DOE 1997e)
- DOE-HDBK-1113-98 RADIOLOGICAL SAFETY TRAINING FOR URANIUM FACILITIES (DOE 1998d)
- DOE-HDBK-1122-99 Radiological Control Technician Training (DOE 1999b)

3.2.3 Internal Audit and Self Assessment

Internal audits and self assessments are two of the numerous checks and balances needed in an effective RPP. Internal audits of the RPP, including examination of program content and implementation, shall be conducted through a process that ensures that all functional elements of the program are reviewed no less frequently than every 36 months (10 CFR 835.102). The RCS discusses how assessments, including internal audits, provide independent feedback to senior line managers concerning the implementation of the RPP.

An audit plan should be developed that identifies the functional elements of the RPP and the schedule for review to ensure that over a 36 month period, all of the functional elements are reviewed. Internal audits should be conducted on a continuing basis. DOE cautions against conducting a single comprehensive internal audit of the entire RPP once every three years. DOE does not believe that such an approach is effective in assuring that a DOE activity will be conducted in conformance with its approved RPP. DOE recommends that, at a minimum, an annual, broad scope audit of the program be conducted. Under this approach, the audit plan would identify each functional element to be reviewed during the annual audit and ensure that all functional elements would be reviewed during a 36 month cycle. Thus, the RPP is under continuing review and deficiencies can be identified and corrected in a timely manner.

The functional elements of a comprehensive RPP are discussed in this Guide. All of these functional elements may not be applicable to a specific DOE activity, but should be selected based upon the type of radiological work being performed and the radiological hazards encountered.

Internal audits should be conducted by individuals who are organizationally independent from the organizations responsible for developing and implementing the RPP.

3.3 RPP Functional Elements

This section identifies the programmatic functional elements of a comprehensive RPP. For each element, the table below identifies the applicable regulatory provisions, contractual requirements, and recommended guidance document(s) which are useful in achieving compliance with these provisions.

Functional Element	Regulatory Provision	Contractual/Guidance Document
1. Organization and Administration	10 CFR 835, Subpart B	Chapter 3.0 of this Guide
2. ALARA Program	10 CFR 835.101(c), Subpart K	Chapter 4.0 of this Guide.
3. External Dosimetry Program	10 CFR 835.401 (a), 402(a), (b)	Chapter 6.0 of this Guide.
4. Internal Dosimetry Program	10 CFR 835.401(a), 402(c), (d)	Chapter 5.0 of this Guide.
5. Area Monitoring and Control		
a. Area Radiation Monitoring	10 CFR 835.401(a)	Chapter 6.0 of this Guide.
b. Airborne Radioactivity Monitoring	10 CFR 835.209, 401(a), 403	Chapter 10.0 of this Guide.
c. Contamination Monitoring and Control	10 CFR 835.401(a), Subpart L	Chapter 11.0 of this Guide.
d. Instrument Calibration and Maintenance	10 CFR 835.401(b)	Chapter 9.0 of this Guide.
6. Radiological Controls		
a. Radiological Work Planning	10 CFR 835.501(d), 1001(b), 1003	DOE-STD-1098-99, RADIOLOGICAL CONTROL
b. Entry and Exit Controls	10 CFR 835, Subpart F	Chapter 7.0 of this Guide.
c. Radiological Work Controls	10 CFR 835, Subpart F, 1003	Chapter 7.0 of this Guide.
d. Posting and Labeling	10 CFR 835, Subpart G	Chapter 12.0 of this Guide.
e. Release of Materials and Equipment	10 CFR 835.1101	Chapter 11.0 of this Guide.
f. Sealed Radioactive Source Accountability and Control	10 CFR 835, Subpart M	Chapter 15.0 of this Guide.
7. Emergency Exposure Situations	10 CFR 835.1301, 1302	DOE O 151.1-1, *Comprehensive Emergency Management System* (DOE 2005c)
8. Nuclear Accident Dosimetry	10 CFR 835.1304	Chapter 6.0 of this Guide.
9. Records	10 CFR 835, Subpart H	Chapter 13.0 of this Guide.
10. Reports to Individuals	10 CFR 835, Subpart I	Chapter 13.0 of this Guide.
11. Radiation Safety Training	10 CFR 835, Subpart J	Chapter 14.0 of this Guide.
12. Limits for the Embryo/Fetus	10 CFR 835, Subpart C	Chapter 8.0 of this Guide.

Appendix 3.A
PREPARATION, REVIEW, AND APPROVAL OF RADIATION PROTECTION PROGRAMS

3.A 1. PREPARATION OF RPPs

The RPPs detail how the site, facility, or activity has met or will meet the requirements of 10 CFR Part 835. The format for the RPP is not specified. This flexibility will permit the RPP submitting organizations to take advantage of pre-existing documents. The following sections describe the minimum content expected in RPPs.

> Note: The term "Operations Office" is used throughout this document. Where it is used, the term "Field Office" or the term "Area Office," as appropriate, should be substituted where there is no Operations Office.

3.A 1.1 RPP SUMMARY

Each RPP should contain a summary section in the front to allow DOE management and reviewers to quickly assess the more significant information contained in the RPP. The summary should identify the following minimum information:

(1) Any requests for exemptions contained in the RPP;

(2) The total additional funding required to meet the commitments of the RPP and the expected sources of funding by fiscal year;

(3) Any significant new programs or activities needed to meet the requirements;

(4) Any significant impacts to other programs or activities not included in the RPP;

(5) Any constraints to implementing the RPP;

(6) Those areas where there is currently full compliance with the requirements.

3.A 1.2 GENERAL INFORMATION

The RPP should include general information which: (1) identifies that the RPP addresses the requirements of 10 CFR Part 835; (2) identifies whether the RPP is the initial submittal or a revision; (3) identifies the facilities or activities, missions, and organizations involved; and (4) briefly discusses the content and format of the RPP.

3.A 1.3 APPLICABILITY OF REGULATORY REQUIREMENTS

The RPP should identify the specific facilities or activities covered by the RPP. Any determination that a specific requirement is not applicable to the facilities or activities addressed in the RPP should be documented in the RPP to ensure that the determination

is clearly communicated. DOE approval of the RPP will constitute agreement with applicability statements contained therein.

Applicability statements may not be used to provide relief where the requirements are clearly stated to be applicable in 10 CFR Part 835. Relief from 10 CFR Part 835 can only be granted by an approved exemption granted in accordance with 10 CFR Part 820, Subpart E as discussed in Section 3.A 1.8 of this technical document.

The information provided in the plan should clearly identify which of the following three categories applies to each requirement for a given facility, site, or activity:

(1) The requirement is applicable and the RPP defines the actions and schedules for compliance;

(2) The requirement is applicable and an exemption is being requested; or

(3) The requirement is not applicable for the reasons documented in the RPP.

The RPP should also identify any requirements that are only partially applicable, the limits of the applicability, and the reasons for the limitation.

Individuals should contact the appropriate Operations Office to assist with any needed clarification of applicability statements. The Operations Office should contact the Office of Health and Safety for any needed technical clarifications or the Office of the General Counsel for legal interpretations of 10 CFR Part 835.

3.A 1.4 GUIDES AND TECHNICAL STANDARDS

The RPP should identify the guides and technical standards that are to be adopted as the means to meet 10 CFR Part 835. The use of guides and technical standards is not required; however, it is encouraged for the following reasons:

(1) The use of previously approved methodologies will streamline the review and approval process; and

(2) The use of guides and technical standards will enhance the consistent and successful implementation of requirements across the DOE complex.

The implementing organization should consider methods and guidance from guides and technical standards when developing the RPPs; however, alternative methods that achieve equivalent or better results are acceptable. When an implementing organization identifies an alternate way to implement the requirements, a reasonable opportunity will always be provided to demonstrate compliance with the requirements using the alternate method. Demonstration of compliance does not require an organization to address the differences between the alternate method and the method in the guide or technical standard unless the comparison is necessary to demonstrate acceptability.

When guides or technical standards are used, the RPP should indicate if they are adopted in their entirety or adopted with exceptions. The exceptions, if any, should be specifically noted. Methodologies and guidance that are adopted with exceptions will be reviewed on a case-by-case basis.

The adopted guides and technical standards should be listed either by:

(1) Including a list of applicable guides and technical standards in the RPP, or

(2) Incorporating a list of guides and technical standards by reference.

Commitments in an RPP to meet all or parts of guides and technical standards are enforceable as part of the RPP.

3.A 1.5 RESOURCE ASSESSMENT

New RPPs should contain an estimate of the additional life cycle costs to implement 10 CFR Part 835. Revised RPPs may contain an estimate of the change in life cycle costs associated with the revision, if the change in life cycle cost is significant. The goals of this element of the RPP are as follows: (1) to communicate the expected new costs of implementation to DOE management for the purposes of budget planning and prioritization; (2) to identify the need to explore more cost effective means of achieving compliance; and (3) to identify cases where exemptions should be requested on the basis of insufficient benefit versus the expected implementation costs. Identification of required resources should also serve to open a dialogue between DOE and the RPP submitting organization on adjusting costs and activities to the available resources.

When performing the assessments, the estimator should consider monetary costs, as well as non-monetary resource considerations such as the limited availability of special job capabilities (e.g., health physicists). The assessment should (1) be guided by available quantitative and qualitative information; (2) reflect the current status of plant conditions, configurations, and processes; (3) consider the availability of materials and resources; and (4) consider any other information that is relevant to the radiation protection requirements.

RPP submitting organizations should seek to achieve the broadest consistency in the methods used to evaluate the resource requirements so that the assumptions, evaluations, and results of the assessment can be objectively compared with the equivalent parameters of other resource assessments. This will assist DOE and RPP activity management to determine priorities for the use of funding. All assumptions and estimates should be made using the best available knowledge and information.

After evaluating the resource impacts, consideration should be given if a more cost-effective means of achieving the intent of the requirement is available. As a minimum, the use of more cost-effective methods of compliance, or exemptions (see

section 3.A 3.1.6.7 of this attachment), should be considered whenever the resource expenditures necessary to meet a requirement are not commensurate with the expected safety improvements. One of the criteria for granting an exemption to a nuclear safety requirements is that the requirement results in resource impacts which are not justified by safety improvements. In the past DOE has granted exemptions on this basis for such topics as radiological postings and recording tritium intakes, see http://www.eh.doe.gov/whs/rhmwp/exemption.html.

There should be limited effort used to develop the resource assessments to only that level of detail necessary to achieve the goals of the assessment as stated above.

3.A 1.6 PRIORITIZATION

The RPP should include a discussion of the prioritization process used to integrate the proposed activities into a facility or site schedule of activities. The prioritization process is to be used to develop the proposed schedules and should be sufficiently flexible to accommodate changes at later dates.

The prioritization process should consider available information from safety analyses and other sources and give primary attention to controlling and reducing risks to the public; the environment, and the workers to an acceptable level. It should also consider other factors such as mission needs, outage schedules, and external regulations.

The prioritization process should be selected in consultation with the applicable DOE Operations Office and Program Offices to ensure that the prioritization of efforts meets DOE expectations. The prioritization schedule should tie budgets to schedules.

3.A 1.7 MILESTONES AND SCHEDULES

Per 10 CFR 835.101(f), the RPP must identify proposed milestones with achievable schedules developed in accordance with the prioritization process identified in the RPP (see Section 3.A 1.6 above). In developing the schedules, consider the resources available to support the work, as well as any major work reductions or schedule changes in other areas that will be required in order to meet the proposed schedules. The RPP should identify major impacts to activities or commitments outside the scope of the RPP that will be caused by the proposed additional activities.

Schedules should be developed using the best information available with any assumptions on availability of resources (monetary or non-monetary) clearly stated. The milestones and schedules will be enforceable commitments upon approval of the RPP. Schedule commitments should be firm commitments and consequently, should not be listed as contingent on funding. Thus, it is essential that line program representatives participate in the review and approval of RPPs that involve additional funding needs. Following approval of the RPPs, DOE has a responsibility to provide appropriate funding to support the RPP schedules, the RPPs should be revised to reflect the new schedules

supported by funding (provided any schedules specifically prescribed in the DOE requirements documents are met or schedule exemptions are approved). Such revisions should be submitted to DOE for review and approval.

Alternatively, RPP developers may consider requesting an exemption for unfunded activities, if the criteria for granting an exemption are met (see Section 3.A 1.8 of this attachment).

3A 1.8 EXEMPTIONS

Exemptions are to be requested whenever relief is sought from applicable DOE requirement. The RPP should clearly identify any exemptions that have been approved or are being requested from the subject requirements. The organization conducting RPP activities may submit requests for exemptions as part of the RPP provided that they relate to the same requirements. Requests for exemption that are submitted as part of the RPP should be identified in the RPP summary for early recognition. Early identification of exemption requests is important because they may need to follow a separate review and approval process.

The provisions for requesting and granting exemptions to rules are stated in 10 CFR Part 820, Subpart E, *Exemption-Relief*.

3.A 2 SUBMITTAL OF RPPS

Per 10 CFR 835.101, RPPs must be submitted to the designated DOE point-of-contact within the schedule specified in 10 CFR Part 835.

Normally, the RPP is submitted to a point-of-contact located in a DOE Operations Office. The Operations Office point-of-contact should date stamp the receipt of the RPP.

Contact the Operations Office point-of-contact in advance of the submittal date to determine the number of copies to be submitted. Documents that are incorporated by reference should be submitted with the RPP unless other arrangements are made with the Operations Office point-of-contact. In addition, if the RPP is not a stand-alone document (able to be reviewed independent of other documents), contact the Operations Office point-of-contact prior to submittal of the RPP to discuss which supporting documents are to be transmitted with the RPP or made available for onsite review.

Also see section 3.4 below for additional submittal requirements for final RPPs.

3.A 3. REVIEW AND APPROVAL OF RPPs

3.A 3.1 REVIEW AND APPROVAL PROTOCOL

The Department's protocol for review and approval of RPPs is described below. The protocol defines the roles, interfaces, and responsibilities of Department organizations

with respect to review and approval of RPPs. Organizations who prepare the RPPs and the DOE organizations responsible for review and approval of the RPPs should have a shared vision of what should be in the completed RPPs before submission f the RPP to DOE. In order to ensure this shared vision and the development of successful RPPs, early and continual dialogue between the RPP submitting organization and the Review Team is essential. This dialogue should begin well before the RPP is submitted to DOE. The process described below was built on the lessons learned in similar efforts and was designed to facilitate that dialogue.

Because review and approval of the RPPs will often involve multiple Departmental organizations, the review and approval process should provide for coordination, consistency of review, and resolution of issues among those offices. In addition, the review and approval process should address both the technical adequacy of the proposed RPPs and the programmatic responsibilities (i.e., funding and mission). These responsibilities will require additional coordination within the Department as they may reside in different organizations.

The review and approval process should be sufficiently flexible to accommodate the subjects addressed by 10 CFR Part 835 and adequately structured to permit efficient completion of the review and approval within the 180 days [*See* 10 CFR 835.101.(i)]. Table 1, at the end of this attachment, provides recommended time periods to meet this 180-day requirement.

In the review and approval process, the Operations Office should be responsible for coordination between the RPP submitting organization and the Department's Headquarters staff. This focused interface will ensure consistency in the information provided to the RPP submitting organization and allow interaction with a single point-of-contact. In addition, the Operations Office should be responsible for coordinating PSO (Program Secretarial Officer) approvals. It should be noted that this attachment contains a detailed protocol. However, individual steps may be modified to or eliminated, based on local conditions, as long as the process involves appropriate review and approval. For example, approval authority may have been delegated to the Manager of the Field Element (or lower), which would obviate the need for specific PSO approval

A RPP Review Team should be formed for each RPP to conduct the review of the RPP. The Review Team members should include DOE Headquarters and Field Operations personnel with technical expertise and coordinating responsibility for program decisions (e.g., funding, schedule). Operations Office personnel should serve as points-of-contact and Review Team Leaders for RPP reviews applicable to their sites. Individual participation in Review Team activities will vary in level of effort and time frame based on review and approval needs.

The Operations Office point-of-contact plays a key role in coordinating all RPP review and approval activities between DOE Headquarters and the RPP submitting organization.

The process for the development, review, and approval of RPPs is discussed below. The provisions of 10 CFR 835.101(i) state that "an initial RPP or an update shall be considered approved 180 days after its submission unless rejected by DOE at an earlier date." See Table 1 for a typical schedule of activities to meet this provision.

3.A 3.1.1 Identifications of Responsible Review Staff

3.A 3.1.1.1 Points-of-Contact

Each Operations Office Manager should identify a point-of-contact for the RPP. The Operations Office point-of-contact should be the primary interface for all activities associated with the development, submittal, review, and approval of the RPPs. The Operations Office point-of-contact should also be the Review Team Leader.

The Review Team Leader should coordinate assignment of Review Team members with the PSOs and the Operations Office.

3.A 3.1.1.2 RPP Review Teams

As discussed in the previous paragraph, the Operations Office point-of-contact should normally be the Review Team Leader. The Operations Office Manager may provide additional team members and technical assistance as necessary. In addition, each affected PSO should identify the Program Office representatives for each Review Team to the Review Team Leaders. The PSO may assign multiple reviewers to a single site or a single reviewer.

3.A 3.1.2. Review Planning

3.A 3.1.2.1 RPP Guide

Each responsible PSO should prepare an RPP Guide that defines DOE's specific technical and programmatic expectations for the RPPs internal to their organization. The guide should include the following types of information: (1) criteria and/or checklists of items to be considered during the review, (2) approaches to key issues, (3) direction on use of existing RPPs and approvals, (4) review and approval authorities, and (5) specific issues relating to Headquarters or Operations Office review responsibilities. The guide should be as brief as possible, should be user friendly, and should not repeat general guidance available in other guidance documents such as this attachment. The PSO should provide assistance and/or training to the Review Teams on the use of the guide.

3.A 3.1.2.2 Implementation Action Plan

For each RPP, the Review Team Group should prepare an Implementation Action Plan that defines the Review Team activities, priorities, and schedule. A copy of the plan should be provided for information.

3.A 3.1.2.3 Responsibility and Interface Matrix

The PSO should prepare and maintain a matrix that identifies the Review Team Leader, Review Team members, and DOE programmatic and technical contacts for each RPP.

3.A 3.1.3 Meetings, Conference Calls, and Status Reports

3.A3.1.3.1 Initial Site Meeting

The Review Team should meet with the RPP submitting organization at the earliest feasible date to discuss the basic expectations for implementation of the DOE requirements document and to discuss any issues that might impact the timely and acceptable completion of the RPP. Issues to be discussed should include (1) how to best use existing plans or other information in developing the RPP; (2) potential exemptions; (3) plans and schedules for ongoing interactions; and (4) funding sources for new activities identified as necessary to come into compliance. The Operations Office point-of-contact has primary responsibility for planning and coordinating this meeting.

3.A 3.1.3.2 Status Meetings

Periodic status meetings should be held with the RPP submitting organization to fully discuss all elements of the proposed RPPs that could affect the acceptability of the RPPs.

3.A3.1.3.3 Periodic Conference Calls

The Operations Office point-of-contact should coordinate regular conference calls with the RPP submitting organization and the Program Offices to address and resolve issues as they arise. As necessary, site or headquarters meetings should be held to resolve difficult issues. The Operations Office point-of-contact has primary responsibility for coordinating phone conferences, as well as necessary meetings to resolve issues.

3.A 3.1.4 Submittal and Distribution of RPPs

As discussed in Section3.A 2 of this attachment, RPPs should be submitted directly to the Operation Office point-of-contact. The Operations Office point-of-contact should transmit a copy of the RPP to the Review Team members and a copy of the transmittal memorandum to the affected PSOs within four working days of the receipt of the RPP. The transmittal memorandum should identify the required date for completing the review.

3.A 3.1.5 Review

3.A 3.1.5.1 Review to Review Teams

RPPs should be reviewed by an integrated Review Team with Program and Operations Office representatives, as discussed in Section3.A 3.1.1.2 above. Program Office team members and their contacts should, as a minimum, participate in the review of issues involving funding, missions, schedules, priorities, and exemptions. The Review Team

Leader should facilitate resolution of unique or difficult issues not addressed in the RPP Guide.

Review Team members should assist the RPP submitting organization in clearly understanding what actions or changes are necessary to result in an acceptable RPP. DOE comments and feedback should be routed through the Review Team Leader to ensure consistent feedback. The Review Team Leader should also be responsible for resolving conflicts prior to communication with the RPP submitter.

All reviewers should expedite their reviews to allow closure on an acceptable RPP as early as possible.

3.A 3.1.5.2 Delegated Approval Authority for RPPs

The PSO may delegate the authority to approve specific RPPs. Any such delegation should be provided in writing to the designee and documented in the Functions, Responsibilities, and Authorities (FRA) document for that organization.

Wherever the authority to approve an RPP has been delegated to the Operations Office by all of the affected PSOs, the Operations Office may choose to have the Review Team consist entirely of Operations Office personnel provided any technical and programmatic requirements can be handled by the designated team.

Per 10 CFR Part 820, Subpart E, the authority to approve exemptions to 10 CFR Part 835 cannot be delegated.

3.A 3.1.6 Approval

3.A 3.1.6.1 Approval Recommendations by the Review Team

The Review Team Leader is responsible for ensuring that the Operation's Office Manager receives the Review Team's final recommendation for approval within 145 days after receipt of the RPP. That recommendation should either endorse acceptance of the RPP as submitted (or changed through negotiations during the review process) or, if issues cannot be resolved, provide recommendations regarding specific additional commitments or changes to be incorporated in the RPP.

3.A 3.1.6.2 Operations Office Review of the Review Team Recommendations

The Operations Office Manager, or equivalent, should review the recommendation of the Review Team and either endorse the recommendation or provide specific recommendations for an acceptable RPP. The Operations Office Manager is responsible for ensuring that the PSO receives the recommendations of the Review Team along with any recommendations from the Operations Office no later than 159 days after receipt of the RPP [with information copy to the affected CSOs [Cognizant Secretarial Officer)].

In some cases involving multiple PSOs, approval authority may be delegated by one or more PSOs, but not all PSOs. In such cases, the Operations Office Manager should coordinate the remaining approvals with the PSOs.

For cases in which the approval authority has been delegated by all affected PSOs to the Operations Office Manager, the Operations Office Manager should skip to step 3.A 3.1.6.4 Approval Letter, below.

3.A 3.1.6.3 PSO Approval Memorandum

In order to ensure the Operations Office has a week to transmit the approval or disapproval of the RPP before it becomes automatically effective 180 days after receipt of the RPP by DOE, each affected PSO should indicate approval or disapproval of the RPP in a memorandum to the Operations Office within 173 days of receipt of the RPP by DOE.

3.A 3.1.6.4 Approval Letter

The Operations Office Manager should transmit the approval memorandum by letter to the RPP submitting organization no later than 180 days after receipt of the RPP by DOE.

3.A 3.1.6.5 Imposition of RPPs

The Review Team will endeavor to resolve any issues identified during the review process. If conflicts exist which cannot be resolved, the Department may exercise its authority [see 10 CFR Part 835.101(b)] to modify proposed RPPs to include those actions and schedules that the Department finds appropriate for achieving full compliance in a reasonable and timely manner. In such cases, the PSO approval memorandum should be replaced with a memorandum imposing a revised RPP. The revised RPP should be transmitted to the RPP submitting organization by the Operations Office Manager. The RPPs may be renegotiated at a later date, but until it is replaced by another approved RPP, it will be the enforceable basis for implementation of 10 CFR Part 835.

3.A 3.1.6.6 RPPs which are not Approved by Final Date

Per 10 CFR Part 835.101(I), RPPs which are not approved within the approval period specified in the DOE requirements document should be considered to be approved unless another RPP is imposed by the Department. These RPPs may be renegotiated at a later date, but until they are replaced by another approved RPP, they will be the enforceable basis for implement of 10 CFR Part 835.

3.A3.1.6.7 Approval of RPPs Containing Exemption Requests

RPPs may contain requests for exemptions. When they do, the requests may be granted in the approval memorandum for the RPP, provided that all of the requirements for processing exemptions are met, including the approval of the DOE Headquarters official

designated by 10 CFR Part 820 Subpart E. When exemptions are approved as part of an RPP, the approval document should state how the provisions of 10 CFR Part 820, Subpart E were met. Alternatively, exemptions may be approved separately and referenced in the RPP approval letter.

Upon submittal of the RPPs, the Review Team Leader should determine if any exemption requests submitted in the RPPs need to be reviewed and approved separate from the RPPs. Where separate review and approval is necessary, the Review Team Leader should alert the PSO Review Team representatives to initiate a separate and expeditious review of the exemption requests.

The provision in 10 CFR 835.101(i) that states that RPPs are considered approved 180 days after submission, does not apply to exemptions.

Approval of an RPP pending granting of an exemption does not constitute or imply approval of the exemptions contained therein.

3.A 3.2 DISTRIBUTION OF COPIES OF THE FINAL RPP

The Operations Office Manager should be responsible for distributing approved RPPs (if changed from the originally submitted RPP), the Office of the Docketing Clerk (in the Office of Price Anderson Enforcement), and to the affected PSOs. Copies of approved RPPs transmitted to the Office of Docketing Clerk should include both a hard copy and an electronic copy. As required by 10 CFR Part 820, the Office of Docketing Clerk will maintain a file of enforceable actions based upon rule violations and noncompliance with RPPs.

3.A 3.3 REVIEW RESPONSIBILITIES

The Review Team should determine if the RPP provides an acceptable method to meet 10 CFR Part 835. The Review Team should also determine if the RPP adequately addresses the elements discussed in Section 3.A 1 of this attachment (Preparation of RPPs). RPP submitting organizations are encouraged to use the methodologies contained in this Guide for implementation of 10 CFR Part 835 where they are reasonable and economical; however, one may elect to propose an alternate way to meet the requirements. In cases where an alternate method is proposed, the Review Team should evaluate the proposed method to ensure that it will be adequate to meet the requirements and provide a comparable level of safety.

The Review Team should verify that the RPP provides sufficient detail to permit DOE to measure the progress towards meeting the DOE requirements.

The Review Team should also ensure that (1) the projected budget and schedule information contained in the RPP is reasonable and consistent with the funding projects, (2) the prioritization of efforts meets the DOE expectations, (3) the proposed milestones

and schedules will meet DOE needs, (4) the applicability of the requirements is correctly identified, and (5) the compensatory actions are acceptable.

The Review Team should expect to see significant variations in the level of detail and size of individual RPPs because of the diversity of types, sizes, and missions of DOE facilities. In order to facilitate timely reviews and agreements on complex RPPs, the members of the Review Team should visit the site and/or facility and have frequent communication during both the preparation and the review of the RPP.

3.A 3.4 APPROVAL RESPONSIBILITIES

DOE approval of the RPP constitutes acceptance by the PSO that:

(1) The proposed activities represent an acceptable method to meet the requirements;

(2) The resources identified in the RPP are necessary and sufficient to ensure completion of the activities contained in the RPP and are expected to be available to support the proposed schedules;

(3) The proposed milestones and schedules are acceptable;

(4) The applicability of the requirements is correctly identified; and

(5) The identified compensatory actions are acceptable.

3A 4. REVISIONS TO RPPs

The RPPs will probably need to be revised and updated during the life cycle of the site, facility, or activity. Approved RPPs should be revised as needed to reflect the addition or deletion of other work at a facility or other factors that affect the ability to meet the approved schedule, such as prospective changes in the level of funding or assumptions regarding the availability of materials and other resources. The provisions in 10 CFR 835.101(h) contain conditions under which RPPs may be revised without prior approval from DOE. In such cases, submit the revised RPP to DOE within 30 days of the effective date of the RPP. All other changes to RPPs should be reviewed and approved by DOE prior to the effective date of the change. Revised RPPs should be submitted in a timely manner for DOE approval (at least 180 days before the change is to be effective), along with justification for the revision. As noted previously, proposed revisions will be considered approved 180 days after submittal to DOE, unless they are approved or rejected by DOE.

The changes to the RPP should be clearly indicated (e.g., sidebars) to facilitate timely review. Revised RPPs are to be submitted to DOE in the manner described in this section and reviewed and approved in the manner described in section 3.A.3 above.

Any changes to RPPs which will result in a requirement not being met, require an approved exemption.

3.A 5. EXTENSIONS TO THE SUBMITTAL SCHEDULE FOR RPPS

Extensions to the schedule for submitting an RPP will generally require an exemption processed in accordance with 10 CFR Part 820, Subpart E, and approved by the Secretarial Officer responsible for environment, safety and health matters (i.e., the Chief Health, Safety and Security Officer).

3.A 6. IMPLEMENTATION TRACKING

Following approval of the RPP and during the implementation process, the DOE Operations Office should oversee progress in meeting the commitments in the RPP (for example, schedules, milestones, and costs) and maintain a dialogue on any problems that arise.

3.A 7. INCORPORATION BY REFERENCE

The RPP submitting organization may choose to incorporate information into the RPP by referencing all or selected portions of other documents. In such cases, the portions of the referenced documents that are incorporated into the RPP are also subject to the provisions of this Guide and attachment.

However there are situations when a citation or reference is used to indicate the origin of some of the text in a document. For example, in this Guide, 10 CFR Part 835 is cited to indicate the basis for statements containing word "should" or "shall" (i.e., requirements). Consequently, the RPP submitting organization should clearly indicate which documents (or portions of documents) are considered part of the RPP commitments. The RPP submittal should maintain a file of all documents incorporated by reference and should make non-DOE documents available to DOE upon their request. See also section 3.A 1.2 above for submittal criteria.

Table 1. TYPICAL SCHEDULE FOR REVIEW AND APPROVAL OF RPPS

Submittal of RPP to Operations Office	0 days
Operations Office send RPP to Review Team/PSOs/Environment, Safety and Health	4 days
Review Team sends recommendation to Operations Office Manager	145 days
Operations Office Manager sends recommendation to PSO*	159 days
PSO Approval to Operations Office*	173 days
Operations Office Manager issues approval/disapproval to RPP submitting organization	180 days

*If approval authority not delegated to the Operations Office by the PSO.

4.0 ALARA

In promulgating 10 CFR 835, DOE considered alternatives to reduce the risk from radiation exposure to workers that included retaining the current occupational dose limits, reducing these limits, and emphasizing efforts to maintain occupational doses As Low As is Reasonably Achievable (ALARA). After considering public comments on this issue, DOE elected to emphasize the ALARA process to maintain occupational dose for DOE and contractor employees well below the current regulatory occupational dose limits. Adopting the ALARA process in DOE occupational radiation protection regulations also provides consistency with recommendations provided in the President's Radiation Protection Guidance to Federal Agencies For Occupational Exposure (EPA 1987), which endorsed the ALARA process.

The importance of the ALARA concept was further stressed in DOE P 441.1, *DOE Radiological Health -and Safety Policy* (DOE 1996), which states:

> *It is the policy of the Department of Energy to conduct its radiological operations in a manner that ensures the health and safety of all its employees, contractors, and the general public. In achieving this objective, the Department shall ensure that radiation exposures to its workers and the public and releases of radioactivity to the environment are maintained below regulatory limits and deliberate efforts are taken to further reduce exposures and releases as low as reasonably achievable. The Department is fully committed to implementing a radiological control program of the highest quality that consistently reflects this policy.*

10 CFR 835 requires formal plans and measures for maintaining occupational exposures ALARA as part of the documented radiation protection program (RPP). Measures include incorporating ALARA considerations into the design of new facilities and modifications of existing facilities, as well as activities that pose the potential for significant occupational dose. Additionally, administrative controls are addressed as measures which supplement physical design features and controls and are integrated into the work planning process. Record keeping and training requirements related to ALARA are also specified. This chapter of this Guide discusses acceptable methods for implementing the ALARA process provisions in 10 CFR 835.

Due to the complex nature of many DOE activities, a combination of radiological and non-radiological hazards may be encountered. Identification of non-radiological hazards is critical to the ALARA process, because efforts to apply the ALARA process may inadvertently increase risks from non-radiological hazards. An integrated safety management approach that optimizes worker protection from all hazards should be considered in the ALARA process for a given DOE activity.

4.1 Implementation Guidance

Subpart B of 10 CFR 835 requires that a DOE activity shall be conducted in compliance with an RPP approved by DOE [10 CFR 835.101(a)]. The content of the RPP shall be

commensurate with the nature of the activities performed and shall include formal plans and measures for applying the ALARA process to occupational exposure [10 CFR 835.101(c)]. Subpart K of the rule provides requirements for design and control for maintaining radiation exposures ALARA. The primary methods used for maintaining radiation exposures ALARA in controlled areas shall be physical design features; administrative controls may be used as supplemental features and for specific activities where physical design features are impractical [10 CFR 835.1001(a) and (b)]. The rule specifies objectives for design of new facilities or modifications to existing facilities (10 CFR 835.1002) and the integration of work controls during routine operations (10 CFR 835.1003). Additionally, the rule requires documentation of the actions taken to maintain occupational exposures ALARA, including actions required by the RPP, as well as facility design and control actions [10 CFR 835.704(b)].

Guidance on complying with the training requirements of 10 CFR 835.103 and 835.901 is provided in Chapters 3 and 14 of this Guide.

This chapter provides the basic guidelines for conducting an occupational ALARA program. It includes the requirements and guidance for developing, implementing, documenting, and providing feedback and lessons learned for improving the program to reduce individual doses to levels that are ALARA.

4.2 ALARA Programs

4.2.0 Formal Plans and Measures

The method of implementing an ALARA program is highly dependent on the complexity and magnitude of potential radiological hazards associated with the DOE activity. The elements of an effective ALARA program should be identified in a formal ALARA plan or procedure. The RPP shall clearly identify the ALARA plans and measures employed by the DOE activity [10 CFR 835.101(c)]. The degree of formality and the level of detail contained in these plans and measures and other pertinent documentation should be commensurate with the magnitude of the radiological hazard associated with the DOE activity. A DOE activity with higher collective dose and/or potential for significant occupational doses should have more detailed ALARA documentation than an activity with low collective doses and/or potential for significant occupational doses. ALARA plans and measures should address the following elements at a level commensurate with the radiological hazards associated with the DOE activity:

- Policy and Management Commitment: Establish commitment and participation of all line management and all levels of the work force;

- ALARA Training: Require ALARA training for all employees, including managers involved with any aspect of radiological operations. Guidance is provided in Chapters 4 and 14 of this Guide and the RCS;

- Plans and Procedures: Consider administrative and engineering controls and optimization methods during work procedure development to assure that the

ALARA process is fully integrated into the development of operational/experimental plans, procedures, and protocols. Document formal plans and measures for applying the ALARA process to occupational doses;

- Internal Assessments/Audits: Conduct comprehensive internal reviews, audits, and evaluations periodically and report the results to the highest levels of site management. Guidance is provided in Chapter 3;

- ALARA Design Review: Ensure the integration of appropriate methods and considerations during the design phase to maintain occupational exposures ALARA during subsequent construction, modification, and operation of the equipment or facility;

- Radiological Work/Experiment Administration and Planning: Implement controls and use optimization methods to assure that occupational dose is maintained ALARA for routine and special operations or experiments; and

- Records: Maintain documents that demonstrate compliance and that the program is adequately carried out. Guidance is provided in Chapter 13.

4.2.1 Policy and Management Commitment

Management commitment to ALARA, consistent with the DOE *Radiological Health and Safety Policy*, is a critical element in ensuring a successful ALARA program. This commitment should take the form of a formal, written, policy statement from a high level of corporate management, generally the senior site executive or company officer responsible for radiological activities that cause the exposures. This commitment should hold all levels of management and individual workers responsible for adhering to the company's ALARA policy. If appropriate, union leadership endorsement of the ALARA policy should be considered.

Senior site and line management should demonstrate their support of the ALARA program through direct communication, instruction, inspection of the workplace, and actions including:

- management decisions that place ALARA considerations before cost or schedule considerations (in accordance with numerical criteria; see section 4.2.5 below);

- encouragement of and praise for workers who identify ALARA solutions;

- support of the ALARA Committee; and

- publication of ALARA success stories.

All site personnel should be made aware of management's commitment to ALARA and radiological workers should be instructed on their responsibility to comply.

Management's ALARA commitment statement should be periodically updated and reaffirmed.

4.2.2 ALARA Training

Specialized ALARA training should be developed for personnel who plan, prepare, schedule, estimate, or engineer jobs that have the potential for significant radiological consequences. The purpose of training these personnel in ALARA concepts and techniques is to empower them to include ALARA considerations in the early phases of job planning and engineering. This training should provide the basics of ALARA concepts and the use of ALARA related equipment such as containment devices, shielding, ventilation, and special tools. Topics such as radiological waste minimization, application of decontamination efforts, and basic contingency planning for mitigation of accidental spills and releases may also be appropriate. DOE has developed specialized training material for these types of positions in DOE HDBK 1110-97, ALARA TRAINING FOR TECHNICAL SUPPORT PERSONNEL (DOE 1997e).

Discipline-specific ALARA training may be appropriate for some organizations including: operations, maintenance, engineering, production, and construction (craft workers). Chapter 3 provides additional guidance with respect to training for such individuals under 10 CFR 835.103. Mock-up training may be appropriate for craft workers and others to prepare them for unique and/or high dose jobs.

4.2.3 Plans and Procedures

10 CFR 835.101(c) requires that the content of each RPP be commensurate with the nature of the activities performed and include formal plans and measures for applying the ALARA process to occupational exposures. The RPP (approved by facility management and DOE) and supporting procedures (approved by facility management) should describe the organization, responsibilities, and method of operation of the ALARA program. These documents should be reviewed and updated according to an established schedule. Chapter 3 provides additional guidance with respect to procedures required under 10 CFR 835.104.

4.2.4 Internal Assessments/Audits

10 CFR 835.102 requires that internal audits of the RPP be conducted such that all functional elements are reviewed no less frequently than every 36 months and shall include program content and implementation. The ALARA program is one of these functional elements. Chapter 3 provides detailed guidance concerning internal audits. Management's responsibilities for reviewing, auditing, and evaluating the ALARA program should be clearly documented. The occupational ALARA program should be evaluated by an individual(s) or members of the ALARA Committee with no direct responsibility for implementing the program.

4.2.5 ALARA Design Review

10 CFR 835.1001 requires that measures be taken to maintain radiation exposures in controlled areas ALARA. The primary method used shall be physical design features (e.g., confinement, ventilation, remote handling, and shielding); administrative controls shall be incorporated only as supplemental methods and for specific activities where physical design features are demonstrated to be impractical (10 CFR 835.1001). 10 CFR 835.1003 further requires that during routine operations, the combination of design features and administrative controls shall provide that the anticipated occupational dose to general employees does not exceed regulatory limits and that the ALARA process is utilized for personnel exposures to ionizing radiation. Physical design features typically include features that are used to control the work environment, such as permanent structures, systems, and controls, including shielding, filtered ventilation systems, remote controls, containment devices, and the use of designs and materials that facilitate operations, maintenance, and other activities. Physical design features may also include engineering controls (e.g., temporary shielding, confinement and ventilation systems) that are typically used to facilitate short-term or emergent operations when the installed physical design features do not provide the desired level of protection. In addition to the physical design features, initial consideration should be given to elimination or substitution of the hazards where feasible and appropriate. This could include use of non-radioactive material or sources. Administrative controls typically include controls that are implemented by the individual at the work site, including written procedures, technical work documents, work authorizations, and other controls that are used to guide individual actions in a manner that will facilitate implementation of the ALARA process.

DOE has an approved set of directives concerning radiological design criteria for the design, construction, operation, and decommissioning phases of its nuclear facilities. (See list below.) The appropriate ALARA design features should be incorporated into modifications of existing facilities and/or equipment and designs of new facilities and/or equipment as early as possible in the engineering and design process. From early in the design phase and throughout the project, a radiological engineer or representative of the radiation protection staff should be assigned to the design team. This individual should ensure that reasonable radiological considerations have been integrated into the design, construction procedures, proposed operating procedures, and plans for decommissioning. Numerical criteria (e.g., dollars per rem avoided) developed for site ALARA decisions should be used to determine those design features that are reasonable. An individual with expertise in radiation protection, preferably from the site staff, but at least familiar with the site program, should perform an independent ALARA design review that includes the following elements:

- review the general configuration of the facility and/or equipment, considering traffic patterns, location of radiation areas, location and size of changing rooms, adequacy of personnel decontamination facilities, location of fixed monitoring

equipment, and adequacy of space for anticipated operations, maintenance, production, research, and decommissioning. Facility design and selection of materials shall include features that facilitate operations, maintenance, decontamination, and decommissioning [10 CFR 835.1002(d)]. The RCS provides additional guidance;

- verify that radiological design criteria are consistent with applicable federal/state regulations, recognized standards and guides, and with the following DOE directives relating to radiological safety in design:
  - 10 CFR 835;
  - DOE 5400.5; *Radiation Protection of the Public and the Environment* (DOE 1993a);
  - DOE P 441.1; *Department of Energy Radiological Health and Safety Policy*
  - DOE O 420.2B, *Safety of Accelerator Facilities* (DOE 2004a);
  - DOE 5480.30, *Nuclear Reactor Safety Design Criteria* (DOE 1993b);
  - DOE O 420.1B, Facility Safety (DOE 2005d);
  - DOE O 413.3A, *Program and Project Management for the Acquisition of Capital Assets* (DOE 2006b);
  - DOE 435.1, *Radioactive Waste Management* (DOE 2001f); and
  - the RCS.
- verify that the design of the confinement and ventilation systems provides the required level of protection from airborne contamination, giving particular attention to patterns of air flow and to the locations of air inlets, penetrations, and exhausts. Releases of radioactive material to the workplace atmosphere should be avoided under normal operating conditions and inhalation of such materials by workers should be controlled to the extent reasonably achievable;
- evaluate and confirm the adequacy of specific control devices for reducing occupational doses, including shielding, hoods, glove boxes, containments, interlocks, barricades, shielded cells, decontamination features, and remote operations. External sources of radiation in areas of continuous occupational occupancy (2,000 hours/year) shall be maintained below an average of 0.5 millirem (0.005 mSv) per hour and as far below this average as is reasonably achievable. For areas where occupancy differs from the above, external dose

rates should be ALARA and should be maintained at a rate so as not to exceed 20% of the limits in 10 CFR 835.202;

- verify that the design will be able to maintain personnel entry control for each radiological area, commensurate with existing or potential radiological hazards within the area, by using one or more of the methods listed in 10 CFR 835.501;

- verify that each entrance or each access point to high and very high radiation areas will have the control features required by 10 CFR 835.502; and

- assess the adequacy of planned radiological monitoring and nuclear criticality safety instrumentation and determine whether the proposed instrumentation is appropriate for the expected types, levels, and energies of the radiation(s) to be encountered, and whether it has sufficient redundancy and capability for operation under normal operating conditions and during emergencies [10 CFR 835.401(b)].

