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This instruction specifies the requirements for protection of USAF personnel and their dependents from ionizing radiation. It also specifies requirements to protect the general public from exposure to ionizing radiation resulting from USAF activities. It is a companion document to AFI 40-201, *Managing Radioactive Materials in the US Air Force*, AFI 91-108, *Air Force Nuclear Weapons Intrinsic Radiation and 91(b) Radioactive Material Safety Program* and AFMAN 48-125, *The US Air Force Personnel Dosimetry Program*. It implements DODI 6055.08, *Occupational Radiation Protection Program*, and AFD 48-1, *Aerospace Medicine Program*. It also implements the requirements of NATO Standardization Agreement 2473, *Commanders Guide to Radiation Exposures in Non-Article 5 Crisis Response Operations-ED 2*, for the protection of personnel from low-level radiation exposures. It defines responsibilities for the protection, monitoring and medical follow-up of military personnel for the full spectrum of military operations or military operations otherwise considered vital to the interests of national security. This instruction applies to all active duty USAF members, members of the USAF reserve and Air National Guard, USAF civilian personnel and personnel living on USAF installations exposed or potentially exposed to ionizing radiation. This instruction directs collecting and maintaining information subject to the Privacy Act of 1974 in regards to the

USAF Master Radiation Exposure Registry. Ensure that all records created as a result of processes prescribed in this publication are maintained in accordance with AFMAN 33-363, *Management of Records*, and disposed of in accordance with the Air Force Records Disposition Schedule (RDS) located at <https://www.my.af.mil/gcss-af61a/afrims/afrims>. Send recommendations and suggested improvements on AF Form 847, Recommendation for Change of Publication, through channels to the Air Force Medical Support Agency/Bioenvironmental Engineering Division/Radiation Programs (AFMSA/SG3PB), 1400 Key Blvd, Nash Bldg, Suite 400, Arlington, VA 22209-1554.

SUMMARY OF CHANGES

This interim change incorporates specific policy, instruction, and guidance on radiation safety programs associated with current nuclear weapons maintenance operations, continental United States (CONUS) legacy maintenance operations, other related nuclear weapons operations and the management of other 91(b) material. Intrinsic radiation safety (INRAD) and the management of mixed waste have been addressed. This change updates organizational changes that have occurred since initial publication. Organizational office symbols are updated. A margin bar (|) indicates newly revised material.

Unit designation changes:

“Air Force Medical Operations Agency (AFMOA)” has been updated to “Air Force Medical Support Agency (AFMSA)” and “SGZR” has been updated to “SG3PB.”

“Air Force Institute of Environment, Safety, Occupational Health and Risk Analysis (AFIERA)” has been updated to “United States Air Force School of Aerospace Medicine (USAFSAM).”

“Air Force Safety Agency (AFSA)” has been updated to “Air Force Safety Center (AFSC).”

“Air Force Radioactive Material Recovery and Recycling Office” has been updated to “Air Force Radioactive Recycling and Disposal (AFRRAD) Office.”

“Radiation Protection Division” has been updated to “Radiation Programs,” of which the Radioisotope Committee Secretariat (RICS) is a function.

(BOLLINGAFB) This publication implements AFI 48-148, 12 October 2001, Ionizing Radiation Protection, and it is supplemented as follows. This instruction establishes local policies and procedures for the Installation Radiation Safety Officer, Unit Radiation Safety Officers, and tenant organizations. It applies to all units on Bolling Air Force Base that maintain, acquire, receive, use, store, transfer, transport, distribute, and dispose of radioactive material or are exposed or potentially exposed to ionizing radiation. Refer recommended changes and questions about this publication to the Office of Primary Responsibility (OPR) using the AF Form 847, Recommendation for Change of Publication; route AF Form 847s from the field through Andrews AFB publications/forms manager. This supplement should be used in

conjunction with AFI 40-201, Managing Radioactive Materials in the US Air Force, 13 April 2007. Ensure that all records created as a result of processes prescribed in this publication are maintained in accordance with AF Manual 36-363, Management of Records, and disposed of in accordance with the Air Force Records Disposition Schedule (RDS) located at <https://afirms.amc.af.mil>. The use of the name or mark of any specific manufacturer, commercial product, commodity or service in this publication does not imply endorsement by the Air Force.

SUMMARY OF CHANGES

(BOLLINGAFB) This instruction has been substantially changed and requires a thorough review by all applicable personnel. (Added)

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Chapter 1

INTRODUCTION

1.1. Purpose. This instruction provides specific policy, instruction and guidance for the protection of USAF personnel and their dependents from sources of ionizing radiation. It also specifies requirements to protect the general public from exposure to ionizing radiation resulting from USAF activities. The instruction addresses an existing gap in regulating exposures resulting from machine produced/naturally occurring radiation sources, deployed environments and operations involving radioactive material covered by Section 91(b) of the Atomic Energy Act (AEA) of 1954. Individuals reviewing this instruction, not familiar with radiation safety, are advised to review **Attachment 2**, Quantities and Terms Used in Radiation Protection and **Attachment 3**, Medical Consequences of Ionizing Radiation Exposure before proceeding.

1.2. Applicability. The requirements of this instruction are intended to protect Airmen and their dependents, DOD civilians and members of the general public. As such, the radiation safety program outlined in this regulation applies to all Air Force units and installations that:

- 1.2.1. Possess or use radioactive materials as specified in AFI 40-201.
- 1.2.2. Possess or use ionizing radiation producing devices.
- 1.2.3. Are exposed to ionizing radiation during the full spectrum of military operations.
- 1.2.4. Are nuclear capable units, have nuclear capable tenant organizations or are geographically separated nuclear capable units (GSUs) that engage in storage and maintenance of current nuclear weapons.
- 1.2.5. Generate or dispose of radioactive waste and/or mixed (i.e., chemical and radioactive) waste. This includes the 91(b) material program elements such as management and disposal of legacy nuclear weapons maintenance wastes, management and disposal of residuals from nuclear weapons accidents, management and disposal of residuals from aircraft wash-down operations from atmospheric testing of nuclear weapons, and management and disposal of residuals from nuclear reactor operations.

1.3. Objectives of the USAF Radiation Protection Program.

- 1.3.1. Prevent the occurrence of clinically significant radiation induced deterministic effects (effects for which a threshold dose exists and whose severity is proportional to dose such as cataracts and acute skin effects) by adhering to dose limits.
- 1.3.2. Limit the risk of stochastic effects (effects whose probability of occurrence is proportional to dose such as cancer and hereditary effects) to a reasonable level in relation to the requirements of the USAF mission, other societal or military risks, benefits gained and economic factors.

1.4. Practices and Interventions. Activities that may result in radiation exposure can be broadly divided into two categories: practices and interventions (ICRP Publication 60, *1990 Recommendations of the International Commission on Radiological Protection*). Routine and controlled operations that incur radiation exposure as an unavoidable and unintentional aspect of the activity are considered practices. This instruction considers all USAF activities that involve

the routine use of radiation emitters or radioactive materials in medicine, research, industry and training to be practices. Interventions encompass two broad types of activity, operations that seek to reduce existing exposures that are not part of a controlled practice and activities conducted to mitigate threats greater than that posed by radiation or otherwise conduct operations necessary to achieve higher objectives, including those of national security. Note that the classification of an action as either an intervention or practice is independent of whether the activity occurs in peacetime, MOOTW or during war.

1.5. Types of Radiation Exposure. For the purposes of this instruction, four types of radiation exposure are recognized as being received by USAF personnel or their dependents: occupational exposures occurring as a result of individuals assigned duties, medical exposures received for the diagnosis and treatment of disease, exposures of the general public (including dependents, retirees, and other members of the general public), and exposures occurring from incidents, accidents, and military operations in radiological environments.

1.5.1. Occupational exposures are those routine exposures incurred as a necessary part of supporting the USAF mission that can reasonably be regarded as being the responsibility of USAF leadership. Common practices that may incur occupational exposures include, but are not limited to: industrial radiography, depleted uranium munitions handling, research involving nuclear materials or radiation producing devices, well-logging, diagnostic radiology, nuclear medicine, radiation therapy and activities involving maintenance of nuclear weapon systems. Further, occupational exposures also include exposures to elevated forms of naturally occurring radiation including operations in workplaces where radon exposure has been identified as significant and where cosmic or solar radiation is elevated during jet aircraft and space flight.

1.5.2. Medical exposure is confined to exposures incurred by individuals as part of their own medical diagnosis and treatment. This does not include occupational exposure of medical staff, nor persons of the general public exposed to stray radiation from the diagnosis and treatment of other persons.

1.5.3. Public exposure encompasses all exposures other than occupational and medical exposures. On average, the largest source of general public exposure is from naturally occurring sources of radiation, with the internal dose from radon progeny being the largest contributor.

1.5.4. Incident or contingency-type exposures are those incurred by USAF personnel as a result of actions or activities not considered practices. These include specific emergency response activities to save life or property, humanitarian assistance operations, and military operations conducted where national interests may force personnel to incur radiation doses beyond occupational limits.

1.6. Radiation Protection Policy for Practices.

1.6.1. Justification: No practice involving exposure to radiation shall be adopted unless there is sufficient benefit to the exposed individual or to achieving necessary military objectives to offset the harm it may cause.

1.6.2. Optimization: The magnitude of individual doses and the number of people exposed shall be kept as low as reasonably achievable (ALARA), economic, military and social factors being taken into account.

1.6.3. Dose Limits: The dose to an individual resulting from a combination of all relevant practices shall not exceed specified dose limits.

1.7. Radiation Protection Policy for Interventions.

1.7.1. Justification: A proposed intervention should do more good than harm, i.e., the action should be of sufficient value in terms of military objective to be achieved or humanitarian assistance to be rendered so as to justify the potential harm and costs.

1.7.2. Optimization: The form, scale, and duration of the intervention should be optimized so the net benefit is maximized and the net detriment is minimized. Again, individual doses should be maintained as low as reasonably achievable.

1.7.3. Dose Guidance: Dose limits do not apply for interventions. Instead, dose guidance is utilized to guide surveillance and protection of forces.

Chapter 2

RESPONSIBILITIES

2.1. The Surgeon General (HQ USAF/SG): Provides policy guidance for force health protection and medical surveillance for the full spectrum of military operations ensuring compliance with relevant Federal policy, Air Force policy, and accepted scientific practice.

2.2. The Civil Engineer (HQ USAF/ILE): Provides policy guidance for major accidents/incidents, enemy attack, and terrorist use of weapons of mass destruction involving nuclear and radiological materials.

2.3. Commander, Air Force Materiel Command (HQ AFMC/CC): Implements the medical surveillance of radiation exposure through operational control of the Air Force Institute for Environment, Safety and Occupational Health Risk Analysis (AFIERA).

2.4. Commander, 311th Human Systems Wing (311 HSW/CC): Provides facilities, equipment, technical expertise and personnel to support USAF health physics, radiation dosimetry, and radioanalytical requirements.

2.5. Director, Air Force Institute of Environment, Safety, Occupational Health and Risk Analysis (AFIERA/CD), through the Radiation Dosimetry Branch (AFIERA/SDRD).

2.5.1. Provide ionizing radiation dosimetry services that meet the requirements of 10 CFR 20.1501(c), the requirements of the intrinsic radiation and 91(b) material radiation safety program as outlined in AFI 91-108. Support both operational requirements and medical-legal documentation of individual external exposures for the full spectrum of military operations.

2.5.2. Maintain the USAF Master Radiation Exposure Registry (MRER). The MRER will archive comprehensive dosimetry records for all USAF personnel and for other personnel who use USAF dosimetry services. Records will meet the requirements of 10 CFR 20.2106 and 20.2110. Records will include negative or positive results of bioassays, administrative dose assignments (including copies of documents supporting dose assignments), and supplementary occupational dose equivalent information (for example, dosimetry information resulting from off-duty employment) that any Radiation Safety Officer (RSO) reports. In particular, AFIERA will meet the requirements of 10 CFR 20.2106(f) for long-term retention of these records.

2.5.3. Provide monthly and quarterly personnel dosimetry reports to RSOs for all personnel who received dosimetry services during the previous calendar quarter. These reports will enable supported RSOs to meet all record-keeping requirements in 10 CFR 20.2106.

2.5.4. Provide annually, upon deactivation or discharge, and/or upon request of the monitored individual, a written record of the radiation exposures and estimated doses to the potentially exposed individual and to the supported commander's designated RSO or medical staff, in accordance with (IAW) AFI 48-125. This record will be provided even if the dose is below detectable limits. Provides other reporting services that enable RSOs to meet all requirements of 10 CFR 19.13, 10 CFR 20.2206, 29 CFR 1910.1096(n) and (o), and 29 CFR 1926.53(p) and (q).

2.5.4.1. Data from classified operations will be included to the fullest extent possible. An individual's assessed dose should not be considered to be classified.

2.5.5. Notify immediately (by telephone or message) the installation RSO, the Air Force Medical Operations Agency, Radiation Protection Division (AFMOA/SGZR), and the major command (MAJCOM) bioenvironmental engineer when any USAF personnel receive a dose that may have exceeded the values in [Table A4.1](#)

2.5.6. Serve as the office of primary responsibility for AFI 48-125, *The US Air Force Personnel Dosimetry Program*.

2.6. Director, Air Force Institute of Environment, Safety, Occupational Health and Risk Analysis (AFIERA/CD), through the Radioanalytical Branch (AFIERA/SDRR).

2.6.1. Maintain a capability suitable for the collection of environmental and bioassay samples, conducts in-vivo monitoring, and performs radioanalyses of samples. The capability shall support both operational requirements and medical-legal documentation of individual internal exposures during peacetime, MOOTW, and war.

2.6.2. Process, analyze and interpret bioassay and environmental samples IAW scientifically established and approved analytical procedures.

2.6.3. Maintain complete records of all bioassay samples, sample analysis results, and estimation of internal dose in perpetuity, including results below detection limits of the analytical method.

2.6.4. Provide bioassay results to the supported commander's medical staff. Bioassay results will be provided with necessary interpretation for clear understanding of their meaning and significance.

2.6.5. Report negative or positive occupational bioassay sample results directly to AFIERA/SDRD for inclusion with the individual's occupational dosimetry record in the MRER.

2.7. Director, Air Force Institute of Environment, Safety, Occupational Health and Risk Analysis (AFIERA/CD), through the Health Physics Branch and Air Force Radioactive and Mixed Waste Office (AFIERA/SDRH).

2.7.1. Provide USAF consultant services on all radiation protection issues including health risk assessments, exposure reconstructions, radiation safety program reviews, radiation safety quality assurance program development, radiation safety training, shielding assessments, medical and industrial scatter surveys, public dose assessments and decommissioning surveys.

2.7.2. Provide operational consultant support during nuclear or radiological contingencies through the Air Force Radiation Assessment Team.

2.7.3. Manage consolidation, disposal, and costs of all USAF generated low-level radioactive wastes and mixed wastes.

2.7.4. Maintain records of all USAF radioactive waste disposal by burial.

2.8. Air Force Radioactive Recycling and Disposal (AFRRAD) Office (88 ABW/CEV). Provide a recycling and reprocessing service for excess radioactive material in the USAF inventory including mixed waste generated by nuclear capable units.

2.9. Air Force Weather Agency.

2.9.1. Provide or arrange for meteorological data to support modeling and hazard prediction from nuclear or radiological incidents.

2.9.2. Provide or arrange for space weather forecasting and dose modeling for protection of aircrews and astronauts.

2.10. Wing or Installation Commanders, as Appropriate. Ensure that the Wing/Installation radiation safety program is comprehensive, compliant with current requirements, and fully integrates the radiation safety programs of units, tenant units and geographically separated units (GSUs). Specific tasks include:

2.10.1. Appoint, in writing, a qualified individual to be the installation radiation safety officer (IRSO), as appropriate. For most installations, this will be the installation bioenvironmental engineer. At small installations without a bioenvironmental engineer, the bioenvironmental engineering flight assigned to support the installation shall provide a qualified individual to perform the duties of the IRSO as specified in this document.

2.10.2. Ensure that tenant organization and unit radiation safety programs (including nuclear capable units, units supporting nuclear capable units and units with 91(b) material) are fully integrated into the Wing or Installation radiation safety program.

2.10.3. Each commander shall afford the AFIA at all reasonable time's opportunity to inspect all radioactive material and the premises and facilities wherein such is used or stored. Each commander shall make available to the AFIA for inspection, upon reasonable notice, records kept by the unit pursuant to federal, DoD and AFIs.

2.11. Organization or Unit Commanders, as Appropriate.

2.11.1. Designate, in writing, an organizational or unit RSO when an organization's practices can potentially result in radiation exposure at or above ten percent of the annual dose limits specified in [Table A4.1](#)

2.11.1.1. **(Added-BOLLINGAFB)** Appoint a primary and alternate Unit RSO.

2.11.1.2. **(Added-BOLLINGAFB)** Appoint a Unit RSO when a unit owns permitted or generally licensed radioactive material, or has the potential to handle radioactive materials (e.g. LRS shipping radioactive material).

2.11.2. Provide adequate facilities, equipment and resources for radiation protection and safety, the nature and extent of which are commensurate with the radiation hazards of the workplace.

2.11.3. Implement policies, procedures and a radiation protection program to ensure the requirements of this instruction are met.

2.11.4. Ensure implementation of a radiation dosimetry and/or bioassay program, as necessary, that meets the record-keeping requirements of AFI 48-125.

2.11.5. Ensure personnel receive education and training IAW this instruction.

- 2.11.6. Ensure reports are made and records are maintained IAW this instruction.
- 2.11.7. Ensure that workers exposed to radiation in the workplace (other than from natural sources), that is not directly related to their work or not required by their work, receive the same level of protection as if they were members of the general public.
- 2.11.8. Establish, review and approve procedures for conducting Operational Risk Management (ORM) with respect to radiation exposure IAW established policy (DODI 6055.1, *DoD Safety and Occupational Health (SOH) Program*) and procedure (Air Force Pamphlet 91-215, *Operational Risk Management Guidelines and Tools*).
- 2.11.9. Coordinate required weather and space weather support with the local weather flight or regional Operational Weather Squadron if local support is not available.
- 2.11.10. Notify the IRSO of significant changes in the amount or types of radioactive materials authorized by permit; new or significant changes to radiation-producing devices; special operations involving radioactive materials or radiation-producing devices; construction of new facilities for radioactive materials or radiation-producing devices; and changes in facilities that affect source or device security requirements, affect the potential for personnel exposures, or affect the potential for the release of RAM. This includes nuclear capable units and units with 91(b) material.

2.12. Unit, Organization and/or Wing Commanders During Contingencies, and Deployed USAF AOR Commander where Radiological Threats Exist.