The ALARA design review should have six discrete phases:

- dose assessment;

- review of projected radiological conditions against the trigger points or numerical criteria established by management to initiate a review (e.g., creation of a new radiation source or an increase in the dose rates from an existing source that causes increased projected facility lifetime collective dose of greater than 5,000 millirem (50 mSv) or annual collective dose of 1,000 millirem (10 mSv), from operations, maintenance, production, research, inspection and decommissioning activities);

- identification of the applicable radiological design criteria;

- review of similar facilities, designs, and processes to assist in the selection of optimum ALARA design features and less costly alternatives using approved numerical criteria; and,

- incorporation and documentation in the design package of features to reduce the: exposure of personnel; spread of radioactive contamination; release of radioactive effluent; and creation of radioactive waste; and

- post-construction review of effectiveness of ALARA engineering features to provide feedback to the design engineers and help refine the design process. The ALARA design review should be conducted and documented in accordance with an approved procedure and the design review package should be readily retrievable. Detailed radiological design considerations are discussed in

PNL-6577, Health Physics Good Practices for Reducing Radiation Exposures to as Low as Reasonably Achievable (ALARA) (PNL 1988a).

Optimization Methodology

Optimization methods are required to assure that occupational exposure is maintained ALARA in developing and justifying facility designs or modifications and physical controls. Optimization methodology provides the technical and managerial basis for setting numerical criteria for ALARA decisions in the design of facilities, development or review of work processes, and the design/purchase of special tools and equipment. Selection of an appropriate cost benefit factor for reducing occupational dose involves a judgment of the relative value of dose, normally in terms of dollars per rem avoided. Additionally, guidance on optimization methodology will also provide the basis for selection of trigger points or collective dose values (facility lifetime, facility annual, job lifetime, one time job, etc.) above which an ALARA design review or job review is appropriate. Numerical criteria for ALARA decision making should include radioactive waste volume, radioactive effluent, contamination levels, and airborne radioactivity levels. Optimization methodology has led to a multi-attribute analysis technique which discussed extensively in ICRP Publication 37, *Cost-Benefit Analysis in Optimization of Radiation Protection* (ICRP 1982) and ICRP Publication 55, *Optimization and Decision-making in Radiological Protection* (ICRP 1990).

At sites with significant collective dose, formally documented optimization methodologies should be developed for ALARA reviews and decisions on implementation of ALARA efforts should be developed. This may be on a site- or facility-specific basis. Application of optimization methodologies to the ALARA process should lead to consistent, rational, repeatable decisions as to which ALARA efforts are justifiable. The level of effort involved in documenting ALARA decisions should be commensurate with the potential dose savings to be realized. A detailed evaluation need not be made if its cost, including the cost of documentation, outweighs the potential value of the benefits. The procedure used to evaluate the "appropriateness" of dose-reduction and contamination minimization decisions should be maintained. The RCS and PNL-6577 provide additional guidance on optimization methodologies.

4.2.6 Radiological Work/Experiment Administration and Planning

10 CFR 835.1003 requires that during routine operations, the combination of design and administrative controls shall provide that the anticipated occupational dose to general employees shall not exceed the limits established in 10 CFR 835.202 and that the ALARA process is utilized for personnel exposures to ionizing radiation. Additionally, 10 CFR 835.501(d) requires written authorizations to control entry into and perform work within radiological areas. Often, these written authorizations take the form of radiological work permits (RWP) or technical work documents (TWD) associated with jobs or experiments. These written authorizations provide a convenient mechanism to integrate ALARA review of work tasks if the requirement for ALARA review is embodied in the written authorization. Optimization methodologies should be used to develop trigger points or numerical criteria be developed for conducting ALARA reviews

of job tasks. These criteria should be incorporated into the written authorization to require ALARA review when appropriate. The RCS provides detailed guidance on the development and use of RWPs and TWDs.

4.2.6.0 Job/Task/Experiment Reviews

A formal ALARA job/task/experiment review should be performed for work or experiments with the potential to exceed the established numerical radiological criteria. The following are examples of criteria that should trigger a formal ALARA review.

- the estimated individual or collective dose is greater than pre-established criteria.
- the predicted concentrations of airborne radioactivity could exceed pre-established criteria (such as 100 times the DAC values provided in 10 CFR 835 Appendices A and C).
- there is potential for significant radiological exposures.
- the removable contamination in work areas could exceed pre-established criteria (such as 100 times the values provided in 10 CFR 835 Appendix D).
- individuals will enter areas where exposure rates could exceed pre-established criteria [such as 1 rem/hour (0.01 Sv/hr)].

The ALARA job/task/experiment review should encompass three discrete phases: (1) pre-job planning and dose assessment; (2) specification and implementation of ALARA controls and dose tracking; and (3) post-job review.

Pre-job Planning and Dose Assessment

Pre-job planning should include an estimate of the collective dose resulting from the job/task/experiment and a determination regarding whether the numerical criteria for an ALARA job/task/experiment review will be exceeded. The estimates may be based on actual or historical radiological monitoring results. If a review is required, the next

step is to identify appropriate ALARA controls and alternatives. This should include an assessment of the cost of controls against numerical criteria.

ALARA Controls

During the work or experiment, periodic inspections should be made to ensure that ALARA controls are being implemented and are effective. Typical ALARA controls implemented in the field include: appropriate use of shielding and personal protective equipment (including respiratory protection devices), monitoring of stay times, minimization of time in radiological areas, maximizing distances from radioactive sources, and effective use of mock-up training and pre-job briefings. In addition,

individual and collective doses should be tracked and periodically compared to the dose estimates to determine if intervention is needed.

Post-Job Review

Criteria should be established to trigger a formal post-job review. Examples include:

- an actual collective dose equivalent of 5 person-rem or greater,
- actual doses outside the range of 25% of pre-job estimates,
- use of the stop radiological work authority,
- issuance of a radiological occurrence/deficiency report, or
- identification of significant lessons learned.

The post-job review should compare the actual person-hours and person-rem with the estimates, evaluate the effectiveness and cost of the ALARA controls, document the lessons learned, and make recommendations on ways to control dose and contamination for similar activities. The ALARA review should be documented and records should be readily retrievable.

In the special case of an ALARA review for a planned special exposure, additional requirements are described under 10 CFR 835.204.

4.2.6.1 Consideration of Non-radiological Hazards

The work planning process should integrate the consideration of other industrial, physical, and chemical hazards that an individual may encounter. Efforts to maintain worker doses ALARA should ensure that the risk of personnel injury from other hazards is not disproportionately increased. The ALARA process must consider the impact of other occupational hazards when optimizing worker radiation dose. For example:

- excessive protective clothing to control personnel contamination events may lead to heat stress situations.
- respiratory protective devices used to reduce intakes of radionuclides may impair visual acuity and communications capabilities between workers.
- protective clothing to protect workers from chemical hazards may slow work down leading to increased worker dose.

An integrated approach during the work planning process will ensure that all occupational hazards are appropriately considered and the ALARA process is followed.

10 CFR 851, *Worker Safety and Health Program* (DOE 2006c) provides requirements for worker safety and health. The worker safety and health program must integrate the

Rule's requirements with other site worker protection activities and the integrated safety management system (ISMS) [851.11(a)(3)(ii)]. Coordination should be established, maintained, and documented among worker safety and health technical disciplines and other safety and health organizations (e.g., radiation control) at a site to ensure successful implementation of the worker safety and health program.

Additional information concerning DOE expectations for integrating safety management can be found in Department of Energy Acquisition Regulations (DEAR) clause 48 CFR 970.5223-1, *Integration of Environment, Safety and Health into Work Planning and Execution.* This states that "the contractor will manage and perform work in accordance with a documented Safety Management System (System)."

DOE G 440.1-8, *Implementation Guide for Use with Title 10 code of Federal Regulations Part 851* (DOE 2006d) provides guidance for establishing and implementing an ISMS program.

4.3 Records

Actions taken to maintain occupational exposures ALARA shall be documented and retained [10 CFR 835.701(a) and 835.704(b)]. Administrative controls discussed in this Guide should include the systematic generation and retention of those auditable records and reports that document major actions considered or taken to attain and maintain occupational doses and the spread of radioactive contamination ALARA. The RCS and Chapter 13 provide detailed guidance on record-keeping.

All documents and legal records used to demonstrate compliance with ALARA program requirements should be reviewed and approved by supervisory or line management.

5.0 INTERNAL DOSIMETRY PROGRAM

Radiation protection programs for limiting intakes of radioactive material are based on the DOE policy of controlling radioactive material at the source. It is nonetheless recognized that low-level, chronic, or intermittent occupational exposures to some materials may be difficult to avoid due to the types of material handled or processed, their chemical or physical forms, and the nature of operations, and that incidents may cause unplanned releases of radioactive material. 10 CFR 835.402(c) requires internal dosimetry programs (including routine radiobioassay programs) be conducted for radiological workers, declared pregnant workers, occupationally exposed minors, and members of the public entering controlled areas who are likely to receive intakes that exceed specified levels for committed effective dose equivalent in a year. An internal dosimetry program generally consists of three elements:

- An air monitoring program, using a combination of real-time, fixed, and portable devices, as appropriate;
- an individual monitoring program, using direct and/or indirect radiobioassay, and personal breathing zone (BZ) air monitoring, as appropriate;
- a dose evaluation program that evaluates the data collected by the air and individual monitoring programs to determine the magnitude of individual doses.

5.1 Implementation Guidance

This section provides guidance for establishing and conducting internal dosimetry programs for individuals who have the potential for intakes of radioactive materials. It includes guidance for design and implementation of the radiobioassay program, and guidance for evaluating, recording, reporting, and managing internal doses. Additional technical guidance is provided in DOE-STD-1121-2003, INTERNAL DOSIMETRY (DOE 2003) and the National Council on Radiation Protection and Measurements (NCRP) Report No. 87, *Use of Radiobioassay Procedures for Assessment of Internal Radionuclide Deposition* (NCRP 1987a).

An acceptable internal dosimetry program includes the following features:

- adequate staff with appropriate technical training;
- internal dosimetry technical basis documentation providing scientific information and other rationale explaining essential elements of the internal dosimetry program to support dose evaluation methods;
- written policies and procedures covering essential steps in the activities used to determine worker internal dose;
- criteria and methods for implementing an appropriate air monitoring program;

- defined criteria for identifying workers who need to participate in the individual monitoring program;
- appropriate radiobioassay measurement methods and frequencies;
- methods for control, accountability, and safe handling of samples;
- appropriate dosimetric models and default parameters for evaluating internal dose;
- timely analysis of radiobioassay samples and measurements, transmission of results, dose evaluation, and recommendations to operations management;
- adequate detection capability and quality of radiobioassay measurements;
- defined criteria and actions for identifying individuals with suspected intakes, based on workplace measurements and radiobioassay measurements;
- appropriate action level guidelines;
- defined program to report internal doses to workers, management, and DOE;
- historical records of radiobioassay measurement results and dose evaluations;
- historical records of the program, and changes in the program over time; and a quality assurance program covering essential steps in the activities that determine worker internal dose.

5.2 Program Management and Administration

5.2.0 General Requirements

The internal dosimetry program shall be adequate to demonstrate compliance with the dose limits established in Subpart C of 10 CFR 835 [10 CFR 835.402(d)]. In addition, radiobioassay programs implemented to demonstrate compliance with the requirements in 10 CFR 835.402(c) (individual monitoring thresholds) shall be:

- accredited or excepted from accreditation in accordance with the DOELAP for Radiobioassay [10 CFR 835.402(d)(1)]; or
- determined by the Secretarial Officer responsible for environment, safety and health matters (i.e., the Chief Health, Safety and Security Officer) to have performance substantially equivalent to that of programs accredited under DOELAP for radiobioassay [10 CFR 835.402(d)(2)].

Guidance for achieving accreditation or exception from accreditation under DOELAP is provided in DOE-STD-1111-98, DEPARTMENT OF ENERGY LABORATORY

ACCREDITATION PROGRAM ADMINISTRATION (DOE 1998b). Requests for other program determinations will be considered by DOE on a case-by-case basis.

The provision requiring accreditation for radiobioassay programs implemented to demonstrate compliance with 10 CFR 835.402(c) does not reflect an intent to provide a lesser degree of protection to individuals unlikely to receive doses exceeding the regulatory monitoring thresholds, nor does it express a desire to establish two separate radiobioassay programs (i.e., an accredited program for individuals likely to exceed the regulatory monitoring thresholds and a non-accredited program for individuals who are unlikely to exceed these thresholds). Rather, those individuals who are unlikely to exceed the regulatory monitoring thresholds are provided an adequate degree of protection by the various engineering and administrative controls that limit their internal doses. Implementation of a comprehensive air monitoring program in accordance with 10 CFR 835.401 and 403 verifies the effectiveness of these controls. When an accredited radiobioassay program already exists and management of any given facility chooses to provide monitoring for those individuals who are unlikely to exceed the regulatory monitoring threshold, consideration should be given to using the accredited program. This will obviate the need to implement two radiobioassay programs, one accredited and the other not. In addition, it will avoid giving workers who are not required to be monitored the impression that they are being provided a lesser degree of protection. However, this does not imply that the monitoring program for those unlikely to exceed the monitoring threshold must be accredited.

Sections 401 through 403 of 10 CFR 835 establish specific monitoring requirements for areas and individuals. 10 CFR 835 also establishes requirements for maintaining individual monitoring records (10 CFR 835.702) and reporting radiation doses to individuals (10 CFR 835.801).

5.2.1 Organization, Staffing, and Facilities

5.2.1.0 Organization

The internal dosimetry program should be administered by the radiological control organization under the leadership of the radiological control manager. The internal dosimetry program should have a designated leader with demonstrated expertise in internal dose evaluation. When elements of the internal dosimetry program are performed by one or more subcontractors, the radiological control organization should establish an arrangement of contractual standards and assessments that ensure that subcontractors meet all applicable requirements in 10 CFR 835, the documented Radiation Protection Program (RPP), DOELAP standards, and the internal dosimetry technical basis document.

5.2.1.1 Staffing

The radiological control organization management should ensure that the internal dosimetry program is adequately staffed to carry out its functions. The analysis of workplace and radiobioassay measurement data and the evaluation of internal dose

involve complex evaluation and professional judgment. Personnel with responsibility for internal dose evaluation should have the necessary expertise and skill, based on appropriate education and training in conjunction with practical experience, to perform their assigned duties. Additional guidance on education, skills, and training is provided in Chapter 3. It is important that internal dosimetry specialists be capable of recognizing conditions warranting follow-up radiobioassay and dose evaluation. Personnel should be familiar with the relevant internal dosimetry literature and the recommendations of national and international scientific organizations with regard to internal dose evaluation.

Management of the radiological control organization should establish minimum requirements for those staff who evaluate internal doses. These requirements should include both experience and education requirements. Suggested educational background and formal training needed for internal dosimetry program key positions are listed in DOE-STD-1107-97, KNOWLEDGE, SKILLS, AND ABILITIES FOR KEY RADIATION PROTECTION POSITIONS AT DOE FACILITIES (DOE 1997b). Members of the internal dosimetry staff should meet these requirements, or the staff should have access to individuals with the required background (perhaps through interdepartmental agreements or contracted services). It is not necessary for all personnel on the staff to have expertise in all of the listed subject areas.

5.2.1.2 Facilities and Resources

Computational facilities and software tools used by internal dosimetry personnel should be adequate for performing calculations required for the evaluation of dose from radionuclides in the body. A library of handbooks, reference materials, scientific publications, and other resources pertaining to internal dosimetry should be readily available. Suggested reference materials are included in the reference chapter of this Guide. DOE O 414.1C, *Quality Assurance* (DOE 2005a), establishes quality process requirements to be implemented under a QA program (QAP) for the control of suspect/counterfeit items (S/CIs), safety issue corrective actions, and safety software.

5.2.2 Technical Basis Document

Internal dosimetry technical basis documentation should be developed and should include technical methods, supporting evidence, and reference information used to provide the technical foundation for the internal Dosimetry program. The internal dosimetry technical basis documentation should provide the approach to evaluating internal doses from radiobioassay data, and for situations in which there is no practical radiobioassay, from representative air monitoring or other appropriate data. The technical basis documentation should address all of the topics listed under Section 3.1 of DOE-STD-1121-2003. The technical basis documentation should be reviewed periodically and updated as necessary to ensure that the scientific bases are appropriate for current conditions. The technical basis documentation should be controlled and retained as a radiation protection program record.

5.2.3 Internal Dosimetry Procedures Manual

10 CFR 835 requires that written procedures be developed and implemented as necessary to ensure compliance, commensurate with the radiological hazards created by the activity and consistent with the education, training, and skills of the individuals exposed to those hazards (10 CFR 835.104). Essential elements of the internal dosimetry program should be addressed in written procedures. These procedures should be consistent with 10 CFR 835, the DOELAP standard, and technical basis documentation.

Detailed guidance on topics that should be addressed in the internal dosimetry procedures manual are discussed in Section 3.2 of DOE-STD-1121-2003. Additional guidance on written procedures is provided in Chapter 3 of this Guide.

5.2.4 Quality Assurance

Quality Assurance for internal dosimetry programs is addressed in DOE-STD-1121-2003, Section 11. Quality assurance in support of internal dosimetry programs should be conducted in accordance with this DOE standard.

The internal dosimetry program should be included as a functional element subject to the internal audit requirements of 10 CFR 835.102. Chapter 3 provides guidance on internal audit programs. External peer-review by qualified individuals, on a periodic basis, is also recommended.

5.3 Air Monitoring and Contamination Control Programs

The objectives of an air monitoring program are to verify the integrity of radioactive material containment, detect the release of radioactive materials from some routine operations, detect inadvertent releases of those materials in the workplace, evaluate and provide the basis for modification to containment systems, provide a basis for the design of radiobioassay programs, and verify that selected groups do not need to participate in a radiobioassay program. Air monitoring programs and internal dosimetry programs are complimentary. The air monitoring program provides an indication of the effectiveness of engineering and administrative controls in preventing or minimizing worker intakes and the internal dosimetry program provides verification of the adequacy of these controls in preventing or minimizing worker intakes.

The air monitoring and contamination control programs supplement the individual monitoring program by providing a prospective assessment of radiological conditions, facilitating decisions regarding postings, access controls, work authorizations, and individual monitoring, and providing back-up data for use in individual dose evaluations. Because of the need to evaluate individual internal doses from intakes of radioactive material from uncontained sources, airborne radioactive material, and surface contamination, the air monitoring and contamination control programs should include methods for assessing the degree of hazard arising from each of these hazards to which individuals may be exposed. Guidance for implementing contamination control and air monitoring programs is provided in Chapters 10 and 11 of this Guide.

In most cases the air monitoring program is used to supplement and validate the individual monitoring program. However, in the case when there is no practical radiobioassay method or when there is a technology shortfall (e.g., the *DIL* is less than the *MDA*) the air monitoring program may be the basis for the determination of internal doses. These two cases are discussed below.

5.3.0 Air Monitoring When There Is No Practical Radiobioassay Method

In situations where no radiobioassay method is available for the radionuclides in question, and no radiobioassay program, either routine or special, can show compliance with 10 CFR 835, personal (BZ) air monitoring may be used for demonstrating compliance with 10 CFR 835. BZ air monitoring is part of the Individual Monitoring Program which is detailed below. However, other fixed or portable monitoring instruments that provide either real-time (such as continuous air monitors) or retrospective (such as grab sampling which is analyzed at some time after the sample is collected) may be required when BZ monitoring data is not available or to supplement or validate the BZ data if it is available. Radionuclides with short half-lives, including the short-lived decay products of ^{222}Rn ("radon" decay products ^{218}Po, ^{214}Pb, ^{214}Bi, and ^{214}Po) and ^{220}Rn ("thoron" primary decay products ^{212}Pb and ^{212}Bi) are examples of radionuclides where intakes cannot be determined through radiobioassay and must be determined from personal air monitoring. For detailed information on non-background exposures to radon and thoron, see DOE-STD-1121-2003, Section 4.5. Monitoring programs for Radon and Thoron should be in accordance with the DOE standard.

5.3.1 Recourse for Technology Shortfall (DIL<MDA)

DILs for reasonable and practical routine radiobioassay programs may be significantly less than the achievable *MDA* for certain radionuclides, such as plutonium. Since a technology shortfall for routine radiobioassay exists, the facility should consider the following actions (note that some of these suggested actions fall under the category of individual as opposed to area monitoring, but for completeness they are all listed below):

- enhance contamination and air monitoring and the use of indicators (e.g., unexpected glove or surface contamination, increase in airborne radioactive material contamination) to trigger early special radiobioassay monitoring;
- enhance personal contamination monitoring (e.g., clothing, skin, nasal smears) to trigger special radiobioassay monitoring;
- use the best practicable radiobioassay monitoring methods;
- implement enhanced design, operation, controls, and personnel protection equipment and procedures to minimize intakes;
- implement supplementary air monitoring; and

- document and justify the planned supplementary approach in the facility's internal dosimetry technical basis documentation.

When air monitoring data are used, each worker's stay times (in hours) and the average concentration (in DACs) to which the worker is exposed should be multiplied to yield exposures to airborne radioactive materials in units of DAC-hours. Forty (40) DAC-hours corresponds to 0.1 rem (0.001 Sv) committed effective dose equivalent for radionuclides with stochastic Annual Limits on Intake.

A technology shortfall for routine radiobioassay should not be sufficient cause for failing to place individuals on a minimum or best-available radiobioassay program. Refer to DOE-STD-1121-2003, Section 4.4.4, for a discussion and examples of technology shortfalls and suggested methods to handle such situations.

5.4 Individual Monitoring Program

Individual monitoring programs should be designed in accordance with Section 4 of DOE-STD-1121-2003 and should:

- provide for investigation of suspected intakes;
- provide data for evaluating internal dose; and
- provide results that are adequate to demonstrate compliance with the radiation dose limits given in 10 CFR 835. The primary methods of routine and special worker radiobioassay are direct (in vivo) radiobioassay and indirect (in vitro) radiobioassay.

International Commission on Radiological Protection (ICRP) Publication 54, *Individual Monitoring for Intakes of Radionuclides by Workers: Design and Interpretation* (ICRP 1989) as well as the previously referenced NCRP Report No. 87 are suggested supplementary references for individual monitoring program design. In situations where there is no practical radiobioassay, representative air monitoring (e.g. breathing zone (BZ) air monitoring) is the preferred measurement method on which to base dose evaluations. Additional guidance on air monitoring programs may be found in Chapter 10 of this Guide.

5.4.0 Establishing the Need for Individual Monitoring

Radiological workers who could likely receive intakes resulting in 0.1 rem (0.001 Sv) or more committed effective dose equivalent in a year shall participate in an internal dose evaluation program [10CFR 835.402(c)(1)]. Declared pregnant workers, occupationally exposed minors, and members of the public are also required, under specific conditions [see 10 CFR 835.402(c)] to participate in internal dosimetry programs. Criteria for participation in individual monitoring programs which include baseline radiobioassay, routine radiobioassay and/or air sampling, Radon and thoron monitoring, special radiobioassay, and termination or task-ending radiobioassay, radiobioassay for declared

pregnant women, and confirmatory radiobioassay are covered in DOE-STD-1121-2003, Section 5. This section of the technical standard also discusses timely receipt of radiobioassay results. Participation in individual monitoring programs for internal dosimetry should be in accordance with the DOE technical standard. ICRP Publication 54 is also a recommended reference.

Situations may arise where a decision is made to monitor radiological workers who are not likely to receive intakes that exceed 0.1 rem (0.001 Sv) committed effective dose equivalent in a year. Such monitoring may be useful for demonstrating compliance with 10 CFR 835.401(a) or established for other purposes. The internal dosimetry program documentation should clearly identify those individuals or groups of individuals being monitored for such purposes.

5.4.1 Investigation Levels/Derived Investigation Levels

Refer to DOE-STD-1121-2003, Sections 4.3 and 4.4 for a discussion of and reference levels for Investigation Levels (*ILs*) and Derived Investigation Levels (*DILs*). Programs should be designed in accordance with this technical standard.

Refer to DOE-STD-1121-2003, Section 4.4.1 for a discussion of factors affecting the *DIL*. Additionally, section 4.4.2 provides guidance for calculating the *DIL* for a given sample frequency, Section 4.4.3 discusses factors affecting the *DIL* for air sampling, and Section 4.4.4 deals with supplementing routine radiobioassay programs when $DIL < MDA$ (technology shortfall). Programs should be designed in accordance with this technical standard.

5.4.2 Minimum Detectable Amount (MDA)

The internal dosimetry program staff should determine the minimum detectable amount (*MDA*) for each radiobioassay and BZ air monitoring method for each radionuclide present. The *MDA*s should be documented in procedures and their statistical bases given in the internal dosimetry technical basis documentation. ANSI Standard N13.30-1996, *Performance Criteria for Radiobioassay*, (ANSI/HPS 1996) provides extensive guidance on the calculation of *MDAs*.

As *MDAs* are affected by various aspects involved with individual monitoring methods, procedures should contain descriptions of the method(s) of individual monitoring measurements (e.g., urinalysis, fecal analysis, *in vivo* counting, BZ air monitoring), analytical methodology (e.g., chemical separation followed by alpha counting), and measurement parameters (e.g., counting time or instrument efficiency) to be used in each component of the individual monitoring program.

Several other factors affect the method of radiobioassay used and its associated *MDA*. They include:

- the possible need for improved detection capability to assess individual dose during the special radiobioassay following an intake requiring internal dose

evaluation, due to diminishing amounts of material in compartments as time goes on;

- the need for improved precision and accuracy if residual retention and excretion from prior intakes interferes with the detection of additional intakes in subsequent years;
- timeliness of results needed to manage individuals and keep subsequent intakes low enough to avoid exceeding dose limits;
- convenience to the affected individuals;
- costs, including lost production time while individuals are participating in the radiobioassay program; and
- the impact of the method of radiobioassay on the frequency of radiobioassay measurements.

Where practicable, the method of individual monitoring, analytical methodology, and measurement parameters should result in an *MDA* less than the corresponding *DIL* for all radionuclides to which an individual might be exposed.

The methods of radiobioassay and air monitoring measurements, their *MDA*s, and their accuracies should be specified in the internal dosimetry technical basis documentation, along with a rationale or justification for the methods chosen.

5.4.3 Frequency of Measurement

The routine radiobioassay measurement frequency depends on the radiobioassay measurement method and associated *MDA*. The frequency should be chosen so that it is unlikely that intakes by an individual in a year will result in doses exceeding one *IL* without detection.

5.4.4 Detection and Confirmation of Intakes

Section 6 of DOE-STD-1121-2003 provides acceptable methods for detecting and confirming intakes through workplace monitoring and radiobioassay. Statistical methods for confirming that an intake has occurred are also discussed. Decisions regarding the detection and confirmation of suspected occupational intakes of radioactive material should be based on answers to the following questions:

- Can it be concluded reliably that the analyte is present in the measured sample ($>L_c$)?
- Is the measurement result unexpected? In other words, is the result beyond the range of values that would be expected due to environmental “background” sources or due to previously recognized intakes?

- Is the intake (and resulting dose) implied by the measurement significant enough (e.g., greater than the *IL*) to warrant follow-up measurements or investigation?

If the answer to all these questions is "yes", then follow-up measurements or investigation is warranted. Internal dosimetry programs should establish appropriate and technically-based decision criteria to assist in answering these questions. Such decision criteria should be included in the technical basis document for the site or facility.

The proper decision criteria for the first question is the L_c which is a purely statistical concept based on an acceptable probability of "false positive" conclusions. The L_c for radiobioassay and air sample measurements should be set by considering the acceptable rate of false positives, the cost and consequences of false positives, and the dosimetric consequences of false negatives. The analytical laboratory L_c should be based on a reagent blank. Radiobioassay results above the L_c may be expected in the absence of a new intake due to normal statistical fluctuations, non-occupational or environmental sources, or prior confirmed intakes. In the case of environmental sources of interference (e.g., uranium in urine) an "occupational decision level" should be established, above which the measurement result is concluded to be statistically significant and above the range of values that would normally be expected from environmental sources of the radionuclide. In the case of prior confirmed intakes, an individual-specific "occupational decision level" should be established, which takes into account the expected contribution from the prior intakes. Finally, for each route of intake, measurement type, and radioactive material of interest (taking into account particle size, inhalation class, etc.), time-dependent *DILs* should be established. Such *DILs* are based solely on dosimetric considerations, and typically correspond to an implied intake (and corresponding dose) of 1 investigation level, i.e., 0.1 rem. This Guide has adopted the value of 0.1 rem (0.001 Sv) CEDE as the value which, for regulatory purposes, is regarded as sufficiently important to justify further investigation. However, a site or facility may wish to establish lower follow-up levels for ALARA purposes.

If the measurement result is statistically significant, unexpected, and dosimetrically significant, then follow-up measurements and/or an investigation should be done to attempt to confirm or rule out the intake. An intake should be considered to be confirmed if the three criteria above are satisfied and the measurement result is associated with a known incident, or appropriate follow-up measurements meet the three criteria above, or follow-up investigation indicates that an intake has occurred.

Refer to DOE-STD-1121-2003, Section 6, for additional information on the detection and confirmation of intakes. Table 3 addresses reference levels for interpreting or responding to intake monitoring results. Program elements which address the detection and confirmation of intakes of radionuclides should be in accordance with the DOE technical standard. ANSI N13.30-1996 and ICRP Publication 54 are suggested references. Additionally, NCRP Report No. 84, *General Concepts for the Dosimetry of Internally Deposited Radionuclides* (NCRP 1985) and ICRP Publication 30, *Limits for Intakes of Radionuclides by Workers* (ICRP 1979), may be useful references.

5.4.5 Internal Dose Management

Internal dose management, which includes routine radiological worker dose management, management of dose from previous intakes (work restrictions), control of dose to the embryo/fetus, control of dose to minors and students, dose limitation, interface with the external dosimetry program, lifetime dose control, accidental dose control, and internal dose control after an incident, is covered in DOE-STD-1121-2003, Section 8. Individual programs should be in accordance with the DOE technical standard.

5.4.6 Planned Special Exposures

Planned special exposures are included in an individual's occupational dose record, but shall not be considered when determining compliance with the occupational dose limits of 10 CFR 835 [10CFR 835.204(a)]. In order to maintain separate records of doses resulting from planned special exposures and routine occupational exposures, dosimetry adequate to measure the potential doses and appropriate for the work to be performed and specific radiological circumstances should be provided for the planned special exposure.

5.4.7 Medical Response

Medical response is addressed in DOE-STD-1121-2003, Section 10. The standard addresses situations where internal dosimetry actions and medical treatment occur simultaneously, the role of the health physicist in medical treatment, when to treat, how to treat, the impact of therapy on dosimetry, and the counseling of workers. Medical response should be handled in accordance with the DOE technical standard.

5.5 Internal Dose Evaluation

10 CFR 835 requires internal dose evaluation programs for assessing intakes of radionuclides and for maintaining adequate worker exposure records. Technical details and extensive references for internal dose evaluation are given in DOE-STD-1121-2003. ICRP Publications 30 and 54, NCRP Report No. 84, and ANSI N13.30 are additional suggested references.

5.5.0 Required Dose Calculations

Internal doses should be evaluated for all confirmed intakes, as defined in Section 5.3.5 of this Guide. For intakes confirmed with radiobioassay results below the *DIL*, no further investigation or follow-up radiobioassay are indicated. For intakes confirmed with radiobioassay results above the *DIL* or exposures greater than 40 DAC-hours, follow-up radiobioassay (if practical) and investigation should be performed.

The extent of the investigation and the number and frequency of special radiobioassay measurements following a suspected or confirmed intake should be determined and documented on an individual, case-specific basis, taking into account the potential magnitude of the intake, the effective clearance half-time, the health of the worker, and the number of measurements needed to evaluate the internal dose.

The schedule and frequency of long-term special radiobioassay measurements to evaluate the CEDE to an individual who has had an intake resulting in a dose in excess of one *IL* should depend on the expected magnitude of the CEDE and the likelihood of the individual receiving additional intakes.

While the investigation should be tailored to the specific individual and exposure circumstances, the trigger levels and preliminary actions to be taken for exposures to the different radionuclides encountered at the facility should be documented in the internal dosimetry technical basis documentation and procedures.

5.5.1 Interpretation of Radiobioassay Data

Technical details on the interpretation of radiobioassay data including the use of biokinetic models are given in DOE-STD-1121-2003, Section 7. Radiobioassay data should be interpreted in accordance with the applicable portions of this DOE technical standard.

Evaluations of CEDE from a specific intake should account for expected values of radiobioassay measurements from prior confirmed intakes.

5.5.2 Evaluation of Internal Dose from Radiobioassay and Air Monitoring Data

Methods for evaluating the various doses from intakes should be specified in the internal dosimetry technical basis documentation. The methods should be based on recommendations, consistent with DOE requirements, given in ICRP Publications, NCRP Reports, and ANSI standards which embody improvements and updates of the science of internal dosimetry. Other methods may be used provided they are documented and justified in the procedures and/or internal dosimetry technical basis documentation.

In the calculation of internal doses less than one *IL*, default parameters may be used. These parameters (e.g., intake date, deposition fractions, retention functions, organ masses, and absorption fractions) should be based on the recommendations of the ICRP, NCRP, other relevant technical references, or facility-specific factors as documented in the internal dosimetry technical basis documentation. If the initial evaluation of an intake indicates a dose in excess of 10 times an *IL*, individual-specific and facility-specific factors should be used when more appropriate parameters are expected to change the dose calculations by a factor of 1.5 or more (ICRP Publication 54, paragraph 74). Between 1 and 10 times the *IL*, either default parameters or individual- and facility-specific parameters may be used, as deemed appropriate and documented by the internal dosimetry staff. The basis for determining which individual-specific and facility-specific factors are expected to change the dose calculations by a factor of 1.5 or more should be documented in the internal dosimetry technical basis documentation. Determination of individual retention patterns for a worker requires participation in the special radiobioassay program and may require temporary work restriction or reassignment to prevent subsequent intakes from confounding the dose evaluation.

5.5.3 Periodic Reevaluation of Internal Dose

In the case of certain well-retained radionuclides (e.g., plutonium), long-term follow-up and reevaluation of doses may be required. The internal contribution to lifetime occupational dose should continue to be reevaluated as further radiobioassay results and improved methods for evaluating internal dose become available.

Evaluations for general employees with prior confirmed intakes should be revised when information demonstrates a change in the currently evaluated CEDE of 0.5 rem (0.005 Sv) or a factor of 1.5 of the previously assigned dose for that intake, whichever is higher. In cases where intakes are detected or confirmed in a year subsequent to the year of the intake, the CEDE should be attributed to the known or assumed year of the intake, and all records and reports for that year should be amended as appropriate.

5.6 Recordkeeping and Reporting

Requirements and guidance for recording and reporting internal doses and related information are provided in Chapter 14 and DOE-STD-1121-2003, Section 9. Record-keeping and reporting of internal doses and related information should be in accordance with these DOE documents.

6.0 EXTERNAL DOSIMETRY PROGRAM

Due to the types of material handled or processed, low-level, chronic occupational exposures to external ionizing radiation are difficult to avoid, necessitating an external dosimetry program at most DOE and DOE-contractor facilities that use, handle, or store radioactive materials. An external dosimetry program generally consists of three elements:

- an area monitoring program, using an array of fixed and portable devices, as appropriate;
- an individual monitoring program, using personnel dosimeters; and
- a dose evaluation program that evaluates the data collected by the area and individual monitoring programs to determine the magnitude of individual doses.

6.1 Implementation Guidance

This chapter provides guidance for establishing and conducting an external dosimetry program for individuals who are likely to be exposed to external sources of ionizing radiation. Conduct of an external dosimetry program involves determining area and individual monitoring methods and frequencies, distributing and controlling monitoring devices, and evaluating external doses. This chapter also addresses program organization, administration, staffing, and training.

An external dosimetry program should include the following features:

- adequate staff provided with appropriate technical training;
- a technical basis document that explains each program element;
- procedures that address each step in the activities that determine external dose;
- criteria and methods for implementing the area monitoring program;
- criteria and methods for identifying individuals who require individual monitoring;
- appropriate personnel dosimeter measurement methods and frequencies;
- methods for control, accountability, and safe handling of dosimeters;
- appropriate dosimetric models and default parameters for evaluating external dose;
- timely analysis of personnel dosimeter measurements and transmission of results, dose evaluation, and recommendations to monitored individuals, management, and DOE, as appropriate;

- historical records of the external dosimetry program, procedures, and results; and
- a quality assurance (QA) program that covers all steps in the activities that determine individual external dose.

6.2 Program Management and Administration

6.2.0 General Requirements

The external dosimetry program implemented to demonstrate compliance with 10 CFR 835.402(a) shall be adequate to demonstrate compliance with the dose limits established in Subpart C of 10 CFR 835 [10 CFR 835.402(b)] and shall be:

- accredited by the DOE Laboratory Accreditation Program (DOELAP); or
- excepted from DOELAP accreditation in accordance with the DOELAP standards; or
- determined by the Secretarial Officer responsible for environment, safety and health to have performance substantially equivalent to that of programs accredited under the DOE Laboratory Accreditation Program for Personnel Dosimetry [10 CFR 835.402(b)].

Guidance for achieving accreditation or exception from accreditation under the DOELAP Program is provided in DOE-STD-1111-98. DOE will consider requests for other program approvals on a case-by-case basis.

The specification of accreditation requirements only for programs implemented to demonstrate compliance with 10 CFR 835.402(a) does not reflect an intent to provide a lesser degree of protection to individuals unlikely to receive doses exceeding the regulatory monitoring thresholds, nor does it reflect DOE's intent for it's contractors to establish two separate individual monitoring programs (i.e., an accredited program for individuals likely to exceed the regulatory monitoring thresholds and a non-accredited programs for individuals who are unlikely to exceed these thresholds). Rather, those individuals who are unlikely to exceed the regulatory monitoring thresholds are provided an adequate degree of protection by the various engineering and administrative controls that limit their doses. Implementation of a comprehensive area monitoring program verifies the effectiveness of these controls. When an accredited dosimeter program already exists and management of any given facility chooses to provide monitoring for those individuals who are unlikely to exceed the regulatory monitoring threshold, consideration should be given to using the accredited program. This will obviate the need to implement two dosimeter programs, one accredited and the other not. In addition, it will avoid giving workers who are not required to be monitored the impression that they are being provided a lesser degree of protection. However, this does not imply that the monitoring program for those unlikely to exceed the monitoring threshold must be accredited.

Sections 401 - 403 of 10 CFR 835 establish specific monitoring requirements for areas and individuals. 10 CFR 835 also establishes requirements for preserving dosimetric records and reporting external radiation doses to individuals.

6.2.1 Organization, Staffing, And Facilities

6.2.1.0 Organization

The external dosimetry program should be administered by the radiological control organization under the leadership of the radiological control manager. When elements of the external dosimetry program are performed by a subcontractor, the radiological control organization should establish contractual standards and assessments that ensure the subcontractor meets all applicable requirements in 10 CFR 835, the documented radiation protection program (RPP), DOELAP standards, and the technical basis document.

6.2.1.1 Staffing

Management should maintain an adequate staff with the necessary expertise and skill to implement the external dosimetry program. For staff members responsible for evaluating external doses, management should establish minimum qualification standards that include both experience and education requirements. Additional guidance on education, skills, and training is provided in Chapter 3 and DOE STD-1107-97, KNOWLEDGE, SKILLS, AND ABILITIES FOR KEY RADIATION PROTECTION POSITIONS AT DOE FACILITIES (DOE 1997b). Personnel should be familiar, at a level commensurate with their assigned responsibilities, with relevant external dosimetry literature and related recommendations of national and international scientific organizations.

6.2.1.2 Facilities and Resources

Computational facilities and software tools used by external dosimetry personnel should be adequate for performing calculations required for dose evaluation. A library of handbooks, reference materials, scientific publications, applicable regulations and guidance documents should be readily available.

6.2.2 Technical Basis Document

A technical basis document should be developed for the external dosimetry program to provide (or provide reference to) the regulatory, scientific, and technical foundation of the program. The technical basis document should include:

- the methods used for evaluating external doses from workplace and individual monitoring data and the technical basis for those methods;
- justification of categories selected for participation in and exception from DOELAP personnel dosimeter performance testing;

- QA procedures for dosimeters that are outside of the DOELAP testing protocol, as appropriate;
- the physical characteristics of external radiation to be monitored, methods for calculating external doses, methods for documenting calculations, dose evaluation quality assurance, and procedures for recording and reporting external dose results;
- the methodology used in determining the dose of record when multiple dosimeters are used and when dosimeters are relocated;
- individual monitoring methods, their lower limits of detectability, and monitoring intervals, along with a rationale or justification for the methods and intervals chosen;
- calibration models, parameters, assumptions, and default values used in dosimetric modeling and evaluation; and
- statistical methods for evaluating dosimeter data, using appropriate controls, identifying above-background values, and analyzing trends.

The technical basis document should be reviewed periodically and updated as necessary to ensure that it remains appropriate for current conditions. The technical basis document should be handled as a controlled document and retained as an RPP record.

6.2.3 Procedures

10 CFR 835 requires that written procedures be developed and implemented as necessary to ensure compliance, commensurate with the radiological hazards created by the activity and consistent with the education, training, and skills of the individuals exposed to those hazards (10 CFR 835.104). All functions of the external dosimetry program should be specified in written procedures that provide for appropriate quality control and QA measures. The procedures should be consistent with 10 CFR 835, the DOELAP technical standards, and the technical basis document. In summary, the procedures should provide the following information:

- methods and requirements for measuring, evaluating, and recording external dose;
- methods for consistent collection of workplace and personnel monitoring data, its evaluation, documentation of results, and records maintenance;
- components and reporting structure of the external dosimetry program;
- responsibilities of line management and members of the dose evaluation group; and

- elements of the area monitoring program that are germane to external dose determination.

Additional guidance on written procedures is provided in Chapter 3.

6.2.4 Quality Assurance

Internal audits shall be conducted such that all functional elements are reviewed no less frequently than every 36 months and shall include program content and implementation (10 CFR 835.102). External peer-review by qualified individuals, on a periodic basis, is also recommended. See Chapter 3 for further information on internal audits.

6.3 Area Monitoring Program

The area monitoring program supplements the individual monitoring program by providing a prospective assessment of radiological conditions, thus facilitating decisions regarding postings, access controls, work authorizations, and individual monitoring, and providing back-up data for use in individual dose evaluations. Because of the need to evaluate individual external doses (prospectively and retrospectively) from contained sources, airborne radioactive material, and surface contamination, the area monitoring program should include methods for assessing the degree of hazard arising from each of these hazards to which individuals may be exposed. Guidance for implementing surface contamination and airborne radioactivity monitoring programs is provided in Chapters 10 and 11. Guidance for implementing area monitoring for other external sources of radiation is provided below. For each element of the area monitoring program, additional guidance is provided in Chapter 5 of the RCS.

6.3.0 Monitoring Instruments and Devices

External radiation monitoring instruments and devices include both fixed and portable instruments that provide real-time indication of radiation levels and passive monitoring devices (such as TLDs and radio-sensitive film) that provide a retrospective indication of radiological conditions. Guidance on portable instrument selection, calibration, and checking for operability is provided in Chapter 9. While Chapter 9 addresses portable instruments, many of the concepts and practices discussed in Chapter 9, and in the referenced consensus standards, may be applicable to fixed instruments.

Although fixed instruments provide the advantage of continuous operation with little or no attention, their application is limited by their lack of mobility. Fixed instruments should be used to monitor areas and installations:

- having a known and relatively predictable operation where little variation in the radiological hazards is expected;

- where monitoring of an access point (and possible provision of an alarm function) is desirable to warn individuals of hazards in the area;

- where it is desirable to continuously monitor an area to detect changes in radiological conditions, possibly as a result of an unplanned change in process functions;

- where continuous monitoring and alarm functions are necessary to prevent unplanned exposures; and

- as necessary to provide input into interlocks, control devices, and alarm systems that are dependent upon or that control the operation being monitored

Portable instruments are most appropriate for use in performing prospective monitoring for the purposes of work planning, radiological condition verification, facility integrity verification, and operational assessments. The quality and utility of the data provided by portable instruments are highly dependent upon the knowledge and skills of the user. Because of these important applications and significant vulnerabilities, portable instruments should be used only by trained individuals (such as specifically-trained radiological workers and radiological control technicians). Passive monitoring devices (e.g., area monitoring TLDs) should be placed in areas surrounding radiological areas to verify that doses in these areas do not exceed the individual monitoring threshold. Passive monitoring devices should be placed where they will be exposed to radiation fields similar to those affecting individuals frequenting the area, but should be protected from loss or vandalism. The use of passive monitoring devices to characterize radiation fields as a part of pre-job planning should also be considered.

6.3.1 Performance of Area Radiation Monitoring

10 CFR 835 defines radiation and high radiation areas in terms of the radiation levels at a distance of 30 centimeters from the source or from any surface penetrated by the radiation. Similarly, 10 CFR 835 defines very high radiation areas in terms of the radiation levels at a distance of 100 centimeters. Therefore, area radiation monitoring should be performed at these distances (consistent with facility hazards) to ensure compliance with the 10 CFR 835.603 area posting requirements. However, actual and likely exposure conditions should be considered when performing monitoring for task planning, hazard analysis or dose assessment should also include consideration of. If an individual is likely to linger at a distance of several feet from a shield wall, use an obvious travel path between stations, or work within a few inches of a radiation source, measurements should be made at those locations (and recorded as such) to provide representative information. Such monitoring should be performed as necessary to ensure compliance with 10 CFR 835.401(a). Methods used in performing area radiation monitoring should also be adequate to identify localized variations in radiation levels to facilitate dosimeter placement and individual exposure reduction actions.

Important variables that should be considered for inclusion in procedures and training include instrument selection, operation, functional testing, detector orientation, response time, operational limitations, source-to-detector distance considerations, and documentation requirements.

6.3.2 Allowance for Physical Characteristics

The physical characteristics of the radiation field present should be considered in the design of the monitoring program and in the evaluation of external dose equivalent. These characteristics include radiation quality, energy, fluence rate, and direction of incidence. If certain characteristics are not known, the assumed values used as the basis for the area monitoring program design should be documented in the technical basis document. For instance, if monitoring for beta particles is performed, but the energies are not known, the energy assumed and rationale used for calibration purposes should be recorded.

6.3.3 Recourse for Technology Shortfall

The technology may not be available to perform area monitoring for some types of radiation at levels indicative of the monitoring requirements. If the performance objectives cannot be achieved for this reason, the facility should

- use the best practicable monitoring methods, and
- implement enhanced design, operational controls, personnel protection equipment, and procedures to control external exposures.

6.4 Individual Monitoring Program

This section discusses program features for individual monitoring, compensatory actions for lost, damaged, or contaminated dosimeters, nuclear accident dosimetry, and dosimetry for planned special exposures.

6.4.0 Establishing the Need for Individual Monitoring

It is usually not necessary for all individuals at a facility to wear dosimeters unless there is a documented technical basis. Unnecessary issuance of dosimeters should be avoided. If an individual does not enter areas where there is a likelihood of external exposure resulting in a dose near or in excess of the regulatory monitoring thresholds, issuance of a dosimeter to that individual is discouraged. For reasons of practicality and uniformity, decisions regarding those individuals to whom dosimeters are issued should be made on the basis of work group affiliation, type of work to be performed, and/or areas to be entered. There is generally no need to perform calculations regarding individual dose expectations to support decisions regarding the provision of individual dosimeters. The issuance of dosimeters to concerned individuals should not be a substitute for providing information, training, access controls, and a comprehensive area monitoring program. The criteria for the selection of individuals to be monitored should be documented in the technical basis document.

10 CFR 835 establishes individual monitoring requirements based on the likelihood of an individual receiving a dose in excess of a regulatory monitoring threshold. In

determining the likelihood of potential exposures, the use of professional judgment is necessary. This judgment should include consideration of the following:

- areas to which the individual will have access;
- the individual's previous occupational dose during the current year;
- activities taking place in the areas to be entered;
- restrictions on areas entered or time in these areas;
- design basis radiological conditions in the areas to be entered;
- documentation of actual radiological conditions in the areas to be entered, obtained through prior individual and area monitoring; and
- potential for changes that may affect the radiological conditions.

Except for provisions for nuclear accident dosimetry, it is not necessary to include consideration of accidents or emergencies, because these events are not considered "likely."

There are many instances where groups conduct site tours. A common practice is to only monitor the individual conducting the tour. This may be appropriate depending on the areas being toured and the classification of the individuals on the tour. For example, this practice is appropriate for tours limited to members of the public touring well characterized areas with no measurable radiation levels above background. If it is later found that there was an unexpected exposure, doses may be evaluated from the dosimeter of the individual conducting the tour. This is consistent with RCS Section 511, which states that DOE discourages the issuance of dosimeters to individuals other than those entering areas where there is a likelihood of external exposure in excess of the monitoring thresholds given in 10 CFR 835.

If the tour group consists of individuals receiving occupational exposure (i.e., situations where being on the tour is part of an individual’s job function, such as tours by external auditors or subject matter experts) and the tour could result in individual receiving measurable doses, then an evaluation should be made on the need for monitoring the individuals on the tour. The evaluation should consider the expected magnitude of any dose received during the tour and during subsequent work as well as consideration of previous occupational doses received during the year, and individual dose monitoring requirements of 10 CFR 835 § 402. Where this evaluation cannot be accurately performed by the site because of complexity or lack of dosimetry information (e.g., the individual has visited, or may visit, more than one site or has not received dosimetry reports) each individual should be monitored.

When the tour guide carries the dosimeter for the tour, each member of the tour should be told that their dose will be assigned based upon the tour guide's dosimeter and given the opportunity to request an individual dosimeter be issued to that individual.

6.4.1 Routine Monitoring of Individual External Doses

Individual monitoring shall be performed for those individuals likely to receive external doses exceeding the monitoring thresholds provided in 10 CFR 835 and for individuals entering high radiation or very high areas [10 CFR 835.402(a)]. The frequency of collecting and processing personnel dosimeters depends on the measurement method and associated lower limit of detectability. The collection/processing frequency should be chosen so that it is unlikely that an individual will receive a dose equivalent equal to or greater than the values listed in 10 CFR 835.402(a) from external radiation without detection and quantification. The specific physical characteristics of the radiation field should be considered in choosing the measurement method. These characteristics include radiation type, quality, energy, fluence rate, and direction of incidence. If these characteristics are not quantified, conservative assumptions should be used until further information is available, and should be stated in the technical basis document.

6.4.1.0 Deep Dose Monitoring

10 CFR 835.402(a) requires monitoring for individuals likely to exceed the specified effective dose equivalent threshold as a result of exposure to external radiation sources. The deep dose equivalent from external exposures may be used as the effective dose equivalent to the whole body, which shall be evaluated at a tissue depth of 1 cm (1000 mg/cm^2) [10 CFR 835.2(b), Deep dose equivalent and Effective dose equivalent].

For individuals who require individual monitoring, external dose should be determined using such devices as thermoluminescent dosimeters, track-etch dosimeters, or radiation-sensitive film. The dosimeter should be worn to provide a measurement of the maximum dose received at any location on the whole body. When the whole body is exposed fairly uniformly, the location should be on the front of the torso between the neck and waist. For non-uniform irradiation, multiple dosimeters should be used or the primary dosimeter should be relocated to the area receiving the highest dose. Guidance on the use of multiple dosimeters and dosimeter relocation is provided later in this chapter.

6.4.1.1 Lens of the Eye Monitoring

The lens of the eye dose equivalent shall be evaluated at a tissue depth of 0.3 cm (300 mg/cm^2) [10 CFR 835.2(b), Lens of the eye dose equivalent].

For uniform exposures, a measurement taken in the torso region is sufficient. For non-uniform exposures that would result in an individual receiving a significantly higher dose to the lens of the eye than to the whole body, such as access to or near reactor beams, X-ray machines, sources of beta radiation, and shield penetrations, the dose

equivalent should be measured near the eye, such as with a dosimeter worn on the side of the head or forehead.

For beta particles with maximum energies less than about 3.5 MeV, the dose limit to the skin is more restrictive than that for the lens of the eye. At higher energies, the lens of the eye dose limit dominates. Therefore, at beta energies below 3.5 MeV, if it can be shown that skin monitoring is not required, then it follows that lens of the eye monitoring is also not required (See International Commission on Radiation Units and Measurements (ICRU) Report No. 43, *Determination of Dose Equivalents from External Sources - Part 2* [ICRU 1988)]. Protective eyewear using 1/10-inch (0.254 cm) of acrylic plastic will completely attenuate beta particles with maximum energies < 800 KeV. This covers most beta-emitting isotopes with the exception of P-32, Y-90, and Pa-234. See the *Radiological Health Handbook* (BRH 1970).

6.4.1.2 Skin and Extremity Monitoring

Exposure to the extremities and skin from external radiation (except for non-uniform exposure of the skin as discussed in Section 6.4.1.4) shall be evaluated using the shallow dose equivalent as evaluated at a tissue depth of 0.007 cm (7 mg/cm^2) [10 CFR 835.2(b), Shallow dose equivalent].

Monitoring for skin exposure is usually performed in conjunction with that for the effective dose equivalent using a single whole body dosimeter. This method is adequate for uniform or nearly uniform fields. Guidance on the use of extremity dosimeters is provided later in this chapter.

When monitoring the extremities, if the most exposed location is not directly monitored, a field correction factor may be applied based the gradient between the location monitored and the most exposed location (or the dose equivalent at contact if there is direct source-to-skin or -extremity contact). Because of difficulties associated with inducing an albedo effect necessary for proper function of commonly-available neutron dosimeters, monitoring for neutron dose to the extremities can present special challenges to the external dosimetry program. Neutron dose to the extremities may be determined by one of three methods:

- direct measurement by neutron sensitive dosimeters, when available;
- application of a gamma dose to neutron dose correction factor determined through the measurement of the gamma and neutron dose rates incident to the affected extremities; or
- application of a whole body dose to extremity dose correction factor determined through measurements of the neutron dose rates incident to both the whole body and the affected extremities.

Justification for the choice of dosimeter and placement of dosimeter and results of field gradient measurements should be provided in the technical basis document.

6.4.1.3 Embryo/Fetal Monitoring

Following the pregnancy declaration, a declared pregnant worker should continue to wear her dosimeter in the normal manner if she will be entering areas or performing work for which individual monitoring is required. If she is in an area where the dose is likely to approach 50 millirem (0.5 mSv) in a month, a supplemental dosimeter should be worn to obtain a monthly estimate of the dose. If she is exposed to localized sources of radiation, the supplemental dosimeter should be worn on or near the abdomen.

Guidance for determining the dose to the embryo/fetus is provided in Chapter 8.

6.4.1.4 Non-Uniform Radiation Fields

When individuals will be exposed to radiation in a manner that will result in significantly non-uniform doses to various areas of the whole body, multiple dosimeters should be issued or the primary dosimeter should be relocated to the area of the whole body likely to receive the highest dose. Such a situation may result from an irregular distribution of radiation sources in the area, a continued positioning of the individual that causes an irregular radiation exposure to the body, or the effects of personal protective equipment (e.g., lead aprons) or other shielding devices that do not protect all portions of the whole body in a uniformly effective manner. Multiple dosimeters should be used to assess whole-body dose when radiation fields vary by > 50% over the whole body and the anticipated dose to the maximally-exposed area is > 100 millirem (1 mSv) (deep dose equivalent) or 1 rem (0.01 Sv) (shallow dose equivalent) during the dosimeter issue period. The technical basis document should provide details regarding the basis for dosimeter location(s) under non-uniform exposure conditions. Preliminary judgments on the need for multiple dosimeters and placement of multiple dosimeters should be made from direct exposure rate surveys with portable monitoring instruments or monitoring with dosimeters placed on phantoms. Multiple dosimeters may be used at any time to provide more detailed information for estimates of whole body dose. Additional guidance on the use of multiple dosimeters is provided in ANSI/HPS N13.41, *Criteria for Performing Multiple Dosimetry* (ANSI/HPS 1997a). Guidance on the evaluation of individual dose from multiple dosimeter results is provided later in this chapter.

When the radiation field is well characterized and the individual's orientation is known, relocation of the primary dosimeter may be preferable to issuance of multiple dosimeters. If dosimeter relocation is desirable, the individual's dosimeter should be relocated to the portion of the whole body likely to receive the highest dose. Dosimeter relocation should be conducted in conformance with management-approved procedures or work authorizations, such as radiological work permits. Dosimeter relocation should not be performed by individuals without written authorization.

Multiple dosimeters should be placed at locations on the body likely to receive the highest dose equivalent. Common locations for multiple dosimeter placement include the head, chest, back, gonads, upper arms, and upper legs. If multiple dosimeters are used,

the routine whole body dosimeter should be replaced with the set of multiple dosimeters during the multibadging activity. This keeps the normal dosimetry on its regular processing cycle and eliminates the possibility of "double counting" dosimetry results.

Note that this guidance is for whole body dosimeters only and does not apply to extremity dosimeters, which are treated separately in this Guide.

6.4.1.5 Supplemental Dosimeters

Supplemental dosimeters include, but are not limited to, electronic dosimeters, pocket dosimeters, and other self-reading, alarming dosimeters. Any individual entering a high radiation area or very high radiation area shall wear a supplemental dosimeter or be monitored by another means capable of providing an immediate estimate of that individual's integrated deep dose equivalent during the entry (e.g., stay-time tracking) [10 CFR 835.502(a)].

Supplemental dosimeters should be read periodically while in use. The range and energy dependence of supplemental dosimeters, particularly to low-energy beta and X-ray radiation, should be considered in determining their applicability. Supplemental dosimeters with a limited range should be selected with the lowest range applicable for the anticipated exposure. Chapters 3 and 5 of the RCS provide additional guidance on the use of supplemental dosimeters.

6.4.2 Lost, Damaged, or Contaminated Dosimeters

An individual whose dosimeter is lost, damaged, or contaminated should place work in a safe condition, immediately exit the area, and report the occurrence to the radiological control organization.

Reentry of the individual into radiological areas should not be made until a review has been conducted, the individual has been issued a new dosimeter, and management has approved reentry. The review may be as simple as a documented survey showing the dosimeter not to be contaminated, in which case the worker may go back to work immediately. Otherwise, a review should include a dose evaluation to replace the results of the lost, damaged, or contaminated personnel dosimeter and should determine if work can continue while an investigation is in progress.

6.4.3 Nuclear Accident Dosimetry

Nuclear accident dosimetry shall be provided to individuals in installations possessing sufficient quantities of fissile material to potentially constitute a critical mass, such that the excessive exposure of individuals to radiation from a nuclear accident is possible [10 CFR 835.1304(a)]. Nuclear accident dosimetry shall include:

- a method to conduct initial screening of individuals involved in a nuclear accident;

- methods and equipment for analysis of biological materials;
- a system of fixed nuclear accident dosimeter units; and
- personal nuclear accident dosimeters [10 CFR 835.1304(b)].

Initial screening methods should include measurements of activation products in and on the bodies of exposed individuals (e.g., sodium-24 in the body, activation of jewelry) and/or evaluation of individual locations during the accident, as appropriate. Methods and equipment for analysis of biological materials should include appropriate counting systems maintained in operable condition and sample collection and preparation processes. Acceptable methods for implementing a nuclear accident dosimetry program are described in ANSI N13.3, *Dosimetry for Criticality Accidents* (ANSI 1988). Additional guidance is provided in Chapter 5 of the RCS.

Placement of fixed nuclear accident dosimeter units should consider the nature of the operations, structural design characteristics, accessibility of areas to personnel, and recovery of units after a criticality accident. The number of fixed nuclear accident dosimeter units, their locations, the effect of intervening shielding, and an analysis demonstrating the above performance criteria should be documented in the technical basis document.

6.4.4 Planned Special Exposures

Planned special exposures are included in an individual's occupational dose record, but shall not be considered when determining compliance with the occupational dose limits [10 CFR 835.1(b)]. In order to maintain separate records of doses resulting from planned special exposures and routine occupational exposures, dosimeters adequate to measure the potential doses and appropriate for the work to be performed and specific radiological circumstances should be provided for the planned special exposure.

6.4.5 Personal Protective Equipment

Use of personal protective equipment (such as shielded aprons or other clothing items) may present special challenges in the placement of personnel dosimeters and the determination of the dose equivalent. Use of such items may create non-uniform radiation field conditions similar to those discussed in Section 4.3.2 of this Guide. If so, the placement of dosimeters and determination of the individual dose equivalent should be conducted consistent with that guidance. If the effect of personal protective equipment is not significant enough to create a non-uniform radiation field as described in the technical basis document, then the dosimeter should be placed on the area of the body likely to receive the highest dose equivalent. The effect of the personal protective equipment on albedo effects that are critical for the proper function of neutron dosimeters should also be considered.

6.5 External Dose Evaluation

Radiation protection requirements are expressed in terms of limiting values of dose equivalent to individuals. The limiting values for dose equivalent in 10 CFR 835 are specified as total effective dose equivalent to the whole body and dose equivalent for other organs and tissues.

Methods for evaluating the various doses from external exposures should be based on recommendations given in International Commission on Radiological Protection (ICRP) Publication 26, *Recommendations of the International Commission on Radiation Protection* (ICRP 1977), NCRP Report No. 91, *Recommendations on Limits for Exposure to Ionizing Radiation* (NCRP 1987b), and other reports of the ICRP and NCRP that address improvements and updates of the science of external dosimetry. Other methods may be used provided they are documented and justified in the procedures and/or technical basis document. The dose calculation methodology shall use the quality factors and tissue or organ weighting factors in the definition section of 10 CFR 835 [10 CFR 835.203(b)].

6.5.0 Required Dose Calculations

Records shall be maintained to document the doses received by all individuals monitored in accordance with 10 CFR 835.402 and to document doses received as a result of planned special exposures, accident exposures, and emergency exposures [10 CFR 835.702(a)]. The following quantities shall be recorded for external dose received during the year:

- effective dose equivalent from external sources (deep dose equivalent may be used) [10 CFR 835.702(c)(3)(i)];
- lens of the eye dose equivalent [10 CFR 835.702(c)(3)(ii)];
- shallow dose equivalent to the skin [10 CFR 835.702(c)(3)(iii)]; and
- shallow dose equivalent to the extremities [10 CFR 835.702(c)(3)(iv)].

For airborne radionuclides that pose an external exposure hazard, the derived air concentration (DAC) values in Appendix C of 10 CFR 835 shall be used to control exposure to airborne radionuclides [10 CFR 835.209(a)]. The technical basis document should note which radionuclides could be present and whether the individual dosimeter responds correctly to the quality of the radiation or whether immersion exposures should be calculated separately and added to dosimeter results. When it is necessary to apply airborne radioactivity monitoring results to individual external dose assessment, such applications should include consideration of the concentration of the contaminant in the workplace and the duration of the exposure (i.e., maintenance of records of DAC-hours of exposure). The air immersion DAC values in 10 CFR 835 Appendix C were calculated for a continuous (2,000 hours per year), non-shielded exposure via immersion in a semi-infinite atmospheric cloud. 10 CFR 835 allows modification of the DAC

values contained in Appendix C to allow for submersion in a cloud of finite dimensions. The method for making this room size modification should be based on recommendations given in ICRP Publication 30, *Limits for Intakes of Radionuclides by Workers* (ICRP 1979).

Personnel dosimeters should be calibrated to monitor for dose equivalent directly or indirectly through the use of a calibration factor. Dosimetry services that process dosimeters typically report personnel doses in units or subunits of rem and no further calculations need be performed unless modifying factors are applied.

When neutron monitoring is performed, the neutron dose equivalent is added to the non-neutron deep dose equivalent to determine the total whole body deep dose equivalent, and added, as applicable, to the extremity dose equivalent, and/or the lens of the eye dose equivalent. Varying neutron energy spectra are encountered at field locations, depending on the original energy of the neutrons and the degree of moderation and attenuation. These neutron energy spectra may not be representative of the energy spectra used in DOELAP. If this situation exists, specific field correction factors should be developed and used to adequately assess the neutron dose equivalent. The development and use of the field correction factors should be reflected in the technical basis document. Examples of methods for developing field correction factors can be found in *Personnel Neutron Dose Assessment Upgrade* (PNL 1988b) and in *Neutron Dose and Energy Spectra Measurements at Savannah River Plant* (PNL 1987).

6.5.1 Special Considerations

Personnel dosimeter measurements are the preferred source of data for evaluating the external dose of individuals likely to exceed the monitoring thresholds. Area monitoring data and other personnel monitoring data should be used to evaluate external dose if personnel dosimeter measurements are not feasible or are not available. When personnel dosimeter measurements are not available, a dose evaluation should be performed for that period. The dose evaluation should be based on personnel dosimeter results from other individuals in the same area, on previously recorded doses (provided no significant changes in exposure rates would be anticipated), or on area monitoring results of the ambient radiation levels. These estimated or assigned doses shall be clearly recorded and maintained as such [10 CFR 835.702(a) and (g)]. When area monitoring results are used to estimate individual dose, the results of surveys, measurements and calculations used to determine individual occupational exposure from external sources shall be recorded [10 CFR 835.703(b)].

When an individual is provided multiple dosimeters, the dose measured by the highest responding dosimeter on the whole body should be assigned as the whole body dose of record. When multiple dosimeters are employed more tan once during the year, dosimeter results may be summed by location and the highest total assigned as the whole body dose of record. However, sufficient records should exist to demonstrate that the dose to portions of the whole body between the monitoring locations did not exceed that recorded for the monitoring location. For example, if both the left and right upper arms were monitored, adequate records should be maintained to demonstrate that the dose to

the head and torso, which may have been exposed as a result of exposure to both arms, did not exceed the dose to either upper arm.

If weighting factors are used to calculate effective dose equivalent from external radiation fields, the weighting factors in 10 CFR 835.2 shall be used [10 CFR 835.203(b)]. If necessary, a compartmentalization methodology, such as that recommended in ANSI/HPS N13.41 (ANSI/HPS 1997), may be applied to the multiple dosimeter results. A calculation of this type provides a better representation of the risk to the monitored individual and is consistent with the recommendations of ICRP Publication 26. Whatever methodology is selected, all multiple dosimeter results shall be recorded [10 CFR 835.702(a) and (g)].

When supplemental dosimeters are used, the results should be compared to the results from the primary dosimeter issued to the same individual (if the issue periods for the primary and supplemental dosimeters are the same). If the dose results differ by >50% from the primary dosimeter and the dose from the primary dosimeter is >100 millirem (1 mSv), an investigation should be initiated to explain the difference.

10 CFR 835.205 places additional requirements on evaluating and recording doses from non-uniform exposures of the skin from X-rays, beta radiation, and/or radioactive materials on the skin, including hot particles. The technical basis document should provide the basis for the action level used to identify the need for such evaluations. Decisions regarding the appropriate action levels should be based upon such factors as the likely magnitude of events resulting in non-uniform exposure of the skin, the likelihood of repeated events, and potential resulting doses (total of all events). An action level of 100 millirem (1 mSv) for the evaluation of skin dose for general employees is recommended. Further information regarding hot particles can be found in NCRP Report No. 106, *Limit for Exposure to "Hot Particles" on the Skin* (NCRP 1989).

For non-uniform exposures of the skin, the assessment of the exposed area should be recorded with the shallow dose equivalent. Non-uniform exposures of the skin of the extremities from X-rays, beta radiation, and radioactive materials on the skin, including hot particles, should be assigned to the extremity, not the skin. If the non-uniform shallow dose equivalent to the skin does not exceed 1 rem (0.01 Sv), then recording of the dose is not required [10 CFR 835.702(b)].

When an individual has been monitored for extremity exposure at some time during the calendar year, but is not monitored for the entire year, the shallow dose equivalent from the whole body dosimeter should be used as the extremity dose of record for periods when extremity dosimeters are not worn.

If it is necessary to determine a lens of the eye dose equivalent in the absence of reliable monitoring data (i.e., in the absence of properly calibrated lens of the eye dosimeters), the shallow dose equivalent should be used as an approximation of the lens of the eye dose or

appropriate dose conversion factors should be used to convert the dosimeter reading to the lens of the eye dose. Appropriate dose conversion factors may be found in ICRP Publication 74, *Conversion Coefficients for Use in Radiological Protection Against External Radiation* (ICRP 1996), or peer-reviewed journals or may be determined locally through performance of a series of tests using dosimeters with different filters.

In the case of a large dose, actual or suspected, quick initial estimates should be made based on stay time and exposure rate. These estimates should be used to limit further external dose until dosimeter and bioassay results are available.

6.6 Recordkeeping and Reporting

10 CFR 835 requires that records be maintained to document certain aspects of the external dosimetry program. These records include radiation dose records, instrument and equipment calibration records, monitoring procedures, and area monitoring results. 10 CFR 835 also requires that certain reports be provided to individuals on their exposure received while performing their duties. Chapter 13 provides detailed guidance on the records necessary to document the external dosimetry program and the reports to individuals required by 10 CFR 835. Chapter 7 of the RCS provides additional guidance.

7.0 RADIATION GENERATING DEVICES

The Radiation Generating Devices (RGDs) addressed in this Guide may be classified as either devices that must be electrically energized to produce ionizing radiation or sealed radioactive sources that emit radiation continuously. RGDs are used at DOE sites with a great variety of configurations and operating characteristics and in a wide spectrum of applications. This Guide addresses RGDs used for industrial and research applications, but does not address RGDs used for patient diagnostic or therapeutic medical applications. Medical RGDs should be registered with the cognizant regulatory agency which typically is a Federal, state or local level authority.

Specific examples of RGDs addressed by this Guide include: sealed photon- or neutron-emitting radioactive sources; X-ray producing radiography equipment; research and analytical X-ray or electron beam machines; sealed radioactive sources used as irradiators; particle accelerators; neutron generators; Van de Graff generators; electromagnetic pulse generators (if capable of producing ionizing radiation); electron microscopes; electron arc welders; microwave cavities that produce X-rays incidentally, and cabinet X-ray machines used for security applications.

Note that sealed radioactive sources are specifically addressed in Chapter 15. The guidance provided in this Guide should be considered in addition to that provided in Chapter 15 for those sealed radioactive sources that produce radiation fields exceeding 100 millirem (1 mSv) in one hour at a distance of 30 centimeters from the source.

7.1 Implementation Guidance

10 CFR 835 must be generic to cover the wide spectrum of facilities and activities within the DOE complex. To ensure an adequate level of radiological safety and compliance with 10 CFR 835, the requirements and guidance provided in the following secondary documents should be implemented, to the extent appropriate to site-specific activities and hazards.

- 10 CFR 34, Licenses for Radiography and Radiation Safety Requirements for Radiographic Operations (NRC 1992a);
- ANSI N43.3, *American National Standard For General Radiation Safety - Installations Using Non-Medical X-Ray and Sealed Gamma-Ray Sources, Energies Up to 10 MeV* (which updates ANSI N543-1974) (ANSI 1993);
- ANSI/HPS N43.2, *Radiation Safety for X-Ray Diffraction and Fluorescence Analysis Equipment* (ANSI/HPS 2001a); and
- ANSI/HPS N43.5, *Radiological Safety Standard for the Design of Radiographic and Fluoroscopic Industrial X-Ray Equipment* (Formerly called N537) (ANSI/HPS 2005).

Should any conflict exist between the requirements and guidance provided in these standards and the requirements of 10 CFR 835, then the requirements of 10 CFR 835 take precedence. This Guide provides guidance that supplements that provided by the ANSI Standards discussed above.

7.2 Administrative Organization and Controls

RGD control should be maintained by individuals responsible for RGD operations. Overview for radiological safety should be provided by the independent radiological control organization. Within smaller organizations, where one individual may be responsible for multiple roles (such as RGD custodian, qualified expert, and radiological control staff), independent oversight of that individual's activities should be provided to ensure the ongoing quality of the RGD program.

7.2.0 Contractor Management

To implement their responsibilities, management should perform the following:

- appoint a RGD Custodian for each RGD;
- exercise supervision to ensure safe RGD operation;
- review RGD procedures and operational and maintenance logs;
- schedule periodic inspections and monitoring;
- approve operating and emergency procedures;
- schedule and otherwise provide for training to ensure that RGD Custodians and RGD Operators are trained and re-certified (see Chapter 14 for guidance concerning training of personnel); and
- promptly terminate the operation of any unsafe RGD installation.

7.2.1 RGD Custodian

The appointed RGD Custodian should provide direct control over RGD installations and operations. The RGD Custodian should ensure that the RGD installation is operated and maintained safely and in accordance with the requirements of the site-specific RPP. Specific responsibilities of the RGD Custodian should include the following:

- controlling the keys to RGD installations, RGDs, and/or RGD storage facilities and authorizing the operation of the RGD installation;
- ensuring that RGD Operators follow applicable operating procedures;
- ensuring that RGD Operators follow the applicable Radiological Work Permit (RWP), or other written authorization;

- ensuring that required dosimeters are properly worn;
- ensuring that inspections of RGD interlocks, warning lights, and other safety features are performed and documented;
- ensuring that all required monitoring is performed and documented;
- ensuring that all RGD Operators are trained;
- reviewing and approving materials used for training RGD Operators, in cooperation with the radiological control staff;
- ensuring that accountability records of assigned RGDs are maintained;
- notifying the radiological control staff of changes in shielding configuration, use, storage, disposal, or loss of a RGD;
- ensuring proper disposition of unneeded RGDs;
- ensuring that sealed radioactive source integrity tests are performed; and
- maintaining schematics (mechanical and electrical), safety device wiring diagrams, manufacturer provided instruction manuals, and operations and maintenance records.

7.2.2 RGD Operator

RGD Operators are those individuals authorized by the RGD Custodian to use the RGD.

The RGD Operator should:

- ensure proper control of the RGD installation and/or area;
- ensure that inspections and monitoring are performed and documented;
- ensure that required dosimeters are worn properly by all individuals in the vicinity of RGD operations;
- follow the applicable RWP, or alternative authorization, and ensures that other individuals also adhere to the requirements of those documents;
- establish control of all adjacent areas where individuals could receive a dose approaching administrative limits and ensure that those areas are unoccupied during RGD operations;
- maintain access control over the actual RGD exposure area;

- follow all applicable operating procedures; and
- promptly terminate unsafe RGD operations.

7.2.3 Qualified Expert

A qualified expert(s) should be appointed by management. To ensure technical qualification, the qualified expert should be approved by the radiological control manager. The qualified expert should have knowledge and training necessary to: (1) measure ionizing radiations; (2) analyze the significance and evaluate the potential health effects of monitoring results; and (3) advise on matters related to radiological control as it pertains to installations covered by this Guide. The qualified expert should have in-depth knowledge of characteristics associated with RGDs, RGD installations, and applicable Rules, Manuals, Orders, and Standards. If the radiation generating device is capable of producing very high acute doses, i.e., such that the hazard must be analyzed in the documented safety analysis, the expertise should include familiarity with any associated safety system software and hardware used to prevent major radiological accidents.

The qualified expert should periodically review the following areas and provide recommendations to the radiological control manager:

- the design or modification of RGD installations;
- the results of pre-operational inspections and radiological monitoring;
- the engineered safety features and administrative controls;
- the need for and adequacy of the personnel monitoring program for the installation; and
- the training materials used for the RGD Custodians and Operators.

7.2.4 Radiological Control Manager

A radiological control manager should be designated to ensure independent overview of radiological operations, including RGDs. The radiological control manager's function is similar to that of the radiological protection supervisor or radiation protection officer, as described in the specific ANSI standards referenced in this Guide and publications of the National Council on Radiation Protection and Measurements (NCRP). Additional guidance for radiological control manager responsibilities is provided in RCS Articles 141and 142 and ANSI N43.3.

7.2.5 Radiological Control Organization

The radiological control organization (RCO) should provide support to managers and radiological workers. The radiological control staff should be established consistent with Chapter 1 of the RCS.

Radiological control staff should perform the following tasks to implement their functions described in RCS Articles 141 and 143:

- evaluate adherence to the RPP by conducting pre-operational and periodic inspections and radiation monitoring of RGD installations;
- under the direction of the radiological control manager, provide radiological support to line managers and RGD operations;
- ensure that all inspections and monitoring are performed and documented;
- perform radiation monitoring of open installations to verify proper posting and control of boundaries during operations and removal of hazards (and associated temporary postings and barriers) after operations;
- monitor all RGD installations for potential or actual unsafe operations or conditions and conformity to the site-specific RPP; and
- review the operational and maintenance logs maintained by RGD Custodians and Operators to ensure that controls are commensurate with existing or potential radiological hazards.

7.3 Development of Site-Specific Documents

10 CFR 835.104 requires that written procedures be developed and implemented as necessary to ensure compliance with that regulation, commensurate with the radiological hazards created by the activity and consistent with the education, training, and skills of the individuals exposed to the hazards (10 CFR 835.104). Written procedures should be developed and implemented as necessary to ensure proper implementation of the radiation protection program elements addressed in this Guide. Additional guidance is provided in Chapter 3.

7.3.0 Radiological Monitoring

Radiological monitoring should be conducted to determine and document the integrity and adequacy of the shielding and to verify that posting and access control requirements are satisfactory before the RGD is turned over to the RGD Custodian for routine operation and periodically thereafter. If there is a potential for exposure in accessible areas adjacent to the installation, then the adjacent areas should be monitored and should be vacated when pre-operational monitoring is performed.

Specifically, the pre-operational monitoring program should be designed to:

- determine dose rate or integrated dose received in any 1 hour as dependent upon the pulse capability of the RGD;
- evaluate the exposure potential of the RGD at the maximum value of applied

voltage or current, *or at the* maximum *exposed position of the source for sealed radioactive source installations*. RGD(s) should be operated in steps of increasing beam strength until the highest values are achieved;

- include the use of mechanical or electrical devices that restrict beam orientation and magnitude, and determine the degree of beam restriction, with and without those devices;
- detect and measure potential leaks in the shielding and barriers; and
- encompass all geometries in which the useful beam can be directed.

Special monitoring should be conducted as follows:

- during the performance of maintenance and alignment procedures if the procedures require the presence of a primary beam;
- when any component in the system is disassembled or removed;
- any time an inspection of the components in the system reveals an abnormal condition;
- whenever personnel monitoring dosimeters or area monitoring show a significant increase over a previous monitoring period or are approaching administrative limits;
- following maintenance or calibration prior to restoration to fully operable status; and
- after any modification.

It is not necessary to perform radiological monitoring of electrically-energized RGDs (that is, those RGDs that do not contain radioactive material) during periods when they have been removed from service and placed in storage. However, when any RGD which has been in "storage" is being reactivated for use, functional and operational inspections and radiological monitoring should be performed prior to initial use.

For open installations, where irradiation configurations and boundary conditions are likely to change frequently, radiation monitoring shall be conducted in response to changing working parameters [10 CFR 835.401(a)].

After the initial assessment, independent inspections and monitoring should be conducted as necessary to verify: 1) that RGD operations continue to remain safe; 2) that during the operation of any open installation, the proper location and posting of boundaries is maintained; and 3) that after any modification or removal from storage of a

RGD installation, the effectiveness and operability of safety features are adequate. Additional guidance on area monitoring is provided in Chapter 6.

7.3.1 Sealed Radioactive Source Leak Testing

A program of sealed radioactive source accountability and leak testing for radioactive contamination and encapsulation integrity shall be implemented (10 CFR 835.1202). Guidance for this program is provided in Chapter 15.

7.3.2 Area Posting

7.3.2.0 Radiological Conditions

Guidance for posting radiological hazards is provided in Chapter 12.

7.3.2.1 Operational Status

Posting should be used to signify the presence of an intermittent radiation condition. The posting should also express the method used to convey that a radiation field is present. An example of such a sign is:

"CAUTION: RADIATION BEING PRODUCED OR RADIATION

AREA EXISTS WHEN RED LIGHT IS ON"

The qualified expert should be notified of status changes and pertinent details, e.g., safety system software errors as well as safety device malfunctioning.

7.3.2.2 Maintenance Status

Any time an installation requires maintenance, the entrance to the area in which the installation is located and the inside of the installation should be conspicuously posted to indicate the maintenance status of the installation. Posting should be established:

- during the performance of maintenance and alignment procedures if the procedures require the presence of radiation; and
- any time an inspection or monitoring reveals a deficient condition for any safety device.

When a safety device or interlock has been approved to be by-passed or is awaiting repair, the entrance to the installation and the RGD enclosure should be posted with a prominent sign bearing the words "**SAFETY DEVICE NOT FUNCTIONING**" or a similar message.

The qualified expert should be notified of status changes and pertinent details, e.g., safety system software errors as well as safety devices affected by maintenance or malfunction.

7.3.3 Training

Guidance for radiation safety training is provided in Chapter 14 of this Guide. This training should be augmented with pertinent material provided in DOE-HDBK-1108-97, RADIOLOGICAL SAFETY TRAINING FOR ACCELERATOR FACILITIES (DOE 2002b) and DOE-HDBK-1109-97, RADIATION SAFETY TRAINING FOR RADIATION-PRODUCING (X-RAY) DEVICES (DOE 1997d). Additional training guidance is provided in Chapters 3 and 6 of the RCS.

7.3.4 Records

Guidance for generation and maintenance of records sufficient to meet the requirements of 10 CFR 835 are provided in Chapter 13.

7.4 Engineered Safety Controls

10 CFR 835.1001 requires that measures be taken to maintain radiation exposures in controlled areas ALARA. The primary method used shall be physical design features (e.g., confinement, ventilation, remote handling, and shielding); administrative controls shall be incorporated only as supplemental methods and for specific activities where physical design features are demonstrated to be impractical (10 CFR 835.1001). 10 CFR 835.1003 further requires that during routine operations, the combination of design features and administrative controls shall provide that the anticipated occupational dose to general employees does not exceed regulatory limits and that the ALARA process is utilized for personnel exposures to ionizing radiation. Safety system hardware and software are sometimes associated with engineered safety features, i.e., for hazards that must be analyzed in a documented safety analysis.

Physical design features typically include features that are used to control the work environment, such as permanent structures, systems, and controls, including shielding, filtered ventilation systems, remote controls, containment devices, and the use of designs and materials that facilitate operations, maintenance, and other activities. Physical design features may also include engineering controls (e.g., temporary shielding, confinement and ventilation systems) that are typically used to facilitate short-term or emergent operations when the installed physical design features do not provide the desired level of protection. Administrative controls typically include controls that are implemented by the individual at the work site, including written procedures, technical work documents, work authorizations, and other controls that are used to guide individual actions in a manner that will facilitate implementation of the ALARA process (10 CFR 835.1001).

ANSI N43.3 and N43.2 provide specific guidance that should be considered for exempt shielded (including cabinet X-ray), shielded, unattended, and open installations. As discussed in the introduction to Chapter 7, not all of the ANSI guidance for shielded, unattended, and open installations meets the requirements of 10 CFR 835. If the design of the facility cannot be upgraded in a practical manner to meet the 10 CFR 835 exposure rate criteria, then the alternative is the implementation of additional access and occupancy controls to meet the design objectives.

7.4.0 Shielding, Controls, & Safety Devices

7.4.0.0 Shielding

Permanent shielding should be designed and installed consistent with the guidance provided in ANSI N43.3.

The effect of temporary shielding should be evaluated prior to its installation. The installation, use, and removal of temporary shielding should be controlled by procedures and in accordance with RCS 314.

7.4.0.1 Access Control and Safety Devices

10 CFR 835.501 establishes requirements for maintaining control over entries into radiological areas. 10 CFR 835.502 establishes supplemental requirements for entry controls for high and very high radiation areas. Viewed collectively, these provisions establish a hierarchy of controls, with general, flexible requirements for all radiological areas and more specific and stringent requirements for areas of greater hazard.

Guidance for establishing appropriate signs and barricades as required by 10 CFR 835.501 is provided in this Guide. Guidance for establishing appropriate administrative controls is provided in Chapters 4 and 11. The RCS provides additional guidance for all three of these Guides. The remainder of this chapter provides guidance for implementing the physical controls required by 10 CFR 835.501 and 502.

The purpose of access control devices is to prevent unauthorized or inadvertent entry into a radiological area and/or to warn of a hazard.

If locked entryways are used, the keys used for one RGD installation or storage facility should not provide access to another RGD installation or storage facility.

Additional measures shall be implemented to ensure individuals are not able to gain unauthorized or inadvertent access to very high radiation areas 910 CFR 835.502(c)]. Such measures (i.e., physical constraints) should include locking or securing service doors and panels with tamper resistant fasteners or the use of multiple and redundant access controls.

Due to the lack of intrinsic shielding and the nature of use, access to a very high radiation area could be possible for an "open" installation. Additional measures (e.g., interlocked "photoelectric eye" light beams) should be established to meet this requirement.

7.4.0.2 Interlocks

Doors and/or access panels in exempt shielded, shielded, and unattended installations should be equipped with one or more fail-safe safety interlocks to prevent irradiation of an individual [ANSI N43.3(6.5.2)].

If an area radiation monitor is incorporated into a safety interlock system, the circuitry should be such that a failure of the monitor shall either prevent normal access into the area or operation of the RGD.

7.4.0.3 Device Controls

One or more physical control devices should be used to secure the RGD to prevent unauthorized access and use. The control system governing the production of radiation should be equipped with a lock and key to prevent unauthorized use. The key controlling the production of radiation in one RGD should not control the production in another.

Control devices used to limit RGD time, position (irradiation geometry), current, voltage, beam intensity, or control panel lights or system indicators should be fail-safe.

7.4.0.4 Run-Safe and Emergency Shutdown Devices

Administrative procedures should be implemented to ensure that the RGD installation and the RGD safety interlock control devices are such that:

- radiation cannot be produced until the interlock system logic has been completely satisfied;
- production of radiation cannot be resumed by merely reestablishing the interlock circuit at the location where an interlock was tripped; and
- the safety circuit cannot be re-energized or reestablished automatically (i.e., there should be a manual safety circuit reset on or near the main control console).

For each area designated as a high radiation area or very high radiation area, 10 CFR 835.502 provides an option that permits a control device to automatically generate audible or visible alarm signals to alert individuals and the cognizant RGD Operator of a potential entry into the area before it occurs. In order to meet ANSI N43.3 guidance, warning devices should be provided as an addition to any other access control feature in accordance with the installation specific requirements delineated in Section 7.4.1 of this Guide. These warning devices are typically warning lights.

All RGD warning lights should be red or magenta for consistency. A sufficient number of lights should be installed so that at least one light is easily visible from all reasonably occupied areas that may have dangerous radiation levels and from reasonable avenues of approach to such areas.

However, warning lights (even though interlocked to fail-safe if burnt out) are only passive in nature. When operating, they generally do not prevent an individual from physical access to a radiation beam unless they are used as part of a photosensitive circuit. Such a circuit would remove the radiation beam or field if any individual intercepted the light beam.