- 2.12.1. Adhere to the requirements of sections **2.10** and **2.11** to the maximum extent possible.
- 2.12.2. Include the Deployed Medical Commander (DMC) or Senior Deployed Medical Officer (SMO), who has access to a qualified expert in radiation protection (see Definitions), in the operations and planning staff to help ensure proper planning and execution of all ionizing radiation safety tasks associated with the operation.
- 2.12.3. Obtain intelligence regarding the nature and extent of actual or potential radiological hazards.
- 2.12.4. Request additional expertise and support as necessary from the CINC and from host nation radiation protection experts, as necessary.
- 2.12.5. Establish or confirm a control dose IAW the dose guidance in **Attachment 7, Table A7.1**, for all operations considered interventions. For all practices, limit doses to those specified in **Attachment 4, Table A4.1**
- 2.12.6. Implement control measures necessary to contain the radiological hazard as indicated in AFI10-2501, *Full Spectrum Threat Response (FSTR) Planning and Operations*, Chapter 4 and Attachment 2.
- 2.12.7. Ensure equipment and protective clothing are decontaminated to the levels designated in **Attachment 4, Table A4.2; Attachment 7, Table A7.2 and Table A7.3**; or IAW host nation agreement, as appropriate.

2.13. Medical Treatment Facility (MTF) Commander.

2.13.1. Ensure complete records are maintained of either measured or estimated radiation dose received by personnel during occupational practices and contingency operations in the member's medical record.

2.13.1.1. Forward records of all such dose determinations to AFIERA/SDRD for incorporation into the MRER (this would also apply to locally performed bioassays, which should be forwarded to AFIERA/SDRR for evaluation prior to being incorporated into the MRER).

2.13.1.2. Medical authorities for organizations or units conducting classified operations shall maintain and be able to access all classified exposure data, ensuring all releasable data is available for maintenance in the MRER and to the monitored individual.

2.13.2. Ensure collection of bioassay and laboratory specimens as necessary to assess internal exposures from ingested or inhaled radioactive material or from wounds contaminated with radioactive material, IAW NATO Allied Engineering Publication-49, *NATO Handbook for Sampling and Identification of Radiological Agents (SIRA)*. Samples shall be forwarded to AFIERA for analysis and interpretation.

2.13.3. Ensure medical follow-up of personnel receiving significant exposures IAW **Chapter 6**.

2.13.4. Ensure compliance through designation of appropriate staff and resources IAW the requirements of **Chapter 4**.

2.14. Deployed Medical Commander (DMC) or Senior Deployed Medical Officer (SMO) Where Radiological Threats Exist.

2.14.1. Consult with personnel with pertinent specialized expertise. These may include: nuclear medicine physicians, diagnostic radiologists or radiation oncologists, bioenvironmental engineers, health physicists, medical physicists, occupational health physicians, and preventive medicine physicians. AFIERA should be contacted if local expertise is not available.

2.14.2. Apply the framework for radiation protection presented in **Chapter 6**, including justification and optimization of exposures.

2.14.3. Apply the principles of operational risk management (ORM) to manage all hazards faced by personnel, including the short and long-term health risks from radiation exposure.

2.14.4. Recommend to the USAF component of Joint Task Force (JTF) Commander, or equivalent, a control dose IAW the dose guidance in **Attachment 7, Table A7.1**, for all operations considered interventions. For all practices, limit doses to those specified in **Attachment 4, Table A4.1**

2.14.5. Ensure implementation of exposure control measures to allow adherence to the respective dose limits or dose guidance.

2.14.6. Ensure establishment, as necessary, a personnel dosimetry and bioassay program IAW **Chapter 3** and **Chapter 6**.

2.14.6.1. Ensures dose records and local bioassay determinations are entered into deployment medical record DD Form 2766, *Adult Preventive and Chronic Care*

Flowsheet or Global Expeditionary Medical System (GEMS) IAW Presidential Review Directive (PRD) 5.

2.14.7. Ensure establishment, as necessary, an environmental surveillance and radiation survey program that allows evaluation of radiological hazards, assessment of individual doses and exposures, and implementation of protective actions.

2.14.8. Provide diagnostic and treatment services for radiation injury, to include psychiatric casualties and internal radioactive contamination, IAW Air Force Manual 44-161 (I), *Treatment of Nuclear and Radiological Casualties*, NCRP Report 65, *Management of Persons Accidentally Contaminated with Radionuclides*; and *NATO Manual AMedP-6(B)*, *NATO Handbook on the Medical Aspects of NBC Defensive Operations, Part I - Nuclear*, or consistent with currently accepted practice.

2.15. Installation RSO.

2.15.1. Provide consultant support to the installation commander on radiation protection issues. Keep installation commanders informed about radiation health and safety issues and effectiveness of measures to control ionizing radiation hazards. The IRSO in most instances is the base bioenvironmental engineer, with additional training as a radiation safety officer.

2.15.2. Establish and manage the base radiation safety program IAW **Chapter 3**, to include the following activities: review of procedures and practices, facility design review and classification, training, exposure control activities and monitoring and surveillance activities.

2.15.3. Provide commanders assistance in developing installation radiation safety operating instructions or radiation safety manuals, as appropriate.

2.15.4. Conduct general public dose assessments and radon exposure monitoring as described in **Chapter 5**.

2.15.5. Work with civil engineering to ensure the adequate design of facilities that will contain radiation sources.

2.15.6. Manage the distribution and record-keeping requirements of the personnel dosimetry and bioassay program for both occupational exposures and interventions.

2.15.7. Oversee routine radiological decontamination and site remediation activities.

2.15.8. Publish an installation instruction detailing local procedures for complying with this instruction.

2.15.9. Know the hazards of the sources of ionizing radiation on the installation (including the INRAD from nuclear weapons) and ensure those units RSOs are aware of the hazards.

2.15.10. Installation RSOs that support nuclear capable units shall (at a minimum): Issue radiation dosimeters to all members of the 2W2, Nuclear Weapons Specialist, career field assigned to nuclear capable units. Exception: 2W2 assigned to duties that do not have the potential for INRAD exposure (i.e., administrative positions).

2.15.11. (**Added-BOLLINGAFB**) The Installation RSO is typically the Bioenvironmental Engineer. The contact information for the Bioenvironmental Engineering (BE) Flight, 579 MDOS/SGPB, is daytime, 202-767-7172, and evening on-call, 240-353-1439.

2.16. Organization or Unit RSO.

2.16.1. Provide consultant support to organization or unit commanders on radiation protection issues. Keep organization and unit commanders, and the installation RSO, informed about radiation health and safety issues and effectiveness of measures to control ionizing radiation hazards.

2.16.2. Establish and manage the organization or unit radiation safety program IAW **Chapter 3**, to include the following activities: review of procedures and practices, facility design review and classification, training, exposure control activities and routine monitoring and surveillance activities.

2.16.3. Provide commanders assistance in developing organization specific radiation safety operating instructions and radiation safety manuals.

2.16.4. Conduct other requirements as specified by regulation or USAF Radioactive Material (RAM) permit.

2.16.5. Maintain and manage records as required by this instruction.

2.16.6. **(Added-BOLLINGAFB)** The Unit RSO will be the main POC of for the Installation RSO when there are requirements for or changes to the unit's radiation program.

2.16.7. **(Added-BOLLINGAFB)** If the unit maintains a radioactive material permit:

2.16.7.1. **(Added-BOLLINGAFB)** Notifies the Installation RSO of upcoming personnel changes to ensure unit has trained and appointed members to act as Permit RSOs.

2.16.7.2. **(Added-BOLLINGAFB)** Will conduct the annual audit and semiannual inventory in conjunction with the installation RSO.

2.16.8. **(Added-BOLLINGAFB)** Will notify the Installation RSO of changes to or shipments of radioactive material inventory.

2.16.9. **(Added-BOLLINGAFB)** Will provide initial and annual radiation safety training to members of unit using permitted or generally licensed radioactive material or ionizing radiation producing devices.

2.16.9.1. **(Added-BOLLINGAFB)** Training can be coordinated through the BE Flight. If units give their own training, BE Flight should review/approve training slides.

2.16.9.2. **(Added-BOLLINGAFB)** An annual training roster must be provided to the BE Flight.

2.17. Civil Engineering/CE Readiness.

2.17.1. Design facilities IAW section **3.2** of this instruction.

2.17.2. In response to major accidents/incidents, enemy attack and terrorist use of weapons of mass destruction involving nuclear or radiological materials, CE Readiness with guidance from the installation/wing RSO:

2.17.2.1. Mitigate and remediate radiological hazards as necessary to keep exposures ALARA and less than the respective dose limits or dose guidance presented in **Attachment 4** and **Attachment 7**, respectively.

2.17.2.2. Assist in conducting radiation surveys to evaluate or confirm the extent and nature of the radiological hazards.

2.17.2.3. Use **Attachment 4, Table A4.2**, and **Attachment 7, Table A7.2** and **Table A7.3** as guides in management of operations involving radiological contamination.

2.17.3. Mitigate structures where exposures to radon or radon progeny exceed the remedial action level specified in section **5.3.1** Incorporate radon reduction measures in the construction of new facilities at medium and high risk installations as identified in the 1987 Radon Assessment and Mitigation Program (RAMP).

2.17.4. Manage and control radioactive wastes generated during remedial actions or interventions.

2.17.5. Conduct training IAW AFI 10-2501/32-4001, *Full-Spectrum Threat Response (FSTR) Planning and Operations* to include NBC defense, shelter management, readiness support team and contamination control team training.

2.18. Workplace Supervisors.

2.18.1. Ensure protection of airmen, USAF civilians, and contractors from occupational exposures.

2.18.2. Ensure protection of the general public from non-occupational exposures resulting from AF practices.

2.18.3. Ensure personnel are trained on radiation hazards in the workplace and appropriate requirements for protection.

2.18.4. Ensure radiation safety procedures are current and adhered to by workers.

2.18.5. Notify the primary care manager of the declared pregnancy status of workers.

2.18.6. Notify the responsible RSO of changes in practices or procedures involving radiation sources.

2.18.7. Notify the responsible RSO of potential violations of this instruction, of unsafe work practices involving radiation sources, or of accidents or incidents involving radiation.

2.18.8. Ensure workplace adherence to the requirements of this instruction.

2.19. Individuals (Occupationally Exposed USAF Military, Civilians, and In-house Contractors).

2.19.1. Properly follow any applicable rules and procedures for radiation protection and safety specified by organizational management and regulations.

2.19.2. Properly use issued dosimeters and personal protection equipment.

2.19.3. Comply with Commander directed radiation protection programs, dose assessment programs and radiological health surveillance.

2.19.4. Provide to the unit or installation RSO such information on their past and current work as is relevant to ensure effective and comprehensive protection and safety for themselves and others. This includes work outside the USAF where they may also incur radiation exposures (IAW 10 CFR 20.2104)

- 2.19.5. Perform operations in a manner that maintains doses ALARA.
- 2.19.6. Accept such information, instruction and training concerning protection and safety as will enable them to conduct their work IAW this instruction.
- 2.19.7. Notify workplace supervisors of changes to procedures or operations that could affect exposure.
- 2.19.8. Notify workplace supervisors of potential violations of this instruction, of unsafe work practices involving radiation sources, or of accidents or incidents involving radiation.
- 2.19.9. A female military member shall, on becoming aware she is pregnant, notify her workplace supervisor, or primary care manager. A non-military member should notify their workplace supervisor or primary care manager. **Note:** It is important to remember that a civilian woman's decision to declare here pregnancy is entirely voluntary. It is the fundamental responsibility of the pregnant worker to decide when, and whether she will formally declare her condition.

2.20. Air Force Inspection Agency: Conduct inspections to assess Air Force compliance with the conditions of this instruction and AFI 91-108, and report critical deficiencies to AFMSA/SG3PB and AFSC/SEW.

2.21. (Added-BOLLINGAFB) Contracting Office for the Installation.

- 2.21.1. (Added-BOLLINGAFB) Coordinates with Installation RSO when contractors require the use of radioactive material on the installation.
- 2.21.2. (Added-BOLLINGAFB) Provide the Installation RSO access to conduct periodic checks of contractors using radioactive materials on the installation.

2.22. (Added-BOLLINGAFB) Logistics Readiness Squadron.

- 2.22.1. (Added-BOLLINGAFB) Contact the Installation RSO or member from BE Flight whenever radioactive material is shipped on or off the installation, due to the infrequent nature of this occurrence.
- 2.22.2. (Added-BOLLINGAFB) Ensures all members with the potential of shipping radioactive material are aware of the proper shipping procedures and have radiation safety training.

2.23. (Added-BOLLINGAFB) Tenant Organizations.

- 2.23.1. (Added-BOLLINGAFB) Provide Installation RSO with an inventory of all radioactive material and updates as inventory changes. If this information is sensitive in nature, the tenant unit will work the Installation RSO on a case-by-case basis.
- 2.23.2. (Added-BOLLINGAFB) Appoint Unit RSO in accordance with 2.11.
- 2.23.3. (Added-BOLLINGAFB) Provide Installation RSO copies of compliance documentation to potentially include licenses, inventories and leak tests.

Chapter 3

RADIATION PROTECTION FOR OCCUPATIONAL PRACTICES

3.1. Introduction. Every organization or installation that uses non-exempt quantities of radioactive material (RE: AFI 40-201)), uses devices that produce ionizing radiation (hereafter referred to as radiation sources), store and maintain current nuclear weapons, manage and dispose of legacy nuclear weapons maintenance wastes, manage and dispose of residuals from nuclear weapons accidents, manage and dispose of residuals from aircraft wash-down operations from atmospheric testing of nuclear weapons, and manage and dispose of residuals from nuclear reactor operations shall implement the radiation safety program outlined in this instruction that is commensurate with the scope of the program and its potential health hazards. Critical elements of this program are in the following sections of this chapter, and are generic to all USAF practices involving potential exposure to ionizing radiation. Specific technical orders or instructions should be referred to for additional detailed information on radiation protection for specific practices (e.g. AFI 91-108 and T.O. 33B-1-1, *Non-destructive Inspection*).

3.1.1. Radiation Safety Organization.

3.1.1.1. Installation RSO: The wing or installation commander shall appoint an Installation RSO in writing. The individual will be responsible for the overall coordination of base radiation safety activities, and provide direct support to the installation commander on radiation safety issues.

3.1.1.2. Unit or Organization RSO. When an organization's practices can potentially result in radiation exposure at or above ten percent of the annual occupational dose limits specified in **Table A4.1**, unit/workplace RSOs shall be appointed in writing by the unit or organization commander. Workplaces normally requiring RSO appointment include medical x-ray, non-destructive inspection, research facilities using machine produced radiation sources, and potentially some high altitude/long duration flight operations. In addition, nuclear capable units and units with 91(b) material will appoint unit RSOs. This individual shall be directly responsible to the senior management of the organization, be properly resourced to execute the requirements of the radiation safety program and have ready access to all levels of the organization that may use radiation sources.

3.1.1.3. Radiation Safety Committee. Facilities, organizations or installations with extensive radiation protection program requirements shall establish a radiation safety committee (RSC) composed of senior management, the installation RSO, organization or unit RSO and other individuals knowledgeable and responsible for radioactive material and radiation producing devices. Examples of extensive programs would include large medical facilities and research organizations to which a health physicist or dual-qualified bioenvironmental engineer is assigned. Generally, organizations with large programs using radioactive material will require an RSC as part of its USAF Radioactive Material Permit requirement. However, installations primarily using a number of machine-produced radiation sources, or that have a number of suborganizations using different radiation sources should consider formulating an RSC. The RSC shall meet at a frequency appropriate to evaluate the purpose, safety and compliance of the radiation

safety program and regulatory requirements, with the exception that all RSCs established as a condition of an USAF RAM permit shall meet quarterly.

3.1.2. Radiation Safety Program Policy, Instructions, Procedures and Manuals.

3.1.2.1. Commanders, organization and unit RSOs, and workplace supervisors shall institute a radiation safety policy that defines the goals of the radiation safety program, the organization and administrative control required for use of radioactive materials and radiation producing devices, and state a commitment to the radiation protection policy for practices (see section 1.6).

3.1.2.2. Commanders, organization and unit RSOs, and workplace supervisors shall ensure radiation safety procedures are incorporated into appropriate procedures or instructions. These procedures and instructions should describe the actions or steps necessary to safely conduct a particular task involving a radiation source and document performance of the task. Radiation safety procedures and instructions shall be clearly written, succinct, readily available to all users of radiation sources, annually reviewed and updated as necessary. The instruction(s) shall describe the safety controls and procedural safeguards necessary to limit exposure, and actions to be followed in the event of an emergency.

3.1.2.3. Commanders of organizations requiring a RSC shall also ensure a radiation safety instruction is developed that includes: command or supervisor commitment to the radiation protection policy of **section 1.6**, a description of the RSC, the radiation safety staff and the radiation safety program, specific policy and regulatory requirements and specific procedures on how to comply with these requirements.

3.1.3. Quality Assurance. Commanders, organization and unit RSOs, and workplace supervisors shall ensure a quality assurance program is established to oversee the radiation safety program (ref: NCRP Report 127, *Operational Radiation Safety Program*), as recommended by the installation RSO. The quality assurance program shall comply with all USAF directives and best industry practices (e.g. T.O. 33B-1-1, JCAHO, etc.). Elements that may be included in the quality assurance program include audits, inspections, surveillance and statistical evaluations, as appropriate, to evaluate the adequacy of:

- 3.1.3.1. Basic control of radiation producing equipment and radioactive material,
- 3.1.3.2. Conformance with organizational policies and regulatory requirements,
- 3.1.3.3. Contamination and effluent control, and protective measures,
- 3.1.3.4. Radiation safety assessment of the workplace and surrounding environment,
- 3.1.3.5. Radiation safety assessment of dose to workers and the general public,
- 3.1.3.6. Incident and accident investigation and corrective actions,
- 3.1.3.7. Training, and
- 3.1.3.8. Record keeping.

3.2. Facility Design, Layout and Area Classification.

3.2.1. Facility Design.

3.2.1.1. Facilities in which non-exempt quantities of radioactive material, nuclear weapons or components, 91(b) material, or devices that produce ionizing radiation are used or stored shall be designed so that exposures from normal operation of the facility are ALARA, and do not result in exposures that exceed applicable limits (**Attachment 4**). Where appropriate, facilities shall also be designed so as to mitigate accidents or incidents involving the radiation sources. Design shall consider, but not be limited to: site selection, facility layout, equipment and system design, shielding, ventilation (including fume hoods and glove boxes), radioactive material waste management, monitoring and surveillance requirements and access controls (REF: NCRP Report No. 127, *Operational Radiation Safety Program, Chapter 4, Facility Design*, NCRP Report No. 88, *Radiation Alarms and Access Control Systems*, NCRP Report No. 147, *Structural Shielding Design for Medical X-Ray Imaging Facilities*, NCRP Report No. 151, *Structural Shielding and Evaluation Megavoltage X- and Gamma-Ray Radiotherapy Facilities*).