Due to the passiveness (i.e., reliance on worker attention and action) of this safety feature and the potential for failure, at least one interlocked warning light should be used in all circumstances. The interlocked warning light should be used to provide visual indication that radiation is being produced, and should be used in conjunction with any interlocked safety device which restricts physical access to a radiation beam or field. This is recommended above and beyond the installation specific requirements in this Guide, or the minimum required by 10 CFR 835.502. When used in this fashion, the RGD should not be operable when the warning light is out.

It should not be possible to override the operation of any warning device activated by a fail-safe function without positive actions by the operator such as resetting controls at the control console. Where feasible, i.e., for new or significantly modified RGDs that are capable of producing very high acute doses, i.e., that must be analyzed in the documented safety analysis, safety system hardware and software should provide additional safety via computer-assisted operations as well as indicate all abnormal events at the console and remotely notify cognizant personnel of abnormal events and conditions.

7.4.0.5 Monitoring Instruments

Requirements and guidance for instruments used to measure radiation are given in 10 CFR 835.401(b) and Chapter 9 of this Guide.

7.4.1 Guidance for Specific RGD Installations

In addition to the general guidance in this Guide, there is specific guidance cited from ANSI N43.3 and N43.2 for each of the primary RGD installations and the open and shielded beam analytical RGDs. The analytical RGD installations may enclose one or more X-ray devices and/or sealed radioactive sources.

The ANSI standards specify dose rates that are to be used for installation categorization only and are not to be interpreted as permissible levels.

7.4.1.0 Accelerators

Small (low voltage, less than or equal to 10 MeV) accelerators used for radiography, ion implantation, or the production of incidental photons or particles (e.g., neutron generators) in exempt shielded, shielded, or open installations should be operated in accordance with the guidance specified by this Guide and the applicable ANSI standards. When accelerators are used outside of exempt shielded or shielded installations, requirements for open-air radiography prevail.

When used within shielded installations, determination must be made whether the requirements for the exempt shielded or shielded installations prevail. Although the basic radiological control program requirements discussed in this Guide are generally applicable to the large multi-purpose research accelerators, the complexities associated with these facilities may require additional consideration beyond the scope of this Guide.

Additional requirements for those RGDs with particle energies exceeding 10 MeV are provided in DOE O 420.2B, *Safety of Accelerator Facilities*.

7.4.1.1 Electron Devices that Generate X-Rays Incidentally

These devices are usually shielded to attenuate the emission of X-rays. Requirements for the exempt shielded or shielded installations prevail. Examples include electron beam welders, electronic microscopes, pulse generators, etc., and microwave cavities if used as beam guides.

Preoperational inspections and monitoring should be performed initially upon receipt. However, the requirement for the routine semiannual inspections and monitoring may be modified at the discretion of the radiological control manager.

7.4.1.2 Cabinet X-Ray Systems

Since these RGDs are used primarily in security applications and are commercially available, manufacturer requirements for these RGDs are delineated in 21 CFR Part 1020.40.

These RGDs should be procured, categorized, inventoried, operated, inspected and monitored, and decommissioned in accordance with this Guide to ensure compliance with 10 CFR 835.1001& 1003). Inspections and surveys should be performed as specified in Section 7.4.1.1, of this Guide.

If not commercially obtained, the requirements for an exempt shielded installation prevail.

8.0 EVALUATION AND CONTROL OF RADIATION DOSE TO THE EMBRYO/FETUS

DOE has codified in 10 CFR 835.206 radiation dose limits for the embryo/fetus as a result of the occupational exposure of a declared pregnant worker. These requirements are established to provide protection to the embryo/fetus in a manner that does not discriminate against the rights of the pregnant worker.

Programs established to evaluate and control radiation dose to the embryo/fetus need to balance protection of the embryo/fetus (from hazards that may arise from the mother's occupational radiation exposure) against the possibility of work discrimination against the mother. The choice of providing additional protection to the embryo/fetus is left entirely to the voluntary discretion of the mother. The Supreme Court ruled in *United Automobile Workers v. Johnson Controls, Inc.*, 499 U.S.187, 206 (USLW 1991) that "... decisions about the welfare of future children must be left to the parents who conceive, bear, support, and raise them rather than to the employers who hire those parents."

8.1 Implementation Guidance

Essential elements of an acceptable program to evaluate and control radiation dose to the embryo/fetus include:

- voluntary, formal declaration of pregnancy, including the estimated date of conception;
- voluntary, formal withdrawal of declaration of pregnancy;
- work restrictions for workers who have voluntarily declared their pregnancies;
- counseling of workers;
- dose calculation and monitoring methods;
- worker training;
- record-keeping; and
- reporting.

Acceptable methods for implementing these program elements are discussed in this chapter.

8.2 Declaration of Pregnancy/Withdrawal of Declaration

Due to the higher sensitivity of the embryo/fetus to ionizing radiation (relative to the sensitivity of adults), 10 CFR 835 establishes provisions for individuals to voluntarily

declare their pregnancy and to accept restrictions on the dose equivalent to the embryo/fetus (i.e., 0.5 rem (0.005 Sv) gestation period dose equivalent limit, uniform exposure rate) (10 CFR 835.206). It remains the sole and fundamental responsibility of the worker to decide whether to formally declare her pregnancy and consequently become subject to the above dose limits and restrictions. It is the employers' responsibility to ensure that the worker is fully informed and provided with counseling to assist in her decision making. Deciding whether or not to accept the risk from radiation dose to the embryo/fetus is entirely the responsibility of the pregnant worker.

A pregnancy may be declared by the pregnant worker or the worker who is planning a pregnancy, and shall be formally declared in writing [10 CFR 835.2(a)]. The declaration shall include the estimated date of conception [10 CFR 835.704(d)], and should be declared as early in the pregnancy as possible. A declared pregnant worker that is planning a pregnancy should notify her supervisor as soon as possible following verification of conception. The statement should be signed by the employee and delivered to her supervisor or to a designated contact in health physics, laboratory safety, occupational health, or medical services. A sample declaration form is provided in Appendix 8.A of this Guide.

10 CFR 835 also allows an individual who has declared her pregnancy to withdraw her declaration and to return to the general employee occupational dose limit (5 rem (0.05 Sv) total effective dose equivalent in a year). The employer is considered to be notified of the withdrawal of the declaration of pregnancy at the time that the individual submits a signed and dated statement to her supervisor or to the designated contact, indicating that she is withdrawing her formal declaration of pregnancy. A sample form is provided in Appendix 8.B of this Guide. No additional explanation or justification should be requested by the employer. The worker shall be allowed to withdraw her declaration of pregnancy at any time [10 CFR 835.2(a), Declared pregnant worker], thus terminating any work restrictions. Once such notification has been made, it is the employer's responsibility to remove any imposed work or area restrictions as discussed in Section 8.3.

The rights (e.g., right to work) and privacy of the worker should be maintained before, during, and following any declaration of pregnancy. All aspects of the worker's withdrawal of the declaration of pregnancy should also be maintained confidential. The rights and privacy of workers who have chosen not to declare their pregnancy should also be respected. Because 10 CFR 835.901 requires that radiation safety training include discussions of the risks of exposure to radiation and radioactive materials during pregnancy, and include an individual's rights and responsibilities as related to the facility's radiation protection program, there is no need to remind an undeclared pregnant worker of the opportunity for a pregnant employee to avail herself of the special limits for protection of the embryo/fetus. Such reminders would be inappropriate in light of the *United Auto Workers v. Johnson Controls, Inc.* case previously cited. Chapter 14 provides guidance on initial and biennial training, as well as recommendations for annual refresher training.

8.3 Work Restrictions Following Declarations of Pregnancy

Following the submittal of a declaration of pregnancy, the radiation dose equivalent received by the embryo/fetus prior to the declaration (i.e., from the estimated date of conception to the date of declaration) should be calculated as soon as practicable. Section 8.5 of this Guide provides an acceptable methodology. Once this dose equivalent

has been calculated, the dose equivalent allowed for the remaining gestation period should be determined. An evaluation of the dose equivalent that the embryo/fetus is likely to receive while the declared pregnant worker is performing her current job duties should be performed to determine if work restrictions are necessary. The evaluation should take into consideration the 0.5 rem dose equivalent limit, the dose equivalent remaining for the gestation period, and the requirement not to vary substantially above a uniform exposure rate that would satisfy the 0.5 rem limit during the gestation period. If the nature of the declared pregnant worker's duties make it likely that either the 0.5 rem limit will be exceeded or that substantial variation will occur, then work restrictions shall be

established [10 CFR 835.206(a) and (b)]. If it is determined that the dose equivalent to the embryo/fetus has already exceeded 0.5 rem, the declared pregnant worker shall not be assigned to tasks where additional occupational exposure is likely during the remainder of the gestation period [10 CFR 835.206(c)], unless she voluntarily revokes her pregnancy declaration.

A uniform exposure rate in rem/week may be calculated by subtracting the dose equivalent received by the embryo/fetus prior to the declaration of the pregnancy from the 0.5 rem limit and then dividing this difference by the approximate number of weeks remaining in the gestation period. For example, for a pregnancy that was declared at 10 weeks into the gestation period with a calculated dose equivalent of 200 mrem to the embryo/fetus prior to the declaration of the pregnancy, a uniform exposure rate for the remainder of the pregnancy would be (500 mrem-200 mrem)/30 week or approximately 10 mrem/week. 10 CFR 835 allows flexibility for a facility specific determination of what constitutes a "substantial variation." The value selected will vary depending on

site-specific factors such as nature of work performed, radiological conditions in the areas to be entered, and the sensitivity and accuracy of the individual monitoring methods used. DOE recommends a value equal to the calculated uniform dose equivalent rate per week +100%. In the example cited above, this would be any dose rate greater than 20 mrem/week. Each facility should determine and document the methods used to identify a "substantial variation."

Additional work or area restrictions for the declared pregnant worker, based on limiting the total dose (internal and external) may be established as necessary to ensure compliance with the total dose equivalent and "substantial variation" criteria. Procedures should provide for coordination between radiation protection and line management, occupational health or medical services. Examples of typical restrictions include

reducing the time allowed in radiological areas (including prohibiting access to certain areas), restricting the time spent in certain areas within a radiological area, restricting performance of certain tasks, and requiring use of supplemental controls, such as shielding, ventilation, and personal protective equipment. To determine whether restrictions should apply, each facility should evaluate the worker's dose history and radiological conditions in those areas to which the declared pregnant worker may have access. Also, employers should provide declared pregnant workers the option of a mutually agreeable work assignment that does not involve additional occupational dose. The training for workers should identify such restrictions and options (see Chapter 14).

Due to difficulties in evaluating fetal dose resulting from radioactive material intakes, restrictions should be imposed to minimize a declared pregnant worker's radioactive material intakes. Consideration should be given to restricting declared pregnant workers from entering areas where they may receive an intake of radionuclides. ALARA (total dose) aspects should also be considered in implementing these restrictions. If it is not practical to restrict the declared pregnant worker from entry into areas where intakes are likely to occur, enhanced use of engineering controls (primary) and administrative controls (secondary) should be considered.

Any additional workplace restrictions for the declared pregnant worker shall (10 CFR 835.206) remain in place until the baby is born, the declaration of pregnancy has been withdrawn (see the sample declaration and withdrawal forms in Appendices 8.A and 8.B), or it is determined that such restrictions are not required to ensure compliance with 10 CFR 835.206.

Radiological work restrictions apply only to declared pregnant workers. If the worker does not declare her pregnancy, she cannot be restricted in her work or in the dose that she receives unless these restrictions apply to all employees of similar position, i.e. general employees or radiological workers as specified in 10 CFR 835.

8.4 Counseling

An employee with expertise in health physics, laboratory safety, occupational health, or medical services should be designated as a contact for female workers to obtain counseling or additional information on the subject of the risks to the embryo/fetus from exposure to ionizing radiation. Individuals who provide this counseling should receive training in risk communication and be knowledgeable of the risks of fetal radiation exposure. NRC Regulatory Guide 8.13, *Instruction Concerning Prenatal Radiation Exposure* (NRC 1987) and NCRP Report No. 116, *Limitation of Exposure to Ionizing Radiation* (NCRP 1993) provides information on the risks of radiation dose to the embryo/fetus.

Counseling of any worker on the risks of exposure to radiation to the embryo/fetus should be documented regardless of the worker's decision to declare or not to declare the pregnancy.

8.5 Dose Determination and Monitoring Methods

8.5.0 Dose Determination

The dose equivalent to the embryo/fetus should be determined as soon as practicable after a worker submits a declaration of pregnancy, at sufficient intervals after declaration to ensure the limit is not exceeded and that substantial variations do not occur, and at the end of the gestation period. It may be necessary to include the dose for the entire reporting period during which conception occurred, unless more detailed records are available to determine the fraction of the dose received since the time of conception. If enough information is available to assume that the previous dose was received in a linear fashion, the fraction of the dose may be used that corresponds to the fraction of the reporting period during which the worker was pregnant. This method is appropriate for the majority of workers who work on a variety of tasks during a reporting period, none of which results in a significant dose. At the conclusion of a declared pregnancy the dose received by the embryo/fetus prior to the declaration of pregnancy plus the dose received during the remainder of the pregnancy should be calculated as the sum of:

- the dose equivalent to the embryo/fetus from external sources of radiation;
- the dose equivalent to the embryo/fetus from intakes of radionuclides in the embryo/fetus; and
- the dose equivalent to the embryo/fetus resulting from intakes of radionuclides in the declared pregnant worker.

A sample dose record form is provided in Appendix 8.C. Detailed dose equivalent calculations should be attached to the record form. The dose to the embryo/fetus from radiation external to the mother should be taken as the deep dose equivalent to the mother's abdomen or torso.

If an intake of radioactive material occurs, or occurred between conception and the declaration of pregnancy, the dose equivalent to the embryo/fetus should be determined as follows. The dose equivalent to the embryo/fetus from radionuclides in the embryo/fetus and in the mother that are relatively uniformly distributed, such as Cs-137 and compounds of H-3 and C-14 that are not organically bound, may be considered to be the same as the dose equivalent to the mother because, under these circumstances, the same energy would be deposited per gram of tissue in both the mother and the fetus. For other exposure conditions, refer to NUREG/CR-5631, Rev. 1, *Contribution of Maternal Radionuclide Burdens to Prenatal Radiation Doses* (NRC 1992b). The information given in this report or in NRC Regulatory Guide 8.36, *Radiation Dose to the Embryo/Fetus* (NRC 1992c), should be used to estimate the internal dose. If other methods are used, the basis for their use in demonstrating an equivalent or better level of protection should be documented.

8.5.1 Monitoring Methods

Guidance on internal and external dose monitoring methods is provided in Chapters 5 and 6 of this Guide.

8.6 Training

It is important that all individuals who enter a controlled area understand the risk to the embryo/fetus from ionizing radiation received as a result of the mother's occupational exposure. It is also important that procedures regarding fetal exposure be well understood by workers and their supervisors.

Note that the radiation safety training requirements in 10 CFR 835.901(which include the risk of prenatal exposure to ionizing radiation) pertain to workers who are allowed unescorted access to, and/or receive occupational radiation dose in, controlled areas. Under certain conditions, it is possible that a pregnant worker outside of the controlled area could receive a dose exceeding the 50 millirem (0.5 mSv) monitoring threshold, but not be subject to the 10 CFR 835.901 training requirements. If such conditions exist, measures should be implemented to ensure that affected workers are aware of the risks of fetal radiation exposure and their rights to declare their pregnancy. This information should be disseminated through radiation safety training or equivalent measures.

Additional guidance on radiation safety training programs can be found in Chapter 14 of this Guide and NRC Regulatory Guide 8.13.

8.7 Record -Keeping and Reporting

Record-keeping and reporting guidance may be found in Chapter 13.

Appendix 8.A
Declaration of Pregnancy Form

DECLARATION OF PREGNANCY

In accordance with Section 206 of 10 CFR 835, I am voluntarily declaring that I am pregnant, for the purposes of lowering the dose received by my embryo/fetus. I realize that work restrictions may be imposed to ensure that the embryo/fetus does not receive a dose in excess of that given in 10 CFR 835 (500 mrem, or 0.005 Sv, during the entire gestation period). I also realize that supplemental dosimetry may be supplied to me, along with periodic reports of the dose received by my embryo/fetus.

Estimated Date of Conception _____

_____
Printed name of worker ID#

_____
Signature of worker Date

_____
Printed name of supervisor Title

_____
Signature of supervisor Date

_____
Printed name of Health Physics or Medical Representative Title

Appendix 8.B
Withdrawal of Pregnancy Declaration Form

WITHDRAWAL OF PREGNANCY DECLARATION

I am withdrawing my previous declaration of pregnancy. I understand that, as a result of signing and submitting this form, any work restrictions that have been imposed as a result of the previously submitted "Declaration of Pregnancy" will be lifted.

Date of Pregnancy Declaration _____

_____
Printed name of worker ID#

_____
Signature of worker Date

_____
Printed name of supervisor Title

_____
Signature of supervisor Date

_____
Printed name of Health Physics or Medical Representative Title

_____
Printed name of Health Physics or Medical Representative Title

_____
Signature of Health Physics or Medical Representative Date

Appendix 8.C
Embryo/Fetal Dose Equivalent Record Form

EMBRYO/FETAL DOSE EQUIVALENT RECORD

_____
Printed name of worker ID#

Date of Declaration of Pregnancy _____

Estimated Date of Conception _____

Estimated External Dose (prior to declaration of pregnancy) _____

External Dose for remaining period of pregnancy _____

Estimated Internal Dose (prior to declaration of pregnancy) _____

From radionuclides in the embryo/fetus _____

From radionuclides in the mother _____

Subtotal _____

Internal Dose for remaining period of pregnancy _____

From radionuclides in the embryo/fetus _____

From radionuclides in the mother _____
Subtotal _____

Total Dose during gestation period _____

_____
Printed name of Evaluator Title

_____
Signature of Evaluator Date

9.0 PORTABLE MONITORING INSTRUMENT CALIBRATION

A comprehensive radiation protection program (RPP) requires reliable means of monitoring radiological conditions. Such monitoring requires the use of properly functioning radiation monitoring instruments.

10 CFR 835.401(b) requires that instruments and equipment used for monitoring radiological conditions shall be appropriate for the radiation(s) encountered and the environmental conditions and be routinely maintained, calibrated, and tested. American National Standards Institute (ANSI) Standard N323A, *Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments* (ANSI 1997a) provides comprehensive guidance for implementing a portable monitoring instrument calibration program.

This Guide provides guidance for a portable monitoring instrument calibration program that addresses selection (acceptance testing), calibration, tests for operability (functional tests and performance tests), maintenance, calibration equipment, calibration quality, laboratory documentation, facilities, and staff. Note that, while 10 CFR 835.401(b) applies to all radiation monitoring instruments and equipment, the guidance provided in this Guide applies specifically to portable monitoring instruments only. This Guide does not provide specific guidance for:

- installed or stationary monitors such as air monitors, portal monitors, and other non-portable monitoring instrumentation;
- laboratory equipment such as liquid scintillation counters and complex laboratory multi-channel analyzers;
- low exposure rate instruments (even if they are portable) with ranges extending below 0.1mrad/h;
- personal monitoring devices, such as thermoluminescent dosimeters and radio-sensitive film. These devices are addressed by DOE-STD-1111-98, DEPARTMENT OF ENERGY LABORATORY ACCREDITATION PROGRAM ADMINISTRATION (DOE 1998b);
- pocket ionization chambers. These devices are addressed by ANSI N13.5, *Performance Specifications for Direct Reading and Indirect Reading Pocket Dosimeters* (ANSI 1989a) and ANSI N322, *American National Standard Inspection, Test, Construction, and Performance Requirements for Direct Reading Electrostatic/Electroscope Type Dosimeters* (ANSI 1997b); and
- electronic dosimeters. Appropriate guidance regarding selection, calibration, testing and maintenance of electronic dosimeters is provided in ANSI N13.27,

Performance Specifications for Pocket-sized Alarming Dosimeter/Ratemeters (ANSI 1992a).

While this Guide does not apply directly to the above listed devices, many of the concepts and practices discussed in this Guide, and in the referenced consensus standards, may be applicable to these devices. These concepts and practices should be considered when establishing calibration and maintenance programs for these devices.

9.1 Implementation Guidance

This chapter provides guidance for selecting, calibrating, testing, and maintaining portable radiation monitoring instruments and equipment. The portable monitoring instrument maintenance and calibration program should be developed and conducted consistent with ANSI N323A.

The essential elements of an acceptable portable instrument calibration program are shown below with reference to 10 CFR 835, with additional elements provided in ANSI N323A:

- a system that ensures calibration shall be performed periodically on each instrument [10 CFR 835.401(b)(1)]. ANSI N323A (4.9) recommends that calibration be performed at least annually;

- an internal audit program shall be conducted no less frequently than every 36 months (10 CFR 835.102); and

- a records program shall be established that documents results of maintenance and calibration performed on instruments and equipment used for area monitoring and contamination control [10 CFR 835.703(d)], includes the maintenance of training records [10 CFR 835.704(a)], documents changes in equipment, techniques, and procedures used for monitoring, [10 CFR 835.704(e)], and documents the results of internal audits [10 CFR 835.704(c)].

Further, the following elements should be in place for those activities that perform their own instrument calibrations:

- procedures addressing the calibration of reference sources, support instruments, and field instruments;

- a method to determine when instruments have been returned out-of-calibration and a method to notify users of out-of-calibration instruments;

- adequate technical staff with appropriate training in instrument calibration; and

- a dedicated facility that permits calibrations without outside physical interference.

For those activities that rely on contracted organizations to perform calibration services, the RPP should include or make reference to a Memorandum of Agreement with the calibration contractor(s) that assures compliance with applicable DOE requirements.

9.2 Instrument Selection

Instruments shall be selected that are appropriate to measure the type(s), levels, and energies of radiation(s) encountered and for the existing environmental conditions [10 CFR 835.401(b)(2) and (b)(3)]. To ensure these requirements are met, the initial instrument selection process should include knowledge of facility radiation types, energies, anticipated or known ranges, and results of available instrument performance and testing data (vendor or independent). The selection process should include type testing and acceptance testing.

9.2.0 Type Testing

DOE encourages implementation of a formal instrument qualification (type testing) process in accordance with the relevant portions of ANSI N323A, ANSI N42.17A, *Performance Specifications for Health Physics Instrumentation - Portable Instruments for Use In Normal Environmental Conditions* (ANSI 1989b), and ANSI N42.17C, *Performance Specifications for Health Physics Instrumentation - Portable Instruments for Use In Extreme Environmental Conditions* (ANSI 1989c).

9.2.1 Acceptance Testing

Prior to use, new instruments should be subjected to acceptance testing as detailed in ANSI N323A. Instruments that do not meet the selected specifications should not be accepted or used by the facility. ANSI N320, *American National Standard Performance Specifications for Reactor Emergency Radiological Monitoring Instrumentation*, (ANSI 1979) provides performance parameters for various types of instruments for monitoring releases of radionuclides associated with an accident at a reactor facility.

9.3 Instrument Calibration

ANSI N323A sets forth criteria for proper portable monitoring instrument calibration. An instrument calibration hall be performed on each instrument periodically at an established frequency [10 CFR835.401(b)(1)]. ANSI N323A establishes an annual calibration frequency for portable monitoring instruments. The calibration frequency should be determined and the calibration should be performed according the details presented in the above referenced consensus standards. If routine checks (e.g., routine operability tests and as-found tests) indicate that the response of an instrument (or type of instrument) remains stable over a long period of time, then the calibration frequency may be extended. Conversely, if routine checks indicate that an instrument (or type of instrument) fails to provide a stable response over the prescribed calibration interval, then the calibration interval should be shortened. The reliability of an instrument (or type of

instrument) and appropriate calibration frequency should be determined by collecting and analyzing data in accordance with National Conference of Standards Laboratories Recommended Practice RP-1, *Establishment and Adjustment of Calibration Intervals* (NCSL 1996).

9.4 Operability Tests

Functional tests should be performed prior to initial use of an instrument in the field. Functional tests should be detailed in the instrument-use procedures and should include, as a minimum: general condition; battery condition; verification of current calibration (i.e., check to see that the date due for calibration has not passed); background readings; and other tests (high voltage, zero setting, alarm functions, etc.) as applicable to the instrument. Functional tests should also include a source response check (i.e., observing the instrument response to a check source) before initial operation. During use in the field, instruments should be tested with a check source to ensure that the readings remain within prescribed limits. This should be done as prescribed in ANSI N323A. The performance of functional tests during use in the field should be appropriately documented. This may be as simple as a check-list on the survey sheet.

Performance tests should be performed periodically and after maintenance to ensure that the instruments continue to meet performance requirements for field measurements. Examples of performance tests are tests for geotropism and response time. Performance requirements should be met as specified in the applicable sections of ANSI N323A, ANSI N42.17A, and ANSI N42.17 C. These tests may be conducted as part of the calibration procedure.

9.5 Maintenance

Maintenance shall be performed periodically on an established frequency [10 CFR 835.401(b)(1)]. Maintenance activities should be directed toward ensuring that the instruments continue to meet the required accuracy for field measurements.

All preventive and corrective maintenance should be performed using components and procedural recommendations at least as stringent as those specified by the instrument manufacturer. If the manufacturer does not provide routine maintenance procedures, a procedure should be written and approved by staff and management in the organization performing the maintenance.

9.6 Calibration Equipment/Calibration Quality

The calibration laboratory should possess and maintain appropriate radiation and non-radiation standards to achieve reliable operation.

Instruments should be calibrated with appropriate standards that are traceable to the National Institute of Standards and Technology (NIST) or its international equivalents.

Calibrations of reference radiation fields or sources, calibration assemblies, maintenance of standards, and check sources should be in accordance with ANSI N323A. For information on acceptable reference sources for calibration for various radiation types, refer to Table 2 of ANSI N323A. Calibration quality including calibration field accuracies and quantities should be in accordance with ANSI N323A.

For non-radiation quantities (e.g., temperature, humidity, pressure, voltage, current, etc.), the facility may use standards based on traceability to NIST.

9.7 Laboratory Documentation

The calibration laboratory should maintain the following sets of documentation: (1) the laboratory protocol; (2) the laboratory records; and (3) the calibration records. Historical records should be maintained to detail any changes or revisions in procedures or protocols. The laboratory protocol describes the laboratory operations, i.e., what the laboratory is expected to do and how it is expected to do it. This documentation should also include the detailed calibration procedures for each instrument routinely calibrated. The laboratory records, on the other hand, are those records that document the activities of the laboratory. Finally, the calibration records are those records that document the maintenance, calibration, and testing of each instrument and source used.

9.7.0 Laboratory Protocol

Each DOE laboratory should have a written protocol for operations. Components that should be included in the protocol are listed in ANSI/NCSL Z540-1-1994, *American National Standard for Calibration - Calibration Laboratories and Measuring and Test Equipment - General Requirements* (ANSI/NCSL 1994).

9.7.1 Laboratory Records

Guidance for record-keeping can be found in ANSI N323A and ANSI/HPS N13.6, *Practice for Occupational Radiation Exposure Records Systems* (ANSI/HPS 1999). Chapter 13 provides additional guidance for maintaining records consistent with the requirements of 10 CFR 835.

9.7.2 Instrument Calibration Records

A record shall be maintained for results of calibration and maintenance performed for each instrument [10 CFR 835.703(d)]. Refer to Chapter 9 and ANSI N323A for specific items that should be included.

9.7.3 Instrument Location

A system for tracking the location of portable survey instruments and for recalling those instruments for recalibration should be established. The location of portable survey instruments should be known by the calibration staff or by some identifiable group

assigned with that responsibility. Because instruments may incorporate or be accompanied by an accountable sealed radioactive source, instrument tracking may be required as part of the sealed radioactive source control program. See Chapter 15 to determine if this is the case.

9.8 Laboratory and Staff

The location, design, and use of the calibration laboratory should ensure that conditions within the laboratory will not affect calibration quality. In addition, the laboratory shall be designed to keep worker exposures ALARA in compliance with 10 CFR 835.1001 - 1003. The laboratory should also have an appropriate selection of calibration equipment and should be operated with a properly organized and trained staff. Additional guidance may be found in Chapter 4 of this Guide and Chapter 3 of the RCS.

9.8.0 Laboratory

The effect of external conditions on the internal environment of the calibration laboratory should be considered in selecting the facility site. The laboratory should be sited away from, or otherwise isolated from, sources of mechanical vibration and shock, sources of electrical and electromagnetic interference, and other potential sources of interference with the proper calibration of instrumentation. If such potential sources exist, the laboratory should have documentation that demonstrates an absence of adverse effects on calibration accuracy.

The electrical power should be appropriate for the equipment used, suitably stable, and free of switching surges and significant line noise. When necessary, local auxiliary voltage stabilizers, filters, and uninterruptible power supplies should be provided.

The laboratory environment should be controlled to ensure that environmental conditions do not affect the calibration quality. The conditions described in ANSI N323A, Table 1, should be considered and implemented, to the extent practicable and appropriate.

Calibration areas should not be used for storage of instruments, equipment, or sources. Such storage may lead to variable scatter or abnormal ambient radiation conditions.

98.1 Calibration Staff Qualifications

The calibration laboratory manager and the individual in charge of the day-to-day operation of the calibration laboratory should have the authority to conduct operations free from any influence that could adversely affect the quality or impartiality of the services offered. Refer to DOE STD-1107-97, KNOWLEDGE, SKILLS, AND ABILITIES FOR KEY RADIATION PROTECTION POSITIONS AT DOE FACILITIES (DOE 1997b) and Chapter 14 for guidance on the recommended education,

training, and skills for these two positions. The laboratory manager should understand the laboratory protocol, ensure it is followed, and should, at least annually, evaluate staff competence and the need for training. In smaller operations, the manager may also be in charge of day-to-day operations.

9.8.2 Calibration Staff Training

All staff employed in calibration work shall be trained in radiation safety prior to receiving occupational exposure [10 CFR 835.901(a)]. Chapter 14 provides additional guidance.

Apart from radiation safety training, the staff should receive training on the theory of radiation detectors, interaction of radiation with matter, basic statistics, maintenance of records, quality assurance, and other topics related to the safe and efficient operation of calibration equipment.

9.9 Assessments

Internal audits of the radiation protection program shall be conducted such that, over a three year period, all functional elements are assessed, including program content and implementation (10 CFR 835.102). Chapter 3 provides guidance on the required internal audits.

10.0 AIR MONITORING

The purposes for conducting an air monitoring program can be characterized as the need to assess individual exposures to airborne radioactive material, determine the need for and prescribe appropriate personnel protection from airborne radioactive material, and provide early warning of unexpected increases in airborne radioactivity levels. The type of air monitoring to be performed will depend on what the monitoring results are needed for. Under 10 CFR 835, air monitoring results are required to measure the concentrations of airborne radioactive material, determine posting requirements, determine the effectiveness of the engineered controls and barriers used to contain and confine radioactive material, determine appropriate protective equipment and measures, and provide warnings of significantly elevated levels of airborne radioactive materials. In addition, air monitoring results may be used to estimate individual intake. 10 CFR 835 establishes the basic elements of an air monitoring program: periodic air samples to assess actual and potential individual exposures and real-time air monitoring to provide immediate warning of increases in airborne radioactive material concentrations.

When implementing an air monitoring program, it is important to achieve a proper balance between the basic elements of the program -- air sampling and real-time air monitoring. The balance will depend on the characteristics of each facility and the justification for the approach taken should be included in program documentation.

The primary difficulty in meeting the air monitoring requirements in 10 CFR 835 is in collecting samples that can reliably reveal and estimate the magnitude of individual exposures. However, it should be possible to reliably detect increases in airborne radioactive material concentrations above baseline levels. This information can be used to initiate bioassay evaluations to verify whether an exposure has occurred and, if so, to estimate the magnitude of the exposure.

Real-time air monitoring is performed to provide warning of significantly elevated levels of airborne radioactive materials. The primary challenge in performing effective real-time air monitoring is placing the monitors where they will provide a rapid and reliable warning that an unexpected release has occurred. The number and placement of real-time air monitors should be optimized. Proper strategy for the placement of real-time air monitors is critical to the effectiveness of the air monitoring program.

The air monitoring program is only one element of a comprehensive radiation protection program. Therefore, individuals involved with the air monitoring program should coordinate their efforts with other radiation protection program personnel, particularly with those involved in contamination control and internal dosimetry.

10.1 Implementation Guidance

Monitoring of airborne radioactivity is required where an individual is likely to receive an exposure of 40 or more derived air concentration (DAC)-hours in a year or as

necessary to characterize the airborne radioactivity hazard where respiratory protective devices for protection against airborne radionuclides have been prescribed [10 CFR 835.403(a)]. Real-time air monitoring is required to be performed, as necessary, to detect and provide warning of airborne radioactivity concentrations that warrant immediate action to terminate inhalation of airborne radioactive material [10 CFR 835.403(b)].

This chapter describes acceptable methods for establishing and operating an air monitoring program adequate to demonstrate compliance with 10 CFR 835. The discussion is divided into the following topics:

- determining the need for air monitoring;
- placement of air sampling and real-time air monitoring equipment;
- selection and operation of air sampling equipment;
- selection and operation of real-time air monitoring equipment;
- sample analysis and data review;
- quality control and quality assurance; and
- administrative controls.

NUREG-1400, AIR SAMPLING IN THE WORKPLACE (NRC 1993), was developed by the U.S. Nuclear Regulatory Commission to provide technical information on air sampling for facilities following NRC's related regulatory guidance. The technical information provided in this document is useful for DOE facilities using this Guide. NUREG-1400 contains the following technical information:

- evaluation of the need for air sampling, including air sampling based on potential intakes and concentrations, and air sampling systems;
- location of air samplers, including purpose of airflow studies, determination of airflow patterns, and selecting sample location;
- demonstration that air sampling is representative of inhaled air;
- adjustments to derived air concentrations;
- measurement of the volume of air sampled; and
- evaluation of sampling results, including detecting changes in air concentrations over time, efficiency of collection media, and detection sensitivity.

NUREG-1400 should be consulted to obtain pertinent technical information concerning regulatory guidance provided in this Guide.

10.2 Determining the Needs for Air Monitoring

The decision to perform air monitoring should be based on consideration of both actual and potential radiological conditions. Actual conditions are typically confirmed by air sampling results with detectable levels of activity. Potential conditions are identified through the use of professional judgment and experience regarding the likelihood that a radiological condition will exist. When evaluating potential conditions, both normal situations and unusual situations which can reasonably be expected to occur should be considered. NUREG-1400, (Section 1) provides an acceptable methodology for evaluating the need for air sampling by predicting likely intakes for some individuals who might receive a significant intake. This methodology provides an acceptable approach to justify and document decisions based on professional judgment and experience.

10.2.0 Exposure Assessment

Air monitoring through the use of representative sampling is used for the assessment of an individual's exposure to airborne radioactivity. Air monitoring results may be used to determine an individual's type and frequency of bioassay measurements and to estimate an individual's dose from exposure to airborne radioactive material.

Determinations of the need for air sampling should include consideration of occupancy factors to determine if an individual is likely to receive a 40 DAC-hour exposure in a year. For example, if a worker is present in a work area only 200 hours per year and enters no other areas of significant airborne radioactivity, the individual could be exposed to an air concentration just less than 20% of a DAC without receiving an exposure equal to or exceeding 40 DAC-hours in a year.

10.2.0.0 Type and Frequency of Bioassay

10 CFR 835 requires that internal dose monitoring programs be conducted for individuals likely to exceed certain internal dose thresholds [10 CFR 835.402(c)]. The air monitoring program can provide significant information for determining the type and frequency of bioassay measurements.

An effective air monitoring program, in combination with an effective and reliable access control program, can facilitate tracking of an individual's exposure to airborne radioactive materials measured in DAC-hours. A DAC-hours tracking program should be considered for DOE activities where individuals could routinely be expected to be exposed to greater than 40 DAC-hours in a year. Internal dose monitoring programs typically assign bioassay frequency and methods based on actual or anticipated individual exposures. Therefore, tracking of individual exposures in DAC-hours can

facilitate determination of the type and frequency of required bioassay measurements. For example, if a radiological worker receives greater than 40 DAC-hours in a year, the individual would be required to participate in the bioassay monitoring program. The bioassay frequency and methodology may be determined based on the radionuclides inhaled and the frequency of intakes or exposure to airborne radioactive material.

10.2.0.1 Estimation of Dose

The estimation of internal dose shall be based on bioassay data rather than air concentration values unless bioassay data are:

- unavailable;
- inadequate; or
- internal dose estimates based on air concentration values are demonstrated to be as or more accurate [10 CFR 835.209(b)].

Bioassay data may meet these conditions as a result of instrumentation limitations, sampling discrepancies, or other conditions. Chapter 5 provides guidance on evaluation of internal dose from air monitoring data.

If bioassay measurements are not available or their validity is questionable, internal dose estimates may be determined from the number of DAC-hours tracked for that individual. When DAC-hours are used for this purpose, any adjustments, such as protection factors for respiratory protection, shall be documented [10 CFR 835.702(g)]. Additional guidance is provided in Chapter 5.

DOE has addressed the special case where the sensitivity of the bioassay analysis is technologically limited (such as with certain plutonium isotopes). Acceptable methods of dealing with technology shortfalls have been addressed in Chapter 5 and DOE-STD-1121-2003 (DOE 2003).

As required by 10 CFR 835.209(b)(3), when used for determinations of individual dose equivalents, air sampling results must provide dose determinations that are as or more accurate than those provided by bioassay. The air sample should closely approximate both the airborne radioactivity concentration and the physical and chemical properties of the airborne radioactive material. Personal air monitoring is typically used for obtaining air samples that are used for dose determination. Chapter 10 provides additional guidance for situations where air monitoring is used when there is no practical bioassay method.

Normally, real-time air monitoring should not be used in lieu of air sampling when the results may be used to estimate an individual's dose and intake. The results from real-time air monitoring may not be representative of the air actually breathed by

individuals, linked to the individual in that area, or sufficient to use in the estimation of internal dose.

10.2.1 Personnel Protection

Air monitoring is performed to determine the need for "Airborne Radioactivity Area" posting and access controls, evaluate the effectiveness of engineering controls, and determine the proper respiratory protective device.

10.2.1.0 Need for Posting

10 CFR 835.603(d) requires posting of airborne radioactivity areas. Air sampling may be used to determine whether an area should be posted as an airborne radioactivity area. Grab sampling is typically used to determine whether the criteria for posting airborne radioactivity areas have been exceeded. The sample volume should be sufficient to ensure the achievement of adequate counting system detection capabilities.

Chapter 12 of this Guide and Chapter 2 of the RCS provide detailed guidance on posting airborne radioactivity areas.

10.2.1.1 Effectiveness of Physical Design Features and Engineering Controls

Physical design features for facilities and systems include measures to preclude and control releases of airborne radioactive material. Air monitoring should be performed in facilities and around systems with physical design features designed to prevent the release of airborne radioactivity and also following modifications which could affect air flow and ventilation balance. Fixed-location air sampling should be considered in the design and modification of facilities where uncontained radioactive material would be used or releases of airborne radioactive material would be anticipated. Results from fixed-location air sampling are particularly useful during the startup of a new facility or new operation within an existing facility to establish baseline airborne radioactive material concentrations and verify containment integrity.

Engineering controls are used to protect individuals when permanent physical design features cannot adequately contain radioactive material. When engineering controls, such as ventilation, vacuum cleaners, or containment devices, are used to reduce or maintain airborne radioactivity concentrations, air monitoring should be performed to determine the adequacy and effectiveness of the engineering controls. Generally, for installed physical design features, such as fume hoods, fixed-location air sampling is preferred, whereas for temporary controls, such as portable ventilation or use of vacuum cleaners, grab sampling is preferred. Real-time air monitoring for determining the adequacy of installed controls may also be appropriate or required. Chapters 4 and 11 of this Guide and the RCS provide guidance on the use of engineering controls.

10.2.1.2 Proper Respiratory Protective Equipment

Respiratory protective equipment is used to reduce an individual's intake of airborne radioactive materials. Each respiratory protective device is assigned a protection factor that indicates the degree of protection afforded by the respirator. Respiratory protective devices should be chosen based on the protection factor and actual or potential airborne radioactivity levels, taking into account ALARA considerations, other industrial hazards, and worker safety. DOE requires its respiratory protection programs to be conducted, for DOE contractors in accordance with 10 CFR 851, and for DOE Federal employees in accordance with DOE O 440.1A, *Worker Protection Management for DOE Federal and Contractor Employees* (DOE 1998e). 10 CFR 851 and DOE O 440.1A require adherence to ANSI Z88.2, *Practices for Respiratory Protection* (ANSI 1992b) and 29 CFR 1910.134.

An important step in selecting the proper respiratory protective equipment is determining the actual or potential concentration of airborne radioactivity in the area the individual is to enter. Air sampling shall be performed as necessary to characterize the airborne radioactivity hazard where respiratory protection against airborne radionuclides has been prescribed [10 CFR 835.403(a)(2)]. Typically, grab sampling is used to determine the airborne radioactivity concentration. Real-time air monitoring may be useful in areas where substantial work is being performed and airborne radioactivity concentrations fluctuate,. If the individual is entering an area where the airborne radioactivity concentration is routinely sampled and is not likely to have changed since air monitoring was last performed, previously obtained samples may be used to characterize the airborne radioactivity hazard. When the need for air monitoring is not clear, historical data from fixed-location air sampling and real-time air monitoring should be analyzed to determine whether respiratory protection is appropriate. NUREG-1400 provides a methodology for predicting the potential intakes which can be useful in determining the need for respiratory protection (Section 1.2).

10.2.2 Early Warning

Real-time air monitoring shall be performed as necessary to detect and provide warning of airborne radioactivity concentrations that warrant immediate action to terminate exposure to airborne radioactive material [10 CFR 835.403(b)]. Typically, real-time air monitoring should be used in areas where unexpected increases in airborne radioactivity levels could result in an exposure to an individual exceeding 40 DAC-hours in one week. This exposure is typically representative of a committed effective dose equivalent (CEDE) of approximately 100 millirem (1 mSv). To provide the necessary warning, real-time air monitors should have alarm capability and sufficient sensitivity to detect airborne radioactivity at these levels.

Unlike air sampling, the need for real-time air monitoring is based on the likelihood that an individual will be exposed to an unexpected increase of airborne radioactivity greater than

a given level. The use of real-time air monitors is based upon the expectations of discrete events, rather than determination of ambient airborne radioactivity concentrations.

Examples of situations for which real-time air monitoring may be appropriate include the following:

- within or at the boundaries of areas where work is performed that creates or has the potential to create airborne radioactivity;
- within or at the boundaries of areas where a power failure or other disruption of engineering controls could result in the release of airborne radioactivity; and
- within or at the boundaries of established airborne radioactivity areas when work is being performed that has the potential to significantly increase the ambient airborne radioactivity levels.

These examples serve to emphasize that real-time air monitoring is intended to protect individuals both inside and outside of work areas.

Real-time air monitors may not be appropriate or necessary in established airborne radioactivity areas where ambient airborne radioactivity levels are not expected to increase (i.e., unexpected releases are not likely). Grab samples are typically used to monitor airborne radioactivity levels and to detect trends. Historical workplace air monitoring records and knowledge of the type of work to be performed in the area can be used to justify the decision not to use a real-time air monitor.

10.3 Placement of Air Sampling and Real-Time Air Monitoring Equipment

Once the need for air monitoring has been established, the monitor/sampler location(s) can be determined. Location is important because inappropriately placed equipment may not provide representative results. Concentrations of airborne radioactivity in an area can vary greatly from one location to another.

In general, air sampling equipment is most effective when located close to individuals to provide an indication of airborne radioactivity levels to which they are exposed. Real-time air monitoring equipment should be located to provide an early warning to individuals of a significant increase in levels of airborne radioactive material.

When selecting locations for air sampling and real-time air monitoring equipment, consideration should be given to the locations of possible release points and workers, the purpose of the sample, and room air flow patterns. The cost of real-time monitors and the time required to collect and analyze sample media limit the number used in a facility. This consideration, together with the need for a rapid response to an unplanned release, means that optimal placement is critical. The technical basis for air sampling

and real-time air monitoring equipment placement should be documented. The following considerations should be included in technical basis documentation:

10.3.0 Locations of Release Points and Individuals

Actual and potential release points in an area should be identified. Actual release points can be determined from past operating experience. Potential release points can be determined from a review of safety analysis documentation for the facility. The location of individuals in relation to these release points should also be identified. Finally, occupancy times for individuals near the release locations should be estimated.

10.3.1 Purpose of Sample

The purpose of air monitoring is to measure the concentrations of airborne radioactive material to:

- estimate individual intakes;
- determine posting requirements;
- determine the effectiveness of the confinement of radioactive material;
- determine appropriate protective equipment and measures; and
- provide warnings of significantly elevated levels of airborne radioactive materials.

To estimate exposures and intakes, a sample representative of the air breathed by the individual should be taken. The air sampling equipment should be positioned in the vicinity of the individual, taking into consideration the air flow path from likely release points to the individual. Alternatively, if the purpose is to indicate containment or confinement control, then air sampling equipment should be positioned near the release point, or likely release point, in a downstream direction. The downstream direction can be determined by performing air flow studies.

Real-time air monitoring equipment, such as continuous air monitors (CAMs), should be positioned strategically in the affected area or at the affected area boundaries. If there is only one potential release point in an area, then placement of the real-time air monitor as close to the release point as possible in a downwind direction may be adequate. If there are multiple release points and a limited number of real-time air monitors, such that one cannot be placed near each release point, then the real-time air monitors should be placed at locations expected to provide the most reliable indication of a release with the least delay from the onset of the release, should one occur. The general objective is to provide a rapid and reliable warning to the greatest number of individuals that a release has occurred.

10.3.2 Room Air Flow Patterns

Air flow studies should be used to determine the placement of air monitors and facilitate the interpretation of the results of air monitoring. The extent of air flow testing will depend on the type of air monitoring being performed. More extensive air flow testing should be performed when locating fixed-location air samplers and real-time air monitors than when locating air samplers being used as grab samplers for short duration jobs. Air flow studies may be useful in placement of grab samplers to ensure that samples are indeed representative. Air flow testing is not needed for personal air monitoring since proper placement of personal air samplers on the worker ensures collection of representative samples. Acceptable methods for determining air flow patterns are discussed, in detail, in NUREG-1400 (Section 2.3).

The radiation protection organization should be aware of facility characteristics, operations, and changes that may affect airflow patterns. The radiation protection organization should perform and document a review of the adequacy of sampling and monitoring systems periodically and as part of any facility or operational change affecting radiological control. The periodicity of the review should be documented as part of the technical basis for the placement of the air sampling and real-time monitoring equipment.

Placement of fixed-location air sampling and real-time air monitoring equipment should be reevaluated after changes to the ventilation system have been made or after equipment or structures have been added that may influence air flow. Air flow patterns in a given area should be reevaluated at a minimum every 36 months or when major room or building renovation has occurred.

10.4 Air Sampling Equipment

Types of air sampling equipment include fixed-location air samplers, portable air samplers (high-volume and low- volume), and personal (lapel) air samplers. Selection of air sampling equipment should be based on the type of sample being collected (e.g., breathing zone air sample, source-specific air sample, or grab air sample). Detailed technical information regarding air sampling systems is provided in NUREG-1400 (Section 1.3).

10.4.0 Breathing Zone Air Monitoring

Breathing zone air monitoring should be used when air monitoring results are used to assign internal doses and when determining the effectiveness of respiratory protection equipment. Breathing zone air monitoring involves collecting an air sample from the individual's breathing environment, making allowances to eliminate interferences the samplers themselves may have on the individual's activities. Such air samples provide the most reliable indicator of the potential for inhalation of airborne radioactivity and can provide an estimate of the magnitude of possible exposures. Breathing zone air samples can be collected using fixed-location air samplers, portable air samplers, or personal air samplers. When fixed-location air sampling equipment will not provide a representative

indication of the individual's breathing zone, then personal air sampling equipment should be used. When using personal air samplers, the radiation protection staff should ensure that the low flow rate will allow collection of enough radioactive material to meet the minimum sensitivity requirement for air monitoring.

Breathing zone air monitoring should also be used in areas where workers are likely to exceed an exposure of 40 DAC-hours in a year, and to identify possible worker internal exposures and the need for follow-up bioassay measurements. Breathing zone air monitoring data may be used to estimate intakes of radioactive material and subsequent internal dose in accordance with the requirements of 10 CFR 835.209(b).

10.4.1 Source-Specific Air Sampling

Source-specific air sampling is the collection of an air sample near an actual, or likely, release point in a work area. Fixed-location and portable air samplers can be used for source-specific air sampling to verify containment or confinement integrity, document airborne radioactive material levels (can be used for determining the need for posting), and provide information relevant to determining when the use of respiratory protective devices is necessary.

10.4.2 Grab Sampling

Grab sampling should be used for temporary or non-routine situations and as a backup for other types of air sampling in the event of equipment failure. Grab sampling can be used to determine whether areas should be posted as airborne radioactivity areas and respiratory protective devices should be used for protection against airborne radioactive material. Portable air sampling equipment should be used for operations requiring grab sampling. Sample flow rates may vary depending upon the specific application, but should always allow collection of a sample volume adequate to ensure that the minimum detectable activity of the sampling and counting system corresponds to an intake of no greater than 2% of an annual limit on intake (ALI) ALI and 10% of the appropriate DAC.

10.4.3 Operability Checks

Operability checks of air monitoring equipment are used to ensure that the equipment is functioning properly prior to and during use. Operability checks shall be performed routinely on flow rate meters [10 CFR 835.401(b)(4)]. In addition, because excessive dust loading interferes with alpha particle detection and reductions in flow rate result in uncertainties in the total air volume sampled, periodic verification of flow rates should be performed. At a minimum, the flow rates should be verified when sample media are exchanged. Rapid or significant changes in flow rate should be investigated immediately. These instances may indicate the need for more frequent changes of sample media or loss of integrity of filter or sampling equipment. The sample flow rate used for estimating air concentration should be the average of the flow rate when the sample was started and the flow rate when the sample medium was removed.

10.5 Real-Time Air Monitoring Equipment

10.5.0 Instrument Selection

Instruments used for real-time air monitoring shall be appropriate for the type(s), levels, and energies of radiation(s) encountered in the workplace [10 CFR 835.401(b)(2)] and for existing environmental conditions [10 CFR 835.401(b)(3)]. The selection of real-time air monitors should be based on the characteristics of the airborne radioactive material, the anticipated range of airborne radioactive material concentrations and the possible variations of the concentrations over time. The type of real-time air monitor used depends on the type of facility in which it is used, the radioisotopes being monitored, and the physical and chemical forms of the radioactive material. Commonly used monitors at DOE facilities are: particulate-radioactive material continuous air monitors (e.g., alpha CAMs and beta CAMs); impactor air monitors; and gaseous radioactive material monitors. Monitors that use background-reduction methods (e.g., activity-fractioning monitors and pseudo-coincidence monitors) may also be used. CAMs should not be used when high levels of contamination or other factors would prevent them from providing reliable results. Use of CAMs for particulates and noble gases is acceptable; however, detection of radon requires a different monitoring methodology that provides real-time information and alarm capabilities. In these cases, the use of working level monitors may be acceptable. If such monitoring instruments are taken credit for in the documented safety analysis, their initial quality and maintenance level should also be appropriate, including any that of any associated safety system hardware and software.

If a real-time air monitor is likely to become highly contaminated or if unreasonably high flow rates are needed, then one of the following techniques can be used: (1) periodic direct reading of fixed air sample media by using portable survey instruments; or (2) periodic grab samples with rapid analysis.

10.5.1 Alarm Set Points

Real-time air monitors should be capable of measuring 1 DAC when averaged over 8 hours (8 DAC-hours) under laboratory conditions. Alarm set points for real-time air monitors used for routine monitoring should be set at the lowest practical level so as to accurately indicate loss of containment or the need for corrective action without causing a significant number of false alarms. When monitoring for alpha emitters shows high radon and thoron concentrations, an alarm set point of up to 24 DAC-hours may be acceptable. In all cases, the actual alarm set point established for each unit and the technical basis for the alarm set points should be documented. If real-time monitors are used during work requiring the use of respiratory protective devices, the alarm set point can be adjusted to provide an early warning that the applicable respiratory protection factor may be exceeded.

10.5.2 Alarm Capabilities

Real-time air monitors shall have alarm capability and sufficient sensitivity to alert potentially exposed individuals that immediate action is necessary to minimize or

terminate inhalation exposure [10 CFR 835.403(b)]. The alarm should be audible and have a distinctive tone or sound so that it is not confused with other work area alarms, such as those for criticality. The audible alarm intensity should be a minimum sound level of 75 dB at 15 cm. In areas that have a high ambient noise level (>95 dB), a visual alarm should activate with the audible alarm. The visual alarm should be distinctive so that it cannot be mistaken for other types of alarms. If the monitor is installed outside the work area, there should be additional audible and visible alarm indicators inside the area to ensure that individuals are promptly notified. ANSI N42.17B, *Performance Specifications for Health Physics Instrumentation - Occupational Airborne Radioactivity Monitoring Instrumentation* (ANSI 1989d), provides additional guidance regarding alarm capabilities.

10.5.3 Operability Checks

Operability checks shall be routinely performed on real-time air monitoring equipment [10 CFR 835.401(b)(4)]. The following periodic operability checks should be performed at the frequency indicated:

- Daily operability checks should include positive airflow indication, presence of a typical non-zero response to background activity, and internal check sources or 60 Hz electronic checks when available. In addition, daily checks should verify the control settings and the operability of strip chart recorders, if used.

- Weekly operability checks should verify instrument response with a check source or with ambient levels of radon or thoron daughters. If an instrument response falls outside established response limits, it should be taken out of service.

- Once each month, every real-time air monitor in active service should be tested to ensure proper operation of the alarm. Alarm testing should also verify alarm response when the detector fails.

The adequacy of battery power should be tested monthly for real-time air monitors that rely on battery backup power in an emergency. Similarly, for those monitors using emergency power supplies, the adequacy of the emergency power for monitor operation should be verified as a part of the emergency power checks.

10.6 Sample Analysis and Data Review

Provisions for detecting changes in radiological conditions, detecting the gradual buildup of radioactive material, verifying the effectiveness of engineering and process controls in containing radioactive material, and identifying and controlling potential sources of individual exposure to radioactive material require that certain evaluations of air monitoring results be performed [10 CFR 835.401(a)(3-6)]. Additional technical information regarding evaluation of sampling results is provided in NUREG-1400 (Section 6).

Air sample results should be evaluated as quickly as practical for special situations, such as the evaluation of the need for respiratory protection, area evacuation (if necessary), individual intake, and relief from use of respiratory protective devices. Preliminary assessments of air samples using field survey techniques should be performed promptly upon removing the sample from its holder. When background levels of radon and thoron daughters interfere with evaluation of alpha air samples, prompt field assessments may not be possible. Procedures should define the methods for counting samples in the field (i.e., detection equipment to use, configuration of the detector and the sample, and conversion factors). Prompt field assessments are not required for fixed-location, portable, or personal air samplers used to routinely sample the individual's breathing environment unless upset conditions have been identified.

Appendix A of 10 CFR 835 has a provision that allows the adjustment of DACs to reflect the actual physical characteristics (e.g., particle size) and chemical characteristics (e.g., solubility in lung fluid) of the airborne radioactive material. Federal Guidance Report No. 11, *Limiting Values of Radionuclide Intake And Air Concentration and Dose Conversion Factors For Inhalation, Submersion, and Ingestion* (EPA 1988), should be used when determining the retention class for the chemical compound of the radionuclide taken into the body. Guidance on making adjustments to DACs can be found in NUREG-1400 (Section 4), and in DOE STD-1121-2003.

10.7 Quality Control and Quality Assurance

Records of the results of air monitoring shall be documented and maintained [10 CFR 835.703(a)]. To meet this requirement, quality control should be applied to all phases of the air monitoring program to include sample identification, handling, and storage, air sampling and real-time air monitoring equipment, counting room equipment, and record-keeping.

10.7.0 Sample Identification, Handling, and Storage

All samples collected should be assigned an identification number that cannot be confused with samples taken at another location. Sample designators should be placed on all collection envelopes or containers to reduce the possibility of mislabeling a sample. Other information on the envelope should include the date and time of sample collection and the sample flow rates.

Samples should be handled carefully to prevent cross-contamination between samples and should be placed in appropriately labeled containers to reduce the potential for loss. Arrangements should be made for sample storage prior to counting and between counts if multiple counts are required.

Each organization should develop a tracking system for its air samples that permits positive identification of any individual sample, while indicating the results of the sample analysis, the flow rate, the dates and times of sample collection, the individual

performing the collection, and pertinent information about the sample collection system. A sample log book or a computerized database should be maintained. This should contain the necessary entries to provide a complete history of the sample and its analysis.

10.7.1 Air Sampling and Real-Time Air Monitoring Equipment

Components of air sampling and real-time air monitoring systems (i.e., air mover, CAM detector, portable air sampler, fixed sampling head, and sampling line) should be uniquely identified. Labeling of equipment and maintaining a log of equipment locations will allow the radiation protection staff to locate a sampling or monitoring unit should there be a questionable sample result.

Equipment used for air monitoring shall be periodically maintained and calibrated on an established frequency [10 CFR 835.401(b)(1)]. ANSI N42.17B indicates that air flow meters, differential pressure indicators, and other devices used to determine volumetric flow rates of air samplers and monitors should be calibrated to within $\pm$15% of the true reading. Calibrations should be performed annually at the atmospheric pressure and temperature conditions that are expected during sampling conditions, or the appropriate correction factor should be applied during the calculation of the flow rate.

Detectors in real-time air monitors should be calibrated with a calibration source(s) typical of the radionuclide(s) present in the work environment. The calibration should also be performed after failure of an operability test. Calibration sources should be traceable to the National Institute of Standards and Technology (NIST).

At a minimum, air inleakage tests should be performed on real-time air monitors when they are calibrated, whenever a monitor is replaced, and whenever a monitor's rubber O-rings or other seals are replaced. Ideally, tests for inleakage should also be performed during monthly or quarterly performance tests. Care should be exercised to prevent equipment damage during testing. For example, rapid changes in sample line pressure on some real-time air monitors may damage the detector.

Procedures should be established to address the appropriate review and use of data when a critical component of an air monitoring system (e.g., detector or airflow meter) is determined to be out of calibration. Procedures should be established to review the accuracy of any data generated by that particular equipment since it was last calibrated.

10.7.2 Counting Room Equipment

Counting room equipment shall be routinely tested for operability [10 CFR 835.401(b)(4)]. Daily performance checks of background count rate and radiation response (source checks) should be performed on the counting system.

10.7.3 Audits

The radiation protection organization should perform and document a review of the adequacy of air monitoring systems as part of any facility or operational changes affecting radiological control. In the absence of such changes, a review should be conducted annually. The air monitoring program should be reviewed as a functional element in the internal audit program required under 10 CFR 835.102.

10.7.4 Recordkeeping

10 CFR 835 establishes specific requirements for the documentation of air monitoring. Chapter 13 of this Guide and the RCS discuss these requirements and provide detailed guidance.

10.8 Administrative Controls

10.8.0 Technical Basis Document

A document should be developed that provides the technical basis for selecting, placing, and operating air sampling and real-time air monitoring equipment. This document should include information such as:

- performance and acceptance testing of new equipment;
- filter media characteristics;
- sample transport line losses (if applicable);
- flow rate and duration of sample collection;
- identification of relevant supplies and equipment by manufacturer, make, and model;
- performance of air flow studies;
- rationale for the use and placement of air samplers and real-time air monitors;
- rationale for demonstrating that air samples are representative of air breathed by workers;
- list of, and a facility map showing, actual locations of air sampling and real-time air monitoring equipment;
- calculation of the decision level, minimum detectable activity, and minimum detectable concentration for sampling/counting configurations;
- procedures for sample analysis;

- procedures for sample accountability; and
- routine maintenance and calibration of equipment.

This information should be readily available to radiation protection staff and should be reviewed periodically and revised as necessary.

10.8.1 Written Procedures

Written procedures should be available for:

- collecting air samples;
- performing operability checks of air sampling and real-time air monitoring equipment;
- calibrating flow rate meters;
- calibrating any radiation detectors that are part of the air monitoring equipment;
- conducting air flow studies to aid in the placement of air sampling and real-time air monitoring equipment; and
- interpreting the air monitoring results.

Other written procedures should be established for the following:

- counting room staff, on the operation and routine maintenance of air sample counting equipment, including the development and continued use of source count statistical control charts.
- radiochemistry staff, on the performance of special analyses.

Any changes in procedures used for monitoring in the workplace shall be documented [10 CFR 835.704(e)].

11.0 RADIOACTIVE CONTAMINATION CONTROL

Work with unsealed quantities of radioactive material creates the potential for generating radioactive contamination. 10 CFR 835 requires, in part, a contamination control program sufficient to provide warning of the presence of surface contamination and to prevent the inadvertent transfer of contamination at levels exceeding specified values outside of radiological areas under normal operating conditions.

An acceptable contamination control program incorporates two types of control: (1) Physical design features, including engineering control, and (2) administrative control. Contamination monitoring is part of and verifies the effectiveness of the contamination control program.

In implementing a contamination control program, physical design features that control contamination at the source are the most important element. Physical design features incorporated into older facilities may not be sufficient to meet modern contamination control standards. The physical design features used in a contamination control program may include engineering controls, including containment and ventilation, which may be the primary methods of controlling airborne radioactivity and internal exposures to workers in older facilities, during relatively short-term operations and maintenance, and in other situations in which permanent physical design features are unavailable or inadequate. For example, a permanently installed high efficiency particulate air (HEPA)-filtered ventilation system may be included as a physical design feature in a facility to control airborne radioactive material concentrations during routine operations, but a temporary HEPA-filtered ventilation system may be used as an engineering control during certain maintenance activities. Similarly, a drain system may be included as a physical design feature to route contaminated fluids to a controlled collection point, but temporary drains may be installed as engineering controls during system breach. Finally, administrative controls, including access restrictions and the use of specific work practices designed to minimize contamination transfer, should be used as the tertiary method to control exposure to contamination hazards. These elements of a contamination control program are not independent. The permanent physical design features included in a facility will dictate the types and levels of administrative controls and engineering controls that are possible and necessary.

A contamination control program is an essential element of a comprehensive radiological control program. In this Guide, when another element of a radiological control program interfaces with the contamination control program, the appropriate chapter is referenced and the topic of interest is listed as it applies to contamination control. Because of these interfaces, individuals involved with the contamination control program should interact with personnel working in other elements of the radiological control program, particularly with individuals involved in instrument calibration, posting and labeling, air monitoring, internal and external dosimetry, As Low As Is Reasonably Achievable (ALARA), training, and record-keeping programs.

Some DOE contractors have developed specific guidance addressing various aspects of contamination control, including radiological engineering, contamination containment design and construction, and radiological work practices. DOE is evaluating these documents to determine their complex-wide applicability and the potential impact of issuing them as DOE technical standards. In the interim, DOE encourages its contractors to review the guidance provided in these documents and to include it in site-specific programs, to the extent that the guidance is applicable to site hazards and controls.

Detailed information on contamination controls applicable to specific radiological hazards is provided:

- for tritium facilities, in DOE-HDBK-1129-2004, TRITIUM HANDLING AND SAFE STORAGE (DOE 1999c);
- for plutonium facilities, in DOE-STD-1128-98, GUIDE TO GOOD PRACTICES FOR OCCUPATIONAL RADIATION PROTECTION IN PLUTONIUM FACILITIES (DOE 1998f); and
- for uranium facilities, in DOE-STD-1136-2004, GUIDE TO GOOD PRACTICES FOR OCCUPATIONAL RADIATION PROTECTION IN URANIUM FACILITIES (DOE 2004b) .

This Guide provides references to detailed guidance provided in the RCS. The referenced guidance provides acceptable methods of achieving and maintaining compliance with related provisions of 10 CFR 835.

11.1 Implementation Guidance

Activities that have the potential to generate surface contamination should be evaluated to ensure appropriate controls are established. To the extent practicable, contamination controls should be consistent to facilitate effective implementation by affected individuals. This chapter describes methods for establishing and operating an acceptable contamination control program. The discussion is divided into the following topics:

- Contamination Control Program Management;
- Physical Design Features;
- Administrative Control; and
- Contamination Monitoring.

Note that the requirements of 10 CFR 835.1101-1102 and the values provided in 10 CFR 835 Appendix D (Surface Contamination Values) apply only to radioactive material that is present in the form of surface contamination. The storage, movement, and use of radioactive material in other forms (e.g., material that is intrinsically

radioactive or that has been made radioactive through activation processes) should be controlled consistent with applicable requirements in 10 CFR 835, including the training requirements under 10 CFR 835.901, the ALARA controls required under 10 CFR 835.101 and 835.1001- 1003, and the controlled area maximum yearly dose expectation provided in 10 CFR 835.602.

11.2 Contamination Control Program Management

Common characteristics of effective contamination control programs include:

- strong, written upper management commitment to control of contamination in the workplace;
- consistent line management implementation of required controls through established procedures, training, and frequent supervision;
- detailed work planning, including effective hazards analysis, pre-job briefings, and post-job debriefings; and
- consistent program support by affected individuals.

Management commitment should be established in a written policy which may be included in the ALARA Policy statement or other policy-level document. The policy should be implemented by written procedures, technical work documents, and radiological work permits commensurate with the hazards and required controls and sufficient to ensure consistent program implementation given the education, training, and skills of the affected individuals. Guidance on developing written procedures and on ensuring the appropriate education, training, and skills of affected individuals is provided in Chapter 3. Guidance on radiation safety training is provided in Chapter 14. The radiological control manager should be responsible for the development of the contamination control program, including associated design reviews.

Contamination control is the responsibility of everyone involved in radiological activities. All individuals working with radioactive material should follow established procedures that meet or exceed the guidance provided in this Guide and applicable DOE Orders and regulations. Line managers should be responsible for overseeing program implementation by their subordinates.

Guidance on effective planning for work with radiological hazards is provided in Chapter 4 of this Guide and Chapter 3 of the RCS.

11.3 Physical Design Features

Appropriate controls that prevent the inadvertent transfer of removable contamination to locations outside of radiological areas under normal operating conditions shall be maintained and verified [10 CFR 835.1102(a)]. 10 CFR 835.1001 requires measures to be

taken to maintain radiation exposure as low as is reasonably achievable through physical design features and administrative controls. The primary methods used shall be physical design features (e.g., confinement, ventilation, remote handling, and shielding). Administrative controls shall be employed only as supplemental methods to control radiation exposure [10 CFR 835.1001(a)].

DOE recognizes the fact that the design and operating history of its facilities and the nature of existing contamination hazards may make control of contamination problematic, particularly in outdoor areas where legacy contamination may exist. Therefore, DOE regulations do not require that the controls implemented to prevent the transfer of removable contamination be impervious to ensure regulatory compliance. However, the controls should be appropriate to the extent of the hazard and the potential adverse effects that may result from such transfer. Should the potential exist for radioactive contamination to be transferred outside of posted or controlled radiological areas (i.e., as a result of human or animal intrusion, containment or system failures, planned work activities, or natural forces), enhanced monitoring and control programs should be developed and implemented to identify affected areas and ensure timely detection of the transfer and institution of appropriate controls over the affected area as required by 10 CFR 835 and further explained in this Guide.

Radiological control is affected by human performance and engineered design features. General and radiological design criteria for new facilities and major modifications to existing facilities are provided in 10 CFR 835, DOE O 420.1B, *Facility Safety* (DOE 2005d), and the RCS. The design of facilities currently under construction or modification should be planned and evaluated for adherence to the applicable criteria. The effectiveness of design features should be evaluated through performance of area and individual monitoring. See Section 11.5 of this Guide and Chapter 5 of the RCS for further information regarding contamination monitoring.

Physical design features that should be considered to enhance control of workplace contamination include:

- containment of process materials to the maximum practicable extent;
- components and materials that minimize leakage across seals;
- catch basins and controlled drains from potential leakage points;
- use of multiple barriers as necessary to control the spread of contamination. (For instance, a room, system or vessel that contains radioactive material should be designed and operated to retain that material, and should also be equipped as necessary with drain and ventilation systems to direct any leakage that may occur to appropriate collection systems);

- adequate working space around serviceable components to facilitate maintenance and repairs;
- filtered ventilation from areas of lower to areas of higher contamination levels;
- adequate space for donning and removal of protective clothing and individual frisking in low-background areas; and
- location of office and break areas away from radiological areas.

In addition to the above, facility design, including materials selected, shall include features that facilitate operations, maintenance, decontamination, and decommissioning [10 CFR 835.1002(d)]. These activities should be facilitated by limiting the size of any contaminated areas and the magnitude of the contamination levels within those areas. To the maximum possible extent, materials used should be readily decontaminated using non-hazardous compounds, particularly water or steam. Smooth, corrosion resistant surfaces and rounded edges also facilitate decontamination. More detailed information on design features is provided in Chapter 4 of this Guide and Chapter 3 of the RCS.

When permanent physical design features are not sufficient to prevent the spread of contamination in the workplace, temporary physical design features in the form of engineering controls, such as containment devices and portable or auxiliary ventilation, should be installed. These circumstances arise frequently during maintenance, modifications, and decontamination and decommissioning. Planning for such activities should include evaluation of the potential for contamination spread and the effectiveness of engineering controls to reduce such potential, and, to the extent that engineering controls will not be effective, prescription of administrative controls to limit the spread of contamination.

Temporary containment devices may be particularly useful in controlling contamination spread resulting from system leaks and from maintenance that requires contaminated system breach. These devices range in complexity from simple plastic catch-basins suspended below leakage points to complex portable buildings used to enclose an entire work area. Many commercially-available designs include provisions for glove and equipment ports, ventilation, and contamination reduction exit portals.

Portable air handling systems used in contaminated areas, including vacuum cleaners, should be equipped with HEPA filtered exhausts or have their exhausts directed to installed systems that are so equipped. These provisions may not be necessary in areas where only tritium or radioactive noble gases are present or when the material to be vacuumed is wet enough to preclude re-suspension after entry into the system collection chamber. Improper use of vacuum cleaners and portable air-handling equipment may result in the generation of airborne radioactive material or removable surface contamination. Extended use of air handling equipment may result in a significant build-up of radioactive material in the ductwork and filters. Periodic monitoring of the

exhausted air and accessible equipment surfaces should be performed to assess the radiological impact of equipment operation. Chapter 4 of the RCS provides more detailed information regarding use of portable ventilation units and vacuum cleaners.

Although use of the devices discussed above has been proven effective in reducing contamination spread and the associated decontamination costs, these benefits must be weighed against the potential costs. Use of engineering controls may require expenditure of worker dose to set up, work in, maintain, and remove the device. There may be financial costs associated with device purchase or manufacture, training, possible reduced productivity, and device or component set-up, maintenance, and disposal. These factors are considered in implementation of an effective ALARA program, which is discussed in more detail in Chapter 4.

11.4 Administrative Control

When the use of physical design features (including engineering controls) to limit individual exposures is impractical, administrative controls shall be implemented to maintain exposures ALARA [10 CFR 835.1001(b)]. To control the spread of contamination and limit individual exposures, a graded, multiple-tier system should be used in and around contaminated areas. The effectiveness of the controls should be verified through the conduct of contamination monitoring, as discussed in Section 11.5 of this Guide and Chapter 5 of the RCS.

11.4.0 Work Authorizations

Guidance on the use of work authorizations is provided in Chapter 4 of this Guide and Chapter 3 of the RCS.

11.4.1 Access Control

Control of entry to contaminated areas is necessary to ensure that personnel entering the area are informed of the radiological status and potential hazards and are provided with the appropriate protective apparel and equipment. Control of egress from contaminated areas ensures that radioactive material is not inadvertently removed from the area by personnel or equipment. Efforts should be made to limit the degree of contamination and the size and number of contaminated areas in the facility, thereby limiting the need for use of protective clothing and the undesirable side effects of restricted access to facility equipment, heat stress, and radioactive waste generation.

11.4.1.0 Entry Controls

Protective clothing shall be required for entry into contaminated areas where removable contamination levels exceed the values provided in Appendix D of 10 CFR 835 [10 CFR 835.1102(e)]. The type of protective clothing required should be prescribed based upon considerations of contamination levels, chemical and physical form of the contaminant, activities to be performed, and area accessibility. Other area and activity

hazards, such as heat, flame, hazardous chemicals, physical obstructions, electrical shock, and limited visibility, should be considered when prescribing protective clothing. Appendix C "Compliance Guidelines" of 29 CFR 1910.120 (OSHA 1974) provides guidance on these considerations as follows:

The use of PPE can itself create significant worker hazards, such as heat stress, physical and psychological stress, and impaired vision, mobility, and communication. For any given situation, equipment and clothing should be selected that provide an adequate level of protection. However, over-protection, as well as under-protection, can be hazardous and should be avoided where possible.

Two basic objectives of any PPE program should be to protect the wearer from safety and health hazards, and to prevent injury to the wearer from incorrect use and/or malfunction of the PPE. To accomplish these goals, a comprehensive PPE program should include hazard identification, medical monitoring, environmental surveillance, selection, use, maintenance, and decontamination of PPE and its associated training.

The written PPE program should include policy statements, procedures, and guidelines. Copies should be made available to all employees, and a reference copy should be made available at the worksite. Technical data on equipment, maintenance manuals, relevant regulations, and other essential information should also be collected and maintained.

Multiple layers of protective clothing should be prescribed for areas in which the removable contamination levels exceed 10 times the values provided in Appendix D of 10 CFR 835, consistent with the consideration provided above. When penetration of the protective clothing by the contaminant is likely, such as during activities likely to induce heavy sweating or otherwise wet the individual, an additional layer of impenetrable clothing should be considered. In some cases, provision of an impenetrable plastic sheet for sitting or kneeling will be adequate and will reduce the hazards of heat stress. Additional guidance is provided in Chapter 3 of the RCS.

Prior to unescorted access to radiological areas (including contaminated areas) and prior to performing unescorted radiological work, each individual shall complete radiation safety training commensurate with the hazards in the area and the required controls [10 CFR 835.901(b)]. Guidance on radiation safety training is provided in Chapter 14 of this Guide and Chapters 3 and 6 of the RCS.

11.4.1.1 Egress Controls

Exits from contaminated areas should include provisions to facilitate retention of contamination in the area and for monitoring of individuals and the area to ensure control has been maintained. Undress methods should be prescribed to minimize the potential for contamination spread. When complex methods are necessary for removal of multiple layers of protective clothing, assistance should be provided.

Individuals exiting contaminated areas shall be monitored, as appropriate, for the presence of surface contamination [10 CFR 835.1102(d)]. At a minimum, individuals exiting contaminated areas should perform a whole body frisk, using either portable or automated devices. The use of automated whole body frisking devices should be considered due to the consistency of results achievable with such devices. For individuals exiting areas where the only contaminated areas are laboratory bench surfaces or fume hoods, or where contamination potential is limited to specific portions of the body, the frisking should concentrate on affected areas. Exiting individuals should be trained to frisk any personal items carried into the area. Personal items include papers, pens, jewelry, security badges, dosimeters, and other items commonly used within the area. Necessary monitoring of tools or other material and equipment should be performed by trained radiological control personnel. See Section 11.5.2 of this Guide for information concerning necessary monitoring of material and equipment.

The instruments and techniques used for contamination monitoring shall be appropriate for the types, levels, and energies of the radiations encountered and for the existing environmental conditions, be periodically calibrated and maintained, and be routinely tested for operability [10 CFR 835.401(b)]. Detailed guidance on selecting, calibrating, and using portable contamination control instruments is provided in Chapter 9 of this Guide and Chapter 5 of the RCS.

Because skin contamination by certain radioisotopes, such as tritium, cannot be reliably detected by currently available hand-held or automated monitoring instrumentation, individual frisking is not an appropriate means of detecting skin contamination, as discussed in 10 CFR 835.1102(d). When individual exposure to such contamination hazards is possible, additional emphasis should be placed on radiobioassay programs and routine contamination and air monitoring programs. Detailed guidance on radiobioassay and air monitoring programs is provided in Chapters 5 and 10 of this Guide.

If background radiation levels or other conditions at the exit point preclude performance of personnel frisking, the exit point should be relocated to an area of lower background levels. If relocation of the exit point is not practicable, individuals should proceed directly from the exit point to an appropriate area to perform a whole body frisk. The travel path should be monitored frequently for contamination spread during use and after the detection of any contamination at the frisking station.

The instruments used for frisking should be capable of detecting contamination at or below the total surface contamination values provided in Appendix D of 10 CFR 835. Individuals should be trained in proper frisking techniques, including detector speed and distance, and proper techniques should be enforced through frequent line management observation. Frisking for skin contamination while wearing protective clothing will not generally provide detection capability adequate to ensure compliance with 10 CFR 835. Frisking for hot particles may require special techniques and should reflect considerations of source to detector size effects. Such factors should be included in radiation safety training and reinforced through line management attention.

11.4.1.2 Posting and Labeling

Guidance on area posting and contaminated item labeling is provided in Chapter 12 of this Guide, and Chapters 2 and 4 of the RCS.

11.4.2 Areas of Fixed Contamination

The control measures discussed above have been proven effective in minimizing the generation and spread of removable contamination. However, these measures may not be appropriate for implementation in areas having only fixed contamination. When surfaces with fixed contamination are located within a radiological area, the radiological area posting and entry control requirements provide for adequate control of entry and egress. Additional control measures may be necessary to prevent inadvertent or unauthorized removal of the fixed contamination by methods that disturb the surface. 10 CFR 835 establishes specific requirements for controlling such locations outside of radiological areas. Although fixative coatings may be used to bind the contamination to the surface, such usage should be minimized and removable contamination levels should be reduced to levels that are ALARA prior to application of the coating.

When located outside of radiological areas, accessible areas in which only the fixed contamination levels exceed the total surface radioactivity values provided in Appendix D of 10 CFR 835 (i.e., removable contamination levels are below the Appendix D removable surface radioactivity values) shall [10 CFR 835.1102(c)]:

- undergo routine monitoring to ensure removable surface contamination levels remain below the Appendix D values. Monitoring should be conducted in and around the area using techniques discussed in Section 11.5.1 of this Guide; and

- display conspicuous markings to warn individuals of the contaminated status. The marking may consist of stencils on affected surfaces or postings established at each access point. The marking should include the radiation warning trefoil and the words "Caution, Fixed Contamination" and should provide radiation protection instructions sufficient to prevent inadvertent removal of the contamination.

Additional guidance on labeling of items having only fixed contamination is provided in Chapter 12. Additional information on control of fixed contamination is provided in Chapter 2 of the RCS.

11.4.3 Conduct of Radiological Work

Work in contaminated areas should be conducted in a manner that minimizes the spread of contamination to adjacent surfaces, individuals in the area, and the workplace atmosphere. The following controls and techniques should be included in work planning and employee training:

- minimization of individuals and materials entering contaminated areas;
- a dedicated contaminated tool program, if justified by the extent of contaminated area work activities;
- proven work techniques to minimize contamination spread, including techniques to minimize the release of hot particles;
- judicious use of stop-work authority to correct radiological problems before they escalate;
- judicious work area monitoring to detect, and decontamination to reduce, contamination spread; and
- priority repair of leaks to minimize the spread of contamination.

Chapter 3 of the RCS provides more information on these issues.

11.4.4 Personnel and Material Decontamination

Two types of personnel contaminations can occur: skin (or personal clothing) contamination and wound contamination. In this context, personal clothing includes work clothing provided by the employer, but does not include protective clothing provided solely for contamination control purposes. Potential internal contamination caused by exposure to airborne radioactive material is discussed in Chapter 5 of this Guide, DOE-STD-1121-2003, and Chapter 5 of the RCS.

11.4.4.0 Skin and Clothing Contamination

When individuals detect skin (or personal clothing) contamination, they should notify the radiological control organization to ensure adequate characterization of the potential for significant skin dose. A qualified radiological control organization representative should:

- assess the extent of the contamination;
- retain samples of the contamination as necessary to perform a detailed dose assessment. Levels of contamination that trigger the need for dose assessments should be established for site-specific radionuclides. These trigger levels should not exceed 100 millirem (1 mSv) (shallow dose equivalent); and
- initiate decontamination procedures that minimize skin abrasion and changes in pore size.

Skin decontamination methods should be established for site-specific radionuclides. Intrusive decontamination methods, such as tissue removal, require medical assistance. Contaminated personal clothing should be decontaminated by laundering or other

appropriate methods, monitored, and returned to the owner or, if necessary, disposed of as radioactive waste.

11.4.4.1 Wound Contamination

Medical treatment of injuries takes precedence over radiological considerations. Emergency medical care should be administered immediately for injuries involving radioactive materials in accordance with National Council on Radiation Protection and Measurements Report Number No. 65, *Management of Persons Accidentally Contaminated with Radionuclides* (NCRP 1980) and DOE-STD-1121-2003.

11.4.4.2 Material and Area Decontamination

In general, water and steam are the preferred decontamination agents. Other cleaning agents should be selected based upon their effectiveness, hazardous properties, amount of waste generated, compatibility with the contaminated surface and other systems or items that may be contacted (including protective clothing and waste handling systems), and ease of disposal.

11.5 Contamination Monitoring

Comprehensive surveillance for contamination is the best available assurance of compliance with the requirements of 10 CFR 835. Frequent routine and special contamination monitoring should be performed in and around contaminated areas to verify the levels and locations of contamination and to alert personnel to changes in levels.

An effective contamination monitoring program includes the capability to calibrate instruments and perform appropriate operational tests, monitor for contamination, determine the lower detection limits both for field and laboratory instruments, and conduct the appropriate quality control checks to assure reliable instrument performance.

11.5.0 Contamination Control Values

Appendix D of 10 CFR 835 establishes values above which contamination controls, including posting, access controls, and radioactive material controls must be implemented. The contamination monitoring program should be sufficient to identify the location of surfaces having contamination at such levels. Contamination levels on surfaces outside of contaminated areas should be maintained below the applicable Appendix D values and as low as is reasonably achievable.

The footnotes to Appendix D of 10 CFR 835 provide guidance on appropriate means of determining the surface contamination levels and comparing these levels against the controlling values. Footnote 3 to Appendix D of 10 CFR 835 indicates that the total contamination levels may be averaged over an area of one square meter. When averaging total contamination levels over a square meter, the applicable Appendix D value shall be considered to have been exceeded if:

- the average contamination level in the one square meter area exceeds the applicable Appendix D value; or

- the sum of the activity in all isolated spots or particles in any 100 square centimeter (cm^2) area exceeds three times the applicable Appendix D value (10 CFR 835, App. D, Footnote 3). In practice, this condition may be determined by evaluating a number of 100 cm^2 grids and ensuring that the contamination level in any grid is less than three times the applicable Appendix D value.

There are two different scenarios under which combinations of radionuclides may be present as radioactive surface contamination:

- there may be a combination of radionuclides all of which are within the same 10 CFR 835 Appendix D category (e.g., one horizontal row of the Appendix D table, such as U-nat, U-235, U-238, and associated decay products); or

- there may be a combination of radionuclides in different 10 CFR 835 Appendix D categories (e.g., radionuclides in more than one horizontal row of the Appendix D table).

If a surface is contaminated with radionuclides all of which fall within the same 10 CFR 835 Appendix D category, then the contamination levels of the various radionuclides should be summed to determine if contamination levels in any area monitored exceeds the applicable Appendix D value. For example, if a surface is contaminated with both U-235 and U-238, then the contamination levels of both radionuclides should be summed to determine whether or not the applicable Appendix D value has been exceeded.

If a surface is contaminated with a combination of radionuclides in different 10 CFR 835 Appendix D categories, then the values provided in Appendix D of 10 CFR 835 may be considered to be independent of one another. It is not necessary to perform a sum of the fractions calculation to determine if the contamination levels in any area monitored exceed the applicable Appendix D value. For example, if a surface is contaminated with both U-235 and Sr-90, then the contamination levels of the two radionuclides may be compared independently to the applicable Appendix D values. Although it is permissible to do so, there is no need to sum the U-235 and Sr-90 contamination levels or their fractions relative to the applicable Appendix D values. In practice however, it is often more convenient to determine the sum of the contamination levels of the various radionuclides and to compare this figure to the most conservative applicable Appendix D value.

Footnote 5 to Appendix D of 10 CFR 835 discusses application of the listed surface contamination values for Sr-90. DOE recognizes that Sr-90 is typically present in equilibrium with its daughter, Y-90. Therefore, the values given for Sr-90 in Appendix D should be applied to the total activity from the Sr-90/Y-90 contamination. If the Sr-90 contamination resulted from processes involving the separation and purification of Sr-90, the lesser values (200 dpm/100 cm^2 - removable, 1,000 dpm/100 cm^2 - total) should be

applied. If the Sr-90 contamination is present as a constituent of a mixture of fission products, the higher values should be applied (1,000 dpm/100 cm^2 - removable, 5,000 dpm/100 cm^2 - total).

If contamination by a radionuclide not listed in 10 CFR 835 Appendix D is suspected or verified, the actual contamination level should be compared to the Appendix D value(s) for radionuclides most similar to the contaminant(s) (i.e., radiological and chemical properties). Appropriate actions (e.g., posting, labeling, access controls) should be based on the results of these comparisons.

11.5.1 Monitoring

Individual and area monitoring shall be performed to demonstrate compliance with 10 CFR 835, document radiological conditions in the workplace, detect changes in radiological conditions, detect the gradual buildup of radioactive materials in the workplace, verify the effectiveness of engineering and process controls in containing radioactive materials and identify and control potential sources of individual exposure to radiation and/or radioactive material [10 CFR 835.401(a)]. Monitoring frequencies should be based on potential and actual radiological conditions, probability of change in conditions, and area occupancy factors. The contamination monitoring program should incorporate the following features:

- scheduled routine monitoring for removable contamination and, where feasible, fixed contamination. Schedules should be adjusted to reflect changes in conditions, activities, and previous results;
- special monitoring as necessary to accommodate planned events, such as maintenance and repairs, barrier breach or leakage, material movement, and unplanned events such as spills;
- sample analysis and monitoring using instruments and techniques capable of detecting contamination below the values specified in Appendix D of 10 CFR 835. To provide for early warning of changes, a sample of smears taken from areas surrounding contaminated areas should be analyzed for contamination at levels below the Appendix D values;
- documentation of survey results;
- timely documented review of results for trends and changes and the need for further action, such as decontamination, posting, changes in monitoring frequency, and access controls; and
- provision of results for use by individuals planning work in or entering the area.