3.2.1.2. New USAF facilities designed for use of radioactive materials or radiation producing devices shall be constructed so that a member of the general public will not likely exceed 0.02 mSv (2 mrem) deep-dose equivalent in any one hour or 1 mSv (100 mrem) total effective dose in a calendar year from the normal, expected operation of the facility.

3.2.1.3. The planning and design of new or significantly modified facilities shall include a review by a qualified expert (installation RSO or medical physicist) to ensure appropriate radiation safety features are incorporated. Shielding evaluations and design review shall be performed by AFI- ERA/SDR.

3.2.1.4. To the greatest extent possible, administrative controls and procedures shall not be used as a substitute for engineering controls and appropriate facility design.

3.2.1.5. Facilities designed for use of unsealed forms of radioactive material, facilities using accelerators producing photons with energies greater than 13 MeV, and facilities using neutron sources shall consider eventual decommissioning requirements during the facility design phase.

3.2.2. Classification of Areas.

3.2.2.1. Restricted Areas. Restricted areas shall be established in any area in which specific protective measures are or could be required for controlling routine radiation exposures, preventing access to radiation sources or preventing the spread of contamination during normal work practices. Restricted areas shall:

3.2.2.1.1. Be delineated appropriately through engineered and physical controls, signage and/or administrative controls, as appropriate.

3.2.2.1.2. Have access controlled so that only personnel having approval of the unit, organization or installation RSO are permitted unescorted access. Visitors and other personnel (e.g. patients) entering restricted areas shall be escorted.

3.2.2.2. Radiation Areas. Any area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.05 mSv (5 mrem) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates, shall designated a radiation area. All such areas shall:

3.2.2.2.1. Be considered restricted areas.

3.2.2.2.2. Be posted with a sign that includes a magenta or black radiation symbol on a yellow background and the words "Caution, Radiation Area", with the exception of medical x-ray facilities and rooms otherwise excepted IAW 10 CFR 20.1903.

3.2.2.3. High Radiation Areas. Any area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 1 mSv (100 mrem) in 1 hour at 30 centimeters from the radiation source or for any surface that the radiation penetrates, shall be designated a high radiation area. All such areas shall:

3.2.2.3.1. Be considered restricted areas.

3.2.2.3.2. Be posted with a sign that includes a magenta or black radiation symbol on a yellow background and the words "Caution, High Radiation Area", with the exception of medical x-ray facilities, and rooms otherwise excepted IAW 10 CFR 20.1903.

3.2.2.3.3. Adhere to the requirements of 10 CFR 20.1601.

3.2.2.4. Very High Radiation Area. Any area, accessible to individuals, in which radiation levels could result in an individual receiving an absorbed dose in excess of 5 Gy (500 rads) in 1 hour at 1 meter from a radiation source, shall be designated a very high radiation area. All such areas shall:

3.2.2.4.1. Be considered restricted areas,

3.2.2.4.2. Be posted with a sign that includes a magenta or black radiation symbol on a yellow background and the words "Grave Danger, Very High Radiation Area", with the exception of medical therapy facilities, and facilities otherwise excepted IAW 10CFR20.1903.

3.2.2.4.3. Adhere to the requirements of 10 CFR 20.1602.

3.3. Training.

3.3.1. General: All personnel (military, civilians and in-house contractors) who have the potential to be occupationally exposed to 10 percent of the annual dose limits in **Table A4.1** shall receive initial and annual training that is appropriate in breadth and depth to the radiation hazards present in the workplace. Training may include other populations based on the judgment of the installation RSO. Training of nuclear weapons specialists (i.e., 2W2) is outlined in **paragraph 3.3.1.11** Training shall address the following topics, as applicable:

3.3.1.1. Types and characteristics of radiation of concern

3.3.1.2. Radioactivity, radioactive decay or x-ray production (as appropriate)

3.3.1.3. Modes of exposure - internal versus external

3.3.1.4. The health risks posed by this exposure including: deterministic and stochastic effects, and somatic and genetic effects and effects on the unborn fetus

3.3.1.5. General radiation protection principles including:

3.3.1.5.1. ALARA and dose limits

3.3.1.5.2. External protection through time, distance, and shielding

- 3.3.1.5.3. Internal protection through respiratory protection, protective clothing and hygiene, as appropriate
 - 3.3.1.6. Use of instruments, equipment, and personal dosimetry, as appropriate, to:
 - 3.3.1.6.1. identify sources of radiation emission and radioactive contamination;
 - 3.3.1.6.2. measure radiation exposure rates or dose rates;
 - 3.3.1.6.3. monitor individual radiation doses.
 - 3.3.1.7. Emergency procedures
 - 3.3.1.8. Reporting requirements
 - 3.3.1.9. Radioactive material permit requirements, as appropriate
 - 3.3.1.10. Other occupation specific hazards and the related skills and procedures that are required for working with the radioactive materials or radiation-producing devices of concern.
 - 3.3.1.11. Intrinsic radiation safety training shall be given to all nuclear weapons specialists (i.e., 2W2) assigned to nuclear weapons capable units or to units with 91(b) materials. Such shall occur within 90 days of assignment and refresher given every 15 months thereafter. The IRSO and unit RSO can expand the scope of this training as appropriate (i.e., handlers, loaders, security forces, etc.). The content of training is provided at the AFMSA Radiation Programs website located on Knowledge Exchange.
- 3.3.2. Training Plan: A written training program shall be developed by the unit, organization or installation RSO, as appropriate. The training program shall be reviewed and revised as necessary to reflect changes in practices in the workplace.
- 3.3.3. Record keeping. Training programs presented, course curricula, and attendance shall be maintained for a period of five years unless otherwise specified. Training shall be documented on personnel's AF Form 55, *Employee Safety and Health Record*.

3.4. Radiation Exposure Control.

- 3.4.1. **Dose Limits.** Occupationally exposed personnel shall not exceed dose limits specified in [Table A4.1](#) Note that Federal regulatory changes that are more conservative would supercede the values published in [Table A4.1](#)
- 3.4.2. **Reference Levels.** Personnel should not receive a dose in excess of 25 percent of the applicable annual dose limits in a quarter, or 10 percent of the applicable annual dose limits in a month without proper justification and optimization of the procedure.
- 3.4.3. **Investigation Levels.** Installation RSOs shall establish local threshold levels for dose or radionuclide intake, above which an investigation is conducted to determine the causative factors, and identify corrective measures, as appropriate. Refer to AFI 48-125 for additional information.
- 3.4.4. **Exposure Control.** Workers shall use the following techniques, as appropriate and under the judgment and discretion of the unit or organization RSO, to ensure dose limits are not exceeded and exposures are ALARA (ref: NCRP Report No. 127, *Operational Radiation Safety Program*).

3.4.4.1. Time, Distance and Shielding: As appropriate, minimize the time around sources of external radiation, maximize the distance to radiation sources, and utilize radiation shielding between radiation sources and potential exposed personnel to control external radiation doses.

3.4.4.2. Personal Protective Clothing:

3.4.4.2.1. As appropriate, personal protective clothing including lead aprons, glasses and thyroid shields to protect from x-rays, plastic face shields and glasses to protect from beta particles, and clothing and gloves to protect from contamination shall be used to the greatest extent possible, consistent with the principles of ALARA and ORM.

3.4.4.2.2. Use of personal protective clothing is not merited where its use may result in: overall more significant internal or external exposure to radiation or other health risks more severe than that posed by the potential radiation exposure.

3.4.4.2.3. Respiratory protection use shall be IAW AFOSHSTD 48-137, *Respiratory Protection Program*.

3.4.4.3. Contamination Control: In the absence of superceeding regulatory or advisory guidance, a surface is contaminated if either the removable or total radioactivity is above the levels in **Table A4.2**

3.4.4.3.1. If a surface cannot be decontaminated promptly to levels below those in **Table A4.2**, the area should be controlled and marked as contaminated. Contact AFIERA/SDRH for additional guidance.

3.4.4.3.2. Always reduce radioactive contamination to levels ALARA.

3.4.4.4. Access Control and Alarm Systems: Provide access control and/or alarm systems to prevent access to or warn of a radiation hazard, as appropriate. Generally, such systems are appropriate for areas that can be classified as high or very high radiation areas under section **3.2.2** For additional information, consult AFIERA/SDR and refer to NCRP Report No. 88, *Radiation Alarms and Access Control Systems*.

3.4.4.5. Radiation Safety Procedures and Work Permits: As appropriate: implement, use and periodically review radiation safety procedures and radiation work permits.

3.4.4.6. Removal from or Change of Duty: Individuals who are likely to exceed the dose limits of **Table A4.1**, even with application of the above measures, shall have duties modified or curtailed so that annual limits are not exceeded. Such changes in duty shall remain in effect until the individual's projected dose will be less than annual limits. This situation is most frequently encountered for the pregnant worker who has declared their pregnancy. Based on the exposure information and workplace assessment of the Installation RSO, the female worker's obstetrician (if military) or civilian health care provider (if civilian) will determine any restrictions to the worker's duties involving occupational radiation exposure. The following guidelines are generally prudent for declared pregnant workers:

3.4.4.6.1. Declared pregnant technologists or providers should be restricted from performing fluoroscopic and interventional procedures.

3.4.4.6.2. Declared pregnant technologists can perform routine radiographic studies, portable examinations to include the operating room (except fluoroscopy, i.e. C-arm), computed tomography, mammography, and radiation therapy.

3.4.4.6.3. Declared Pregnant Nuclear Medicine Technologists may work in imaging rooms, but should be restricted from dosing patients and working in the hot lab.

3.4.4.6.4. Female nuclear weapons specialists (i.e., 2W2) who declare pregnancy per [paragraph 2.19.9](#) should be restricted from duties requiring contact with or occupancy in rooms where tritium is present. If operation requirements of the unit make it necessary for pregnant females to work in areas where tritium is present, then the unit commander shall review the exposure potential. The unit commander should consult AFSC/SEWN, the installation RSO, and/or the worker's Primary care Manager to discuss the potential for exposure and risk associated with such exposure.

3.5. Radiation Dosimetry, Reporting and Record Keeping.

3.5.1. Personnel Monitoring Criteria. Eligible persons shall be entered into the USAF dosimetry program (see AFI 48-125) if any of the following apply:

3.5.1.1. Adults likely to receive, in 1 year from sources external to the body, a dose in excess of 10 percent of any of the occupational limits in [Table A4.1](#)

3.5.1.2. Minors (defined as individuals 16 to 18 years of age and who are authorized to work within a restricted area) and who have the potential to receive a dose in excess of 10 percent of the limits specified in [Table A4.1](#)

3.5.1.3. All pregnant occupational workers likely to exceed 0.5 mSv (50 mrem) during the gestation period.

3.5.1.4. Individuals entering a high or very high radiation area.

3.5.1.5. Any individual likely to receive in the current year, a cumulative radiation dose likely to exceed 10 percent any of the limits listed in [Table A4.1](#) when combined with occupational dose received during the same year while employed by any other employer (ref 10 CFR 20.1201(f)).

3.5.1.6. Personnel monitoring may be provided to individuals not meeting any of the above criteria as the discretion of the installation RSO, if the following apply:

3.5.1.6.1. The type of radiation to which the individual could be exposed is detectable by the USAF personnel monitoring program;

3.5.1.6.2. Provision of monitoring services would be helpful in demonstrating compliance with ALARA; or

3.5.1.6.3. Monitoring is desirable to evaluate potential exposure conditions to allay worker concern.

3.5.1.7. Members of the 2W2, Nuclear Weapons Specialist, career field assigned to a nuclear capable unit. **Exception:** 2W2 assigned to duties that do not have the potential for INRAD exposure (i.e., administrative positions).

3.5.2. Bioassay Criteria. Perform bioassays to assess internal exposures if either of the following applies.

3.5.2.1. An individual is likely to receive, in one year, an occupational intake (i.e., inhale, ingest and/or absorb) in excess of 10 percent of applicable annual limits of intake (ALI). The ALIs for NRC-licensed radioactive material are in 10 CFR 20, Appendix B, Table 1, columns 1 and 2. The Surgeon General, through AFMOA/SGZR, will provide, as necessary, ALIs for radioactive material used under USAF authority but not listed in 10 CFR 20, Appendix B.

3.5.2.2. Minors and declared pregnant women likely to receive, in one year, an occupational intake resulting in a committed effective dose in excess of 0.5 mSv (50 mrem).

3.5.3. Reference Levels. Any dosimeter and/or bioassay result which indicates a dose in excess of 25 percent of the applicable annual dose limit, received for a quarterly monitoring period, or 10 percent of the applicable annual dose limits if monitored monthly, shall be investigated. The investigation, which validates an exposure, shall be submitted to AFIERA/SDRD through MAJCOM Bioenvironmental Engineer within 30 days of exceeding the reference level. The report shall include:

3.5.3.1. Name, SSAN, occupational dosimetry code, and AFSC of individual involved.

3.5.3.2. Description of circumstances surrounding the abnormal exposure.

3.5.3.3. Estimates of each individual's dose equivalent to include a detailed discussion of how this value was determined.

3.5.3.4. Cause of the exposure.

3.5.3.5. Corrective actions taken to prevent recurrence.

3.5.3.6. Statement signed by the individual involved either supporting or contesting the investigation report.

3.5.3.7. Results of any medical examinations.

3.5.3.8. **(Added-BOLLINGAFB)** Bolling AFB exposures have not historically exceeded detection limits. Installation RSO will informally investigate levels greater than 10 mrem.

3.5.4. Overexposures. Any dosimeter and/or bioassay result exceeding the applicable limit in **Table A4.1** shall be considered an overexposure and immediately investigated.

3.5.4.1. Notification:

3.5.4.1.1. When a dosimeter and (or) bioassay indicates an overexposure may have occurred, AFIERA/SDRD immediately notifies the installation RSO by telephone and follows up with a facsimile letter within 3 hours.

3.5.4.1.2. The individual shall be removed from all duties involving potential radiation exposure until an investigation of the incident can be completed.

3.5.4.2. Reporting:

3.5.4.2.1. The installation RSO shall investigate suspected overexposures, with a written report of the investigation submitted through the MAJCOM Bioenvironmental Engineer to AFIERA/SDRD and AFMOA/SGZR within 7 days of notification. The

written report must include those elements required in section 3.5.3 (RCS: HAF-SG(AR)0116, Report of Occupational or Public Overexposure to Radiation). This report is designated emergency status code C-1. Continue reporting during emergency conditions.

3.5.4.2.2. The reporting requirements established here do not replace or supercede the reporting requirements associated with a nuclear reactor or radiological mishap or deficiency as established in Chapter 12, AFI 91-204, *Safety Investigation and Reports*.

3.5.5. Record keeping.

3.5.5.1. Annual Report of Occupational Exposure. The installation RSO shall provide a copy of all applicable SDRD Form 1527-1, *Annual Report of Individual Occupational Exposure to Ionizing Radiation*, to routinely monitored personnel on an annual basis. The installation RSO shall maintain a record copy for 5 years.

3.5.5.1.1. The SDRD Forms 1527-1 will be filed in the individual's outpatient medical record annually in the following manner: In the AF Form 2100A Series, *Health Record - Outpatient* (four-part folder), file the forms in Section 3. (See AFI 41-210, *Patient Administration Functions*, paragraph A3.4.2.2.24).

3.5.5.2. Cumulative History of Occupational Exposure. Upon written request by the individual, installation RSO, or other authorized organizations and individuals, AFIERA/SDRD shall provide a copy of all applicable SDRD Form 1527-2s, *Cumulative History of Individual Occupational Exposure to Ionizing Radiation*. All requests other than those made for official USAF use must have a release signed by the individual for whom the report is requested.

3.5.5.3. Previous or Concurrent Occupational Dose. The installation RSO shall make a reasonable effort to collect dosimetry records for individuals having either past or present non-USAF employment that involve radiation exposure. USAF personnel moonlighting in jobs where they are monitored for radiation exposure shall make arrangements to routinely (e.g., annually or based on monitoring period) provide these results to the installation or unit RSO. The installation RSO shall ensure these results are forwarded to AFIERA/SDRD for incorporation in the MRER. The individual bears ultimate responsibility for ensuring any non-USAF dosimetry results become part of the MRER.

3.6. Monitoring and Surveillance Programs, and Instrumentation.

3.6.1.1. Routine surveys shall be performed as specified by AFMSA/SG3PB (Radiation Programs), this instruction or based on AFMAN 48-153, *Health Risk Assessment*.

3.6.1.1.1. Routine surveys shall be performed as specified by USAF Radioactive Material Permit, or applicable Technical Order or otherwise based on hazard as assessed by the installation RSO.

3.6.1.2. Non-routine surveys shall be performed by a qualified expert (**Attch 1**, Terms) on any new or substantially modified facility where a radiation source is used or if the characteristics of the radiation source are significantly changed. This includes nuclear weapons storage and maintenance facilities, as well as facilities housing 91(b) materials. The survey shall determine the efficacy of any installed shielding to protect surrounding

areas from primary or scattered radiation, as applicable. In all cases, the survey shall be conducted within 90 calendar days of the facility acceptance date or the change in the radiological characteristics of the source. Measurements must be re-accomplished after modification of the facility impacting the shielding or RAM control, replacement or change of the radiation source, and/or a significant change in the practice the uses the radiation source.

3.6.2. Instrumentation: Instrumentation used to perform surveys shall be appropriate to the type of radiation(s) and energy of radiation(s) being detected. Installation RSOs shall consult with AFIERA/ SDRH on instrumentation requirements prior to performing intrinsic radiation, atmospheric ionizing radiation, high energy (>13 MeV) accelerator surveys or other mixed radiation environments.

3.6.2.1. Instrumentation shall be calibrated annually, or at a frequency specified in applicable USAF RAM Permit or Technical Order, using National Institute of Standards and Technology (NIST)-traceable radiation sources.

3.6.2.2. Records of instrument calibration shall be maintained by the installation, organization or unit RSO, as appropriate, for three years.

3.6.2.3. Instrument performance shall be checked before and after each use, IAW manufacturer's recommendations, as applicable.

3.6.3. Record keeping.

3.6.3.1. Survey results should be maintained for a period of no less than three years, or as specified in applicable USAF radioactive material permit, Technical Order or AF Files Disposition Instruction, whichever is most stringent.