Monitoring for removable contamination should be conducted using conventional smear techniques for quantitative analyses and, where practicable, large-area smears for qualitative analyses. The use of large-area smears, adhesive pads or adhesive rollers is

also helpful in identifying hot particles. Direct frisking is necessary for detecting fixed contamination; however, the application of direct frisking may be limited by such items as; background radiation levels, frisking surface characteristics (smooth/rough, wet/dry), frisking detector capabilities, frisking speed and distance, and type and energy of radiation being detected. Monitoring techniques should be developed and documented to ensure that the collected data are representative of the entire surface, with special attention paid to likely points for collection of contamination, such as leakage points, rough surface areas, areas that are infrequently cleaned, current work areas, and high traffic areas.

Conventional dry smear monitoring techniques may prove to be ineffective in the detection of tritium contamination. If tritium contamination is likely, monitoring should be performed using wet smears or direct frisking techniques or a combination of these methods. The monitoring method should be selected with due consideration of the characteristics of the radiation emitted by tritium. DOE-HDBK-1129-99 provides guidance on monitoring for tritiated water and tritium gas (DOE 1999c). DOE DOE-HDBK-1184-2004, RADIOLOGICAL CONTROL PROGRAMS FOR SPECIAL TRITIUM COMPOUNDS (DOE 2004e) provides guidance for radiological controls, including monitoring, for special tritium compounds.

Under certain conditions, radioactive contaminants may tend to penetrate the contaminated surface and then return to the surface over an extended period of time. This phenomenon is often encountered when dealing with tritium contamination (off-gassing) and when handling items that are stored or used under water (leaching), such as high level waste storage and shipping casks. When such conditions are likely, enhanced contamination monitoring methods that are capable of detecting changes in contamination levels as a result of leaching or off-gassing should be used.

Because of difficulties in implementing conventional removable contamination monitoring techniques (e.g., smear surveys), the presence of radioactive contamination in or on soil or other surfaces contaminated with granular solids may present significant challenges to the contamination monitoring program. Although the measurement of contamination levels in the granular solid (on a quantity of radioactive material per weight or volume basis) may be relatively straightforward, it may be difficult to compare the results of such measurements to the 10 CFR 835 Appendix D values, which are provided in units of contamination levels per unit area. Such comparisons are necessary to ensure compliance with the 10 CFR 835 requirements for posting and area and material control. DOE recognizes the difficulties associated with such measures. To ensure compliance, an assessment should be performed to determine the likelihood that radioactive contamination may be dispersed from the surface in question to surrounding areas or to items or individuals who may come in contact with the surface. The assessment may include a review of the operating history to determine whether significant contamination dispersion has occurred in the past, calculations based on realistic dispersion scenarios, performance of tests to determine the magnitude of contamination dispersion under actual operating conditions, or other technically defensible measures. If the results of the assessment indicate that contamination at levels

exceeding the 10 CFR 835 Appendix D values is likely to be dispersed from the contaminated surface to surrounding or contacting surfaces, then the surface in question should be considered contaminated at levels exceeding the Appendix D values. If the surface in question is considered contaminated at levels exceeding the Appendix D values appropriate protective measures shall be implemented [10 CFR 835.1001(a)]. See the hierarchy of controls discussion in the introduction to Chapter 11.0.

10 CFR 835.401(b) requires that instruments and equipment used for monitoring be appropriate for the types, levels, and energies of the radiation(s) encountered. The effectiveness of the contamination monitoring techniques discussed in this chapter may be limited due to the physical conditions and specific characteristics (chemical and radiological) of radionuclides present in some DOE facilities. For example, common frisking and smear counting techniques and instruments may not be effective in detecting certain low-energy radiations. Detailed technical guidance for performing monitoring under these conditions is outside the scope of this Guide. Monitoring under these conditions should be conducted in accordance with applicable DOE Technical Standards and other documents, including those referenced in Chapter 11 of this Guide.

Other scientific standards (e.g., ANSI or Health Physics Society Standards or International Commission on Radiological Protection (ICRP) or National Council on Radiation Protection and Measurement (NCRP) publications) should also be considered.

Additional information regarding requirements for instruments and documentation is provided in Chapters 9 and 13 of this Guide, and in Chapters 5 and 7 of the RCS.

11.5.2 Control of Material and Equipment

Release of material and equipment from contaminated areas presents special challenges. Many items have surfaces that are inaccessible, making adequate monitoring of surface contamination difficult. Monitoring of large items and vehicles can be time consuming and difficult in inclement weather. For these reasons, to the maximum extent practical, materials and equipment that enter contaminated areas should be retained there.

Except as noted below, any material and equipment that enters contaminated areas shall be retained there if [10 CFR 835.1101(a)]:

- monitoring of accessible surfaces indicate the presence of removable surface contamination at levels exceeding the removable surface contamination values provided in Appendix D of 10 CFR 835; or

- prior use of the material and equipment indicates that removable surface contamination levels on inaccessible surfaces are likely to exceed these levels.

Material and equipment control programs should include features that:

- provide for assessment of the likelihood of material and equipment contamination through documentation of material and equipment location and

use, monitoring of material and equipment surfaces, or a combination of these techniques;

- where monitoring is necessary, include monitoring for both fixed and removable contamination;
- for materials and equipment with inaccessible surfaces that are likely to be contaminated, require disassembly to the extent necessary to perform monitoring on those surfaces;
- require reduction of surface contamination before release to levels that are as low as reasonably achievable; and
- require retention of materials and equipment having contamination levels in excess of the values provided in Appendix D of 10 CFR 835.

A prospective and retrospective assessment of the likelihood of material and equipment contamination should consider:

- the nature of the material and equipment;
- radiological conditions in the locations in which it will be or was stored and used;
- controls established to reduce the likelihood of contamination transfer (wrapping or taping);
- the degree of assurance that exists regarding knowledge of the material's and equipment's storage and use; and
- material and equipment properties that are or were likely to preclude contamination transfer or enhance the likelihood of contamination transfer (e.g., surface irregularities, installed fans and air inlets).

Under certain circumstances, materials and equipment having removable surface contamination levels in excess of the values provided in Appendix D of 10 CFR 835 may be released to controlled areas. Materials and equipment having either removable or total contamination levels in excess of these values may be released for movement to another radiological area. Appropriate monitoring and controls shall be implemented [10 CFR 835.1101(b)] and should include:

- determining the contamination levels before movement;
- wrapping or containing the material and equipment to prevent the spread of contamination;
- applying appropriate labels to the material and equipment and postings at the destination;

- selecting the transport path to minimize the potential for contamination spread; and

- monitoring the transport path as necessary after movement to ensure that contamination has not been spread

Materials and equipment having fixed contamination (in either accessible or inaccessible locations) in excess of the total surface radioactivity values provided in Appendix D of 10 CFR 835 may be released for use in controlled areas. Release of such materials and equipment shall require that [10 CFR 835.1101(c)]:

- removable contamination levels be below the values provided in Appendix D. Contamination levels should be assessed in accordance with the guidance provided in this Guide;

- routine monitoring be conducted. The monitoring should be adequate to ensure that the radiological hazard resulting from the release is fully characterized and that appropriate posting, labeling, and access control measures are implemented; and

- the material and equipment is clearly marked or labeled. Guidance for material and equipment labeling is provided in Chapter 12 of this Guide, and Chapter 4 of the RCS.

Written records of material and equipment release monitoring are required [10 CFR 835.703(c)]. These records should include:

- a description of the material and equipment. Where large quantities are involved, a simple entry such as "box of nails" or "tool box full of hand tools" is adequate;

- monitoring date;

- identity of individual performing the monitoring;

- survey meter type and identification number; and

- monitoring results.

The provisions of 10 CFR 835 do not apply to release of materials and equipment from controlled areas. These activities are subject to DOE standards for protection of the environment. The release of materials and equipment from DOE control requires following the process specified in DOE O 5400.5.

11.5.3 Portal Monitors, Laundry Monitors, and Tool Monitors

DOE encourages the use of automated monitoring devices for evaluating material and equipment for release to controlled areas. Automated monitoring devices are typically

large gas proportional or plastic scintillation detectors arranged in a shielded counting chamber into which objects may be placed. The monitor counts the object using a count time sufficient to achieve the desired confidence level and compares the net count rate from the object with a pre-determined alarm set point.

Automated monitoring devices are appropriate for monitoring of the external surfaces of non-porous, industrially clean objects. Objects with potential internal contamination should be surveyed using portable survey instruments. In general, automated monitoring devices are not appropriate for releasing porous material that has been contaminated in depth (e.g., wood, concrete) or in volume (e.g., activated material, smelted contaminated material). However, such devices may have limited application to monitoring of items contaminated in depth or volume by radioisotopes that emit high energy gamma radiation.

12.0 POSTING AND LABELING FOR RADIOLOGICAL CONTROL

The goal of a radiological hazard posting and labeling program is to identify and effectively communicate radiological hazards to individuals, allowing them to take the appropriate protective actions. In pursuit of this goal, a radiological posting and labeling program works in concert with other hazard communication programs, including programs for radiation safety training, work authorizations, written procedures, and briefings.

10 CFR 835 requires that certain areas and items be posted or labeled to control personnel exposure to radioactive material and ionizing radiation and to prevent the spread of contamination. 10 CFR 835 also provides exceptions from the posting and labeling requirements under certain circumstances; these exceptions apply to posting or labeling requirements only. They do not apply to entry control or radiation safety training requirements.

This Guide provides references to detailed guidance provided in the RCS. The referenced guidance provides acceptable methods of achieving and maintaining compliance with related provisions of 10 CFR 835.

12.1 Implementation Guidance

This chapter discusses the regulatory requirements for radiological hazard posting and labeling and provides guidance for achieving compliance with those requirements. Postings for other health and safety concerns, such as those for nuclear criticality and industrial safety concerns should be in addition to the postings specified for radiological control.

12.2 General

10 CFR 835 establishes specific requirements for posting of controlled areas, radioactive material areas (RMAs), and radiological areas. Controlled areas are established to warn individuals that they are entering areas that, because of the presence of radiological areas and/or RMAs, are controlled for radiation protection purposes. RMAs and radiological areas are established within the controlled area to provide warning of specific hazards that may require individual protective action for safe entry and egress.

10 CFR 835 also establishes specific requirements for labeling of items or containers of radioactive material exceeding specified threshold activity levels. Radioactive material labels are used to provide warning to individuals of the presence or radioactive material, particularly in areas in which the radiological hazard does not warrant area posting in accordance with 10 CFR 835. Use of electronic means to label items or containers (e.g., bar codes) in conjunction with human readable labels may help reduce human error rates and assist in tracking and inventory of materials.

10 CFR 835.104 requires that written procedures be developed and implemented as necessary to ensure compliance, commensurate with the radiological hazards and

consistent with the education, training, and skills of the exposed individuals. With regard to the radiological hazard posting and labeling program, written procedures should be developed to address the program elements addressed in this Guide. The level of detail provided in these procedures should be sufficient to provide assurance that the affected individuals can implement the program in a manner that will achieve and maintain regulatory compliance. 10 CFR 835.104 provides flexibility for a site- or facility-specific determination of the appropriate balance between individual education, training, skills, and specificity of the required written procedures. As an example, if responsibility for posting radiological hazard signs is assigned to radiological control technicians (RCTs) qualified in accordance with the RCS, then the written procedures may be relatively brief, based upon the detailed knowledge possessed by the RCTs. Conversely, if responsibility for posting radiological hazard signs is assigned to another work group in the facility whose members have a less-detailed knowledge of the regulatory requirements, then more detailed procedures should be developed and implemented, based on the cognizant individuals' presumably more rudimentary understanding of the specific requirements of 10 CFR 835.

10 CFR 835.604 and 835.606 establish specific conditions under which radiological hazard posting and radioactive material labeling are not required, generally due to the minimal hazards present in certain areas or the implementation of other controls that are sufficient to limit individual exposures to radiological hazards. Care should be exercised in implementing these posting and labeling exceptions to ensure that both the specific and general requirements of 10 CFR 835 will be met in the absence of the area postings and material labeling. For example, 10 CFR 835.604 provides a posting exception for areas in which the radioactive material consists solely of activated structures or installed components. Likewise, 10 CFR 835.606 provides a labeling exception for radioactive material having an activity less than one tenth of the 10 CFR 835 Appendix E values. However, omission of postings and labels under these conditions may affect the status of compliance with other requirements of 10 CFR 835, including the ALARA requirements of 10 CFR 835.101 and 1001, the dose limit requirements of 10 CFR 835.207 and 835.208, and the maximum controlled area dose expectation of 10 CFR 835.602(a). Compliance with these requirements is generally achieved through implementation of a comprehensive program that includes physical design features, administrative controls, training, area posting, and material labeling. Therefore, decisions regarding omission of area postings and radioactive material labels should consider the full impact of such omissions and the ability of the remaining program elements to ensure continued compliance. Such decisions should be made on the basis of management-approved standards documented in the radiation protection program, site-specific procedures, and/or the site-specific radiological control manual.

12.2.0 Design

Postings for controlled areas may be selected by the contractor to avoid conflict with local security requirements [10 CFR 835.602(b)]. To the extent practicable, controlled area postings should use the yellow and magenta radiological hazard warning color

scheme, but the flexibility provided in 10 CFR 835.602(b) extends to the shape, color scheme, and content of the controlled area postings.

Postings for radiological areas and radioactive material areas and labels on radioactive items and containers of radioactive material shall include the standard radiation warning trefoil in black or magenta imposed upon a yellow background [10 CFR 835.601(a)]. Magenta is the preferred color for the trefoil and any lettering on the posting. The standard radiation warning trefoil is illustrated in Appendix A of this Guide. Unless circumstances do not permit, the standard radiation warning trefoil should be oriented with one blade downward and centered on the vertical axis. The standard radiation warning trefoil should be displayed as prominently as is practicable.

Lettering should not be superimposed on the standard radiation warning trefoil, ANSI N2.1-1971(R1989), *Radiation Symbol*, (ANSI 1989e). The size of lettering used on the sign should not detract from the clarity of the standard radiation warning trefoil.

The background for the entire sign or label should be yellow. The lettering and standard radiation warning trefoil should be proportional to the size of the sign or label. The color scheme used for radiological postings and labels should be consistent throughout the site and should be approved by the head of the cognizant radiation protection organization before use. The color scheme used for radiological hazard posting and labeling should be reserved for radiological hazards communication only

Signs and labels should be constructed of materials that can endure expected environmental conditions without significant deterioration of color, legibility, strength, or other physical characteristics. Although magenta is the preferred color for both the standard radiation warning trefoil and the lettering, the magenta color tends to fade when exposed to sunlight. Therefore, special consideration should be given to the selection of signs for outdoor postings to ensure durability. If signs or labels will be used under conditions that are likely to result in significant degradation, routine surveillances should be performed as necessary to verify continued legibility. Signs and labels should not be altered or defaced in any way to change their meaning. Inserts (on signs containing insert slots) may be changed, as appropriate.

12.2.1 Content

In addition to the standard radiation warning trefoil discussed above, postings and labels required by 10 CFR 835 shall include the appropriate heading ("Caution," "Danger," or "Grave Danger") and wording describing the radiological hazard (10 CFR 835 hazard designation) (10 CFR 835.603 and 835.605).

Signs required by 10 CFR 835 may include radiological protection instructions [10 CFR 835.601(b)]. Supplemental wording describing additional warnings or directions should be included on the postings or labels, as appropriate. Recommended supplemental wording on potential and actual radiological conditions and specific controls is discussed in Chapters 2 and 4 of the RCS. 10 CFR 835 requires that each radiological area be posted. Therefore, if more than one radiological condition exists in

an area and requires posting, each condition shall be identified (10 CFR 835.603). Multiple radiological conditions may be posted using one of two common practices:

- by posting each radiological condition on a separate sign with any appropriate supplemental wording; or

- by posting all radiological conditions on one or more signs (user-changeable signs using inserts, for example) using the most stringent heading and listing the radiological areas in decreasing order of importance. Any supplemental information should follow the radiological area designations.

The second method is preferred because it reduces clutter and is more efficient.

Very high radiation area postings should be established on an exclusive sign without other radiological area designations.

In recognition of the broad range of radiological conditions encompassed by the 10 CFR 835.2(a) definitions of the terms “airborne radioactivity area,” “high contamination area,” and “high radiation area,” 10 CFR 835.603 allows use of either the "Caution" or "Danger" heading on the required postings. This allows the hazard in the area to be more accurately characterized. This is also an option for radioactive material labeling (see 10 CFR 835.605). Accordingly, the "Caution" heading should be used for lower hazards and "Danger" for higher hazards. With respect to radioactive material labeling, the amount, specific activity, and chemical and physical characteristics of the radioactive material should be taken into consideration. However, the use of only one heading for the entire range of conditions is also acceptable.

Chapter 2 of the RCS provides guidance for posting of additional areas, including:

- buffer areas surrounding radiological areas;

- areas where soil contamination is present;

- areas where underground radioactive materials are present; and

- access ports to enclosures having limited accessibility, such as glove bags and boxes.

While posting of these areas is not required to ensure compliance with the posting requirements of 10 CFR 835, such postings may provide an additional regulatory margin and degree of protection to affected individuals.

12.2.2 Visibility

Signs required by 10 CFR 835 shall be clearly and conspicuously posted [10 CFR 835.601(b)]. Each item or container of radioactive material that requires labeling shall bear a clearly visible label (10 CFR 835.605).

When posting is required, appropriate signs should be placed intermittently along the boundary (fences, barricades, ropes, tapes, etc.). The effect upon visibility of opening of doors or other changes in configuration should be considered when posting radiological hazard warning signs. At least one sign should be on each side of an area's boundary, and a sign should be visible from any normal avenue of approach. A distance of 40 feet (12.2 m) between signs along the area's boundary is considered acceptable. Radiological posting and labeling should be securely affixed and located such that signs and labels can be expected to remain in place when subjected to expected adverse conditions and environments.

When one radiological area is completely contained within another radiological area having similar hazards (e.g., a high contamination area inside a contamination area) or individuals must pass through one radiological area to enter another, it is not necessary to post the exits from the inner area to indicate entry into the outer area.

12.2.3 Conditions

Radiological warnings are posted based upon actual or likely radiological conditions. Actual conditions are determined through area monitoring. Likely conditions should be identified based on professional judgment or experience regarding the probability that a radiological condition will exist. When evaluating the likelihood of specified conditions, normal situations as well as unique situations which can reasonably be expected to occur should be considered.

In many operations, the likelihood that a radiological condition will exist, rather than the actual condition, will define the boundaries and posting of a radiological area. For example, opening a contaminated ventilation system in a non-contaminated area may require a contamination area to be established, or opening a radiological vacuum cleaner in a contamination area may require that an airborne radioactivity area be established. Therefore, past monitoring data, work-specific experience, and professional judgment should be included in the decision on the correct posting of each area.

Radiological postings should be completed before work begins, updated periodically when changes in radiological conditions occur or are expected, and removed as soon as is practicable when no longer required.

Radiological posting and labeling should be used or displayed only to signify the actual or likely radiological conditions. However, posting and labeling may also be used for illustrative purposes in appropriate educational or informational matter. When used for this purpose, signs and labels should be clearly marked to indicate that they are for training use only.

12.2.4 Accessibility

Radiological areas and radioactive material areas are defined based upon area accessibility. An area is considered to be accessible to individuals when it contains

entrance or access points of sufficient size to permit human entry, i.e., such that any portion of the body may be exposed to the radiological hazard.

Areas with entrance or access points consisting of locked doors or other controls and interlocks (including those specified under 10 CFR 835.502), should be considered accessible to individuals. In contrast, areas with entrance or access points consisting of doors or portals, such as man hole covers, that are bolted or otherwise more permanently sealed, may be considered inaccessible, unless such doors or portals are opened on a routine basis. Likewise, areas in which the radiological hazard is located underground, such that significant soil excavation, drilling, natural forces, or other forms of intrusion would be required to gain access, may be considered inaccessible. In general, areas with entrance or access points that require the use of tools or lifting or excavation equipment to gain access may be considered inaccessible to individuals. However, for ALARA purposes, these entrance or access points should be marked indicating the radiological hazard that exists, or is likely to exist, behind the entrance or access point and a warning not to open the barrier without authorization from the radiation protection organization. In lieu of or in addition to such markings, physical controls (e.g., physical barriers, entry alarms) and/or administrative controls (e.g., procedural controls, additional training) should be implemented as necessary to prevent unauthorized or inadvertent entry to the area or exposure of the hazard. Once the entrance point has been unsealed (or for underground hazards, the covering soil has been disturbed or penetrated) such that individuals may be exposed to the radiological hazard (whether or not such acts have been authorized), the area should be considered to be accessible.

12.2.5 Boundaries and Barriers

Controlled areas, radioactive material areas, and radiological areas should be identified by the use of a boundary identifier or a physical barrier and sufficient signs. The combination of signs and boundary identifiers should be sufficient to warn approaching individuals that they are entering an area controlled for radiation protection purposes. Boundary identifiers may consist of ropes, chains, color-coded adhesive tape, or other materials sufficient to delineate the boundary of the area. Because color-coded adhesive tape applied to floors may not be highly visible and provides no impediment to entry, its use as a boundary identifier should be limited to counter-top applications or to use in conjunction with other boundary identifiers.

Boundary identifiers and physical barriers should be clearly visible from all directions and various elevations to prevent inadvertent access to areas. For example, rope barriers should be approximately 24 to 40 inches (60 to 100 cm) in height. Area monitoring should be used to determine the adequacy of boundary placement.

Existing physical barriers, such as fences or walls, may be used as boundary identifiers if the posting is adequate to prevent inadvertent access to the area. For example, a wall that could be crossed by ladder could suffice as a boundary identifier, but would not prevent an individual from entering an area; thus posting would be required.

10 CFR 835.501(b) requires that the degree of personnel entry control be commensurate

with the existing and potential radiological hazards within the area. There may be site-specific situations where the use of boundary identifiers (ropes, chains, fence, etc.) may not be appropriate. These might include large areas with minimal radiological hazards. For these types of situations the time and expense of erecting and maintaining boundary identifiers may not be warranted. Site-specific controls such as a gate and posting on the access road, supplemented by postings at suitable intervals around the area may be adequate to provide appropriate warning and minimize inadvertent intrusions.

12.3 Controlled Areas

Controlled areas are established and posted to warn individuals that they are entering areas in which radiological areas and/or RMAs exist. All radiological areas and RMAs lie within the boundaries of controlled areas (although the boundaries may be contiguous).

Each entrance or access point to a controlled area shall be posted if that area contains radioactive materials or radiation fields that require posting under 10 CFR 835.603 [10 CFR 835.602(a)]. The sign should contain wording equivalent to "CONTROLLED AREA"; however, the actual wording, color scheme, and sign may be selected by the contractor to avoid conflict with local security requirements [10 CFR 835.602(b)]. In the event that the boundaries of the controlled area are contiguous with those of radiological areas or RMAs, the area should be posted with both the controlled area and radiological area/RMA postings.

A controlled area may incorporate one or more radiological areas and/or radioactive material areas. Controlled area borders should not be contiguous with the site boundary.

12.4 Posting for Control of Exposure to External Radiation

10 CFR 835 establishes requirements for three areas that shall be posted to provide warning of external radiation fields - radiation areas, high radiation areas, and very high radiation areas [10 CFR 835.603(a-c)]. The need to post these areas is contingent upon two factors:

- area accessibility, as discussed in Section 4.1.5 of this Guide; and
- the radiation field intensity and duration, such that an individual’s dose may exceed the specified threshold in one hour.

The posting thresholds established in 10 CFR 835 are based on the radiation field intensity measured at a specified distance from the radiation source or from any surface penetrated by the radiation (30 centimeters (12 inches) for radiation and high radiation areas and 100 cm (39 inches) for very high radiation areas). To ensure continuing compliance with the posting requirements, a degree of conservatism should be established in the local posting requirements. The desired degree of conservatism may be established by:

- posting affected areas at an exposure rate lower than that specified in 10 CFR 835 (i.e., requiring area posting when an individual is likely to exceed a specified fraction of the 10 CFR 835 posting threshold); or

- measuring the exposure rate at a distance less than that specified in 10 CFR 835; or

- both of the above.

The degree of conservatism established in the posting regimen for external radiation hazards should be adequate to address issues of monitoring equipment variability and likely variations in area radiological conditions.

12.5 Posting for Control of Contamination

12.5.0 Removable and Airborne Radioactive Contamination

10 CFR 835 establishes requirements for three areas that shall be posted to provide warning of the presence of radioactive contamination - contamination area and high contamination area postings for removable surface contamination and airborne radioactivity area postings for airborne contamination [10 CFR 835.603(d-f)]. The need to post contamination areas and high contamination areas is contingent upon two factors:

- area accessibility as discussed in Section 4.1.5 of this Guide; and

- the presence of removable surface contamination at levels exceeding the specified removable surface contamination values (1x the values provided in Appendix D of 10 CFR 835 for contamination areas, 100 x these values for high contamination areas).

For detailed guidance on contamination measurements and the use of the 10 CFR 835 Appendix D surface contamination values, see Chapter 11 of this Guide.

The need to post airborne radioactivity areas is contingent upon three factors:

- area accessibility, as discussed previously in this Guide;

- the concentration of airborne radioactive material in the area; and

- the extent to which individuals will be in the area during the area during a week.

10 CFR 835 establishes two criteria requiring posting of airborne radioactivity areas. The first criterion, based upon airborne radioactive material concentrations exceeding the derived air concentration (DAC) value(s) provided in Appendices A and C of 10 CFR 835 is absolute. That is, if the airborne radioactive material concentration exceeds or is likely to exceed the specified value(s), then the area shall be considered an airborne radioactivity area [10 CFR 835.2(a), Airborne radioactivity area]. The second

criterion, based upon individual exposure to airborne radioactive material, allows consideration of individual stay times. Under this criterion, an area shall be considered to be an airborne radioactivity area if an individual could receive an intake exceeding 12 DAC-hours in a week (i.e., if an individual was present in the area for 40 hours during a week and the airborne radioactive material concentration exceeded 30% of the specified DAC value(s); 40 hours multiplied by >0.30 DAC exceeds 12 DAC-hours) [10 CFR 835.2(a) Airborne radioactivity area]. Note that this criterion requires consideration of individual exposures without the benefit of respiratory protective devices, whether or not such devices are required for entry. The definition of the term "week" provided in 10 CFR 835.2(a) does not specify a starting day. A starting day for the week should be selected and maintained constant, to the extent practicable. It is not necessary to track individual exposures in DAC-hours over rolling seven day periods to ensure compliance with the airborne radioactivity area posting requirements of 10 CFR 835.603(d).

To ensure continuing compliance with the posting requirements for removable and airborne radioactive contamination hazards, a degree of conservatism should be established in the local posting requirements. The desired degree of conservatism may be established by posting affected areas at surface contamination/airborne radioactivity concentrations lower than those specified (i.e., requiring area posting at a specified fraction of the applicable 10 CFR 835 Appendix value). The degree of conservatism established in the posting regimen for radioactive contamination hazards should be adequate to address issues of monitoring equipment variability, sample collection efficiency variations, and likely variations in area radiological conditions.

12.5.1 Areas of Fixed Contamination

10 CFR 835 establishes specific requirements for areas that have total contamination levels greater than the Appendix D values, but removable contamination levels less than the Appendix D values. 10 CFR 835 establishes no requirements for posting of these areas (although 10 CFR 835 does establish requirements for marking these areas, which may be satisfied through area posting, surface stenciling, or other appropriate means); however, it does establish requirements for control of these areas. These requirements are discussed in Chapter 11 of this Guide.

12.6 Radioactive Material Posting

10 CFR 835 requires that certain areas in which radioactive material is used, handled, or stored be posted as radioactive material areas. The need to post RMAs is contingent upon two factors:

- area accessibility, as discussed in Section 12.2.4 of this Guide; and
- the presence of items or containers of radioactive material in the area in quantities exceeding the applicable Appendix E value(s).

The RMA posting exists as a means of supporting the 10 CFR 835.602(a) controlled area

maximum total effective dose equivalent expectation of 0.1 rem (0.001 Sv) in a year and provides an alternative to labeling of multiple radioactive items or containers of radioactive material. Therefore, 10 CFR 835.604 allows for the use of radioactive material labeling in lieu of RMA posting and 10 CFR 835.606 likewise allows for the use of the RMA posting in lieu of individual item or container labeling. The flexibility provided under these provisions permits individual DOE activities to tailor their programs to meet specific needs.

Under conditions commonly associated with DOE activities, determinations of the quantities of radioactive materials in an area are not as straightforward as determinations of radiation and contamination levels and airborne radioactive material concentrations. The process of making accurate determinations of the quantities of radioactive materials present in some areas may be relatively cumbersome and time-consuming relative to the benefits obtained. Because of the relatively low hazards present in RMAs, such a designation carries no additional regulatory burden in terms of required entry controls. Reliable, good faith measures should be implemented to assess the quantities of radioactive material present in all areas. Such measures may include provisions for inventory tracking, exposure rate-to-activity, concentration-to-activity, or contamination level-to-activity calculations, activation analyses, or other technically-justified means for determining the activity of containers of radioactive material or radioactive items. If there is doubt about whether or not the quantity of radioactive material in an area exceeds the applicable Appendix E value(s), the area should be posted as a radioactive material area to ensure compliance.

Another difficulty that may arise in identifying RMAs is in determining the location of the RMA boundaries. While the boundaries of the radiological areas are readily identified through the conduct of area monitoring, the boundaries of a radioactive material are more nebulous. While it may be apparent that the quantity of radioactive material in a specified room or enclosure does not exceed that level defining an RMA, the sum of the quantities of radioactive material in a series of adjoining rooms or enclosures may exceed the threshold level. Such a condition will necessarily lead to questions regarding whether or not an RMA exists and, if so, regarding the logical RMA boundaries.

Two acceptable approaches to defining the boundaries of RMAs are provided in this Guide; the approach selected will be determined based predominantly on considerations of the nature of the operations taking place, the education, training, and skills of the affected individuals, and convenience. Under the first acceptable approach, the quantity of radioactive material in individually identifiable rooms or enclosures may be considered. Note that the footnote to Appendix E of 10 CFR 835 requires summing of the fractions of all radionuclides present in the designated room or area. If there are multiple radioactive items or containers, then the activity of each radionuclide present in all of the items and containers should be summed, divided by the appropriate Appendix E value and then added to the similarly determined ratios for all other radionuclides present to determine the activity-to-threshold value ratio for the designated room or area. The postings, if necessary, should be erected at the individual room or enclosure entry or

access point(s) or, if there is a common access point to the rooms or enclosures, then the posting may be erected at that point. Under the second acceptable approach, the quantity of radioactive material present in a group of rooms or enclosures may be considered (using the sum-of-the-fractions rule as discussed above) and the postings, if necessary, should be erected at the common entry or access points. The decision regarding the appropriate location for the posting(s) will be based largely on considerations of convenience (i.e., the establishment of radiological hazard postings and associated entry controls at the common entrance point(s) may disrupt or impede the activities of individuals who must enter the area or create the need for additional radiation safety training for these individuals).

The use, handling, or storage of items or containers of radioactive material in outside areas may pose special challenges in identifying areas requiring posting as RMAs, particularly when the items or containers are spread over a wide area. These challenges result from the absence of identifiable rooms or enclosures, thus making the identification of the identified "area" problematic. To the extent practicable and consistent with ALARA principles, such items or containers should be consolidated in a localized area to facilitate activity determinations, posting, and control. Piles or areas of radioactive rubble or granular solids, such as soil or sand, would not normally be considered "items" or "containers." Therefore, areas in which the radioactive material consists solely of such piles or areas would not be subject to posting as an RMA. However, appropriate controls may be required to ensure compliance with other requirements of 10 CFR 835, including the ALARA requirements of 10 CFR 835.101 and 835.1001, the dose limits of 10 CFR 835.207 and 835.208, and the controlled area maximum dose expectation of 835.602(a).

12.7 Exceptions from Posting Requirements

Accessible areas may be excepted from the radiological area and radioactive material area posting requirements for periods of <8 continuous hours duration when the area is placed under the observation and control of individuals who are knowledgeable of and empowered to implement required access and exposure control measures [10 CFR 835.604(a)]. The observing/controlling individual(s) should be stationed to provide line of sight surveillance of the area boundaries and verbal warnings. For situations that require only simple access control measures, such as entry prevention, a minimally-trained individual would suffice. For situations that require more complicated access and exposure control measures, a radiological control technician should be used. A sufficient number of individuals should be used to provide for adequate access and exposure control.

The following accessible areas are excepted from the radioactive material area posting requirements [10 CFR 835.604(b)]:

- radiological areas posted in accordance with 10 CFR 835.603(a) - (f). In this case, the radiological area posting provides adequate warning of the area hazards;
- areas in which each item or container of radioactive material is clearly and

adequately labeled in accordance with Subpart G of 10 CFR 835 such that individuals entering the area are made aware of the hazard. In this case, the radioactive material labels provide adequate warning of the area hazards; and

- areas in which the radioactive material of concern consists solely of structures or installed components which have been activated (i.e., such as by being exposed to neutron radiation or particles produced in an accelerator).

Areas containing only packages received from transportation need not be posted in accordance with 10 CFR 835.603 until the packages are monitored in accordance with 10 CFR 835.405 [10 CFR 835.604(c)]. For ALARA purposes, the time between package receipt and monitoring should be minimized.

Even though certain areas may be excepted from posting in accordance with the conditions provided in 10 CFR 835, appropriate controls should be established over these areas as necessary to limit exposures consistent with the ALARA controls required under 10 CFR 835.1001. Decisions regarding the omission of radiological hazard postings should be made in full consideration of the information provided in Section 12.2 of this Guide.

The exceptions discussed above apply only to radiological area and/or radioactive material area posting requirements and do not apply to the entry control requirements established in 10 CFR 835.501 and 10 CFR 835.502 or to the radiation safety training requirements established in 10 CFR 835.901. Decisions regarding omission of postings should be made in full consideration of the guidance provided in Section 12.2 of this Guide.

12.8 Radioactive Material Labeling

12.8.0 Radioactive Material Labeling

Each item or container of radioactive material shall be labeled (10 CFR 835.605). The label shall contain the standard radiation warning trefoil and the words "CAUTION, RADIOACTIVE MATERIAL" or "DANGER, RADIOACTIVE MATERIAL" (10 CFR 835.605). The label shall also provide sufficient information to permit individuals handling or using the containers or working in the vicinity of the containers to take precautions to avoid or minimize exposures (10 CFR 835.605).

The following information should be included on the labels, as appropriate:

- radiological hazard (e.g., radiation and/or contamination levels);
- an estimate of the quantity of radioactivity;
- radioisotope(s) and activity;
- dates monitored;

- any special handling instructions necessary to permit individuals to implement appropriate protective measures;

- name of the individual performing the monitoring; and

- a description of the material, as appropriate.

If the item is too small to accommodate a label, then the label should be applied to the container or storage location.

The label shall be clearly visible on the item or container (10 CFR 835.605). If a label applied to the items will not be clearly visible, then the label should be placed on the exterior of containers holding the radioactive material.

12.8.1 Exceptions from Labeling Requirements

Containers and items are excepted from the radioactive material labeling requirements of 10 CFR 835.605 under any one of the following circumstances:

- the items or containers are used, handled, or stored in areas posted and controlled in accordance with Subpart G of 10 CFR 835 and sufficient information is provided to permit individuals to take appropriate protective actions [10 CFR 835.606(a)(1)]. This information may be provided on or in conjunction with the area postings, radiation safety training, written procedures, controlling work authorization for that area, or other suitable means.

- the quantity of radioactive material is less than one tenth of the values specified in Appendix E of 10 CFR 835 [10 CFR 835.606(a)(2)]. For containers that contain numerous items of radioactive material, the determination of the need for labeling should be based upon the sum of the activities of the individual items. Section 4.5 of this Guide provides guidance on determining the activity of radioactive items and containers of radioactive material and on determining the sum of the fractions of the activities of the items in question.

- the items or containers are packaged and labeled in accordance with Department of Transportation regulations or corresponding DOE Orders [10 CFR 835.606(a)(3)]. When such labels are used as an alternative to the labeling required by 10 CFR 835, measures should be implemented to ensure that affected individuals are familiar with the labels and the hazards and precautions associated with the labeled materials.

- the items or containers are inaccessible or accessible only to individuals authorized to handle or use them, or to work in the vicinity [10 CFR 835.606(a)(4)]. In such situations, the individuals should be trained in accordance with 10 CFR 835.901(b) and knowledgeable of the types and quantities of radioactive material present in the area. Chapter 14 of this Guide provides guidance on developing appropriate radiation safety training programs.

- the items or containers are installed in manufacturing or process equipment, such as reactor components, piping, and tanks [10 CFR 835.606(a)(5)].

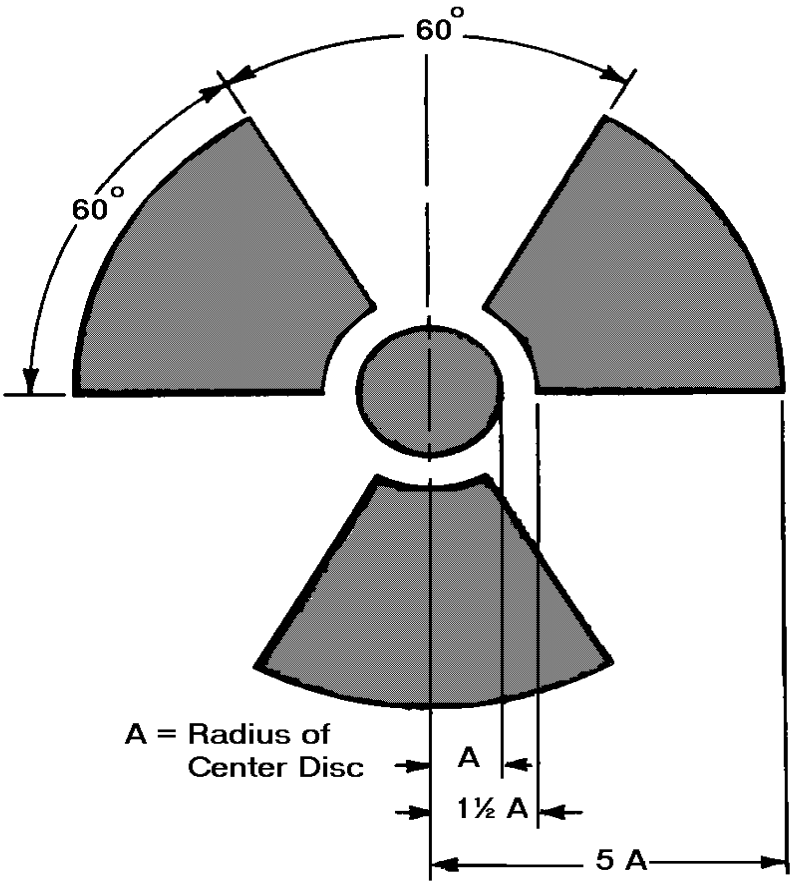
- the radioactive material consists solely of nuclear weapons or their components [10 CFR 835.606(a)(6)].

Even though items and containers of radioactive material may be excepted from labeling in accordance with the conditions provided in 10 CFR 835, appropriate controls should be established over the storage, movement, and use of unlabeled items and containers as necessary to limit exposures consistent with the ALARA controls required under 10 CFR 835.1001. Decisions regarding the omission of radioactive material labels should be made in full consideration of the information provided in Section 12.2 of this Guide.

Although 10 CFR 835.606(a)(1) provides a labeling exception for radioactive material that is used, handled, or stored in areas posted and controlled in accordance with Subpart G of 10 CFR 835, caution should be exercised in applying this exception to ensure that the radiological area posting or associated information will be sufficient to inform affected individuals of the area hazards and required protective actions. For example, a trained individual's response to a "Contamination Area" posting (i.e., protective clothing, personnel frisking) may not be sufficient to protect that individual from the hazards associated with an unlabeled radioactive item or container in the area. Similarly, a trained individual's response to a "Radiation Area" posting may not be sufficient to protect that individual from the hazards arising from the opening of a wrapped, but unlabeled, contaminated item in that area. In such cases, the exception provided in 10 CFR 835.606(a)(1) requires that sufficient information be provided to permit individuals to take appropriate protective actions. As discussed above, this information may be provided in conjunction with the area postings, radiation safety training, written procedures, controlling work authorizations or other suitable means.

Appendix 12.A – Standard Radiation Warning Trefoil

The standard radiation warning trefoil should be proportioned as shown below (ANSI N2.1). The trefoil color shall be either magenta or black on a yellow background [10 CFR 835.601(a)].



13.0 OCCUPATIONAL RADIATION PROTECTION RECORD-KEEPING AND REPORTING

This Guide provides instructions for implementing a program that will meet DOE requirements for generating, administering, and retaining occupational radiation protection records and reports. Complete and accurate radiation protection records are necessary to:

- provide information used to protect individuals from radiation exposure;
- evaluate the effectiveness of the radiation protection program;
- demonstrate compliance with regulations and requirements; and
- defend the radiation protection program against unwarranted litigation.

Supporting guidance useful in developing and implementing occupational radiation protection record-keeping programs is provided in N13.6, *Practice for Radiation Exposure Records Systems* (ANSI/HPS 1999) and NCRP Report No. 114, *Maintaining Radiation Protection Records* (NCRP 1992). These documents should be used in concert with this Guide and 10 CFR 835 because they may not address every DOE-specific occupational radiation protection record-keeping requirement.

The RCS provides detailed information concerning various aspects of records management programs, including record-keeping standards. The RCS provides detailed technical guidance concerning employee records, radiological control procedures, area monitoring, and instrumentation and control. The information provided by the RCS, used in conjunction with this Guide, will assure that a records management program will meet the record-keeping requirements and relevant DOE contractual requirements.

13.1 Implementation Guidance

This chapter describes acceptable methods for conducting a functional and effective program for generating and administering occupational radiation protection program records and reports. An acceptable radiation protection records program should:

- be implemented by individuals who are knowledgeable of the record-keeping requirements. Guidance on appropriate education, training, and skills is provided in the RCS and in Chapter 3 of this Guide;
- have documented policies and procedures for record and report generation and administration;
- demonstrate accuracy, completeness, timely record and report generation, and retrieval capability; and

- maintain documents that are traceable, trackable, verifiable, and retrievable, to substantiate historical events.

Unless otherwise specified, all radiation protection program records and reports shall use the special radiological units of curie, rad, roentgen, and rem, including their multiples and subunits (10 CFR 835.4). Certain radiological conditions, such as surface contamination levels, are provided in 10 CFR 835 in alternate units (e.g., dpm/100cm^2), and should be so recorded in facility records and reports. The international system of units may be used to facilitate calculations (e.g., Becquerel, Gray, Sievert) but final records and reports should always be provided in the required units.