3.6.3.2. Survey results shall include: a description or drawing of each measurement location; measured dose or contamination levels at each location; the type, model number, serial number, and calibration date of the instrument; name of individual performing the survey, date and time of the survey and applicable comments.

3.7. Radioactive Waste Management.

3.7.1. Radioactive Waste Minimization: Waste generation shall be minimized, or preferably prevented at the source. Unavoidable wastes should either be recycled, when feasible, or be reduced in volume and treated, when feasible, to render it less hazardous, toxic and harmful to the environment.

3.7.2. Radioactive Waste Storage: All waste pending disposition shall be stored in a restricted area, in clearly marked containers.

3.7.2.1. Rooms in which there is sufficient radioactive material to exceed 10 times the quantity of such material specified in Appendix C of 10 CFR 20, or Attachment 2 of AFI 40-201, shall be posted with a conspicuous sign or signs bearing a radiation symbol, and the words, "CAUTION" or "DANGER", "RADIOACTIVE MATERIAL(S)."

3.7.3. Radioactive Waste Disposal and Material Recycling, including 91(b) material, shall be requested through the AFRRAD (88 ABW/CEV).

3.7.4. (DELETED) .

3.8. Occupational Medical Surveillance and Follow-Up. For personnel who are occupationally exposed and whose doses do not exceed the applicable dose limits in **Table A4.1**, testing and monitoring should be the same as standard clinical preventive services that follow guidelines for the general population (e.g. routine mammography, pap smears, and prostate specific antigen testing). Medical surveillance of overexposures shall be evaluated on a case-by-case basis by the MAJCOM/SG in coordination with AFMOA.

Chapter 4

RADIATION PROTECTION FOR MEDICAL PRACTICES

4.1. Introduction. The use of radioactive materials and radiation-producing devices in USAF medicine is the single largest source of man-made exposure to USAF personnel. This section describes the requirements for radiation protection in medical practices to ensure patient, practitioner and general public doses are ALARA, while still obtaining clinical objectives. This section applies to all active USAF Medical Treatment Facilities (MTFs) worldwide that acquire, possess, install, calibrate, maintain, evaluate, use or dispose of radiation sources used for diagnosis, therapy or for medical research. Responsibility for complying with the requirements in sections 4.4–4.14 rests with the facility commander or that individual so delegated by the commander that has the appropriate training, skills, credentials, and resources to ensure compliance.

4.2. Responsibilities.

4.2.1. Radiologist, Radiation Oncologist, Nuclear Medicine Physician, and Physicians: The radiologist, radiation oncologist, nuclear medicine physician and other physicians working with radiation shall: control all aspects of the conduct and extent of examinations, ensure radiographic examinations, radiation therapies or nuclear medicine procedures are only performed by properly trained personnel with adequate knowledge of the physical properties and harmful effects of ionizing radiation and that the procedures used are appropriate and optimized for the clinical problem presented.

4.2.2. Medical Physicists (Organizational and Regional). For nuclear medicine and diagnostic radiology: A medical or health physicist may be considered a qualified expert when they have had modality specific training and performed three surveys for a particular type of equipment under the supervision of a board certified medical physicist or a medical physicist who meets all the education, training and experience necessary to complete all aspects of ABR or ABMP board certification. For radiation therapy, a board certified radiation therapy physicist must supervise the medical physicist until all education, training and experience necessary to complete board certification is met. Organizational medical physicists shall be directly responsible to the organization to which they are assigned, and support those MTFs within their host organization's geographic region (see [Attachment 5](#) for specified regions). Medical physicists shall:

4.2.2.1. Oversee quality control practices for the MTF to which the physicist is assigned and provide review and guidance for quality control programs in departments utilizing ionizing radiation for imaging within the physicist's geographic region.

4.2.2.2. Oversee training for junior health or medical physicists and supervise technologists who perform nuclear medicine and diagnostic radiology quality control and quality assurance functions.

4.2.2.3. Provide or support medical physics consultant services necessary to support the requirements of the Mammography Quality Services Act, 21 CFR Parts 16 and 900. (*Note:* for mammography support, medical physicists must meet all qualifications of 21 CFR Part 900.)

4.2.2.4. Provide or support acceptance testing services for all new diagnostic medical systems.

4.2.2.5. Consult on patient radiation protection requirements; including those involving exposure to the unborn fetus and embryo.

4.2.2.6. Further, a qualified radiation therapy physicist shall provide services as listed in section [4.12.1](#)

4.2.3. Medical Equipment Repair Technicians: will support collection of data for entrance skin exposure IAW AFI 41-201, *Managing Clinical Engineering Programs*, and perform acceptance testing on diagnostic radiology equipment.

4.2.3.1. Entrance skin exposure data must be collected annually for each diagnostic radiology unit including new equipment under warranty. Data must be provided to the installation RSO and to the MTF's Chief of Radiology.

4.3. General.

4.3.1. Qualifications to Prescribe the Use of Radiation in Medicine.

4.3.1.1. The use of radiation or radioactive material for the purposes of diagnosis or treatment of disease or injury shall only be prescribed by Doctors of Medicine or Osteopathy who are licensed by the United States or one of its territories or possessions. Exceptions include properly trained nurse practitioners, physician assistants and persons in post-graduate training status under the supervision of a licensed Doctor. The Chief of Radiology may recommend to the Credentials Committee other healthcare providers (physical therapy, occupational therapy, orthopedics) be granted privileges for ordering radiographic exams, consistent with their training and abilities. The use of radioactive material for the purposes of diagnosis or treatment of disease or injury shall only be prescribed by authorized users listed on USAF Radioactive Material Permits.

4.3.1.2. Doctors of Dental Surgery or Dental Medicine may request appropriate examinations of the head, neck and chest, although such requests are normally confined to the oral region. Podiatrists and Chiropractors may request x-ray examinations appropriate to their specialty.

4.3.1.3. Variances to the above qualification requirements should occur only for emergency or life-threatening situations. Non-peacetime operations in the field could require variances from this policy.

4.3.1.4. Any request for specialized radiography and fluoroscopy, such as angiography, computerized tomography or other complex studies should be made by providers credentialed by the MTF.

4.3.2. Operator Qualifications.

4.3.2.1. Physician Performance. Eligible physicians include radiologists and other physicians granted privileges in radiology on the basis of the needs of patients serviced by the facility. Such privileges might include the use of x-ray equipment by cardiologists for cardiac catheterizations and by dentists or podiatrists as part of their practice. Before physicians and dentists are granted radiology privileges they should have received adequate training in equipment use, radiation protection and hazards.

4.3.2.2. Technologist Performance. The application of radiation for diagnosis or treatment shall only be performed by technologists (Diagnostic Imaging 4RXXX) who are trained and who have demonstrated proficiency in the use of the specific radiation producing device, or in the administration and use of the prescribed radioactive materials. Such proficiency should be IAW the American Society of Radiologic Technologists (ASRT) Position Statements and Scopes of Practice for technologists, assessed through national-performance-oriented evaluation procedures (American Registry of Radiologic Technologists—ARRT-- or equivalent), or by didactic training and practical experience equivalent or superior to training programs and examination requirements of recognized credentialing organizations (ARRT or equivalent). Technologists shall strive to ensure patient doses are as low as reasonably achievable while ensuring diagnostic and therapeutic objectives are achieved. Technologists, in general, are the largest population responsible for implementing and following the requirements of this Chapter.

4.3.2.3. The above consideration for operators of radiation producing equipment should be implemented by the chief radiologist or NCOIC/Superintendent, Diagnostic Imaging through the responsible authority (MTF commander) in an instruction which details:

4.3.2.3.1. Who may operate diagnostic x-ray equipment and the supervision required

4.3.2.3.2. The education-training and/or proficiency requirements for imaging technologists, and

4.3.2.3.3. Requirements for continuing education and demonstration of proficiency.

4.3.2.3.4. This policy should be reviewed periodically and revised as appropriate.

4.3.3. Nuclear Medicine and Radiation Therapy using Byproduct Material. All USAF medical facilities offering nuclear medicine or radiation therapy services involving byproduct material shall adhere to the applicable requirements of Title 10, Code of Federal Regulations Parts 19, 20, 35 and conditions of their USAF Radioactive Material Permit.

4.3.4. Medical X-ray and Dental X-ray Services. All medical and dental x-ray systems used shall adhere to the most current requirements of Title 21, Code of Federal Regulations, Parts 1020.30 through 33 – Performance Standards for Ionizing Radiation Emitting Products. The radiation safety program for medical x-ray systems should be evaluated annually and once every four years for dental x-ray systems.

4.3.5. Dosimetry Systems.

4.3.5.1. Dosimetry systems used in diagnostic radiology or nuclear medicine shall be calibrated annually using National Institute for Standards and Technology (NIST) traceable sources. Records of calibration shall be maintained for three years.

4.3.5.2. Dosimetry systems used in external beam radiation therapy shall have been calibrated by the NIST or by an American Association of Physicists in Medicine (AAPM) Accredited Dosimetry Calibration Laboratory (ADCL). The calibration shall have been performed within the previous 24 months and after any servicing that may have affected system calibration. A record of each dosimetry system calibration, inter-comparison, and comparison shall be maintained for three years. Each facility shall maintain two independent dosimetry systems or alternatively have a means of obtaining an independent determination of beam calibration on an annual basis using an ADCL-

calibrated electrometer and ionization chamber(s) not normally used by the facility for routine calibration.

4.4. General Requirements in the Clinical Use of X-Ray, Electron Beam and Gamma-Ray Radiation. As a general principle, the dose to the patient shall be kept to a minimum consistent with clinical objectives. Each MTF shall have and implement written operating and safety procedures. These procedures shall be made available to each individual operating a radiation-producing machine, including any restrictions of the operating technique required for the safe operation of the particular system. These procedures shall be reviewed annually. Specific requirements shall include, but are not limited to:

4.4.1. The useful beam shall be limited to the smallest area practical and consistent with the objectives of the radiological examination or treatment.

4.4.2. The tube potential, filtration and source-to-skin distance (SSD) employed in medical diagnostic examinations should be as large as practical, consistent with study objectives.

4.4.2.1. Special care should be taken to insure that adequate and proper filtration is used for all diagnostic and therapeutic procedures.

4.4.2.2. The operator should use the maximum source to skin distance consistent with medical requirements of the procedure. For diagnostic procedures, other than dental procedures, distances less than 30 cm shall not be used.

4.4.3. Protection of the embryo or fetus during radiological examination or treatment of women known to be pregnant shall be given special consideration, as described in section 4.5 below.

4.4.4. Techniques shall be appropriately modified for pediatric patients.

4.4.5. Sensitive body organs (e.g. lens of eye, gonads) should be shielded whenever they are likely to be exposed to a useful beam provided such shielding does not interfere with useful diagnostic information or proper treatment. In addition:

4.4.5.1. Gonadal shielding using at least 0.5 mm lead equivalence shall be used whenever potentially procreative individuals are likely to receive direct gonadal radiation in an exam or treatment or the primary beam is within 2.5 cm of the gonadal area.

4.4.5.2. Shielding of breasts for scoliosis radiographs should be used due to the sensitivity of breast tissue in young women and the number of films likely to be taken in a lifetime. The lead must be placed between the source of x-rays and the patient. If there is no lead available, a posterior-anterior view should be used.

4.4.5.3. The lens of the eye should be shielded with a least 2 mm lead equivalence during tomographic procedures that include the eye in the useful beam (Not required for posterior-anterior projections).

4.4.6. Fluoroscopy (with the exception of microampere systems used in orthopedics) shall not be used as a substitute for radiography, but should be reserved for the study of dynamics, spatial relationships, guidance in spot film recording of critical detail and simulation in radiation therapy. Last image hold should be utilized whenever possible.

4.4.7. X-ray films, intensifying screens, and other image recording devices shall be reviewed annually for maximum sensitivity, consistent with the requirements of the examination. Facilities shall adhere to the manufacturer's processing instructions.

4.4.8. No person should routinely hold patients during diagnostic examinations.

4.4.8.1. When a patient must be held in position mechanical supports or immobilization aids should be used.

4.4.8.2. If mechanical devices cannot be used, the individual selected to hold the patient should be a relative, nursing or transport personnel. Diagnostic Imaging (4RXXX) technologists should be used at a last resort and then only in emergent (life/death) cases.

4.4.8.3. Pregnant woman or persons under 18 years should not be permitted to hold patients.

4.4.8.4. If a patient must be held by someone, the individual shall be protected with appropriate shielding devices such as gloves and aprons. Positioning should be arranged so that no part of the holder's torso is struck by the useful beam, and that the holder's body is as far as possible from the useful beam.

4.4.9. Only individuals whose presence is necessary shall be in diagnostic x-ray, fluoroscopy or low-energy (< 150 kV) therapy x-ray rooms during exposures. These personnel shall be protected (e.g. leaded aprons, leaded gloves and/or portable shields).

4.4.10. Individuals, other than the patient, shall not be in high energy (over 150 kV) therapy rooms during exposures.

4.4.11. Protective devices, including aprons, gloves, and shields (include dental, cardio-lab and operating room gowns) shall be stored properly and checked annually for defects such as holes, cracks, and tears. These checks may be performed by the flight/element personnel by visual means (obvious rips or tears), or by diagnostic imaging technologists using x-ray imaging. Each facility must develop operating instructions stating unique identification methods, testing procedures, pass/fail criteria, documentation (i.e., device tagging and audit outcome) and proper procedures for disposal of rejected lead protective material.

4.4.12. The operator shall stand behind a barrier, if provided, and shall observe the patient during diagnostic or therapeutic procedures. The operator shall be able to maintain verbal, visual, and aural contact with the patient.

4.4.13. Radiation source systems and imaging systems, as well as film processors shall be subjected to an appropriate quality assurance program as described in section 4.6

4.4.14. Radiographic film should not be used beyond its expiration date. Unprocessed film shall be protected by appropriate shielding and should not be exposed to more than 0.002 mGy (0.2 mrad) prior to use.

4.5. X-Ray Examination of Women. Because of the radiation risk to the embryo or fetus, the possibility of pregnancy shall be addressed in any woman of reproductive capacity when considering any nuclear medicine procedure or any radiographic examination involving the lower abdomen.

4.5.1. Before any diagnostic radiology or nuclear medicine procedure, the patient shall be asked if they are pregnant. Before any therapeutic procedure a pregnancy test will be given to all fertile women.

4.5.2. Ideally, elective abdominal/pelvic examination of a woman of childbearing age should be performed during the first 14 days following the onset of menses to minimize the possibility of irradiation of the embryo. In practice, the timeliness of medical needs should be the primary consideration in deciding the timing of an examination.

4.5.3. Radiographic and nuclear medicine waiting and/or examination rooms, other than those used exclusively for dentistry, shall be posted with appropriate signs alerting patients that if they may be pregnant to notify the physician or technician before the examination.

4.5.4. In the event of a fetal exposure (i.e., the fetus or embryo is exposed to radiation) the responsible department shall:

4.5.4.1. Have a qualified medical physicist (**Attachment 5**) determine by measurement or modeling the estimated dose to the fetus. These calculations shall be reported to the patient's physician who will interpret them to the patient.

4.5.4.2. Adhere to the requirements of section **4.14**

4.6. Quality Control. A properly designed quality assurance program will contain a quality control (QC) program that provides adequate confidence that a diagnostic x-ray or nuclear medicine facility will produce consistently high quality images with minimum exposure to the patients and medical staff. Similarly, a radiation therapy quality control program assists in assuring treatments are performed with the optimum dose to tumor tissues and minimal dose to healthy tissue of the patient with the least possible exposure to medical staff.

4.6.1. Diagnostic Imaging Departments and Other Departments Utilizing Radiation Sources: All diagnostic imaging departments shall implement a quality control program; with the objective to minimize patient and staff dose while obtaining optimal clinical objectives. As a minimum, the program shall consist of the following elements:

4.6.1.1. Acceptance Testing: A qualified (as defined in AFI 41-201) medical equipment repair center (MERC) technician or biomedical equipment technician (BMET) shall perform acceptance testing prior to clinical use of all new diagnostic x-ray systems and systems having undergone a significant component change (e.g., a new x-ray tube). Further, a qualified expert (medical physicist) should conduct or review an acceptance test of all new diagnostic medical systems, excluding dental radiology and veterinary radiology. Documentation of the acceptance test shall be maintained by the BMET or MERC for the duration of system use.

4.6.1.2. Compliance Inspections: Annual compliance inspections by the responsible MERC and/or BMET. Inspection results shall be maintained IAW AFI 41-201.

4.6.1.3. Quality Control Program: The department shall implement a quality control program that includes the following elements: reject/repeat or retake analysis program for film use or exposure factor for digital systems, dark room and film processor quality control, cassette/screen and view box inspection and cleaning, x-ray generator compliance with 21 CFR 1020, x-ray tube and collimator compliance with 21 CFR 1020, automatic exposure control performance and stability, and patient dose. Quality control

data shall be reviewed annually and maintained for a period of five years. The repeat/reject rate will be tracked and should be within or below the national average repeat rate of 8%. Trends indicating a deterioration in performance or increase in patient dose should be investigated.

4.6.2. Nuclear Medicine Departments: Nuclear medicine departments shall implement a quality control program for gamma cameras consisting of the following four elements (*Note:* other aspects of these departments quality control program are controlled by USAF Radioactive Material Permit):

4.6.2.1. Acceptance Testing: A qualified medical physicist shall perform acceptance testing of a gamma camera prior to clinical use. The following tests shall be performed, based on current standards of practice (ref: American Association of Physicists in Medicine Report Numbers: 6, 9, 22, and 52): physical inspection of mechanical and electrical components, intrinsic energy peaking, intrinsic energy resolution, head shielding integrity, intrinsic and extrinsic uniformity, intrinsic linearity and spatial resolution, pixel size calibration, collimator integrity, rotational uniformity, maximum count rate performance, collimator sensitivity, center-of-rotation, temporal resolution, multiple window spatial resolution, and SPECT phantom evaluation. The following tests should be performed: intrinsic off-peak uniformity, collimator hole angulation, and system network verification. One must perform the planar imaging tests prior to the SPECT imaging tests. For multiple-plane gamma cameras, each plane or camera head must be evaluated and held within a tight tolerance of the other imaging planes. Also, each collimator must be evaluated for the respective tests for collimators and center-of-rotation. Documentation of the acceptance test shall be maintained for the duration of system use.