13.2 Records to be Generated and Maintained

Required records include individual monitoring and dose, workplace monitoring and control, and administrative records

13.2.0 Individual Monitoring and Dose Records

10 CFR 835.702(a) and (b) require maintenance of monitoring results to document doses received by:

- all individuals monitored pursuant to 10 CFR 835.402;

- all individuals who received unplanned doses exceeding the monitoring threshold; all individuals who receive doses as a result of planned special exposures and authorized emergency exposures; and

- all individuals for whom monitoring was provided, but not required under 10 CFR 835.402.

Individual monitoring records shall be sufficient to evaluate compliance with the regulatory provisions for internal and external exposures [10 CFR 835.702(c)(1)]. These records shall be sufficient to provide dose information necessary to complete mandated reports to individuals [10 CFR 835.702(c)(2)].

10 CFR 835.702(d) requires that documentation of all occupational doses received during the current year be obtained to assure individuals do not exceed the dose limits provided in 10 CFR 835.202(a). A written estimate signed by the individual may be accepted if complete records documenting previous occupational dose during the year cannot be obtained. Doses from planned special exposures conducted in accordance with 10 CFR 835.204 and emergency exposures authorized in accordance with 10 CFR 835.1302(d) are not included when determining compliance with the occupational dose limits.

Individual monitoring records identified with a specific individual shall be readily available to that individual [10 CFR 835.702(f)]. Individuals should be informed as to

how they may access their records. Guidance on reports to individuals is provided in section 13.3.0 of this Guide. See Section 13.8 for Privacy Act considerations.

Each individual's dose records should be identified by the following information, as appropriate:

- full name;
- social security number, employee, or other unique identifying number;
- date of birth;
- sex;
- employment status;
- occupation code;
- facility type or building number; and
- organization code.

13.2.0.0 Internal Doses

10 CFR 835.702(c)(4) requires that individual internal dose records include the committed effective dose equivalent, the committed dose equivalent to any organ or tissue of concern, and the identity of the radionuclide(s). These records should also typically include the estimated intake to facilitate future reassessments of doses [see 10 CFR 835.702(g)]; however, the estimated intake is not needed for determination of dose from certain forms of some radionuclides, such as tritiated water vapor or elemental tritium. In these cases, the intake need not be recorded. In cases where intakes are detected or confirmed in a year subsequent to the year of the intake, the CEDE should be attributed to the known or assumed year of the intake, and all records and reports for that year should be amended as appropriate. Records of the results of air monitoring when used to determine individual occupational dose shall be documented and maintained [10 CFR 835.703(b)].

Internal dosimetry technical basis documentation should be developed and should include technical methods, supporting evidence, and reference information used to provide the technical foundation for the internal dosimetry program. The technical basis documentation should be controlled and retained as a radiation protection program record. Guidance for determining individual internal doses is provided in Chapter 5 of this Guide.

Special radiobioassay measurements should be performed following suspected or confirmed intakes. The extent of the investigation and the number and frequency of these

radiobioassays should be determined and documented on an individual, case-specific basis, taking into account the potential magnitude of the intake, the effective clearance half-time, the health of the worker, and the number of measurements needed to evaluate the internal dose.

Additional guidance for recording and reporting internal doses and related information is provided in Section 9, of DOE-STD-1121-2003. Record-keeping and reporting of internal doses and related information should be in accordance with this standard.

13.2.0.1 External Doses

10 CFR 835.702(c)(3) requires that individual external dose records include the effective dose equivalent, lens of the eye dose equivalent, shallow dose equivalent to the skin, and shallow dose equivalent to the extremities. When the lens of the eye is not specifically monitored, the skin dose (shallow dose equivalent) may be used to determine regulatory compliance. When the extremities are not specifically monitored, the dose to the skin of the whole body (shallow dose equivalent) may be used for determination of regulatory compliance.

When the extremities are specifically monitored, the dose should be recorded as dose equivalent to 1) hands and arms below the elbows and, separately, 2) feet and legs below the knees. When both left and right extremities are monitored, the higher dose equivalent should be recorded.

When an individual is provided multiple dosimeters, the dose measured by the highest responding dosimeter on the whole body should be assigned as the whole body dose of record (see Chapter 6 for special considerations). When multiple dosimeters are employed more than once during the year, dosimeter results may be summed by location and the highest total assigned as the whole body dose of record. However, sufficient records should exist to demonstrate that the dose to portions of the whole body between the monitoring locations did not exceed that recorded for the monitoring location.

When personnel dosimeter measurements are not available, a dose evaluation should be performed for that period, if necessary. These estimated or assigned doses shall be clearly recorded and maintained as such [10 CFR 835.702(a) and (g)]. When area monitoring results are used to estimate individual dose, the results of surveys, measurements and calculations used to determine individual occupational exposure from external sources shall be recorded [10 CFR 835.703(b)].

A technical basis document should be developed for the external dosimetry program to provide (or provide reference to) the regulatory, scientific, and technical foundation of the program. The technical basis document should be handled as a controlled document and retained as a RPP record. Guidance to determine individual external doses is provided in Chapter 6.

The number of fixed nuclear accident dosimeter units, their locations, the effect of intervening shielding, and an analysis demonstrating these performance criteria should be documented in the technical basis document.

13.2.0.2 Summation of Internal and External Doses

10 CFR 835.702(c)(5) requires that individual dose records include the total effective dose equivalent, for any organ or tissue assigned an internal dose during the year, the sum of the deep dose equivalent from external exposures and the committed dose equivalent to that organ or tissue, and the cumulative total effective dose equivalent (see guidance regarding lifetime occupational dose, below). When only internal or external dose has been monitored, then the summed doses will be equivalent to the component of the dose (internal or external) that has been monitored.

13.2.0.3 Lifetime Occupational Dose

For each radiological worker monitored in accordance with 10 CFR 835.402 [i.e., the radiological worker's dose is expected to exceed the monitoring threshold(s)], efforts shall be made to obtain records of prior years' occupational dose [10 CFR 835.702(e)]. Efforts to obtain such records should include at least three written requests to each prior employer. If the prior employer is non-responsive or complete records cannot be obtained for any reason, a written estimate signed by the worker may be accepted.

10 CFR 835.204(b) requires that an individual's dose from all previous planned special exposures and all doses in excess of the occupational dose limits be determined prior to requesting the individual to participate in a planned special exposure. For this situation, estimates of dose from previous planned special exposures and estimates of doses in excess of the limits are not permitted for meeting the requirements of 10 CFR 835.204(b). The records of prior years exposure required by 10 CFR 835.204(b) need only be obtained for radiological workers who are chosen and elect to participate in a planned special exposure.

On the basis of available dose records and written estimates, records of each radiological worker's cumulative total effective dose equivalent shall be maintained [10 CFR 835.702(c)(5)(iii)] and efforts should be made to determine the lifetime occupational dose of each radiological worker who is monitored in accordance with 10 CFR 835.402. The contribution to an individual's lifetime occupational dose since January 1, 1989, should be recorded as CTEDE. DOE did not require determination of CEDE prior to January 1, 1989; consequently, annual TEDE information may not be available. While determination of CEDE for internal exposures received prior to January 1, 1989, is recommended to improve the consistency of available information, such conversion may not be possible due to resource or data limitations. If conversion to CEDE is not possible or practical, all available dose and intake data should be recorded.

13.2.0.4 Non-Uniform Exposure to the Skin

Non-uniform exposures to the skin (such as from non-penetrating radiation or skin contamination) shall be recorded in the individual's dose record and included in the dose equivalent to the skin for the year if the area of skin exposure equals or exceeds 10 cm^2 and the dose equals or exceeds 1 rem (0.01 Sv) [10 CFR 835.205(b)(1) and (2) and 10 CFR 835.702(b)]. If the dose does not exceed 1 rem, the dose may be included in the individual's dose records as dose equivalent to the skin, but in any case, records of the dose assessment should be maintained. If the dose exceeds 1 rem (0.01 Sv) and the area of the skin exposure is less than 10 cm^2, the dose shall be recorded as a special entry in the individual's dose record, but shall not be included in the dose equivalent to the skin for the year [10 CFR 835.205(b)(3)].

If the exposure to the skin is to the hands or arms below the elbows or feet and legs below the knees, the dose should be included in the shallow dose equivalent to the extremity for the year. Otherwise the dose should be recorded as shallow dose equivalent to the skin.

13.2.0.5 Planned Special Exposures (PSEs)

The dose resulting from PSEs shall not be considered in controlling future occupational dose to the individual under 10 CFR 835.202(a), but shall be included in the records and reports required by 10 CFR 835 [10 CFR 835.204(f)]. Doses resulting from PSEs should be included in the determination of the individual's yearly doses, CTEDE, and lifetime dose. These doses are not considered in the individual's yearly dose when demonstrating compliance with the dose limits in 10 CFR 835.202(a). Doses resulting from PSEs should be recorded and treated separately, even if the dose does not exceed the value of the dose limits provided in 10 CFR 835.202(a).

13.2.0.6 Doses Resulting from Emergency or Accidental Exposures

The dose received from an authorized emergency exposure or unplanned exposure exceeding the applicable monitoring threshold shall be documented in each individual's dose record [10 CFR 835.702(a)]. Doses resulting from accidents shall be included in assessments with compliance with the dose limits provided in 10 CFR 835 [10 CFR 835.2(a), Occupational dose]. Doses resulting from authorized emergency exposures shall not be considered in assessments of compliance with the regulatory dose limits and should not be considered in controlling the affected individual's future routine occupational exposure under 10 CFR 835.202(a).

13.2.0.7 Records of Embryo/Fetus Dose and Declared Pregnant Workers

Records pertaining to the embryo/fetus and the declared pregnant worker shall include:

- the dose equivalent to the embryo/fetus of a declared pregnant worker [10 CFR 835.702(c)(6)];

- the written declarations of pregnancy for the individual, including estimated conception date [10 CFR 835.704(d)]; and
- the written revocations of declarations of pregnancy for the individual, if any [10 CFR 835.704(d)].

Other records that should be maintained include:

- any work restrictions imposed;
- any counseling performed;
- monitoring performed (e.g., dosimeter placement, bioassay frequency, supporting workplace monitoring); and
- records of reports provided.

Guidance for determining dose to the embryo/fetus may be found in Chapter 8 of this Guide.

13.2.0.8 Individual Monitoring Program Records

Data that are necessary to support or recalculate doses at a later date shall be retained [10 CFR 835.702(g)]. Records that should be retained include the following:

- the monitoring program technical basis documents and any changes;
- decisions to include or exclude program participants and the monitoring results (individual and workplace) supporting these decisions;
- calculations of dose based on workplace monitoring data, when performed;
- sample collection dates, times, volumes, analysis results, and dose assessment;
- models used (i.e., individual specific parameters versus Reference Man, etc.);
- records of program accreditation, exceptions from accreditation, or other approvals;
- contractual arrangements for contractor dosimetry services;
- program cross-checks;
- instrument capability, calibration and functional tests;
- workplace monitoring results;
- results of trend analyses;

- monitoring device issue, return, readings, dose assessment, inter-device agreement, and investigations;
- dosimeter relocation or multi-badge issue, as appropriate;
- field correction factors used;
- calculations of external dose from airborne radionuclides and surface, skin, or clothing contamination; and
- employee radiological safety concerns that have been formally investigated.

13.2.0.9 Equipment Capabilities

The capabilities of radiation monitoring instruments, including individually worn dosimeters, should be documented. Recorded information should include the identification, description, and functional specifications and the results and date of any acceptance or performance tests that are performed to demonstrate equipment capabilities with regard to sensitivity, range, and energy dependence (ANSI/HPS N13.6). Additionally, records of computer program capabilities, limitations, and validation and verification should be maintained.

13.2.1 Monitoring and Workplace Records

This chapter applies to the records that may be required to establish the conditions under which individuals were exposed to radiation or radioactive material. These records supplement the individual dose records that are based on individual monitoring. In some cases, workplace records provide the only means for estimating individual doses. These records are also helpful in assessing the overall quality and effectiveness of the radiation protection program. ANSI/HPS N13.49-2001*, Performance and Documentation of Radiological Surveys,* provides guidance on documentation of radiological surveys (ANSI/HPS 2001b). The following information shall be documented and maintained:

- results of monitoring for radiation and radioactive material as required by Subparts E and L of 10 CFR 835 [except for that monitoring required by 10 CFR 835.1102(d)] [10 CFR 835.703(a)];
- results of monitoring used to determine individual occupational dose from external and internal sources [10 CFR 835.703(b)];
- results of monitoring for the release and control of material and equipment as required by 10 CFR 835.1101 [10 CFR 835.703(c)]; and
- results of maintenance and calibration performed on instruments and equipment as required by 10 CFR 835.401(b) [10 CFR 835.703(d)].

13.2.1.0 Radiation Safety Analysis and Evaluation Records

Reports of initial evaluations and periodic re-evaluations of the long-term radiation protection aspects of a work area, equipment, or specific location should be retained. These evaluations may be used to supplement the monitoring that is required for transient conditions. The details and content of the evaluation reports depend upon the purpose of the report, the nature of the operation, and the associated potential hazards. The evaluation report should include or make reference to:

- descriptions of the facility, equipment, and nature of the operation, including modifications to any facilities, equipment or operations;
- design criteria for systems, components, and structures;
- identification of potential hazards, including the types and magnitude of the sources of radiation allowed in the facility, and the nature and magnitude of those found during the review;
- training and experience requirements for individuals employed in the operation;
- probability of occurrence and predicted consequences of hazards expressed in quantitative terms where feasible;
- physical design features and administrative controls provided to prevent or mitigate potential accidents;
- the scope of the periodic surveillance program and the radiation instrumentation required;
- the appropriate emergency actions to be taken in the event of accidents;
- operational limitations; and
- identification of the individual(s) who made the evaluation.

13.2.1.1 Work Authorizations

Written authorizations shall be required to control entry into and perform work within radiological areas [10 CFR 835.501(d)]. Records of these authorizations shall be maintained [10 CFR 835.701(a)] and should include the information provided in Chapter 3, Part 2 of the RCS pertaining to preparation of RWPs. The RCS also provides guidance regarding the preparation and use of written work authorizations, such as RWPs and technical work documents. The supporting records, such as monitoring records used to prepare work authorizations, should be linked so that reference can be made to the data when required.

13.2.1.2 Area and Material/Equipment Monitoring Records

Results of area and material/equipment monitoring activities should be recorded on appropriate standard forms (to the extent practicable) and include the following common elements:

- date, time, and purpose of the monitoring activity;
- general and specific location monitored;
- name and signature of the individual performing the monitoring;
- pertinent information needed to interpret the monitoring results;
- reference to a specific work authorization if the monitoring is performed to support the authorization;
- model and serial number of the instrument (locations of fixed instruments may be used as identifiers where the model and serial numbers are not available).

The value of some types of area monitoring is enhanced by the use of sketches of building, room, or equipment layouts to clearly define the areas monitored and results observed. Monitoring of certain items however, may be adequately documented by simply describing the item and its radiological status. Additional records that should be maintained include:

- the technical bases for assumptions on which the monitoring program is based, including radionuclide inventories, system functions, specific activities involving radioactive materials, and air flow studies;
- records of alarms and alarm responses;
- placement of fixed dosimeters and nuclear accident dosimeters;
- results of samples, including location, time, occupancy, volume, radionuclides, concentrations, counting equipment data, etc.;
- field analysis and follow-up analysis results;
- pertinent facility conditions when monitoring is performed;
- corrective actions resulting from performance of monitoring;
- personnel and area decontamination records; and

- times and dates as necessary to assess compliance with time sensitive requirements, such as receipt of material from radioactive material transportation.

Many facilities employ area monitoring instrumentation that records on charts the radiation levels in work locations. The record on the chart should include, or be directly linked to, the information described in ANSI/HPS N13.6.

See Chapter 7, Part 5 of the RCS for additional guidance concerning radiation and contamination monitoring records.

13.2.1.3 Airborne Radioactivity Monitoring Records

In addition to the guidance provided in section 4.1.2.3, the results of monitoring for airborne radioactivity shall be documented and maintained [10 CFR 835.703(a)] and should include:

- measured airborne radioactivity concentrations in general areas and breathing zones;
- supporting parameters, including collection efficiency, flow rate, duration of sampling, correction factors, and filter medium;
- individual DAC-hour calculations, when performed; and
- linkage of air sample results to individuals in the area, when monitoring results will be used for individual dose assessment or exposure control.
- Airborne monitoring program records should include:
- the technical basis for alarm set points for real-time monitors;
- the technical basis for air sampling and real-time air monitoring equipment selection, placement, and operation; and
- any adjustments to DACs.
- When air monitors with chart recorders are used, the following additional information should be recorded on the chart or be directly linked to the chart:
- type of instrument, e.g., fixed filter or moving tape;
- tape and chart speed;
- identity of scale or range of operation; and

- specific calibration and relationship between the chart divisions and the concentration of the airborne radioactive material depending on the tape speed and flow rate of a moving filter unit or the flow rate of a fixed filter unit.

13.2.1.4 Records of Releases of Materials and Equipment from Radiological Areas

Records of monitoring for the release and control of material and equipment as required by 10 CFR 835.1101 shall be documented and maintained [10 CFR 835.703(c)]. These records should contain the following:

- description of the material or equipment;
- date on which the material or equipment was monitored;
- type and identification number of the survey instrument used;
- results of the monitoring; and
- identification of the individual(s) who performed the monitoring.

When the material to be released consists of many small or identical items, then the material may be described in a general manner (e.g., "box of tools" or "pallet of lumber"). Large or unique items should be specifically identified by identification number, if available.

13.2.2 Administrative Records

This section applies to the administrative records that describe various elements of the radiation protection program.

The following records shall be maintained:

- training records, as necessary, to demonstrate compliance with 10 CFR 835.901 [10 CFR 835.704(a)].
- actions taken to maintain occupational exposures ALARA, including the actions required for this purpose by 10 CFR 835.101, as well as facility design and control actions required by Subpart K of 10 CFR 835 [10 CFR 835.704(b)];
- results of internal audits and other reviews of program content and implementation [10 CFR 835.704(c)]; and
- changes in equipment, techniques, and procedures used for monitoring [10 CFR 835.704(e)].

13.2.2.0 Radiation Safety Training

Records of radiation safety training are essential to show that each individual received appropriate training. Records shall be maintained, as necessary, to demonstrate compliance with 10 CFR 835.901 [10 CFR 835.704(a)]. These records should include documentation of on-the-job and practical factor training as well as formal classroom training. Training and qualifications records should be readily available to first-line supervision and management to aid in work assignment.

Course-related items, including all revisions and dates used, should be retained include the following:

- the course title and outline or syllabus;
- copies of handouts distributed to the attendees;
- instructor's manuals and lesson plans;
- copies or transcriptions of any video and audio training that is provided;
- attendance sheets showing dates, attendees' names and signatures, and names of instructors;
- documentation of job-specific training, such as radiological procedures, RWP procedure, and special training requirements, pre-job briefings, and mockup training;
- documentation of exceptions to training requirements and extension of qualifications;
- on-the-job training records;
- records demonstrating the practical application of a learned skill;
- copies of any certificates issued;
- the basis for decisions to alter standard course content for specific candidates due to prior education, experience, escort provided, etc.;
- program accreditation records;
- effectiveness evaluations and actions in response;
- training/briefings provided between full training cycles;
- basis for site/facility-specific materials;

- individual tests, or if a test bank is used, the test series number and a copy of the bank and the series code; and
- confirmation of satisfactory completion of training.

If training or qualifications received at other locations are to be accepted in place of training, documentation should be obtained and placed in the individuals' training records. Additional guidance on training records may be found in the RCS.

13.2.2.1 ALARA Records

Actions taken to maintain occupational exposures ALARA, including actions required by the RPP, as well as facility design and control actions shall be documented [10 CFR 835.704(b)]. As discussed in Chapter 4, this documentation includes formal plans and measures for applying the ALARA process to occupational doses. This documentation should include the following, to the extent the programmatic elements are used in the specific program:

- the ALARA committee charter, membership, and meeting minutes;
- implementation of administrative control levels;
- forms demonstrating approval to exceed administrative control levels;
- dose, intake, and personnel contamination investigation forms;
- radiological performance goals, status, and annual performance records;
- pre-job briefing, with content and attendance;
- post-job reviews, with dose estimates, and actual doses received;
- collective doses received by the total facility, by specific work groups, and for specific high dose jobs;
- annual or special ALARA reports, e.g., dose/dosimetry trend data;
- records of ALARA design review;
- results of optimization analysis;
- work planning, including procedures and technical work documents;
- work authorizations, including RWPs;
- records of ALARA job/experiment review; and

- ALARA training records.

Formally documented optimization methodologies should be developed for ALARA reviews and decisions on implementation of ALARA efforts. The degree of formality should be commensurate with the radioactive material contamination and dose potential. Chapter 1 of the RCS provides additional guidance on the degree of program formality.

All documents and legal records used to demonstrate compliance with the requirements for an ALARA program should be reviewed and approved by supervisory or line management.

13.2.2.2 Facility Design

Records necessary to evaluate compliance with the design and control requirements of Subpart K of 10 CFR 835 shall be maintained [10 CFR 835.701(a)]. These records should include the following:

- the design and control considerations documenting the rationale for selecting physical controls or administrative controls, when necessary;
- the design criteria used and technical basis for these criteria;
- the optimization methodology employed for facility design and modifications;
- the technical basis for design objectives;
- the results of design reviews, including features that facilitate operations, maintenance, decontamination, and decommissioning; and
- the technical basis for workplace controls used.

13.2.2.3 Entry and Access Control Records

Records necessary to evaluate compliance with 10 CFR 835.501 shall be maintained [10 CFR 835.701(a)]. These records should include the following:

- system/device design, test criteria, and data;
- system/device failure and corrective actions;
- assessments of adequacy for actual and design conditions; and
- administrative controls used in lieu of physical controls.

13.2.2.4 Sealed Radioactive Sources

Records shall be maintained as necessary to evaluate compliance with the requirements of 10 CFR 835.1201 and 10 CFR 835.1202 for sealed radioactive source control, inventory, and source leak tests [10 CFR 835.704(f)].

Records that should be maintained include:

- source acquisition, monitoring, leak tests, inventories, loss;
- storage and use locations;
- investigations conducted; and
- exceptions taken due to source inaccessibility or sources taken out of service.

See Chapter 7, Part 5 of the RCS for additional guidance concerning sealed radioactive source leak tests and inventories records.

13.2.2.5 Radiation Protection Program, Policies and Procedures

Documentation supplementing the approved RPP should be developed and maintained to demonstrate that an RPP can be effectively managed and administered to achieve compliance with 10 CFR 835. This documentation should include a site radiological control manual, detailed implementing procedures, appropriate management policy statements, and technical basis documentation. While this documentation need not be part of the RPP, it should be clearly linked to the compliance commitments contained in the RPP. Records of this documentation should be recorded in accordance with ANSI/HPS N13.6. All policies and procedures should have effective dates.

Documentation of changes made to the RPP without prior DOE approval should include the rationale applied to such changes and should be retained for future reference and demonstration of compliance.

Programmatic documentation should be developed to document the organizational and administrative aspects of the RPP.

Records shall be maintained, as necessary, to demonstrate that individuals who are responsible for the development and implementation of measures necessary to ensure compliance with 10 CFR 835 have the appropriate education training, and skills to execute these responsibilities [10 CFR 835.103 and 701(a)]. These records should include records of the training provided in accordance with Chapter 6, Parts 4 and 5 of the RCS.

If the provisions of 10 CFR 835.3(e) are exercised, documentation of the schedule deviation should be developed and include a discussion of the specific activity involved and the reason for the schedule deviation.

Revisions to procedures, policies, or methods of evaluation used for monitoring shall be documented [10 CFR 835.704(e)]. The original document and all approved revisions of subject documents should also be retained.

13.2.2.6 Audits and Programmatic Reviews

Assessments of radiation protection programs by external agencies and internal groups are valuable in determining the adequacy of the program. Records shall be maintained to document the results of internal audits and other reviews of program content and implementation [10 CFR 835.704(c)]. These records should include records of corrective actions and audit procedures.

13.2.2.7 Posting and Labeling

Records necessary to evaluate compliance with the posting and labeling requirements of 10 CFR 835 shall be maintained [10 CFR 835.701(a)]. These records should include the following:

- documentation of area postings on area monitoring records. These records need not show the placement of each sign, but should be adequate to demonstrate that areas are posted consistent with the radiological conditions recorded on the monitoring record;
- variance from facility design parameters;
- documentation of compensatory measures implemented to obviate the need for posting; and
- long term changes in postings.

13.2.2.8 Calibration, Functional Tests, and Maintenance Records

Calibration and maintenance procedures, criteria, and schedules for dosimeters and radiation protection instruments are important to demonstrate their dependability, reliability, and accuracy. The results of maintenance and calibration performed on instruments and equipment used for monitoring shall be recorded [10 CFR 835.703(d)]. These records should include equipment, sources, and fields used, results of initial (as found) tests and post-adjustment tests, and corrective actions taken for instruments found to be out of calibration or inoperable.

The calibration laboratory should maintain the following sets of documentation: (1) the laboratory protocol; (2) the laboratory records; and (3) the calibration records. Historical

records should be maintained to detail any changes or revisions in procedures or protocols.

The performance of functional tests during use of portable monitoring instruments in the field should be appropriately documented. This may be as simple as a check-list on the survey sheet.

13.3 Reports

Many reports are prepared for a variety of purposes by the radiation protection program. This chapter describes the reports required by the previously cited references.

13.3.0 Reports to Individuals

Each individual monitored in accordance with 10 CFR 835.402 shall be provided an annual report of his/her dose [10 CFR 835.801(c)]. The report shall include, at a minimum the data required under 10 CFR 835.702(c), and the following additional information [10 CFR 835.801(a) & (c)]:

--The DOE site or facility name;

--the name of the individual, and;

--the individual's social security number, employee number, or other unique identification number.

Individuals who were not monitored in accordance with 10 CFR 835.402 but who were determined to have received an occupational dose in excess of any of the monitoring thresholds of 10 CFR 835.402 should also be provided an annual report of his/her dose. This report should also include the information discussed above.

DOE O 231.1A, *Environment, Safety and Health Reporting* (DOE 2004c), and DOE M 231.1-1A, *Environment, Safety and Health Reporting Manual* (DOE 2004d), provide additional detailed information with respect to occupational dose reporting requirements.

Whenever a report concerning radiation protection matters is written about or to an individual, a copy of the report should be placed in the individual's dose records.

13.3.0.0 Records Requested by Monitored Individuals

Detailed information on any individual's exposure shall be made available to him/her upon request, consistent with the provisions of the Privacy Act (PA 1974) [10 CFR 835.801(d)]. See section 13.4 of this Guide for Privacy Act considerations. Requests for exposure information should be answered as soon as possible. At a minimum, the response should provide the information supplied on the termination

report. Other data that may be requested by the individual should be supplied if available.

13.3.0.1 Termination Dose Reports

10 CFR 835.801(b) requires that a termination dose report be provided only upon request of the individual terminating employment. This requirement includes visiting scientists and transient workers, such as technicians, and specialists who perform work at a facility and then leave to work elsewhere. The termination dose report shall be provided to the requesting individual as soon as data are available, but not later than 90 days after termination. 10 CFR 835.801(b) also requires that a written estimate of the radiation dose received by the individual based on available information shall be provided at the time of termination, if requested. The provisions for termination dose reports and written estimates only apply if the individual requests this information on or before the individual's last day of employment. If the request is made after the termination date, then the request should be handled in accordance with 10 CFR 801(d). When a termination dose report is provided to an individual, then an annual report to that individual, under 10 CFR 801(c), is not necessary.

13.3.0.2 Reports to DOE

Reports identifying a specific individual and his or her exposure data may be required to be sent to DOE. These reports include occurrences reported under DOE O 231.1A, *Environment, Safety and Health Reporting*, of exposure of an individual to radiation and/or radioactive material, or planned special exposures conducted in accordance with 10 CFR 835.204(e). Under 10 CFR 835.801(e), each individual specifically identified in such reports shall be provided a report on his or her exposure data included in the report to DOE at a time not later than the transmittal to DOE. A separate report should be provided to each affected individual discussing the nature and content of the report to DOE and his or her exposure data contained in the DOE report. Alternatively, a copy of the report sent to DOE may be sent to each affected individual to satisfy this requirement. Privacy Act (PA 1974) restrictions shall be considered since DOE report may contain personal information concerning other affected individuals.

13.3.1 Reports of Planned Special Exposures

A written report of the conduct of a planned special exposure shall be submitted to the cognizant Program Office and the Secretarial Officer responsible for environment, safety and health matters (i.e., the Chief Health, Safety and Security Officer) within 30 days after the exposure [10 CFR 835.204(e)]. This written report is required even though the actual doses may not have exceeded the values of occupational dose limits established in 10 CFR 835.202.

The report should address, but need not be limited to:

- a description of the circumstances requiring the use of a planned special exposure;

- identification of involved individuals, including exposed individuals, supervisors, approving management and DOE personnel;
- date(s) on which the exposure(s) occurred;
- estimated and actual personnel doses, including doses received by affected individuals before the planned special exposure; and
- records of ALARA plans, work authorizations, briefings, approvals, and other work documentation.

13.4 Privacy Act Considerations

Any system of records that retrieves information concerning individuals by personal identifiers, such as name, any identifying numbers (e.g., Social Security Number or payroll number), symbol, or other identifying particulars assigned to the individual, is subject to the Privacy Act. The principal records that would apply in this Guide are the individual radiation dose records. Other records, such as program records, are subject to the FOIA (FOIA 1986).

No information on an individual should be revealed to anyone other than the individual, DOE, or DOE contractor personnel who have a need to know without prior written consent of the individual, unless authorized by the Privacy Act or for routine uses as published periodically in the Federal Register. Records of deceased individuals are not covered by the Privacy Act, but are subject to the FOIA.

The following subsections discuss applicable parts of the Privacy Act as implemented by DOE through 10 CFR 1008 (DOE 1980).

13.4.0 Informing Individuals

Individuals about whom information will be collected should be informed of the authority for collection of the information, the principal and routine uses of the information, and the effects of not furnishing the information.

13.4.1 Identifying Individuals

10 CFR 1008.4 sets forth procedures for identifying the individual making a request for access to, information from, or amendment of his/her records. Identification of the individual should be established by one of the following three methods:

- if making a request by mail, a photocopy of two identifying documents bearing his/her name and signature must be submitted, one of which should bear his/her current home or business address and date of birth;
- if appearing in person, the individual must present either one identifying document bearing his/her photograph and signature or two identifying documents

bearing his/her name and signature, one of which should bear his/her birth date and current home or business address; or

- the individual can provide other proof of identity that the Privacy Act Officer deems satisfactory in the particular circumstances.

13.4.2 Requesting Correction or Amendment of a Record

If an individual requests a correction or amendment to his/her records, the record shall be changed or the Privacy Act Officer shall inform the requestor that the change has been denied. The denial should include the record system manager's name and title, the reasons for the denial, notification of the individual's right to appeal the denial, and the individual's right to submit a statement of disagreement.

13.4.3 Responding to Requests

Every reasonable effort should be made to respond with the requested material, correction, or amendment within 10 days. Response should be made within 20 days unless unusual circumstances prevail. If a response cannot be made within 10 days, an interim response should be made providing information on the status of the request and an estimate of when the response will be made.

13.4.4 Accounting for Disclosures

An accounting of all disclosures of information, except those to DOE and DOE contractor personnel with a need to know or those required by the FOIA, should be maintained as prescribed by the Privacy Act.

13.5 Record – Keeping Standards

Records shall be retained until final disposition is authorized by DOE [10 CFR 835.701(b)]. Individual dose records shall be transferred to DOE upon cessation of activities at the site that could cause exposure to individuals [10 CFR 835.702(h)].

General standards for maintenance and retention of radiation protection records, including media, media conversion, corrections, retention, and retrievability, are provided in the RCS.

14.0 RADIATION SAFETY TRAINING

While there are significant differences in the missions of various DOE and DOE-contractor operations, and thus significant differences in the content of radiation safety training programs necessary for adequate protection of employees, the basics of radiation safety for DOE activities can be taught using core course material augmented by site-specific material.

Different levels of radiation safety training are used to ensure the safe and efficient conduct of work. Training courses, such as Radiological Worker Training (RWT), take into account different levels of risk associated with various job functions and duty locations. Training shall be commensurate with the level of potential radiological hazards [10 CFR 835.901(c)].

A training program that evaluates the knowledge and skills that a worker needs for safe job performance, in conjunction with core course material for teaching the fundamentals of radiation safety, should be implemented to ensure that individuals can perform their assigned duties safely and respond appropriately to both normal and abnormal situations they may encounter.

14.1 Implementation Guidance

14.1.0 General Information

Radiation safety training shall be provided to all individuals before being:

- permitted unescorted access to controlled areas; or
- occupationally exposed to ionizing radiation during access to controlled areas, whether escorted or not [10 CFR 835.901(a)].

10 CFR 835 requires that radiation safety training shall include certain topics (discussed in detail in Section 14.3) to the extent appropriate to the individual's prior training, work assignments, and degree of exposure to potential radiological hazards [10 CFR 835.901(c)]. Radiation safety training program requirements should be established in specific procedures that address, at a minimum, the issues discussed in this Guide.

In addition to the radiation safety training requirements discussed in this Guide, 10 CFR 835.103 establishes requirements for the education, training, and skills of individuals who are responsible for developing and implementing measures required to ensure compliance with 10 CFR 835. Chapter 3 provides guidance for achieving compliance with these requirements.

To ensure that appropriate radiation safety training is provided to all individuals entering controlled areas, DOE has sponsored development of radiation safety training core course material for General Employee Radiological Training (GERT) (DOE 1998h) and

Radiological Worker Training (RWT) (DOE 1998i). RWT has been developed in a modular format to support two distinct core courses, RWT-I and RWT-II. RWT-II includes the material provided in RWT-I, augmented by additional modules on more complex radiation protection issues, such as high radiation area and contaminated area entry and exit controls. Detailed guidance for use of the DOE core course material is provided in the associated Program Management Guides.

DOE developed and implemented the core course material to enhance the content of radiation safety and other training programs across the DOE complex and to bring these training programs up to a standard consistent with similar programs implemented in the commercial nuclear industry. DOE recommends the use of the radiation safety training core course material, updated as necessary to reflect recent changes in regulatory requirements and other applicable standards, to satisfy the corresponding requirements of 10 CFR 835. Use of the radiation safety training core course material is no longer mandatory; however, the core course material for GERT and RWT should be strongly considered as a basis for developing and implementing radiation safety training programs.

A radiation safety training program sufficient to meet the requirements of 10 CFR 835.901 should include:

- course materials from the DOE core training materials applicable to the radiological hazards and controls associated with the specific DOE activity;
- site- and activity-specific content and instruction;
- performance demonstrations and examinations as appropriate to demonstrate understanding of key concepts and practices; and
- an evaluation of other applicable DOE requirements.

A satisfactory training program for radiation safety should also include training evaluations and provisions for maintaining training records. Detailed requirements and guidance for maintenance of radiation safety training records are provided in Subpart H of 10 CFR 835 and Chapter 13 of this Guide.

14.2 Determination of Required Training

10 CFR 835.901(a) and (b) establish requirements for distinct levels of radiation safety training. If an individual will be permitted unescorted access to controlled areas or receive occupational exposure to ionizing radiation during escorted or unescorted access to controlled areas, a determination must be made regarding the appropriate level of knowledge and the type of training to be provided. This determination should be based on:

- the nature of the radiological hazards in area(s) to which the individual will be granted access and the nature of the work to be performed. This determination

may be made on an individual basis, but is most commonly made in accordance with standardized procedures on a group basis, such as work group affiliation, level of access to certain areas, or type of work to be performed. If an individual determination is needed to meet special needs (such as for a dignitary or technical representative), the supervisor responsible for the individual's activities should establish and document this information. Based upon the information provided by the cognizant supervisor, the radiological control organization, training organization, or other cognizant organization should determine the appropriate level of training;

- the type and complexity of protective actions that the individual might be expected to undertake in the areas to be entered. This should include an assessment of both routine and emergency actions;

- a determination with regard to whether or not the individual will be under constant escort or supervision; and

- the individual's previous education, training, and experience in working with radioactive materials and in the vicinity of radiological hazards. This determination may be made by review of available training records, provision of a challenge examination, knowledge of individual experience and capabilities, personal documented interviews conducted by cognizant radiation protection or training personnel, documented working agreements with the individual's sponsoring organization (e.g., International Atomic Energy Agency or Defense Nuclear Facilities Safety Board), or a combination of these activities.

Challenge examinations may be given based on the individual's prior experience, education, and/or training. The radiological control organization should determine appropriate criteria for allowing challenge examinations. Challenge examinations should be based on the objectives stated for the training program, and are an approved form of proficiency testing. Challenge examinations should cover the entire applicable core training program.

Challenge examinations should address learning objectives from each topic or subject area of the training to ensure that workers not benefiting from classroom instruction have the requisite knowledge. With successful completion of the challenge examination, the student should be granted an exemption from the appropriate core training course or lesson. DOE 5480.20A requires DOE nuclear facilities to prepare and submit for approval procedures governing the processes used to grant exceptions from training or qualification requirements. Such procedures should be developed to govern radiation safety training for all DOE activities.

DOE encourages the establishment of reciprocity agreements to facilitate the acceptance of training provided at other sites. It is particularly beneficial to implement a practice of accepting training provided by other sites and facilities having similar hazards, processes, and facilities. Such agreements require some assurance that the training provided by the member sites provide a level of training acceptable to all signatory parties. In general,

completion of the applicable sections of the DOE core course material within the past two years in accordance with the Program Management Guides should be considered reasonable grounds for acceptance of previously completed core training (see Section 14.6.). In addition, consideration may be given for completion of training from other (non-DOE) nuclear facilities, formal education applicable to radiation safety, and previous experience working in facilities with similar hazards and controls. Whenever the full radiation safety training core course is not provided, the justification for any omissions (i.e., identification of any previous education, training, or experience accepted in lieu of providing radiation safety training) should be documented.

14.3 Training Course Content

GERT provides the appropriate level of training for individuals who:

- enter controlled areas unescorted; or
- receive occupational exposure during controlled area entry (whether escorted or not).

These are the individuals addressed in 10 CFR 835.901(a). GERT does not provide the appropriate level of training for individuals who enter radiological areas unescorted or for those individuals who perform unescorted duties as a radiological worker.

RWT-I provides the appropriate level of training for individuals who:

- enter non-contaminated radiation areas (but not high or very high radiation areas) or areas in which they are likely to receive doses exceeding 0.1 rem (0.001 Sv) in a year (e.g., certain radioactive material areas and areas surrounding radiological areas);
- work with sealed or fixed radioactive material that does not produce high radiation fields (i.e., fields exceeding 0.1 rem (0.001 Sv) in an hour); or
- work with radiation producing devices that do not produce high radiation fields (i.e., fields exceeding 0.1 rem (0.001 Sv) in an hour).

RWT-I is not appropriate for individuals who enter contaminated areas or high radiation areas unescorted. However, RWT-I may be augmented by the specific High/Very High Radiation Area Entry Training module to prepare RWT-I trained individuals for safe entry into high or very high radiation areas.

RWT-II has been developed to provide the appropriate level of training for individuals who, in addition to the above criteria:

- are expected to enter high radiation areas;
- are expected to enter contaminated areas; or

- are otherwise expected to work with unsealed quantities of radioactive materials.

10 CFR 835 establishes provisions allowing the use of escorts in lieu of providing radiation safety training. Guidance on implementing these provisions is provided in Section 14.8 of this Guide.

RWT uses a modular format to allow training to be customized to be commensurate with the hazard present in the area. This format facilitates upgrading of an individuals' status from RWT-I to RWT-I with High/Very High Radiation Area Training or RWT-II by simply completing the necessary additional modules.

Employment status (i.e., permanent, contract, temporary) should not be used to determine the appropriate level of training. As stated above, the type and level of training may be adjusted to be commensurate with the individual's level of access, assigned duties, and type of previous training and experience.

Radiation safety training shall include the following topics, to the extent appropriate to each individual's prior training, work assignments, and degree of exposure to potential radiological hazards [10 CFR 835.901(c)]:

- basic radiological fundamentals and radiation protection concepts;
- risks of exposure to radiation and radioactive materials, including prenatal radiation exposure;
- physical design features, administrative controls, limits, policies, procedures, alarms, and other measures implemented to control exposures to radiation and radioactive materials, including both routine and emergency actions;
- individual rights and responsibilities as related to implementation of the radiation protection program;
- individual responsibilities for implementing as low as is reasonably achievable (ALARA) measures required by 10 CFR 835.101; and
- individual exposure reports that may be requested in accordance with 10 CFR 835.801.

The DOE core course material provides this type of information to the level of detail that is broadly applicable to all DOE activities, but do not address site-specific information that individuals may need to conduct work safely.

14.4 Facility-Specific Materials

To implement an effective radiation safety training program, the core courses should be augmented with facility-specific information as necessary to adequately address the

course content requirements of 10 CFR 835.901(c). The following information should be considered in developing facility-specific training materials:

- procedures for entering and exiting the authorized areas, including use of work authorizations;
- controls on radiation exposures, including administrative control levels and fetal exposure control;
- measures for use of protective equipment, including protective clothing and respiratory protective devices;
- alarms, warning signals, and response actions;
- ALARA measures implemented at the facility;
- requirements for interfacing with the radiation protection organization;
- skills required by the worker to execute his radiation safety responsibilities;
- worker responsibilities for self and coworker protection, including exercise of stop work authority; and
- measures for requesting personal dose records and reports.

Following assessment of all of the necessary facility-specific information, the facility-specific portion of the training courses should be developed to augment the DOE core course material. The final radiation safety training materials should receive the concurrence of the Radiological Control Manager or his designee.

Although a systematic approach to training is currently required only at DOE facilities under the requirements of DOE 5480.20A, all DOE activities should, as much as practicable, use this approach in developing specific training. Suggested learning objectives and examples for different target audiences and types of facilities, such as accelerators, radiation generating devices, plutonium, uranium, and tritium facilities, are provided in the additional radiation safety courses developed by DOE. DOE encourages use of these materials, revised as appropriate to reflect recent changes in applicable requirements and standards, to identify learning objectives appropriate for the specific target audiences and facilities. (See www.eh.doe.gov/radiation/RST/rst.html.)

14.5 Conduct of Radiation Safety Training

Radiation safety training should be conducted in an appropriate training facility, such as a classroom or computer-based training facility, augmented by suitable mock-up and/or laboratory facilities and on-the-job training and evaluation for RWT. Training media, such as handouts, slides, and video presentations, should be appropriate to the subject matter and the audience. Computer-based training may be used as appropriate to ensure

consistent and reliable presentation of the course materials. Chapter 6 of the RCS and the Program Management Guides provide detailed guidance regarding instructor qualifications and recommended performance demonstrations.

14.6 Completion of Radiation Safety Training

Due to the limited access granted to individuals who complete only GERT, examinations are not required.

Successful completion of RWT shall be demonstrated by completion of an examination [10 CFR 835.901(b)]. Examinations should be written, but other measures may be implemented to accommodate those with special needs.