4.6.2.2. Technologists QC Program: Routine QC shall be performed by nuclear medicine technologists each day the equipment is used, prior to clinical use. Technologists are responsible for ensuring the tested parameters are within performance limits. Each manufacturer provides minimal QC instructions in their associated operator's manual and the performance limits for each required test. If no manufacturer's guidance, at a minimum, technologists must perform the following: energy peaking and extrinsic uniformity (flood) measurements daily; and center-of-rotation, intrinsic uniformity, and intrinsic linearity/ resolution images weekly. Potential trends should be tracked for energy peaking, center-of-rotation, intrinsic uniformity, and sensitivity. The SPECT phantom test should be performed once a quarterly plus a monthly uniformity test of each collimator. Documentation (electronic or film) of the uniformity, center-of-rotation, collimator, and SPECT phantom data shall be maintained for three years.

4.6.2.3. Preventive Maintenance: The manufacturer or a third party contractor should perform preventive maintenance on the gamma camera twice a year. The service contract should provide for additional site visits when problems occur.

4.6.2.4. Periodic Physics Inspection: A medical physicist shall implement a periodic QC program based on equipment age and performance. The specific tests listed in the acceptance testing section (Section 4.6.2.1) should be completed as well as using the data collected by the technologists.

4.6.3. Radiation Oncology Departments using Therapy Linear Accelerators: Radiation oncology departments shall implement a quality control program overseen by a qualified therapeutic radiological physicist to insure the safe and optimum use of radiotherapy simulators, therapeutic x-ray units, medical linear accelerators, radiation therapy treatment planning systems, brachytherapy sources, therapeutic radiopharmaceuticals, and associated ancillary equipment. See sections 4.11.3., 4.12.4. and 4.12.4.5 for additional specific requirements.

4.7. Specific Radiation Safety Requirements for Stationary Radiography (including digital radiography and dental radiography). In addition to the general requirements specified under section 4.4, the following requirements shall be applied to use of stationary radiographic systems:

4.7.1. Measurements of radiation exposure for each diagnostic x-ray unit shall be measured annually by MERC or BMET personnel. Measurements shall be made at least once every four years for dental x-ray units. The regional and/or MTF health or medical physicist shall use this data to estimate patient entrance skin exposures (ESE) for common radiographic procedures (ref: AAPM Monograph 20, 1991 AAPM Annual Summer School Proceedings held at University of California, Santa Cruz and OEHL Technical Report 97-12, DOSIMETRY IN DIAGNOSTIC RADIOLOGY, A Guide for Meeting JCAHO and ACR Requirements and ICRP Recommendations, Armstrong Laboratory, Occupational and Environmental Health Directorate, Brooks Air Force Base, TX, 1997) These ESEs will be available to each MTF.

4.7.2. Exposures which are double the National Evaluation of X-Ray Trends (NEXT) data in **Table 4.1** for the appropriate speed system used, should be evaluated. Exposures should not exceed the Entrance Skin Exposure Guidance (ESEG) listed in **Table 4.1**

4.7.3. A technique chart relevant to the particular radiation producing machine shall be provided or electronically displayed in the vicinity of the control panel and used by all operators.

Table 4.1. Selected for Entrance Skin Exposure Guidance (ESEG) for Common Diagnostic Procedures .

Projection	Patient Thickness (cm)	NEXT (200 speed) (mR) ^a	NEXT (400 speed) (mR)	ESEG (mR)
Chest (PA)	23	25	15	30
Skull (Lat)	15	145	70	300
Abdomen (AP)	23	490	300	750
Cervical Spine (AP)	13	135	95	250
Thoracic Spine (AP)	23	260	145	900
Full Spine (AP)	23			300
Lumbar Spine (AP)	23	570	330	
Lumbo-Sacral Spine (AP)	23			1000

Retrograde Pyelogram (AP)	23		900
Dental/Bitewing	0	334	700

^aConference of Radiation Control Program Directors, Inc 1991

4.8. Specific Radiation Safety Requirements for Fluoroscopy. In addition to the general requirements specified under section 4.4, the following requirements shall be applied to use of fluoroscopic systems.

4.8.1. Specific Radiation Safety Requirements for General Fluoroscopy.

4.8.1.1. Fluoroscopic tabletop radiation exposure rates and spot films/cine exposures shall be measured annually. The regional and/or MTF health or medical physicist shall use this data to provide patient entrance skin exposure rates to each MTF or clinic. Clinicians shall be aware of the radiation exposure rates for the specific fluoroscopic system and for each mode of operation used during the clinical protocol.

4.8.1.2. The radiation exposure rate used in fluoroscopy should be as low as is consistent with fluoroscopic requirements and not exceed those listed in 10 CFR 1020.32 at the point where the beam enters the patient.

4.8.1.3. The total exposure time, physician, procedure type, and unit should be recorded for all fluoroscopic exams except during simulation for radiation therapy (general fluoroscopy, angiography, cardiac catheterization lab, etc.) per FDA guidelines. This data should be monitored on a monthly or quarterly basis to identify equipment, procedural, or personnel issues resulting higher than average exposures (i.e., average values listed in AAPM Report No. 58, *Managing the use of Fluoroscopy in Medical Institutions*).

4.8.1.4. The smallest practical field sizes and the shortest irradiation times shall be employed, consistent with clinical objectives.

4.8.1.5. Medical fluoroscopy shall be performed only by or under the immediate supervision of a physician properly trained in fluoroscopic procedures. The physician shall understand the proper use and limitations of the device to avoid needless exposure of the patient and other persons in the vicinity during use.

4.8.1.6. Protective lead aprons of at least 0.5 mm lead equivalence shall be worn in the fluoroscopy room by all personnel (except the patient) during all fluoroscopy operations.

4.8.1.7. Lead gloves of at least 0.25 mm lead equivalent should be worn by physicians during near beam work. The physician should not place hands in the direct beam, even with lead glove protection. If not using gloves, a ring dosimeter should be used.

4.8.1.8. Eye protection in the form of leaded glass shields or leaded (prescription) eye glasses should be used for clinicians with high fluoroscopic workloads, such as those frequently performing interventional angiography and cardiac catheterization procedures.

4.8.2. Specific Radiation Safety Requirements for Portable Fluoroscopic and Radiographic Procedures. In addition to the general requirements specified under section 4.4, the following additional requirements shall be applied to portable fluoroscopic and radiographic procedures (with the exception of microamp orthopedic units).

4.8.2.1. All unessential personnel possible shall stand at least 2 m (6 ft) from the patient, the x-ray tube and the useful beam during procedures.

4.8.2.2. Mobile equipment should be used only for examinations when it is not practical or of necessary expediency to transfer patients to fixed radiographic or fluoroscopic installations.

4.8.3. Specific Radiation Safety Requirements for Cardiac and Fluoroscopically Guided Procedures, and Simulators used for Radiation Therapy. In addition to the general requirements specified under section 4.4, the following additional requirements shall be applied during cardiac and interventional radiography procedures, pain management procedures and procedures involving simulators used in planning radiation therapy:

4.8.3.1. In serial (cine) radiography, the number of films per second and the duration of the procedure should be kept to a minimum, consistent with clinical objectives.

4.8.3.2. Cardiac/simulator fluoroscopy shall be performed only by or under the immediate supervision of a physician properly trained in cardiac/simulator fluoroscopic procedures.

4.8.3.3. Avoidance of Serious X-Ray-Induced Skin Injuries to Patients During Fluoroscopically-Guided Procedures (ref: Burlington B.D., *FDA Public Health Advisory: Avoidance of Serious X-Ray-Induced Skin Injuries to Patients During Fluoroscopically-Guided Procedures*). To avoid skin doses which may result in acute injury, facilities performing fluoroscopically-guided procedures shall:

4.8.3.3.1. Establish and document standard operating procedures and clinical protocols for each specific type of interventional procedure performed. The protocols should address all aspects of the procedure, such as patient selection, normal conduct of the procedure, actions in response to complications and consideration of limits on fluoroscopy exposure time. Protocols should also include a mechanism to report estimated patient exposure to the patient's primary care physician for follow-up of lengthy procedures that might result in delayed reactions.

4.8.3.3.2. Assess the impact of each procedure's protocol on the potential for radiation injury to the patient.

4.8.3.3.3. Modify the protocol, as appropriate, to limit the cumulative absorbed dose to any irradiated area of the skin to the minimum necessary for the clinical tasks, and particularly to avoid approaching cumulative doses that would induce unacceptable adverse effects. Use equipment that aids in minimizing absorbed dose.

4.8.3.3.4. Enlist a qualified medical physicist to assist in implementing these protocols in such a manner so as not to adversely affect the clinical objectives of the procedure.

4.8.3.3.5. Report, IAW the Safe Medical Devices Act of 1990 (SMDA) and 21 CFR Parts 803 to 807, any fluoroscopically induced injuries, following the procedures established by the facility for such mandatory reporting. Practitioners who become aware of any medical device related adverse event or product problem/malfunction should report to their Medical Device User Facility Reporting person. **NOTE:** Physicians should know that radiation-induced injuries from fluoroscopy are not

immediately apparent. Other than the mildest symptoms, such as transient erythema, the effects of the radiation may not appear until weeks following the exposure. Physicians performing these procedures may not be in direct contact with the patients following the procedure and may not observe the symptoms when they occur. Missing the milder symptoms in some patients can lead to surprise at the magnitude of the absorbed doses delivered to the skin of other patients when more serious symptoms appear. For this reason, the FDA recommends information be recorded in the appropriate folder from the AF Form 2100A series. Patients should also be informed via the consent form SF 522, *Request for Administration of Anesthesia and for Performance of Operations and Other Procedures*, of potential injuries and advised to report signs and/or symptoms of radiation induced injury to their attending physician.

4.9. Specific Radiation Safety Requirements for Mammography Procedures. In addition to the general requirements specified under section 4.4, the following requirements shall be applied during mammography procedures.

4.9.1. All Mammography services offered by USAF medical facilities shall adhere to the requirements of the Mammography Quality Standards Act, Title 21 CFR Parts 16 and 900.

4.9.2. Diagnostic imaging technologists shall meet the federal standards of the Mammography Quality Standards Act of 1992 (MQSA) (Public Law 102-539), and the American Society of Radiologic Technologists (ASRT) Position Statement and Scopes of Practice for technologists.

4.10. Specific Radiation Safety Requirements for Computed Tomography Procedures. In addition to the general requirements specified under section 4.4, the following requirements shall be applied to computed tomography procedures.

4.10.1. The slice thickness should be as great as practical and the number of slices in the study should be as small as possible.

4.10.2. Contrast studies should be made only when necessary to provide critical diagnostic information.

4.10.3. The user shall be familiar with the relationship between patient dose (both the maximum values and its distribution) and the operation techniques factors (kVp, mAs per slice and slice thickness) for the system. Special attention shall be given to pediatric patients. Patient size shall be matched to exposure settings and inappropriate referrals should be eliminated.

4.10.4. Dose measurements of the radiation output of the CT x-ray system shall be performed by a qualified expert on an annual basis, or when a major change (i.e tube replacement) occurs in the system or in system operation. The computed tomography dose index (CTDI) or the multiple scan average dose (MSAD) shall be determined for common system parameters using the current procedures prescribed by the AAPM (ref: AAPM Monograph 20, *1991 AAPM Annual Summer School Proceedings held at University of California, Santa Cruz*).

4.11. Specific Requirements for Photon Therapy Systems Using Energies Less Than 500 kV. In addition to the general requirements specified under section 4.4, the following

requirements shall be applied to radiation therapy systems operated at a potential less than 500 kV.

4.11.1. Operating Procedures.

4.11.1.1. When a patient must be held in position for radiation therapy, mechanical supporting or immobilization aids shall be used;

4.11.1.2. The tube housing assembly shall not be held by an individual during operation unless the assembly is designed to require such holding and the peak tube potential of the system does not exceed 50 kV. In such cases, the holder shall wear protective gloves and apron of not less than 0.5 millimeters lead equivalency at 100 kV;

4.11.1.3. A copy of the current operating and emergency procedures shall be maintained at the therapeutic radiation machine control console; and

4.11.1.4. Any individual, other than the patient, in the treatment room shall be protected by a barrier sufficient to prevent exposures from exceeding applicable limits.

4.11.2. Calibration Requirements.

4.11.2.1. Frequency. Full calibration of a therapeutic radiation machine subject to [4.11](#) shall be performed by, or under the direct supervision of, a qualified radiation therapy physicist:

4.11.2.1.1. Before the first medical use following installation or reinstallation of the therapeutic radiation machine;

4.11.2.1.2. At intervals not exceeding 1 year;

4.11.2.1.3. Whenever quality assurance check measurements indicate that the radiation output differs by more than 2 percent from the value obtained at the last full calibration and the difference cannot be reconciled; and

4.11.2.1.4. Following any component replacement, major repair, or modification of components that could significantly affect the characteristics of the radiation beam.

4.11.2.2. Calibration Requirements. Full calibration shall include all measurements recommended for annual calibration by the most current applicable AAPM report or NCRP Report 69, *Dosimetry of X-Ray and Gamma Ray Beams for Radiation Therapy in the Energy Range 10 keV to 50 MeV*.

4.11.2.3. Record Keeping. The department shall maintain a record of each calibration for five years. The record shall include: the date of the calibration; the manufacturer's name, model number, and serial number for both the therapeutic radiation machine and the X-ray tube; the model numbers and serial numbers of the instruments used to calibrate the therapeutic radiation machine; and the signature of the Radiation Therapy Physicist responsible for performing the calibration.

4.11.3. Periodic Quality Assurance Checks.

4.11.3.1. Periodic quality assurance checks shall be performed on therapeutic radiation machines IAW written procedures established by the Radiation Therapy Physicist with the procedures specifying the frequency at which tests or measurements are to be

performed, and the acceptable tolerance of the check. Checks shall include monthly assessment of:

- 4.11.3.1.1. Electrical interlocks at each external beam radiation therapy room entrance;
 - 4.11.3.1.2. The "BEAM-ON" and termination switches;
 - 4.11.3.1.3. Beam condition indicator lights on the access door(s), control console, and in the radiation therapy room;
 - 4.11.3.1.4. Viewing systems;
 - 4.11.3.1.5. If applicable, electrically operated treatment room doors from inside and outside the treatment room.
- 4.11.3.2. The cause for a parameter exceeding a tolerance set by the Radiation Therapy Physicist shall be investigated and corrected before the system is used for patient irradiation;
- 4.11.3.3. Whenever a quality assurance check indicates a significant change in the operating characteristics of a system, as specified in the Radiation Therapy Physicist's quality assurance check procedures, the system shall be recalibrated as required;
- 4.11.3.4. The department shall have the Radiation Therapy Physicist review and sign the results of each radiation output quality assurance check within 1 month of the date that the check was performed;
- 4.11.3.5. The department shall maintain a record of each quality assurance check for five years. The record shall include: the date of the quality assurance check; the manufacturer's name, model number, and serial number of the therapeutic radiation machine; the manufacturer's name; model number and serial number for the instrument(s) used to measure the radiation output of the therapeutic radiation machine; and the signature of the individual who performed the periodic quality assurance check.

4.12. Specific Requirements for Photon Therapy Systems (500 kV and Above) and Electron/Proton Therapy Systems. In addition to the general requirements specified under section 4.4, the following requirements shall be applied to radiation therapy systems operated at a potential at 500 kV and above, and for electron or proton therapy systems:

- 4.12.1. Therapy Physicists: The services of a Radiation Therapy Physicist shall be required in facilities having therapeutic radiation machines with energies of 500 kV and above. The Radiation Therapy Physicist shall be responsible for:
- 4.12.1.1. Full calibration(s) and protection surveys;
 - 4.12.1.2. Supervision and review of patient dosimetry;
 - 4.12.1.3. Beam data acquisition and transfer for computerized dosimetry, and supervision of its use;
 - 4.12.1.4. Quality assurance, including quality assurance check review;
 - 4.12.1.5. Consultation with the Radiation Oncologist in treatment planning, as needed; and

4.12.1.6. Perform calculations/assessments regarding misadministrations.

4.12.1.6.1. If the Radiation Therapy Physicist is not a full-time employee of the MTF, the operating procedures required by 4.12.2 shall also specifically address how the Radiation Therapy Physicist is to be contacted for problems or emergencies, as well as the specific actions, if any, to be taken until the Radiation Therapy Physicist can be contacted.

4.12.2. Operating Procedures.

4.12.2.1. No individual, other than the patient, shall be in the treatment room during treatment or during any irradiation for testing or calibration purposes;

4.12.2.2. Therapeutic radiation machines, when not in operation, shall be secured to prevent unauthorized use;

4.12.2.3. When adjustable beam-limiting devices are used, the position and shape of the radiation field shall be indicated by a light field.

4.12.2.4. If a patient must be held in position during treatment, mechanical supporting or immobilization devices shall be used; and

4.12.2.5. A copy of the current operating and emergency procedures shall be maintained at the therapeutic radiation machine control console.

4.12.3. Acceptance Testing, Commissioning and Full Calibration Measurements.

4.12.3.1. Acceptance testing, commissioning and full calibration of a therapeutic radiation machine subject to section 4.12 shall be performed by a qualified radiation therapy physicist meeting requirements in section 4.2.2

4.12.3.2. Acceptance testing should be performed IAW manufacturer's recommendations or any additional contractual requirements before the first medical use following installation or reinstallation of the therapeutic radiation machine. Commissioning should be accomplished using "AAPM Code of Practice for Radiotherapy Accelerators: Report of AAPM Radiation Therapy Task Group 45" and shall be conducted before the first medical use of that particular beam or modality following installation or reinstallation of the therapeutic radiation machine.

4.12.3.3. Full calibration should include measurement of all parameters required by Table II of "Comprehensive QA for Radiation Oncology: Report of AAPM Radiation Therapy Committee Task Group 40" and should be performed IAW AAPM Code of Practice for Radiotherapy Accelerators: Report of AAPM Radiation Therapy Task Group 45. Although it shall not be necessary to complete all elements of a full calibration at the same time, all parameters (for all energies) shall be completed at intervals not exceeding 12 calendar months.

4.12.3.4. The Radiation Therapy Physicist shall perform all elements of a full calibration necessary to determine that all parameters are within acceptable limits:

4.12.3.4.1. Whenever quality assurance check measurements indicate that the radiation output differs by more than 2 percent from the value obtained at the last full calibration and the difference cannot be reconciled. Therapeutic radiation machines

with multi-energy and/or multi-mode capabilities shall only require measurements for those modes and/or energies that are not within their acceptable range; and

4.12.3.4.2. Following any component replacement, major repair, or modification of components that could significantly affect the characteristics of the radiation beam. If the repair, replacement or modification does not affect all modes and/or energies, measurements shall be performed on the effected mode/energy that is in most frequent clinical use at the department.

4.12.3.5. The department shall maintain a record of each calibration in an auditable form for five years. The record shall include: the date of the calibration; the manufacturer's name, model number and serial number for the therapeutic radiation machine; the model numbers and serial numbers of the instruments used to calibrate the therapeutic radiation machine; and the signature of the Radiation Therapy Physicist responsible for performing the calibration.

4.12.4. Periodic Quality Assurance Checks.

4.12.4.1. Periodic quality assurance checks shall be performed on all therapeutic radiation machines subject to section 4.12 at intervals not to exceed those specified in "Comprehensive QA for Radiation Oncology: Report of AAPM Radiation Therapy Committee Task Group 40";

4.12.4.2. To satisfy the requirement of 4.12.4 quality assurance checks shall include determination of central axis radiation output and a representative sampling of periodic quality assurance checks contained in "Comprehensive QA for Radiation Oncology: Report of AAPM Radiation Therapy Committee Task Group 40". Representative sampling shall include all referenced periodic quality assurance checks in an interval not to exceed 12 consecutive calendar months;

4.12.4.3. The department shall perform periodic quality assurance checks IAW procedures established by the Radiation Therapy Physicist;

4.12.4.4. The department shall review the results of each periodic radiation output check according to the following procedures:

4.12.4.4.1. The Radiation Oncologist or Radiation Therapy Physicist shall be immediately notified if any parameter is not within its acceptable tolerance. The therapeutic radiation machine shall not be made available for subsequent medical use until the Radiation Therapy Physicist has determined that all parameters are within their acceptable tolerances;

4.12.4.4.2. If all quality assurance check parameters appear to be within their acceptable range, the quality assurance check shall be reviewed and signed by either the Radiation Oncologist or Radiation Therapy Physicist; and

4.12.4.4.3. The department shall have the Radiation Therapy Physicist review and sign the results of each radiation output quality assurance check within 1 month of the date that the check was performed; and

4.12.4.5. Therapeutic radiation machines subject to 4.12 shall have safety quality assurance checks listed in "Comprehensive QA for Radiation Oncology: Report of

AAPM Radiation Therapy Committee Task Group 40" performed at intervals not to exceed 1 week; these checks shall ensure proper operation of:

- 4.12.4.5.1. Electrical interlocks at each external beam radiation therapy room entrance;
 - 4.12.4.5.2. Proper operation of the "BEAM-ON", interrupt and termination switches;
 - 4.12.4.5.3. Beam condition indicator lights on the access doors, control console, and in the radiation therapy room;
 - 4.12.4.5.4. Viewing systems;
 - 4.12.4.5.5. Electrically operated treatment room door(s) from inside and outside the treatment room;
 - 4.12.4.6. Emergency power cutoff switch. If more than one emergency power cutoff switch is installed and not all switches are tested at once, each switch shall be tested on a rotating basis (monthly or by manufacturer recommendation). Safety quality assurance checks of the emergency power cutoff switches may be conducted at the end of the treatment day in order to minimize possible stability problems with the therapeutic radiation machine.
 - 4.12.4.7. The department shall promptly repair any system identified above that is not operating properly;
 - 4.12.4.8. The department shall maintain a record of each quality assurance check for five years. The record shall include: the date of the quality assurance check; the manufacturer's name, model number, and serial number of the therapeutic radiation machine; the manufacturer's name; model number and serial number for the instrument(s) used to measure the radiation output of the therapeutic radiation machine; and the identity of the individual who performed the periodic quality assurance check.
- 4.12.5. The following information or records shall be maintained by the MTF in auditable form.
- 4.12.5.1. Reports of acceptance testing;
 - 4.12.5.2. Records of all surveys, calibrations, and periodic quality assurance checks of the therapeutic radiation machine required by section 4.11 and 4.12, as well as the name(s) of person(s) who performed such activities;
 - 4.12.5.3. Records of maintenance and/or modifications performed on the therapeutic radiation machine after the date of this instruction, as well as the name(s) of person(s) who performed such services;
 - 4.12.5.4. Signature of person authorizing the return of therapeutic radiation machine to clinical use after service, repair, or upgrade.

4.13. Report and Notification of a Medical Event.

4.13.1. A radiation oncology service at USAF medical treatment facilities, hereafter referred to as the service, shall report treatment misadministrations. A misadministration is defined as an adverse event which places the patient at risk of injury (except for an event that results

from patient intervention) in which the administration of machine produced radiation results in:

4.13.1.1. A dose that exceeds 0.05 Sv (5 rem) effective dose equivalent, 0.5 Sv (50 rem) to an organ or tissue, or 0.5 Sv (50 rem) shallow dose equivalent to the skin, and any of the following:

4.13.1.1.1. The total dose delivered differs from the prescribed dose by 10 percent or more;

4.13.1.1.2. The fractionated dose delivered exceeds the prescribed dose, for a single fraction, by 50 percent or more;

4.13.1.1.3. An administration of a dose or dosage to the wrong individual;

4.13.1.1.4. An administration of a dose or dosage delivered by the wrong mode of treatment; or

4.13.1.1.5. A geographic miss causing a dose to an organ or tissue other than the treatment site that exceeds 50 percent or more of the prescribed fraction size.

4.13.2. The service shall report any event resulting from intervention of a patient or human research subject in which the administration of machine produced radiation results or will result in an unintended permanent functional damage to an organ or a physiological system, as determined by a physician.

4.13.3. The service shall notify the responsible Medical Group's Chief of Hospital Services (SGH), or his/her designee, no later than the next calendar day after discovery of the medical event. The SGH will then determine, based upon consultation with the responsible oncologist and referring physician or service, whether or not the event involves risk of permanent injury to the patient or subject. If such risk is determined to be present the event becomes a reportable medical misadministration. The Service will then telephonically report the misadministration to the AFMOA/SGZR within 7 calendar days.

4.13.4. The service shall submit a written report to AFMOA/SGZR through the responsible MAJCOM/SGP within 15 days after discovery of the medical event (RCS: HAF-SG(AR)0117, Report of Medical Events and Unplanned Fetal Exposures). This report is designated emergency status code C-1. Continue reporting during emergency conditions.

4.13.4.1. The written report must include --

4.13.4.1.1. The Service's organization and base;

4.13.4.1.2. The name and unit of the prescribing physician, Head of Radiation Oncology, and Head of Medical Physics;

4.13.4.1.3. A brief description of the event;

4.13.4.1.4. Why the event occurred;

4.13.4.1.5. The effect, if any, on the individual(s) who received the administration;

4.13.4.1.6. What actions, if any, have been taken or are planned to prevent recurrence;

4.13.4.1.7. Whether the department notified the individual (or the individual's responsible relative or guardian), and if not, why not; and

4.13.4.1.8. If there was notification, what information was provided.

4.13.4.2. The report may not contain the individual's name or any other information that could lead to identification of the individual.

4.13.5. The service shall notify the referring physician, or, if unavailable, the responsible referring service chief and also notify the individual affected by the medical event no later than 24 hours after its discovery, unless the referring physician or service chief elects to personally inform the individual or that, based on medical judgment, telling the individual would be harmful. The service is not required to notify the individual without first consulting the referring physician. If the referring physician or the affected individual cannot be reached within 24 hours, the service shall notify the individual as soon as possible thereafter. The Service may not delay any appropriate medical care for the individual, including any necessary remedial care as a result of the medical event, because of any delay in notification. To meet the requirements of this section, the notification of the individual receiving the medical event may be made instead to that individual's responsible relative or guardian.

4.13.6. If the individual was notified under [paragraph 4.13.5](#) of this section, the Service shall also furnish a written report to the individual within 15 days after discovery of the medical event. A department may send either --

4.13.6.1. A copy of the report that was submitted to the MAJCOM/SGP; or

4.13.6.2. A brief description of both the event and the consequences as they may affect the individual.

4.13.7. Aside from the notification requirement, nothing in this section affects any rights or duties of facilities, services, and physicians in relation to each other, to individuals affected by the medical event, or to that individual's responsible relatives or guardians.

4.13.8. The service shall retain a record of a medical event for three years. The record shall contain the information specified in [4.13.4.1](#)

4.14. Report and Notification of a Dose to an Embryo/Fetus or Nursing Child.

4.14.1. A medical or dental clinic shall report any cumulative dose to a conceptus (i.e., conception thru embryo/fetus developmental stages) or nursing child that is greater than 50 mSv (5 rem) dose equivalent that is a result of the administration of machine produced radiation and/or radioactive materials to a pregnant individual or nursing mother from studies/treatments where the resultant dose was not specifically approved, in advance, by the requesting physician.

4.14.2. The clinic shall notify the responsible Medical Group's Chief of Hospital Services (SGH), or his/her designee, and the IRSO of any actual or potential dose to the conceptus that meets the reporting criteria as specified in Section 4.14.1 within the following time suspenses: immediately after discovery for incidents involving radioactive materials, and within 24 hours after discovery for incidents involving radiation producing devices. In addition, for incidents involving radioactive materials, notify AFMSA/SG3PB (Radiation Programs) by telephone per the reporting criteria specified in AFI 40-201, Atch 11; for

incidents involving machine produced radiation, notify AFMSA/SG3PB (Radiation Program) by telephone no later than seven calendar days after discovery.

4.14.3. The clinic shall submit a written report to AFMSA/SG3PB (Radiation Programs) through the IRSO and appropriate MAJCOM/SGP no later than 15 days after discovery of a dose to the conceptus or nursing child that requires a report in Section **4.14.1**

4.14.3.1. The written report must include --

4.14.3.1.1. The organization and base;

4.14.3.1.2. The name and organization of the prescribing physician, head of service and responsible medical physicist or Radiation Safety Officer;

4.14.3.1.3. A brief description of the event;

4.14.3.1.4. Why the event occurred;

4.14.3.1.5. The effect, if any, on the embryo/fetus; and

4.14.3.1.6. What actions, if any, have been taken or are planned to prevent recurrence;

4.14.4. The service shall notify the referring physician, or if unavailable, the referring physician's service responsible chief of service and also notify the pregnant individual or mother, both hereafter referred to as the mother, no later than 24 hours after discovery of an event that would require reporting under **paragraph 4.14.1** of this section, unless the referring physician or chief of service personally informs the service either that he or she will inform the mother or that, based on medical judgement, telling the mother would be harmful.

4.14.5. To meet the requirements of this section, the notification may be made to the mother's or child's responsible relative or guardian instead of the mother, when appropriate.

4.14.6. The service is not required to notify the mother without first consulting with the referring physician. If the referring physician or mother cannot be reached within 24 hours, the service shall make the appropriate notifications as soon as possible thereafter. The service may not delay any appropriate medical care for the embryo/fetus or for the nursing child, including any necessary remedial care as a result of the event, because of any delay in notification.

4.14.7. If notification was made under **paragraphs 4.14.4** and **4.14.5** of this section, the department shall also furnish a written report to the mother or responsible relative or guardian within 15 days after discovery of the event. The service may send either --

4.14.7.1. A copy of the report that was submitted to AFMOA/SGZR; or

4.14.7.2. A brief description of both the event and the consequences as they may affect the embryo/fetus.

4.14.8. A service shall retain a record of a dose to an embryo/fetus or a nursing child reported in accordance with this section for 3 years. The record shall contain the information specified in section **4.14.3.1**

Chapter 5

RADIATION PROTECTION OF THE GENERAL PUBLIC

5.1. General. Public exposures of concern for the purposes of this instruction include those resulting directly from USAF occupational and medical practices, and those resulting from uncontrolled sources such as naturally occurring radiation and from accidents or incidents.

5.2. Control of General Public Exposures from USAF Practices. In almost all cases, engineering controls, policies or procedures are implemented to control general public exposures from USAF practices. The following requirements are specified for all USAF practices that may result in public exposure:

5.2.1. All practices shall be conducted so as to minimize general public exposures, with economic, military and social factors being taken into account.

5.2.2. All practices shall be conducted in such a manner that a member of the general public will not exceed the dose limits specified in **Table A4.1**. For non-medical practices, the installation RSO shall be responsible for the assessment either by measurement or calculation that this dose is not exceeded, and maintain this record for a period of three years. For medical practices, the responsible medical physicist, health physicist or bioenvironmental engineer, as appropriate, shall be responsible for this assessment.

5.2.3. Unrestricted areas. The dose in any unrestricted area resulting from USAF controlled radiation sources will not exceed 0.02 mSv (2 mrem) in any one hour, or 1 mSv (100 mrem) in a year, occupancy and use factors being taken into account. This requirement does not apply to those excepted by 10 CFR 35.75. The installation RSO shall be responsible for the assessment, either by measurement or calculation that these dose rates are not exceeded, and maintain this record for a period of three years.

5.2.4. Control of Visitors.

5.2.4.1. Visitors to any restricted area must be accompanied by persons knowledgeable about the protection and safety measures in the area.

5.2.4.2. Visitors must be provided adequate information and instruction before they enter a restricted area to ensure appropriate protection of the visitors and of other personnel in the area.

5.2.4.3. Visitors entering defined "Radiation Areas" or "High Radiation Areas", or that could incur a deep dose equivalent in excess of 0.10 mSv (10 mrem) shall be provided personal monitoring devices. The department shall maintain a log of all such monitored individuals, and communicate the results of monitoring to the individual.

5.2.5. Public Overexposures. If an individual member of the general public may have received a dose in excess of the applicable limit in **Table A4.1**, that dose and practice shall be immediately investigated by the installation RSO. If appropriate, the unit, organization or installation RSO should implement, with commander's approval, protective actions to mitigate further exposures.

5.2.5.1. Notification:

5.2.5.1.1. When a member of the general public may have received a dose above the limits set in **Table A4.1**, the installation RSO shall be contacted immediately, who in-turn should contact AFIERA/SDRH ((210) 393-6968) to validate the assessment of dose.

5.2.5.1.2. If the dose is validated, the installation RSO should then notify within 3 hours the MAJCOM Bioenvironmental Engineer and AFMOA/SGZR, in-turn.

5.2.5.2. Reporting: The installation RSO, with the assistance of AFIERA/SDRH, shall investigate suspected exposures above the limits specified in **Table A4.1**, with a written report of the investigation submitted through the MAJCOM Bioenvironmental Engineer to AFMOA/SGZR within 7 days of notification (RCS: HAF-SG(AR)0116, Report of Occupational or Public Overexposure to Radiation). This report is designated emergency status code C-1. Continue reporting during emergency conditions. The written report must include:

5.2.5.2.1. The organization's name and office symbol where the exposure occurred

5.2.5.2.2. A brief description of the event

5.2.5.2.3. A description of the person(s) exposed and their estimated dose equivalent

5.2.5.2.4. Why the event occurred

5.2.5.2.5. What actions, if any, have been taken or are planned to prevent recurrence;

5.3. Protection of the General Public from Uncontrolled Radiation Sources. This section specifies requirements to protect members of the general public from uncontrolled sources of ionizing radiation. Two specific sources are identified: general public exposures resulting from natural sources of radiation, specifically radon, and general public exposures that may occur from a nuclear or radiological incident. For each case, interventions may be necessary to protect the public. For the prior case, the exposure at which an intervention is merited is referred to as a remedial action level. During a nuclear or radiological incident, a protective action or intervention is merited when a certain dose, referred to as the avertable dose, can be avoided by conducting the intervention or implementing the protective action.

5.3.1. Radon Exposure: Radon is a naturally occurring decay product of uranium that can infiltrate structures. The decay of radon produces a series of radioactive progeny, which, when inhaled, can lead to exposure of the bronchial epithelium, principally by alpha radiation. Radon in existing structures, either residences or places of work can only be influenced by an intervention, i.e. mitigation. The following requirements are specified to address those facilities and operating locations not originally assessed in the USAF Radon Assessment and Mitigation Program of 1987 (USAF OEHL Report 87-132RZ0111KRD, *The Bioenvironmental Engineer's Primer to the Air Force Radon Assessment and Mitigation Program (RAMP)*). During that study, all installations at the time were screened for radon in existing structures. Bases were classified as being of low, medium or high risk if any of the screening measurements identified at least one department with radon concentration greater than 4 pCi/l (EPA medium risk guideline), or 20 pCi/l (EPA high risk guideline).

5.3.1.1. Newly Constructed or Acquired Structures on Medium and High Risk Installations: Any new enclosed structure for installations that underwent a detailed assessment as part of the Radon Assessment and Mitigation Program of 1987 shall be

assessed by the installation RSO for exposure to radon progeny, with the exception of: hangars, maintenance bays, dedicated storage facilities, structures occupied less than four hours per day, temporary facilities, and elevated structures with unobstructed air flows underneath.

5.3.1.1.1. New structures should not be tested for one year after construction to allow for foundation settling.

5.3.1.1.2. Monitoring shall be performed using a long-term monitor (e.g. alpha track detector or long-term electret), processed by an EPA certified supplier, in the lowest occupied location of the structure.

5.3.1.1.3. Structures identified with radon concentrations greater than 4 pCi/l (resulting in exposures of 3.5×10^{-3} Jh/m³ per year or one WLM per year) shall be remediated by base civil engineering to levels as low as reasonably achievable, and result in exposures less than 4 pCi/l (or one WLM per year). The remediation schedule should adhere to the following schedule: > 20 pCi/l within one year, 4-20 pCi/l, within 1-3 years. All structures requiring remediation shall be remediated within 6 years from the time of assessment.

5.3.1.1.4. Structures having been remediated shall be reassessed by the installation RSO for ambient radon concentrations no less than two weeks and no greater than 6 months post remediation to validate the efficacy of the remedial action. A combination of short-term and long-term monitoring should be conducted to assure acceptable radon levels have been achieved.

5.3.1.2. New Installations or Installations Never Previously Assessed: For existing installations not assessed during the Radon Assessment and Mitigation Program of 1987, and for all new, permanent operating locations, a random sampling of the structures shall be assessed for radon. AFI- ERA shall be consulted on designing an appropriate sampling program. Any installation found to have a single structure with concentrations greater than 4 pCi/l shall undergo a detailed assessment, consistent with the Radon Assessment and Mitigation Program of 1987.

5.3.1.3. Base civil engineering should design and construct new structures on bases on medium and high risk bases with radon resistant features.

5.3.1.4. **(Added-BOLLINGAFB)** Bolling AFB is considered a low radon risk based on the Radon Assessment and Mitigation Program (RAMP) Initial Screen Survey Results. Mitigation and additional sampling is not required.

5.3.2. Exposure Resulting from Other Natural Sources of Radiation: On rare occasions, members the general public may be exposed to natural sources of radiation, other than radon, that are significant. If the installation RSO becomes aware of conditions when exposures to a member of the general public from a natural source, other than radon, would exceed 5 mSv (500mrem) annually, AFIERA/SDRH through the MAJCOM Bioenvironmental Engineer should be consulted for additional guidance.