When measures other than written examinations are used, an evaluation should be made to ensure that all individuals will be able to execute their responsibilities safely. For example, individuals with reading comprehension impairments may take an oral examination, but an evaluation should be performed to ensure that the student:

- can read and understand any radiological warning signs and labels, work authorizations, and procedures affecting their work; or
- will always be provided the same level of assistance during area access and work performance as was provided during the examination.

Computer-based examinations, using automated examination composition and scoring, may be used as appropriate. The minimum passing score for examinations, including challenge examinations, should be established at or above 80 percent. Chapter 6 of the RCS and the core course Program Management Guides provide detailed guidance for conducting examinations.

In addition to an examination, students in RWT classes shall be required to complete performance demonstrations commensurate with their duties [10 CFR 835.901(b)]. Performance demonstrations typically involve such activities as safely entering and exiting simulated radiological areas, donning and removing protective clothing, and performing whole body frisking. Chapter 6 of the RCS and the RWT core course material provide detailed guidance for conducting performance demonstrations.

Proof of successful course completion, such as a certificate, wallet-sized card or access control or other database entry, should be provided to indicate the successful completion of DOE core radiation safety training. To be acceptable as proof of training at other DOE activities, the proof of completion should include the:

- individual's name;
- date of training;
- modules covered; and

- name of certifying official (such as the instructor or examination evaluator).

To allow reciprocity for completion of the core courses, the proof of completion should provide the course title (i.e., GERT, RW I, RW II) and, if the entire core course was completed, a statement to that effect.

For sites planning frequent use of training reciprocity, DOE encourages close prior coordination to establish inter-facility (or inter-site) working agreements that define mutually-acceptable standards for acceptable training program implementation. Regardless of such agreements, each site should retain the discretion to evaluate incoming workers individually and, to require challenge examinations or retraining as necessary to ensure compliance. Consideration must still be given to the provisions for facility-specific training discussed above.

Individuals who do not pass all required examinations and performance demonstration requirements should not be allowed to proceed with unescorted tasks involving exposure to radioactive materials or radiation until they have completed remedial actions. Remedial actions for failure to pass a written examination or meet performance demonstration requirements should include remedial instruction and re-examination, repetition of the training program, or restriction from job duties. Because challenge examinations are designed to provide credit toward required training, the remedial action for failure of a challenge examination should be to deny credit for that examination toward the required training. The choice and extent of remedial actions should be determined based upon the extent of the knowledge or skill deficiencies demonstrated by the individual.

14.7 Periodic Radiation Safety Training

In addition to the initial training provided before an individual is granted access to the specified areas, radiation safety training shall be conducted at least once every 24 months and whenever significant changes are implemented that might affect the individual [10 CFR 835.901(e)]. This periodic training should not simply repeat the initial training, but should review key principles, provide more detailed knowledge of the subject matter required in 10 CFR 835.901(c), and stress new program requirements and seldom-used knowledge and skills. Periodic radiation safety training should be conducted in accordance with the guidance provided in Section 14.5.

Although many possible program changes may affect individual workers, the assessment of their need for periodic radiation safety training at intervals of less than 24 months should at least consider the factors discussed in Section 14.4 of this Guide. If the program change is judged to be significant, then training should be completed either before the change is implemented or the individuals should be restricted from their duties until training has been completed.

The requirements for periodic radiation safety training are not intended to deter cognizant management from providing routine updates to workers on radiation safety requirements. Updates may be necessary to alert workers to radiation protection program changes that

are judged to be non-significant and whose impact does not warrant formal training or examinations. These updates are typically provided in the form of memoranda or posted notices. DOE encourages the use of such communication devices.

Periodic radiation safety training for RWT shall include successful completion of an examination [10 CFR 835.901(e)]. Examinations should be conducted in accordance with the guidance provided in Section 14.6 of this Guide. If challenge examinations are used to satisfy all or part of the requirements for periodic radiation safety training, those examinations should be developed and conducted in accordance with Section 14.6.

14.8 Use of Escorts in Lieu of Training

As indicated in Section 14.2, constant escort of an individual may affect the extent of required training. The use of constant escort may obviate the need for certain types of training by making the escort responsible for the protection and actions of the affected individual. This approach should only be used when:

- the individual will enter the area for a short period of time (i.e., a few hours);
- provision of an escort will provide for an adequate level of safety; and
- provision of an escort will not result in significant adverse dose effects (ALARA considerations). This determination should be based upon consideration of the resources (including collective dose) that must be expended to escort the individual versus those necessary to provide the appropriate training.

Use of an escort is also helpful when an individual has completed portions of the required training and would benefit from on-the-job experience. In these cases, a fully qualified individual should directly oversee the trainee's performance of tasks for which the appropriate training, examinations, and performance demonstrations have not been completed.

The assigned escort shall have completed the requisite training and shall ensure that the untrained individual complies with the documented radiation protection program [10 CFR 835.901(d)]. For instance, an individual assigned to escort an untrained individual in a contaminated area shall have completed RWT-II or equivalent training. In addition, the untrained individual, if occupationally exposed in a controlled area at a DOE site or facility, shall complete at least those portions of the training related to the risks of exposure to radiation and radioactive materials, including prenatal radiation exposure and individual exposure reports that may be requested [10 CFR 835.901(a)].

For individuals who are expected to remain in the controlled area for an extended period (i.e., more than a few hours) or to make repeated entries, the full training course should be completed, as appropriate to the individual's prior training, experience, and potential exposure risks.

14.9 Refresher Training

The RCS recommends and provides guidance for the conduct of radiation safety refresher training every other year when biennial radiation safety training is not required.

14.10 Other Training Programs

In addition to the radiation safety training requirements discussed in this Guide, 10 CFR 835.103 establishes requirements for the education, training, and skills of individuals who are responsible for developing and implementing measures required to ensure compliance with 10 CFR 835. Chapter 3 provides guidance for achieving compliance with these requirements.

14.11 Training Effectiveness Evaluations

Training effectiveness evaluations are quality assurance measures used to determine whether qualified workers have retained all the required knowledge and skills and that are applying them properly. Feedback is an important form of evaluation that encourages improvements and upgrades to the training programs. Comments from supervisors, instructors, and trainees should be used to enhance course effectiveness. Although other means of evaluating training programs are currently in place (such as industry and facility exchanges, instructor evaluations, and routine assessments), they are not addressed in this Guide.

The effectiveness of radiation safety training should be verified in accordance with the applicable training course program management guide. DOE has issued guidance for evaluating the effectiveness of radiation safety training in *Evaluating the Effectiveness of Radiological Training*. This document is also included as an attachment to the DOE-developed Radiological Worker Training and General Employee Radiological Training Handbooks. In addition, DOE 5480.20A requires that evaluations of training and qualification programs be conducted in accordance with DOE-STD-1070-94, GUIDELINES FOR EVALUATION OF NUCLEAR FACILITY TRAINING PROGRAMS (DOE 1994).

15.0 SEALED RADIOACTIVE SOURCE ACCOUNTABILITY AND CONTROL

A program to control sealed radioactive sources is necessary to prevent unplanned exposures and loss of sources. DOE has codified a general requirement indicating that all sealed radioactive sources (both accountable and exempt) shall be used, handled, and stored in a manner commensurate with the hazards associated with operations involving the sources (10 CFR 835.1201). For accountable sealed radioactive sources, specific measures, including inventories and source leak tests, shall be implemented (10 CFR 835.1202).

Exempt sealed radioactive sources need not be inventoried and leak tested. However, exempt sealed radioactive sources and the individuals using them are still subject to all other applicable requirements of 10 CFR 835 (e.g., radioactive material control, posting and labeling, radiation safety training, etc).

If a sealed radioactive source contains more than one radionuclide, the sum-of-the-fractions rule (i.e., $\sum A_1/Q_1 + A_2/Q_2 + ... \blacktriangleleft 1$; where A is source activity and Q is the accountability value for the radionuclide) shall be used to determine if the source is accountable (10 CFR 835, Appendix E, Footnote 1). For radionuclides that are not listed in Appendix E, 10 CFR 835 provides values of 10 microcuries for alpha emitters and 100 microcuries for all other radionuclides. The values provided in Appendix E of 10 CFR 835 are not material release values and should not be used to determine the acceptability of releasing materials from radiological controls either within or outside of the controlled area.

10 CFR 835.3(e) establishes provisions allowing for extensions of the intervals between mandatory sealed radioactive source inventories and source leak tests. Chapter 3 provides guidance for implementing necessary extensions of the required intervals.

15.1 Implementation Guidance

This chapter provides guidance for establishing and operating a sealed radioactive source accountability and control program. Key components of a sealed radioactive source accountability and control program should include:

- organization and responsibilities;
- receipt;
- labeling and storage;
- inventory;
- source leak testing; and
- handling and disposal.

Responsibilities of the organizational components, including line management, the radiological control organization (hereinafter referred to as the RCO), the source custodian, and the source user are presented.

15.2 Organization and Responsibilities

The responsibilities of the RCO for a sealed radioactive source accountability and control program should include the following:

- establishing the program;
- maintaining records related to the accountability and control of sealed radioactive sources;
- providing each source custodian with an inventory list of accountable sealed radioactive sources; and
- assisting the source custodian in training source users.

Some of these responsibilities may be delegated to another contractor group, for example, the safeguards and security group may be given the responsibility for maintaining accountability records. Non-delegatable responsibilities of the RCO should include:

- coordinating procurement of all sealed radioactive sources with the source custodian or user;
- performing receipt monitoring;
- performing source leak tests; and
- monitoring storage and use areas.

Sealed radioactive source custodians and source users are generally expected to work directly with radioactive materials and therefore would meet the 10 CFR 835.2(a) definition of the term "radiological worker." Such individuals would therefore be subject to the radiation safety training requirements of 10 CFR 835.901(b). An individual shall be trained in accordance with 10 CFR 835.901(b) prior to performing unescorted assignments as a radiological worker. 10 CFR 835.103 establishes additional requirements for the education, training, and skills of those individuals who are responsible for developing and implementing measures necessary for ensuring regulatory compliance. That training should include site-specific source accountability and control measures discussed in this Guide. See Chapters 3 and 14 for additional guidance.

The source custodian should notify and obtain approval of the RCO prior to:

- any significant change in the use of a sealed radioactive source;

- transfer of a sealed radioactive source to a new permanent storage location or to a new source custodian;
- modification of a device containing a sealed radioactive source;
- disposal or off-site transfer of a sealed radioactive source; and
- any procurement or acquisition of additional sealed radioactive sources.

The source custodian should notify the RCO in the event of the loss of, or suspected or actual damage to, any sealed radioactive source. The source custodian should ensure that source leak tests are conducted and inventory checks are performed for accountable sealed radioactive sources at least every 6 months. The RCO should actually perform the source leak tests. The source custodian should maintain records of the storage and use locations of all assigned sealed radioactive sources.

Prior to taking possession of the sealed radioactive source, the source user should receive authorization from the RCO and the source custodian. Source users should use, handle, and store assigned sealed radioactive sources consistent with the training provided and in accordance with the programmatic requirements established by the RCO.

15.3 Receipt

Prior to receipt of sealed radioactive sources, the RCO should assign the sources to the proper source custodians. Immediately upon receipt of sealed radioactive sources, the RCO should be notified. The packaging shall be inspected for damage and contamination and radiation monitoring performed in accordance with 10 CFR 835.405. Except for gaseous sealed radioactive sources and tritium, a source leak test shall be performed upon receipt of all accountable sealed radioactive sources [10 CFR 835.1202(b)]. The receipt monitoring and source leak test should be performed by the RCO. The source leak test should be performed in accordance with Section 15.6 of this Guide. The source custodian should be notified of the arrival of the sealed radioactive sources to ensure that proper accountability and controls are initiated. The sources should be placed into storage or into the device in which they will be used. The source custodian’s and site's records should be updated to include the new sealed radioactive sources.

15.4 Labeling and Storage

Unless specifically excepted under 10 CFR 835.606, all sealed radioactive sources having an activity exceeding 10% of the applicable 10 CFR 835 Appendix E values shall be labeled (10 CFR 835.605). Labels should be applied to all

sealed radioactive sources, regardless of the activity of the source, to minimize the likelihood of loss or unauthorized usage. In recognition of the differing labels permanently applied to certain sealed radioactive sources by their manufacturers, labels applied to sealed radioactive sources may be excepted from the color specifications of 10 CFR 835.601(a) [10 CFR 835.606(b)(6)]. However, standard colors and designs

should be used to the extent practicable to foster instant recognition by affected individuals.

Appropriate designs for radioactive material labels applied to sealed radioactive sources are described in Chapter 12. Labels should be applied directly to the sealed radioactive source or, if that is not practicable, the labels should be applied to the storage containers and devices containing sealed radioactive sources. The label should identify the radionuclide, source activity, date of assay, model and serial number of the source and container or device, and a method for identifying the source custodian.

In addition, labels should include the contact radiation levels, removable contamination levels, dates monitored, and name of the individual performing the monitoring. The label should be sufficiently durable to remain legible for the useful life of the device or storage container and should be located in a readily visible place. Another method of labeling makes use of electronic means such as bar codes along with human-readable labels. These will minimize human errors and compensate for the small size of some sources.

Ideally, all the labeling information should be on a label affixed to the source; however, due to the extensive list of information and the small size of many sealed radioactive sources, this is not always possible. If the source is too small to label, then either its source container (unless it is also too small) or its radioactive material storage location should be labeled. A method of tracing a source to its label should be implemented if the label is affixed to the source container or radioactive material storage location. Commercially manufactured sources should have a serial number on the source itself which should be traceable to the serial number on the label. For sources without serial numbers, the contractor should permanently mark the source, such that the integrity of the source is not violated, with a unique identification, and should use the same identification mark on the label.

If the radiation intensity around the sealed radioactive source container will change significantly upon opening the container or changing the position of the source in the container, that information should be provided on a label so that it is easily observable by the operator.

The storage location should also be marked in order to ease location identification during inventory. Storage locations, containers, and devices should be appropriate for the specific sources, and should only be used to contain radioactive materials. Storage rooms or cabinets selected to contain accountable sealed radioactive sources should either be isolated from occupied areas or located in radiological areas, be of a design which would minimize damage from fire, and be free of flammable or combustible substances. Storage rooms or cabinets containing sealed radioactive sources should be locked, monitored routinely, and posted.

Radiation and contamination monitoring of the sealed radioactive source storage area or facility should be performed before its initial use and periodically thereafter. Monitoring shall be performed whenever changes in status (e.g., receipt of a new sealed radioactive

source, modification to shielding) are made that may significantly affect radiological conditions [10 CFR 835.401(a)(3)].

Proper storage practices should be used to limit unauthorized use of a sealed radioactive source and to minimize the potential for sealed radioactive source rupture, excessive personnel exposure, or loss of the sealed radioactive source.

15.5 Inventory

Except for certain circumstances discussed below, all accountable sealed radioactive sources shall be inventoried at intervals not to exceed six months. These inventories shall accomplish the following:

- establish the physical location of each source;
- verify the presence and adequacy of associated postings and labels; and
- establish the adequacy of storage locations, containers, and devices [10 CFR 835.1202(a)].

The presence and adequacy of postings and labels and adequacy of storage locations may be assured through verification that these features have been established and maintained consistent with the guidance provided in this Guide. Upon determination that an accountable sealed radioactive source has been lost or is not stored, posted, and labeled consistent with 10 CFR 835, the RCO should be notified.

Although exempt sealed radioactive sources are not required to be inventoried, steps should be taken to prevent the loss of these sources, regardless of activity, as required by 10 CFR 835.1201. Measures should be implemented to restrict the removal of sources from specified locations and, when sources are moved, to administratively track source locations.

Appendices 15.A and 15.B are examples of typical accountable sealed radioactive source accountability forms. A form similar to Appendix 15.A should be completed for each new source. This form should cover initial receipt and registration of the source, changes in source status (e.g., disposal, new use, failure of a leak test), custodian information, and initial/receipt leak testing information. As changes occur in the source status or the source custodian, applicable portions of the form should be updated as necessary. For example, if the source is transferred, that portion of the form should be revised by the source custodian and the updated form sent to the responsible RCO.

The site organization responsible for sealed radioactive source accountability (i.e., the RCO or delegated organization) should maintain an individual form similar to the one in Appendix 15.A for each accountable sealed radioactive source at each facility. Each source custodian should also maintain a form for each accountable sealed radioactive source under their responsibility.

A form similar to the one in Appendix 15.B should be provided to the source custodian when inventory checks and/or leak tests are scheduled. This form should be completed and a copy sent to the responsible RCO to update the accountability records. It is recommended that the source custodian schedule the conduct of the periodic leak tests for all of the sealed radioactive sources under his or her responsibility. The inventories may be done by the source custodian or the RCO (at the time of the leak testing).

Most accountable sealed radioactive sources are used in a location near their radioactive material storage location. Some portable survey instruments and fixed-location detection systems have check sources with activities high enough to classify them as accountable sealed radioactive sources. The source custodian is not required to know the exact location of each check source affixed to a portable survey instrument because radiological control technicians frequently carry such instruments from facility to facility. Notifying the source custodian each time a portable survey instrument with an accountable check source is moved is not required. Therefore, the source custodian for check sources in portable survey instruments and fixed-location detection systems should be an individual in the calibration facility who can perform the inventory check and get the leak test performed.

Similarly, notification of the RCO should not be required for the movement of any accountable sealed radioactive source as long as it is being used according to approved operations (e.g., according to a procedure or radiological work permit) as long as the source will be returned to its original storage location.

15.6 Leak Testing

Except for those sources consisting solely of gaseous radioactive material or tritium, accountable sealed radioactive sources shall undergo a source leak test upon receipt, when damage is suspected, and at least every six months [10 CFR 835.1202(b)]. A leak test should be performed prior to initial use of an accountable sealed radioactive source and when any measurable contamination is detected on handling or storage equipment (unless the contamination is known to be from another source).

The integrity of an accountable sealed radioactive source should be established by a wipe test or other leak test method as recommended in ISO/DIS Report 9978, *Radiation Protection Sealed Radioactive Sources Leakage Test Methods* (ISO 1990); ISO/TR Report 4826, *Sealed Radioactive Sources - Leak Test Methods* (ISO 1979); ISO Report 1677, *Sealed Radioactive Sources - General* (ISO 1977); NCRP Report No. 40, *Protection Against Radiation from Brachytherapy Sources* (NCRP 1972); and ANSI/HPS N43.6-1997, *Sealed Radioactive Sources, Classification* (ANSI/HPS 1997b). Appendix V of NUREG-1556, Volume 11, *Consolidated Guidance About Materials Licenses* (NRC 1998), provides an acceptable procedure for performing source leak tests.

Electroplated sources should not be tested for leakage by wiping the foil directly. An indication of leakage can be obtained by checking the storage container for radioactivity or by checking the exhaust ports of items such as gas chromatography

devices (ICRP 1977). The integrity of an accountable sealed radioactive source contained within a shield or device may be checked by wiping the area where contamination is most likely to occur from a failure of source integrity. If it is necessary to provide direct access to such a source to perform an adequate leak test, then appropriate controls should be established in accordance with 10 CFR 835, the RCS, and the manufacturer's directions. Due to the high whole body or extremity doses that can result, leak tests on high activity sources should never be performed by direct contact. Remote handling devices or indirect monitoring techniques, such as monitoring of exhaust ports or accessible areas likely to be contaminated by a leaking source, should be used.

If analysis of the leak test sample (e.g., smear) indicates that the sample has removed less than 0.005 microcurie (185 Bq) from the area wiped, then the leakage may be considered to be less than the 10 CFR 835.1202(b) maximum leakage criterion of 0.005 microcurie (185 Bq). For indirect monitoring techniques, the presence of any detectable removable contamination should be evaluated to determine if the source leakage is greater than the 10 CFR 835.1202(b) maximum leakage criterion of 0.005 microcurie (185 Bq).

An accountable sealed radioactive source is not subject to periodic source leak testing if that source has been removed from service. However, unless leak testing is precluded by other radiological safety considerations, these sources should be leak tested periodically to determine the condition of the source. Such sources shall be stored in a controlled location, subject to periodic inventory, and subject to source leak testing prior to being returned to service [10 CFR 835.1202(c)]. Additionally, a documented and updated accountable sealed radioactive source form similar to Appendix 15.A should be maintained for each accountable sealed radioactive source, recording the last known leak test.

An accountable sealed radioactive source is not subject to periodic inventory and source leak testing if that source is located in an area that is unsafe for human entry or otherwise inaccessible, e.g., oxygen deficient or very high radiation areas [10 CFR 835.1202(d)]. If a source is removed from the unsafe area or otherwise becomes accessible, then this exception would no longer apply. This provision is not applicable to sources that are located in instruments or other devices located in accessible areas, nor should it be applied to sources that may be considered inaccessible due to radiological conditions created by the presence of the source itself; leak tests may be performed on these sources by wiping the instrument or device consistent with the guidance provided above. If a source is determined to be inaccessible for inventory and source leak testing, then appropriate measures should be implemented to control access to the affected area and to monitor for the presence of contamination that may be spread as a result of source failure (See Chapter 11). When the conditions that resulted in the area being inaccessible have been eliminated, the required inventories and source leak tests should be completed prior to rescinding these measures.

The source custodian should be responsible for ensuring that source leak tests of accountable sealed radioactive sources are conducted at least every six months. If a

sealed radioactive source cannot be leak tested at the proper time, the source should be removed from service until the leak test is performed. If a source is installed in an inaccessible area, the device should not be used until the source has been leak tested.

A test result that reveals the presence of removable radioactivity on the non-radioactive surfaces is an indication that the sealed radioactive source has lost its integrity. The leaking source shall be controlled in a manner that minimizes the spread of radioactive contamination [10 CFR 835.1202(e)]. Any sealed radioactive source that fails a leak test should be immediately removed from service and controlled in accordance with contamination control practices defined in 10 CFR 835. The source should be placed in a separate container to prevent the spread of contamination. All personnel and equipment that were in contact with the leaking source should be checked for contamination; this includes transportation vehicles and the work site. The source custodian, working with the RCO, should either return the leaking source to the manufacturer or send it to other qualified personnel for repair or disposal. Refer to Chapter 7 for additional guidance.

15.7 Handling and Disposal

Certain sealed radioactive sources may create significant localized radiation fields under both normal and abnormal operating conditions. Receipt, storage, use, and disposal of sealed radioactive sources should be conducted in accordance with 10 CFR 835, applicable DOE Orders, consensus standards, and the guidance provided in the following Guides:

- For specific guidance on maintenance of records, see Chapter 13;
- For ALARA practices, see Chapter 4;
- For posting and labeling practices, see Chapter 12;
- For specific guidance regarding external dosimetry considerations, see Chapter 6; and
- For specific contamination controls that should be considered for leaking sealed radioactive sources, see Chapter 11.

Off-site sealed radioactive sources, including radiography sources, should not be brought on-site by external organizations without the prior written approval of the RCO.

Radiation protection precautions, dose reduction methods, and special dosimetry and monitoring requirements should be specifically identified in procedures for use of accountable sealed radioactive sources capable of generating external radiation fields in excess of 100 millirem/hour (1 mSv/hour) at 30 cm. Radiation monitoring should be performed during and after use of such sources to verify the adequacy of controls, posting of immediate and adjacent areas, and return of the source to a safe condition

Immediately upon determination of the loss of a sealed radioactive source, the user should notify the source custodian who in turn should notify the RCO. A formal search of all designated use locations, likely transfer paths, and possible collection points for the source should be performed. In addition, an investigation should be conducted by facility management to determine the root cause of the loss.

Obsolete, excess, or leaking sealed radioactive sources should be disposed of according to RCO instructions.

Appendix 15.A Example Individual Accountable Sealed Radioactive Source Form

Individual Accountable Sealed Radioactive Source Form

SOURCE DESCRIPTION

Source Model and Serial Number: _____

Electronic Label (as applicable): _____

Manufacturer: _____

Radionuclide(s): _____ Radiation Type: _____

Chemical Formula: _____ Physical Form:_____

Original Activity:_____ Date of Original Assay: _____

Physical Description: _____

Radiation Reading at Reference Distance: _____

SOURCE STATUS

Date of Receipt:_____ Date of Update: _____

Status Change:	☐ Active - in use	☐ Source integrity failed	☐ New Source - Initial Entry
☐ Lost	☐ In storage	☐ Awaiting disposal	☐ Transferred to new location
☐ Disposed	☐ Returned to manuf.	☐ Decayed below accountability threshold	

SHIPPING RECORDS (if transferred to off-site location)

Shipping Order Number: _____

Shipping Organization: _____

Individual Receiving Source: _____

SOURCE CUSTODIAN

Custodian's Name: _____ Badge Number:_____

Mailing Address: _____ Phone Number:_____

SOURCE LOCATION

Facility: _____ Room:

Location Within Room: _____

Device Model and Serial Number: _____

INITIAL/RECEIPT LEAK TEST

Date of Test: _____

Type of Instrument Used:_____ Instrument ID Number:_____

Surveyor's Name and Badge Number:_____

Test Results: _____

Appendix 15.B – Example Sealed Radioactive Source Accountability Form

Sealed Radioactive Source Accountability Form

Date:_____ Surveyor's Name and Badge Number (Print): _____

Instrument Type	Identification Number	Date Calibrated	Minimum Detectable Activity	Background (cpm)
A.				
B.				
C.				

Source Model & Serial Number	Radionuclide & Activity	Date of Last Leak Test	Instrument(s) Used	Total Counts	Net Counts	Net Activity	Posting / Labeling Check

Signature: _____

REFERENCES

(AEC1954) Atomic Energy Commission 1954. U.S. Atomic Energy Act of 1954, as amended. Public Law 83-703 (68 Stat. 919), Title 42 U.S.C., Section 2011.

(ANSI 1979) American National Standards Institute 1979. ANSI N320, *American National Standard Performance Specifications for Reactor Emergency Radiological Monitoring Instrumentation*, New York, NY.

(ANSI 1988) American National Standards Institute 1988. ANSI N13.3, *Dosimetry for Criticality Accidents*. McClean, VA.

(ANSI 1993) American National Standards Institute 1993. ANSI N43.3-1993, *General Radiation Safety -Installations Using Non-Medical X-Ray and Sealed Gamma-Ray Sources, Energies up to 10 MeV*. New York, NY.

(ANSI 1997a) American National Standards Institute 1997. ANSI N323A-1997, *American National Standard Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments*. New York, NY.

(ANSI 1997b) American National Standards Institute 1997. ANSI N322, *American National Standard Inspection,Test, Construction, and Performance Requirements for Direct Reading Electrostatic/Electroscope Type Dosimeters,*New York, NY.

(ANSI 1989a) American National Standards Institute 1989. ANSI N13.5-R1989, *American National Standard Performance Specifications for Direct Reading and Indirect Reading Pocket Dosimeters*. New York, NY.

(ANSI 1989b) American National Standards Institute 1989. ANSI N42.17A-1989, *Performance Specifications for Health Physics Instrumentation - Portable Instrumentation for Use in Normal Environmental Conditions*. New York, NY.

(ANSI 1989c) American National Standards Institute 1989. ANSI N42.17C-1989, *Performance Specifications for Health Physics Instrumentation - Portable Instrumentation for Use in Extreme Environmental Conditions*. New York, NY.

(ANSI 1989d) American National Standards Institute 1989. ANSI N42.17B, *Performance Specifications for Health Physics Instrumentation - Occupational Airborne Radioactivity Monitoring Instrumentation*. New York, NY.

(ANSI 1989e) American National Standards Institute 1989. ANSI N2.1-1971(R1989), *Radiation Symbol*. New York, NY.

(ANSI 1992a) American National Standards Institute 1992. ANSI N13.27, *Performance Specifications for Pocket-sized Alarming* Dosimeter/*Ratemeters*. New York, NY.

(ANSI 1992b) American National Standards Institute 1992. ANSI Z88.2-1992, *Practices for Respiratory Protection*. New York, NY.

(ANSI/HPS 1996) American National Standards Institute/Health Physics Society 1996. ANSI/HPS N13.30-1996, *Performance Criteria for Radiobioassay*. McLean, VA .

(ANSI/HPS 1997a) American National Standards Institute/Health Physics Society 1997. ANSI/HPS N13.41-1997, *Criteria for Performing Multiple Dosimetry*. McClean, VA.

(ANSI/HPS 1997b) American National Standards Institute/Health Physics Society 1997. ANSI/HPS N43.6-1997, *Sealed Radioactive Sources Classification*. Mclean, VA.

(ANSI/HPS 1999) American National Standards Institute/Health Physics Society 1999. ANSI /HPS N13.6-1999, *Practice for Occupational Radiation Exposure Records Systems*. McClean, VA.

(ANSI/HPS 2001a) American National Standards Institute/Health Physics Society 2001. ANSI/HPS N43.2-2001, *Radiation Safety for X-Ray Diffraction and Fluorescence Analysis Equipment*. McClean, VA.

(ANSI/HPS 2001b) American National Standards Institute/Health Physics Society 2001. ANSI/HPS N13.49-2001, *Performance and Documentation of Radiological Surveys*. McClean, VA.

(ANSI/HPS 2005) American National Standards Institute/Health Physics Society 2005. ANSI/HPS N43.5-2005, *Radiological Safety Standard for the Design of Radiographic and Fluoroscopic Industrial X-Ray Equipment*. McClean, VA.

(ANSI/NCSL 1994) American National Standards Institute/National Conference of Standards Laboratories 1994. ANSI/NCSL Z540-1-1994, *American National Standard for Calibration - Calibration Laboratories and Measuring and Test Equipment -General Requirements,* Boulder, Colorado.

(BRH 1970) Bureau of Radiological Health. *Radiological Health Handbook*, U.S. Government Printing Office. Washington, D.C.

(DOE 1993a) DOE O 5400.5, Ch. 2, *Radiation Protection of the Public and the Environment,* U.S. Department of Energy. Washington, D.C.

(DOE 1993b) DOE O 5480.30, Ch 1, *Nuclear Reactor Safety Design Criteria*, U.S. Department of Energy. Washington, D.C.

(DOE 1994) DOE-STD-1070-94, GUIDELINES FOR EVALUATION OF NUCLEAR FACILITY TRAINING PROGRAMS, U.S. Department of Energy. Washington, D.C

(DOE 1996) DOE P 441.1, *Department of Energy Radiological Health and Safety Policy*, U.S. Department of Energy. Washington, D.C.

(DOE 1997a) 10 CFR 820, U. S. Department of Energy, Procedural Rules for DOE Nuclear Activities, 58 FR 43680, *Federal Register* Vol. 58, No. 157, dated 10-8-97. Washington, D.C.

(DOE 1997b) DOE-STD-1107-97, KNOWLEDGE, SKILLS, AND ABILITIES FOR KEY RADIATION PROTECTION POSITIONS AT DOE FACILITIES, U.S. Department of Energy. Washington, D.C.

(DOE 1997c) DOE-HDBK-1106-97, RADIOLOGICAL CONTAMINATION CONTROL TRAINING FOR LABORATORY RESEARCH, U.S. Department of Energy. Washington, D.C.

(DOE 1997d) DOE-HDBK-1109-97, RADIOLOGICAL SAFETY TRAINING FOR RADIATION-PRODUCING (X-RAY) DEVICES, U.S. Department of Energy. Washington, D.C.

(DOE 1997e) DOE-HDBK-1110-97, ALARA TRAINING FOR TECHNICAL SUPPORT PERSONNEL, U.S. Department of Energy. Washington, D.C.

(DOE 1998a) 10 CFR 835, U.S. Department of Energy. Occupational Radiation Protection. 63 FR 59662, *Federal Register*, Vol. 63, No. 213, dated 11-4-98. Washington, D.C.

(DOE 1998b) DOE-STD-1111-98, DEPARTMENT OF ENERGY LABORATORY ACCREDITATION PROGRAM ADMINISTRATION, U.S. Department of Energy. Washington, D.C.

(DOE 1998c) DOE-STD-1112-98. DEPARTMENT OF ENERGY LABORATORY ACCREDITATION PROGRAM FOR RADIOBIOASSAY, U.S. Department of Energy. Washington, D.C.

(DOE 1998d) DOE-HDBK-1113-98, RADIOLOGICAL SAFETY TRAINING FOR URANIUM FACILITIES, U.S. Department of Energy. Washington, D.C.

(DOE 1998e) DOE O 440.1A, *Worker Protection Management for DOE Federal and Contractor Employees*, U.S. Department of Energy. Washington, D.C.

(DOE 1998f) DOE-STD-1128-98, GUIDE TO GOOD PRACTICES FOR OCCUPATIONAL RADIATION PROTECTION IN PLUTONIUM FACILITIES, U.S. Department of Energy. Washington, D.C.

(DOE 1998g) DOE-STD-1136-98, GUIDE TO GOOD PRACTICES FOR OCCUPATIONAL RADIATION PROTECTION IN URANIUM FACILITIES, U.S. Department of Energy. Washington, D.C.

(DOE 1998h) DOE-HDBK-1131-98, GENERAL EMPLOYEE RADIOLOGICAL TRAINING, U.S. Department of Energy. Washington, D.C.

(DOE 1998i) DOE-HDBK-1130-98, RADIOLOGICAL WORKER TRAINING, U.S. Department of Energy. Washington, D.C.

(DOE 1999a) DOE-STD-1098-99, RADIOLOGICAL CONTROL, U.S. Department of Energy. Washington, D.C.

(DOE 1999b) DOE-HDBK-1122-99 RADIOLOGICAL CONTROL TECHNICIAN TRAINING, U.S. Department of Energy. Washington, D.C.

(DOE 1999c) DOE-HDBK-1129-99, TRITIUM HANDLING AND SAFE STORAGE, U.S. Department of Energy. Washington, D.C.

(DOE 2001a) 10 CFR 830 Subpart A, U.S. Department of Energy, Quality Assurance Requirements. 66 FR 1810, *Federal Register*, Vol. 66, No. 7, dated 1-10-2001. Washington, D.C.

(DOE 2001b) DOE O 5480.20A. Ch. 1, *Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities*. U.S. Department of Energy. Washington, D.C.

(DOE 2001c) DOE-HDBK-1143-2001, RADIOLOGICAL CONTROL TRAINING FOR SUPERVISORS, U.S. Department of Energy. Washington, D.C.

(DOE 2001d) DOE-HDBK-1145-2001, RADIOLOGICAL SAFETY TRAINING FOR PLUTONIUM FACILITIES, U.S. Department of Energy. Washington, D.C.

(DOE 2001e) DOE-HDBK-1141-2001, RADIOLOGICAL ASSESSOR TRAINING, U.S. Department of Energy. Washington, D.C.

(DOE 2001f) DOE O 435.1, Ch.1, *Radioactive Waste Management.* U.S. Department of Energy. Washington, D.C.

(DOE 2002a) DOE-HDBK-2002, RADIOLOGICAL SAFETY TRAINING FOR TRITIUM FACILITIES, U.S. Department of Energy. Washington, D.C.

(DOE 2002b) DOE-HDBK-1108-2002, RADIOLOGICAL SAFETY TRAINING FOR ACCELERATOR FACILITIES, U.S. Department of Energy. Washington, D.C.

(DOE 2003) DOE-STD-1121-2003, INTERNAL DOSIMETRY, U.S. Department of Energy. Washington, D.C.

(DOE 2004a) DOE O 420.2B, *Safety of Accelerator Facilities,* U.S. Department of Energy. Washington, D.C.

(DOE 2004b) DOE-STD-1136-2004, GUIDE TO GOOD PRACTICES FOR OCCUPATIONAL RADIATION PROTECTION IN URANIUM FACILITIES, U.S. Department of Energy. Washington, D.C.

(DOE 2004c) DOE O 231.1A, *Environment, Safety and Health Reporting,* U.S. Department of Energy. Washington, D.C.

(DOE 2004d) DOE M 231.1-1A, Ch. 1, *Environment, Safety and Health Reporting Manual,* U.S. Department of Energy. Washington, D.C.

(DOE 2004e) DOE DOE-HDBK-1184-2004, RADIOLOGICAL CONTROL PROGRAMS FOR SPECIAL TRITIUM COMPOUNDS, U.S. Department of Energy. Washington, D.C.

(DOE 2005a) DOE O 414.1C, *Quality Assurance*, U.S. Department of Energy. Washington, D.C.

(DOE 2005b) DOE O 226.1, *Implementation of Department of Energy Oversight Policy*, U.S. Department of Energy. Washington, D.C.

(DOE 2005c) DOE O 151.1C, *Comprehensive Emergency Management System,* U.S. Department of Energy. Washington, D.C.

(DOE 2005d) DOE O 420.1, *Facility Safety,* U.S. Department of Energy. Washington, D.C.

(DOE 2006a) DOE M 251.1-1B, *Departmental Directives Program Manual*, U.S. Department of Energy, Washington, D.C.

(DOE 2006b) DOE O 413.3A, *Program and Project Management for the Acquisition of Capital Assets*, U.S. Department of Energy, Washington, D.C.

(DOE 2006c) 10 CFR 851, U.S. Department of Energy, *Worker Safety and Health Program.* F*ederal Register*, Vol. 71, No. 27, dated 02-09-2006. Washington, D.C.

(DOE 2006d) DOE G 440.1-8, *Implementation Guide for Use with Title 10 code of Federal Regulations Part 851*, U.S. Department of Energy. Washington, D.C.

(EPA 1987) U.S. Environmental Protection Agency 1987. *Radiation Protection Guidance to Federal Agencies for Occupational Exposure*. 52 FR 2822, *Federal Register*, Vol. 52, No. 17. Washington, D.C.

(EPA 1988) U.S. Environmental Protection Agency 1988. Federal Guidance Report No. 11, *Limiting Values of Radionuclide Intake And Air Concentration and Dose Conversion Factors For Inhalation, Submersion, and Ingestion*. Washington, D.C.

(FOIA 1986) Freedom of Information Act 1986. Public Law 99-570, Title 5 U.S.C. sec. 552.

(ICRP 1977) International Commission on Radiological Protection 1977. ICRP Publication 26, *Recommendation of the International Commission on Radiological Protection*, Pergamon Press. New York, New York.

(ICRP 1979) International Commission on Radiological Protection 1979. ICRP Publication 30, *Limits for Intakes of Radionuclides by Workers: Design and Interpretation*, Pergamon Press. New York, New York.

(ICRP 1982) International Commission on Radiological Protection 1982. ICRP Publication 37, *Cost-Benefit Analysis in the Optimization of Radiation Protection*, Pergamon Press. New York, New York.

(ICRP 1989) International Commission on Radiological Protection 1989. ICRP Publication 54, *Individual Monitoring for Intakes of Radionuclides by Workers: Design and Interpretation*, Pergamon Press. New York, New York.

(ICRP 1990) International Commission on Radiological Protection 1990. ICRP Publication 55*, Optimization and Decision-Making in Radiological Protection*, Pergamon Press. New York, New York.

(ICRP 1996) International Commission on Radiological Protection 1996. ICRP Publication 74, *Conversion Coefficients for Use in Radiological Protection Against External Radiation*, Pergamon Press. New York, New York.

(ICRU 1988) International Commission on Radiation Units and Measurements 1988. ICRU Report No. 43, *Determination of Dose Equivalents from External Radiation Sources - Part 2*. Bethesda, MD.

(ISO 1977) International Organization for Standardization 1977. ISO 1677, *Sealed Radioactive Sources - General*. Geneva, Switzerland.

(ISO 1990) International Organization for Standardization 1990. Draft International Standard ISO/DIS 9978, *Radiation Protection Sealed Radioactive Sources Leakage Test Methods*. Geneva, Switzerland.

(NCRP 1972) National Council on Radiation Protection and Measurements 1972. NCRP Report No. 40, *Protection Against Radiation from Brachytherapy Sources*. Bethesda, Maryland.

(NCRP 1980) National Council on Radiation Protection and Measurements 1980. NCRP Report No. 65, *Management of Persons Accidentally Contaminated with Radionuclides*. Bethesda, Maryland.

(NCRP 1985) National Council on Radiation Protection and Measurements 1985. NCRP Report No. 84.,*General Concepts for the Dosimetry of Internally Deposited Radionuclides*. Bethesda, Maryland.

(NCRP 1987a) National Council on Radiation Protection and Measurements 1987. NCRP Report No. 87, *Use of Radiobioassay Procedures for Assessment of Internal Radionuclide Deposition*. Bethesda, Maryland.

(NCRP 1987b) National Council on Radiation Protection and Measurements 1987. NCRP Report No. 91, *Recommendations on Limits for Exposure to Ionizing Radiation*. Bethesda, MD.

(NCRP 1989) National Council on Radiation Protection and Measurements 1989. NCRP Report No. 106, *Limit for Exposure to "Hot Particles" on the Skin*. Bethesda, MD.

(NCRP 1992) National Council on Radiation Protection and Measurements 1992. NCRP Report No. 114, dated 11-30-92, *Maintaining Radiation Protection Records*. Bethesda, MD

(NCRP 1993) National Council on Radiation Protection and Measurements 1993. NCRP Report No. 116, *Limitation of Exposure to Ionizing Radiation*. Washington, D.C.

(NCSL 1989) National Conference of Standards Laboratories 1989. *Recommended Practice RP-1, Establishment and Adjustment of Calibration Intervals*. Boulder, Colorado.

(NRC 1987) U.S. Nuclear Regulatory Commission 1987. Regulatory Guide 8.13, *Instruction Concerning Prenatal Radiation Exposure*. Washington, D.C.

(NRC 1992a) U.S. Nuclear Regulatory Commission 1992. 10 CFR 34, *Licenses for Radiography and Radiation Safety Requirements for Radiographic Operations*. Washington, D.C.

(NRC 1992b) U.S. Nuclear Regulatory Commission 1992. NUREG/CR-5631, Rev. 1, C*ontribution of Maternal Radionuclide Burdens to Prenatal Radiation Doses*, Washington, D.C.

(NRC 1992c) U.S. Nuclear Regulatory Commission 1992. Regulatory Guide 8.36, *Radiation Dose to the Embryo/Fetus*. Washington, D.C.

(NRC 1993) U.S. Nuclear Regulatory Commission 1993. NUREG-1400, Rev. 1, *Air Sampling in the Workplace*. Washington, D.C.

(NRC 1998) U.S. Nuclear Regulatory Commission 1998. NUREG-1556, Volume 11, *Consolidated Guidance About Materials Licenses*. . Washington, D.C.

(OSHA 174) Occupational Safety and Health Administration 1974. Occupational Safety and Health Standards, 29 CFR 1910, 39 FR 23502. Washington, D.C.

(PA 1974) Privacy Act 1974. Privacy Act of 1974, as amended, Public Law 93-579, Title 5 U.S.C. sec. 552a.

(PNL 1987) Pacific Northwest Laboratory 1987. PNL-6301, *Neutron Dose and Energy Spectra Measurements at Savannah River Plant*, Richland, WA.

(PNL 1988a) Pacific Northwest Laboratory 1988. PNL-6577, *Health Physics Manual of Good Practices for Reducing Radiation Exposure to As Low As Reasonably Achievable (ALARA)*, Richland, WA.

(PNL 1988b) Pacific Northwest Laboratory 1988. PNL-6620, *Personnel Neutron Dose Assessment Upgrade,* Richland, WA.

(USLW 1991) United States Law Week. *United Automobile Workers v. Johnson Controls, Inc.* 499 U.S. 187, 206 (1991).