5.3.3. Uncontrolled Exposures Resulting from Radiological Incidents and Accidents.

5.3.3.1. Members of the general public that are under the protection of an installation commander shall be protected during emergency situations from exposure to radiation to

the greatest extent possible. Specific protective measures that can be implemented are listed in **Attachment 6, Table A6.2**. The decision to invoke a protective action, i.e. sheltering or evacuation, should be based on whether the action will allow the population to avert (or avoid) the recommended threshold dose provided with a given action or intervention. Political, military, legal or other factors will also influence implementing a given protective action.

5.3.3.2. **Table A6. 2.**, (IAEA, *Intervention Criteria in a Nuclear or Radiation Emergency*, Safety Series No. 109 and IAEA, *International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources*, Safety Series No. 115) specifies *generic intervention levels* (GILs) at which urgent and longer-term protective actions should be taken to protect the general public. These levels were selected so that the protective actions would do more good than harm. For example, potassium iodide (100 mg IPO) should be administered if a thyroid dose of 100 mGy (10 rad) or greater is expected to occur as a result of some accident or incident. It must be recognized that implementing a protection action carries its own inherent risks. Specified GILs are intended to allow avoidance of health risks from radiation exposure that would be greater than the risks posed by the protective action. Applying protective actions at considerably lower or higher GIL values could increase the overall risk to the general public or workers.

5.3.3.3. GILs are difficult to apply in emergency situations because they cannot be directly measured. Local or regional planners should derive Operational Intervention Levels (OILs) for easily measured quantities that allow determination of whether a protective action should be implemented (refer to **Table A6.2**).

Chapter 6

RADIATION PROTECTION DURING INTERVENTIONS

6.1. General. This chapter provides policy for protecting USAF personnel conducting actions in uncontrolled radiation environments. These environments may include deployed locations where known or suspected nuclear or radiological hazards exist and radiological environments created by hostile action or nuclear incident or accident. Interventions are specific actions performed in these environments to mitigate the source(s) of exposure, to save life or limb, protect high value assets, or achieve higher objectives that may merit personnel incur risks greater than those permitted for practices (RE: section 1.4). This section also applies to nuclear capable units and units with 91(b) material.

6.2. Radiation Protection Policy and Guidance for Interventions.

6.2.1. An intervention should be justified. A proposed intervention should do more good than harm, i.e., the action should be of sufficient value in terms of military objective to be achieved or humanitarian assistance to be rendered so as to justify the harm and costs (including societal costs) of the action.

6.2.2. An intervention should be optimized. The form, scale, and duration of the intervention should be so established that there is maximum benefit and minimum risk and harm to those performing the action. Individual doses should be maintained as low as reasonably achievable.

6.2.3. Dose guidance should be developed for a given intervention. Dose limits do not apply for interventions. Instead, the operational dose guidance (ODG) presented in **Table A7.1** is to be utilized to guide surveillance and protection. The table lists five categories of dose and recommended protection and surveillance actions for doses projected in that range. The commander's decision to allow this exposure should be made in the context of the situation and balance the anticipated benefit with both short and long-term health risks the exposure may cause.

6.2.3.1. Although the dose contributed by ingestion or inhalation of radioactive material cannot be accurately measured in the field, it can be estimated for operational purposes. Depending on the type of radioactive material and its dispersed form, the internal dose may be much larger than the external dose for a given operation.

6.2.3.2. Medical authorities should recommend personal protective equipment (PPE), including respiratory protection. Commanders will dictate PPE use based on operational risk analysis. Operational risk analysis should include the detriment posed by reduced vision, hearing, mobility, and tactile sensation; increased heat and psychological stress; increased time to complete tasks, and decreased task accuracy when wearing PPE. These in turn can lead to increases in external radiation exposures and the magnitude of other mission risks.

6.2.4. Voluntary Participation. Where practical, interventions predicted to result in significant exposures (those greater than practice limits) should make use of volunteers to the greatest extent possible.

6.2.5. Excluded Populations. Operational personnel that are, or may be, pregnant, or that are less than 18 years of age shall not conduct interventions.

6.3. Allowable Contamination Levels.

6.3.1. Attachment 7, Table A7.2 and Table A7.3 provide recommended contamination levels for clothing and equipment for each of the five dose categories listed in Table A7.1. Table A7.2 provides accepted level for a week-long (7 day) operation and Table A7.3 provides comparable values for a 3-month operation.

6.3.2. Contamination detected on skin should be managed through appropriate decontamination to levels that are as low as reasonably achievable using methods described in AFMAN 44-161(1) or AFJ- MAN 44-151. In some operational environments where thorough decontamination may be unavailable, skin contamination should not exceed the levels specified for Category 1A of Table A7.3

6.3.3. Operational implementation of these contamination standards should follow procedures in Allied Engineering Publication-49, *NATO Handbook for Sampling and Identification of Radiological Agents (SIRA), Volume 1 (Operational) and 2 (Forensic)*, or guidance provided by the assigned radiation protection personnel.

6.4. Training and Risk Communication. Personnel participating in an intervention shall be informed of the potential health risks their radiation exposure may result in, and trained in the necessary principles and procedures to minimize their exposure consistent with section 3.3 of this instruction. Dependent on the nature of the intervention, training should be provided by medical radiation protection personnel.

6.5. Monitoring During Interventions. Implementing operational risk management and supporting operational dose guidance requires the ability to estimate or measure individual doses. This is optimally done through the use of radiation survey instruments (e.g. ADM-300, AN/VDR-2, AN/PDR-77), environmental sampling, personnel dosimeters, bioassays, and biodosimetry assays.

6.5.1. Personnel deployed in known or potential radiation environments shall be provided individual dosimeters.

6.5.2. Personnel entering contaminated environments should be afforded in-vitro or in-vivo bioassays to determine the extent of internal exposures if internal contamination is suspected.

6.5.3. If individual dosimetry or prompt bioassay measurements are not available, efforts will be made to estimate individual doses through group dosimetry, radiation survey and environmental monitoring data, modeling, dose reconstructions, or other methods consistent with currently accepted scientific practice.

6.5.4. Systematic, individual dose records for external and internal exposures shall be maintained indefinitely, even if the dosimeter or bioassay result is zero. Results shall be maintained in the USAF MRER, and the individuals medical record.

6.5.4.1. For units for which group dosimetry is used, doses as measured shall be averaged and applied to the entire group for the purposes of applying the Commanders Dose Guidance in Table A7.1. The radiation safety officer supporting the unit shall track unit doses, determine the acceptability of the unit dose to reflect individual doses, and

forward this dose information for each unit member for inclusion in the MRER and the individuals medical records.

6.5.4.2. Classification of exposure data may prevent its inclusion in the MRER. Medical authorities for the command conducting classified operations shall maintain and be able to access all classified exposure data, ensuring all releasable data is available for maintenance in the MRER and to the monitored individual.

6.5.5. Reports of dosimetry or bioassay results shall be given promptly to the potentially exposed individual and their commander or his delegated representative.

6.5.6. The risks of stochastic health effects (e.g. cancer) are considered directly proportional to the total dose received by an individual. Commanders need to be aware of individual dose histories when planning future operations where radiation threats exist.

6.6. Medical Diagnosis and Treatment. Personnel receiving unknown doses of radiation or doses exceeding the limits established for practices should receive care IAW Air Force Manual 44-161 (1), *Treatment of Nuclear and Radiological Casualties*, NCRP Report 65, *Management of Persons Accidentally Contaminated with Radionuclides*; and *NATO Manual AMedP-6(B), NATO Handbook on the Medical Aspects of NBC Defensive Operations, Part I - Nuclear*, or consistent with currently accepted practice.

6.7. Medical Surveillance.

6.7.1. Doses Greater than 50 mSv (5 rem): On completion of a military operation or operations involving radiation exposure, long term, periodic health monitoring is required for individuals receiving cumulative effective doses in excess of 50 mSv (5 rem). Such follow-up shall be formed through AFIERA, and may include, but not be limited to:

6.7.1.1. Creation of a registry for the impacted population.

6.7.1.2. Submission of biological or bioassay samples to determine absorbed dose and residual burdens of radioactive material, respectively.

6.7.1.3. Annual or biannual medical examination, particularly following the latent periods of known radiogenic cancers. Known radiogenic cancers include leukemia, multiple myeloma, lymphomas, thyroid, breast, lung, esophageal, stomach, urinary tract, skin, and colon.

6.7.2. Doses Less than 50 mSv (5 rem): For those personnel who have received doses less than current occupational dose limits, testing and monitoring should be limited to those testing and monitoring programs included in guidelines for the general population (e.g. routine mammography, pap smears, and prostate specific antigen testing).

6.7.2.1. Health monitoring may include submission of bioassay samples to document intakes of radionuclides, and screening for cancers consistent with current medical practices.

PAUL K. CARLTON JR., Lt General, USAF,
MC, CFS Surgeon General

(BOLLINGAFB)

CEDRIC D. GEORGE, Colonel, USAF
Commander

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Abbreviations and Acronyms

AAPM—American Association of Physicists in Medicine

ABC—Automatic Brightness Control

ABR—American Board of Radiology

ABH—American Board of Health Physics

ABMP—American Board of Medical Physics

ACR—American College of Radiology

ADCL—Accredited Dosimetry Calibration Laboratory

AFI—Air Force Instruction

AFIERA—Air Force Institute of Environment, Safety, Occupational Health and Risk Assessment

ALARA—As Low As Reasonably Achievable

ALI—Annual Limits of Intake

AFMAN—Air Force Manual

AFMSA—Air Force Medical Support Agency

AFMOA—Air Force Medical Operations Agency

AFPD—Air Force Policy Directive

AOR—Area of Responsibility

BE—Bioenvironmental Engineer
BMET—Biomedical Equipment Technician
CFR—Code of Federal Regulations
CINC—Commander-in-Chief
CRCPD—Conference of Radiation Control Program Directors
CTDI—Computed Tomography Dose Index
ESEG—Entrance Skin Exposure Guide
FDA—Food and Drug Administration
ICRP—International Commission on Radiological Protection
INRAD—Intrinsic Radiation
HLC—High Level Control
JCAHO—Joint Commission on Accreditation of Health Care Organizations
JTF—Joint Task Force
IAEA—International Atomic Energy Agency
MOOTW—Military Operations Other than War
MERC—Medical Equipment Repair Center
MRER—Master Radiation Exposure Registry
MSAD—Multiple Scan Average Dose
MQSA—Mammography Quality Services Act
MTF—Military Treatment Facility
NATO—North Atlantic Treaty Organization
NBC—Nuclear, Biological and Chemical
NCRP—National Council on Radiation Protection
NEXT—Nationwide Evaluation of X-ray Trends
NIST—National Institutes of Standards and Technology
NRC—Nuclear Regulatory Commission
NORM—Naturally Occurring or Accelerator Produced Material
ODG—Operational Dose Guidance
ORM—Operational Risk Management
PPE—Personal Protective Equipment
RADIAC—Radiation Detection Instrumentation and Calculation
RAM—Radioactive Material

RCS—Reports Control System

RSC—Radiation Safety Committee

RSO—Radiation Safety Officer

SMDA—Safe Medical Devices Act of 1990

SSD—Source-to-Skin Distance

USAFSAM—United States Air Force School of Aerospace Medicine

Terms

91(b) Material—Radioactive material exempted from NRC licensing controls under Section 91(b) of the AEA of 1954, as amended, in the interest of national defense, under the possession of the DOD. These include the radioactive materials in nuclear weapons – e.g. uranium isotopes, plutonium isotopes, tritium, and other radioactive components of nuclear weapons. These also include the components of nuclear reactors that fall under the definition of 91(b).

Absorbed Dose—The energy imparted by ionizing radiation per unit mass of irradiated material. The units of absorbed dose are the rad and the gray (Gy), (100 rad = 1 Gy).

Activity—The rate of disintegration (transformation) or decay of radioactive material. The units of activity are the Curie (Ci) and the becquerel (Bq).

Administrative Dose—The total effective dose equivalent that an RSO assigns when dosimetry is inaccurate or has been misused or lost.

ALARA—Acronym for “as low as is reasonably achievable” means making every reasonable effort to maintain exposures to radiation as far below applicable dose limits as is practical, consistent with the purpose for which the activity is undertaken, taking into account the state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations and in relation to utilization of nuclear energy, radioactive materials, and ionizing radiation in the public interest.

Annual Limit of Intake (ALI)—The derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. The ALI is the smallest value of intake of a given radionuclide in a year that would result in a committed effective dose equivalent of 0.05 Sv (5 rems) or a committed dose of 0.5 Sv (50 rems) to any organ or tissue.

Background Radiation—Radiation from cosmic sources; naturally occurring radioactive material, including radon; and global fallout as it exists in the environment from the testing of nuclear explosive devices or from past nuclear accidents such as Chernobyl that contribute to background radiation. “Background radiation” does not include radiation from source, byproduct, or special nuclear materials that the NRC regulates or from NORM that the Air Force regulates through AFI 40-201.

Becquerel (Bq)—The SI unit of radioactivity equivalent to one nuclear transformation per second.

Bioassay (radiobioassay)—The determination of kinds, quantities or concentrations, and, in some cases, the locations of radioactive material in the human body, whether by direct

measurement (in-vivo bioassay) or by analysis and evaluation of materials excreted or removed from the human body (in-vitro bioassay).

Byproduct Material—Any radioactive material (except source material and special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material.

Curie (Ci)—A unit of radioactivity equal to 37 billion becquerels.

Committed Dose Equivalent—The dose equivalent to organs or tissues that will be received from the intake of radioactive material by an individual during the 50-year period following the intake.

Conceptus—The developing human organism from conception until time of birth. Also referred to as the embryo/fetus.

Declared Pregnant Woman—A woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception.

Deep Dose Equivalent—The dose assigned to personnel from external whole-body exposure, it is the dose equivalent at a tissue depth of one cm (1000 mg/cm²). Expressed in units of rem or seivert (Sv).

Derived Air Concentration (DAC)—The concentration of a given radionuclide in air that, if breathed for a working year of 2,000 hours under conditions of light work (inhalation rate of 1.2 cubic meters of air per hour), results in an inhalation of one ALI.

Deterministic Effect—Biological effects for which the severity of the effect in an exposed individual varies with the dose, and for which a threshold usually exists (e.g. skin erythema and cataracts).

Diagnostic Source—In the healing arts, a source of radiation used in the diagnosis of injury or disease. Includes: x-ray units (fixed, portable, fluoroscopy, computed radiography, computed tomography, etc.), radioactive materials (capsules, liquids or gases) used in nuclear medicine, and radioactive materials used in a laboratory setting to perform “in-vitro” studies (on blood, urine, cells, etc.).

Dose Equivalent—A quantity used for radiation protection to indicate the biological effectiveness of different radiations to cause stochastic health effects (e.g. cancer). The dose equivalent equals the absorbed dose multiplied by a radiation quality factor, Q. Expressed in units of rem or seivert (Sv).

Effective Dose—The sum over specified tissues of the equivalent dose or dose equivalent in a tissue multiplied by a weighting factor for that tissue, wT. Expressed in unit of seivert (Sv) or rem (100 rem = 1

Sv).

Electron Volt (eV)—A unit of energy equal to 1.6×10^{-19} joule.

Equivalent Dose—A quantity used for radiation protection to indicate the biological effectiveness of different radiations to cause stochastic health effects (e.g. cancer). The equivalent dose equals the absorbed dose multiplied by a radiation weighting factor, wR. Expressed in units of seivert (Sv) or rem.

Exposure—In radiation protection, the act or occurrence of being exposed to ionizing radiation or radioactive material. In risk management, the frequency and length of time subjected to a hazard.

Gray (Gy)—The SI unit of any absorbed dose. One gray is equal to the absorption of one joule per kilogram of material (1 Gy =100 rads).

Hazard—Any real or potential condition that can cause injury, illness, death of personnel, damage to or loss of equipment or property, or mission degradation.

High Radiation Area—An area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 1 mSv (100 mrem) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

Installation—A grouping of facilities located in the same vicinity, which support particular functions. Installations may be elements of a base. The term “installation” applies to real properties such as depots, arsenals, hospitals, terminals, and other special mission installations.

Intervention—An activity that is not part of a controlled practice and is intended to reduce or mitigate sources of existing exposure (e.g. radon in structures); actions that save life or limb or mitigate threats greater than that posed by radiation; or those that are done to achieve higher objectives, including those of national security.

Intrinsic Radiation—Ionizing radiation emitted through the weapon surface or directly from exposed components of nuclear weapons.

Investigation Level—A dose set by the installation RSO that requires further investigation when exceeded. Levels are normally tailored to each practice based on historical dosimetry records. The investigation is conducted to determine causative factors, and identify corrective measures, as appropriate.

Ionizing Radiation—Any electromagnetic or particulate radiation capable of producing ions, directly or indirectly in its passage through matter. Ionizing radiation includes gamma rays, X rays, alpha particles, beta particles, neutrons, protons and other particles and electromagnetic waves capable of producing ions.

Lens Dose Equivalent (LDE)—The external exposure of the lens of the eye, taken as the dose equivalent at a tissue depth of 0.3 cm (300 mg/cm²). Expressed in units of rem or seivert (Sv).

Medical Event—An event that meets the criteria in [4.13.1](#)

Member of the General Public—Any individual except when that individual is receiving an occupational dose.

Occupational Dose—The dose received by an individual in the course of employment in which the individual’s assigned duties involve exposure to radiation or to radioactive material from regulated and unregulated sources of radiation, whether in the possession of the employer or other person. Occupational dose does not include dose received from background radiation; from any medical administration the individual has received; from exposure to patients administered radioactive material and released IAW applicable regulations; from voluntary participation in medical research programs; or as a member of the general public.

Practice—Routine, controlled operations that produce radiation exposures as an unavoidable and unintentional aspect of the activity.

Prescribed Dose—(1) For stereotactic radiosurgery, the total dose as documented in the written directive; (2) For external beam radiotherapy, the total dose and dose per fraction as documented in the written directive;

Public—All persons who are not already considered occupationally exposed by a source or practice under consideration.

Qualified Expert—A person who, by virtue of training and experience, can provide competent authoritative guidance about certain aspects of radiation safety. In radiation protection, a person having knowledge and training to provide advice regarding radiation protection principles, standards and measurements. In general, a bioenvironmental engineer or health physicist with training and experience appropriate to the radiation protection issues to be managed is considered a qualified expert. Ideally, persons should have certification from the American Board of Health Physics, the American Board of Medical Physics, the American Board of Radiology, or the American Board of Industrial Hygiene, to be considered a qualified expert in these respective fields.

Note: For the purpose of this instruction, a biomedical equipment repair technician is considered a qualified expert to support quality control, equipment repair, collection of data and calibration IAW AFI41—201.

Note:—For the purpose of this instruction in regards to nuclear medicine or diagnostic radiology: A medical or health physicist may be considered a qualified expert when they have had modality specific training and performed three surveys for a particular type of equipment under the supervision of a board certified medical physicist or a medical physicist who meets all the education, training and experience necessary to complete all aspects of ACR or ABMP board certification.

Note:—For the purpose of this instruction in regards to radiation therapy, a medical physicist must be supervised by a board certified radiation therapy physicist until all education, training and experience necessary to complete board certification is met. In regards to mammography physics, a qualified expert must meet the education, training and experience in FDA's Mammography Quality Standards Act, 10 CFR Part 900.

Note:—For the purposes of this instruction in regards to contingency operations involving radiation threats, a senior health physicist or bioenvironmental engineer with readiness experience (i.e. a current or former member of AFRAT or BE NBC unit type codes) can be considered a qualified expert.

Quality Factor—The modifying factor (listed in 10 CFR 20.1004, tables 1004(b).1 and 1004(b).2) that is used to derive dose equivalent from absorbed dose.

Rad—A conventional unit for the measurement of absorbed dose. One rad is equal to an absorbed dose of 100 ergs per gram of material (1 rad = 0.01 Gy).

Radiation—For the purposes of this regulation, unless otherwise specified, radiation includes both ionizing and nonionizing radiation.

Radiation Area—An area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.05 mSv (5 mrem) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

Radiation Safety—For the purposes of this instruction, a scientific discipline whose objective is the protection of people and the environment from unnecessary exposure to radiation. Radiation safety is concerned with understanding, evaluating, and controlling the risks from radiation exposure relative to the benefits derived. Same as “health physics” and “radiation protection.”

Radiation Safety Committee—An advisory committee for the commander to assess the adequacy of an organization’s radiation safety program. Same as “radiation control committee” and “radiation protection committee.”

Radiation Safety Officer—The person that the commander designates, in writing, as the executive agent for the installation, organization or unit radiation safety program. Same as “radiation protection officer” or “health physics officer.”

Radiation Safety Program—A program to implement the objectives of radiation safety. a. The USAF’s radiation safety program includes all aspects of—

- (1) Measurement and evaluation of radiation and radioactive material pertaining to protection of personnel and the environment.
- (2) USAF compliance with Federal and DOD radiation safety regulations.
- (3) The USAF’s radiation dosimetry, radiation bioassay, radioactive waste disposal, radiation safety training, and radiation instrument and calibration programs.

b. An installation’s radiation safety program includes all aspects of—(1) Measurement and evaluation of radiation and radioactive material at the installation to assure protection of personnel and the environment.

- (2) Compliance with Federal, DOD, and USAF radiation safety regulations.

Radiation Source—Any non-exempt quantity of radioactive material or a device that produces ionizing radiation.

Radiobioassay—See bioassay

Reference Levels—A dose established at one-quarter the applicable annual dose limit, for monitoring performed on a quarterly basis, and one-tenth the applicable annual dose limit for monitoring performed on a monthly basis.

Reject rates—include “repeats/retakes” as well as “waste film” (green, black, clear, test).

Rem—The conventional unit of any of the quantities expressed as dose equivalent. The dose equivalent in rems is equal to the absorbed dose in rads multiplied by a radiation quality factor, Q.

Repeats (or retakes)—are those images that had to be obtained a second time due to error (dark, light, motion, processor etc) thus resulting in a repeated “exposure” to the patient.

Restricted Area—An area, access to which is limited by the facility for the purpose of protecting individuals against undue risks from exposure to radiation sources.

Risk—Chance of hazard or bad consequences; exposure of chance of injury or loss. Risk level is expressed in terms of hazard probability and severity.

Risk Assessment—The identification and assessment of hazards (first two steps of the risk management process).

Occupancy Factor—The fraction of time an area of interest is physically occupied by the same individual.

Operational Risk Management—A logical six step thought process, applicable to any situation or environment, for identifying and controlling hazards to protect the force.

Shallow or Skin Dose Equivalent—The external exposure of the skin or an extremity, taken as the dose equivalent at a tissue depth of 0.007 cm (7 mg/cm²) averaged over an area of 1 cm². Expressed in units of rem or sievert (Sv).

Sievert (Sv)—The SI unit of any of the quantities expressed as equivalent dose. The equivalent dose in sieverts is equal to the absorbed dose in grays multiplied by appropriate radiation weighting factors, w_R.

Stochastic Effects—Health effects that occur randomly and for which the probability of the effect occurring, rather than its severity, is proportional to dose received, assumed without threshold. Examples are hereditary effects and cancer.

Surveys—Periodic determination of the amount of radiation or amount of radioactive material present in an area.

Therapeutic Source—In the healing arts, a source of radiation used in the treatment of disease, normally cancer. Includes high energy linear accelerators generating x-rays and/or electron beams used in radiation therapy, radioactive material based therapy units (e.g. using Co-60), sealed radioactive sources (e.g. Cs-137, Ir-192, I-125) temporarily or permanently implanted within a patient, and unsealed radioactive drugs (e.g. I-131) used for patient treatment.

Total Effective Dose—The sum of the deep-dose equivalent (for external exposures) and the committed effective dose (for internal exposures).

Unrestricted Area—An area, access to which is neither limited nor controlled (for the purposes of ionizing radiation safety).

Use Factor—The fraction of time a particular device is utilized, or the fraction of time the primary beam of a device is directed towards a given area.

Very High Radiation Area—An area, accessible to individuals, in which radiation levels could result in an individual receiving an absorbed dose in excess of 5 gray (500 rads) in 1 hour at 1 meter from a radiation source or from any surface that the radiation penetrates.

Weighting Factor (Radiation)—A factor that accounts for differences in biological effectiveness between different radiations.

Weighting Factor (Organ or Tissue)—For an organ or tissue, the proportion of the risk of stochastic effects resulting from irradiation of that organ or tissue to the total risk of stochastic effects when the whole body is irradiated uniformly.

Working Level—Defined as the concentration of radon progeny which has a potential alpha energy release of 1.3x10⁵ MeV per liter of air. One working level month is the exposure incurred from being exposed to a concentration of one working level for 170 hours.

Table A1.1.—Prefix Symbols for Units

10 ¹⁸ exa –E	10 ⁻³ milli - m
10 ¹⁵ peta – P	10 ⁻⁶ micro - μ
10 ¹² tera – T	10 ⁻⁹ nano - n
10 ⁹ giga – G	10 ⁻¹² pico - p
10 ⁶ mega – M	10 ⁻¹⁵ femto - f
10 ³ kilo –k	10 ⁻¹⁸ atto - a
10 ¹⁸ exa –E	10 ⁻³ milli - m
10 ¹⁵ peta – P	10 ⁻⁶ micro - μ
10 ¹² tera – T	10 ⁻⁹ nano - n
10 ⁹ giga – G	10 ⁻¹² pico - p
10 ⁶ mega – M	10 ⁻¹⁵ femto - f
10 ³ kilo –k	10 ⁻¹⁸ atto - a
10 ¹⁸ exa –E	10 ⁻³ milli - m
10 ¹⁵ peta – P	10 ⁻⁶ micro - μ
10 ¹² tera – T	10 ⁻⁹ nano - n
10 ⁹ giga – G	10 ⁻¹² pico - p
10 ⁶ mega – M	10 ⁻¹⁵ femto - f
10 ³ kilo –k	10 ⁻¹⁸ atto - a

Attachment 2

QUANTITIES AND TERMS USED IN RADIATION PROTECTION

A2.1. General. Ionization is the process by which atoms lose, or sometimes gain electrons and thus become electrically charged. Ionizing radiation are those forms of sub-atomic particles and electromagnetic waves that are capable of causing ionization in matter. Historically, the quantities used to measure the “amount” of ionizing radiation have been defined by the gross number of ionizing events in a given mass of material. The most commonly used quantity reported in early radiation protection was the Roentgen (R) equal to the quantity of x-ray or gamma radiation producing ions in air carrying one electrostatic unit of charge per cubic centimeter of air. At standard temperature and pressure, this is equivalent to 2.58×10^{-4} Coulomb per kilogram of air. Although this quantity is still in use, the more appropriate units for radiation protection are based on the ionizations that occur in given mass of human tissue, and the subsequent risk of biological affect that that “dose” may cause.

A2.2. Absorbed Dose. The fundamental dose quantity in radiation protection is the *absorbed dose*, *D*. This is the energy absorbed per unit mass and is in units of joule per kilogram, which is given the special name gray (Gy). One Gy is equal to 100 rad, the conventional quantity of absorbed dose equal to 100 ergs/ gm.

A2.3. Quality Factors and Dose Equivalent. The probability of stochastic health effects (like cancer) is dependent not only on the absorbed dose, but also on the type of radiation causing the dose. This has been taken into account by weighting the absorbed dose at a point in tissue with a quality factor, *Q*, for a given radiation. The quality factor in turn is based on the density of ionization along a track of the radiation as it traverses a tissue, referred to as its linear energy transfer or LET. The weighted absorbed dose under this system is called the *dose equivalent*, *H*, and expressed in units of rem. The dose equivalent is the dosimetric quantity used in Title 10, Code of Federal Regulations, Part 20, for the purposes of radiation protection from radioactive material. For the purposes of individual monitoring using personnel dosimetry, three specific quantities of dose equivalent are used:

A2.3.1. Deep Dose Equivalent, *H_d*, is the dose equivalent measured at a tissue depth of 1 cm (1000 mg/cm²) beneath the outer surface of the skin. It is the primary dose reported in the USAF personnel dosimetry program. The deep dose equivalent is derived from the more general Individual Dose Equivalent, Penetrating, *H_p(d)*. This is defined as the dose equivalent in soft tissue at a depth “d” in the body that is appropriate for penetrating radiations.

A2.3.2. Shallow Dose Equivalent, *H_s*, is the dose equivalent measured at a tissue depth of 0.007 cm (7 mg/cm², the average depth of the germinal cell layer) averaged over an area of 1 cm². This is otherwise referred to as the shallow or skin dose in the USAF personnel dosimetry program. The shallow dose equivalent is derived from the Individual Dose Equivalent, Superficial, *H_s(d)*. This is defined as the dose equivalent in soft tissue at a depth “d” in the body that is appropriate both weakly and strongly penetrating radiations.

A2.3.3. Lens Dose Equivalent, *H_E*, is the dose equivalent to the lens of the eye from external irradiation. It is measured at an eye lens tissue depth of 0.3 cm (300 mg/cm²).

A2.4. Radiation Weighting Factors and Equivalent Dose. The most recent paradigm in radiation protection emphasizes the absorbed dose averaged over a tissue or organ (as opposed to a point) and weighted for the radiation quality. The weighting factor for this purpose is currently called the radiation weighting factor, w_R , and is selected for the type and energy of the radiation incident on the body or, in the cases of sources within the body, emitted by the source. The absorbed dose in a tissue, multiplied by the radiation weighting factors is called the *equivalent dose*, H_T . This can be expressed as:

$$H_T = \sum_R w_R \cdot D_{T,R}$$

where $D_{T,R}$ is the absorbed dose averaged over the tissue or organ T, due to radiation R. The unit of equivalent dose is the joule per kilogram, with the special name sievert (Sv).

The radiation weighting factor, w_R , for a given type and energy of radiation is representative of the *relative biological effectiveness* (RBE) of that radiation to inducing stochastic health effects at low doses. The values of w_R are roughly comparable with the values of Q, and are summarized in **Table A2.1**.

Table A2.1. Quality and Radiation Weighting Factors .

Type and energy range	Quality Factor ^a , Q	Radiation Weighting Factor ^b , w_R
Photons, all energies	1	1
Electrons, muons, all energies	1	1
Neutrons < 10 keV	2	5
10 keV to 100 keV	5	10
> 100 keV to 2 MeV	10	20
> 2 MeV to 20 MeV	8	10
> 20 MeV	5	5
Protons, other than recoil protons	10	5
Alpha particles, fission fragments, heavy nuclei.	20	20

a. Title 10, Code of Federal Regulations, Part 20, *Standards for Protection Against Radiation*.

b. Report 60--1990 Recommendations of the International Commission on Radiological Protection. ICRP Publication 60. Annals of the ICRP 21(1-3), 1991.

A2.5. Tissue Weighting Factors and Effective Dose. The relation between the probability of stochastic effects and equivalent dose also depends on the organ or tissue irradiated. The effective dose is used to express the probability of occurrence of cancer and hereditary effects whether the dose is received by the whole body via uniform irradiation or by partial body or individual organ irradiation. The factor by which the equivalent dose in tissue or organ T is weighted is called the *tissue weighting factor*, w_T , and represents the relative contribution of that organ or tissue to the total detriment due to cancer and hereditary effects resulting from uniform

irradiation of the whole body. The weighted equivalent dose is given the name effective dose equivalent, or more simply, the *effective dose*, E , and again has units of joule per kilogram with the special name sievert (Sv). The effective dose is the sum of the weighted equivalent doses for all irradiated tissues or organs.

$$E = \sum_T w_T \cdot H_T$$

where H_T is the equivalent dose in tissue or organ T and w_T is the weighting factor for tissue T. Tissue weighting factors are given in **Table A2.2**. So that a uniform whole body equivalent dose results in an effective dose that is numerically the same, the sum of the tissue weighting factors is one.

Table A2.2. Tissue Weighting Factors for Different Organs and Tissues.

Organ	10 CFR 20 ^a	ICRP, 1991 ^b
Gonads	0.25	0.2
Bone marrow	0.12	0.12
Colon		0.12
Lung	0.12	0.12
Stomach		0.12
Bladder		0.05
Breast	0.15	0.05
Liver		0.05
Esophagus		0.05
Thyroid	0.03	0.05
Skin		0.01
Bone Surfaces		0.01
Remainder	0.3	0.05

a. Title 10, Code of Federal Regulations, Part 20, *Standards for Protection Against Radiation*.

b. Report 60--1990 Recommendations of the International Commission on Radiological Protection. ICRP Publication 60. Annals of the ICRP 21(1-3), 1991.

A2.6. Committed Equivalent Dose and Committed Effective Dose. Following an intake of radionuclides in the body, there is a period during which the material irradiates various organs and tissues. The committed equivalent dose, $H_T(\tau)$ is the integral of the equivalent dose rate in a specific tissue (T) following intake of a radionuclide in the body. For the purpose of radiation protection, the time of integration is taken as 50 years for occupational exposures and 70 years for members of the general public. The committed effective dose, $E(\tau)$, for each internally deposited radionuclide is calculated by summing the products of the committed equivalent doses and the appropriate w_T values for all tissues irradiated. The expression for the occupational committed effective dose equivalent is given as:

$$E(50) = \sum_T w_T \cdot H_T(50)$$

A2.7. Total Effective Dose. This is the sum of the deep dose equivalent, H_d , and committed effective dose, $E(50)$. Limits on occupational and public radiation dose apply to the sum of relevant doses from external exposure deep-dose equivalent in a year and the 50 year committed effective dose from intakes in the same year. The total effective dose can be expressed as:

$$E_t = E(50) + H_d$$

A2.8. Working Level Months. Exposure to radon and its progeny is not measured in the conventional dosimetric quantities described above. Instead exposures are generally indicated by the working-level, a unit originally developed to describe exposures of uranium miners to radon. One working level is defined as that concentration of radon daughters in air that has a potential alpha energy release of 1.3×10^5 MeV in a liter of air, equivalent to 2×10^{-5} Joule per cubic meter of air (J/m³). One working level month (WLM, or 3.5×10^{-3} Jh/m³) would be the exposure received by being present in that concentration for one working month, equivalent to 170 hours. Exposure to one WLM results in an estimated absorbed dose to the lung of 4 - 13 mGy (0.4 to 1.3 rad). Based on uranium minor cohorts, lung cancer probabilities are estimated in the broad range of 1 to 4×10^{-4} per WLM. One WLM is approximately equal to an annual exposure of 4 pCi per liter of radon, if the radon decay products are in 50 percent equilibrium with the radon.

A2.9. Conversion Table Between SI and English Units. *Rule of Thumb:* In x-ray/gamma radiation environments: 1 R ~ 1 rad = 0.01 Gy. \approx 1 rem = 0.01 Sv

0.001 rad	= 0.01 mGy		= 0.001 rem	= 1 mrem	= 0.01 mSv	
0.01 rad	= 0.1 mGy		= 0.01 rem	= 10 mrem	= 0.1 mSv	
0.1 rad	= 1 mGy	= 0.001 Gy	= 0.1 rem	= 100 mrem	= 1 mSv	= 0.001 Sv
1 rad	= 10 mGy	= 0.01 Gy	= 1 rem	= 1,000 mrem	= 10 mSv	= 0.01 Sv
10 rad	= 100 mGy	= 0.1 Gy	= 10 rem		= 100 mSv	= 0.1 Sv
100 rad	= 1,000 mGy	= 1 Gy	= 100 rem		= 1,000 mSv	= 1 Sv
1000 rad		= 10 Gy	= 1000 rem			= 10 Sv

A2.10. Annual Average Effective Dose Equivalent in the US Populationa. The following table provides a list of common exposure sources and the annual average dose an individual in the US receives from each source. The rounded annual dose for non-smokers per year is 3.6 mSv, or 360 mrem. It provides a basis for comparison to the limits and dose guidance specified in this instruction.

Source	Average annual effective dose, H
Radon	2 mSv (200 mrem)
Terrestrial Radiation	0.27 mSv (27 mrem)
Cosmic Radiation	0.28 mSv (28 mrem)
Radioactivity in the Body	0.39 mSv (39 mrem)
Occupational Exposures	0.009 mSv (0.9 mrem)

Nuclear fuel cycle	0.0005 mSv (0.05 mrem)
Consumer Products	0.05 – 0.13 mSv (5 – 13 mrem)
Medical exposures	0.53 mSv (53 mrem)

- a. National Council on Radiation Protection and Measurements, Report 93-- *Ionizing Radiation Exposure of the Population of the United States*, 1987.

Attachment 3

MEDICAL CONSEQUENCES OF IONIZING RADIATION EXPOSURE

A3.1. General. Exposure of living cells by ionizing radiation can result in changes to their atoms and molecules and thus may result in damage to the cells. If cellular damage does occur, and is not adequately repaired, it may prevent the cell from surviving or reproducing, or it may result in a viable but modified cell. These two outcomes have very different implications for the organism as a whole.

A3.2. Risk of Deterministic Effects. Most organs and tissues of the body are unaffected by the loss of even a substantial number of cells following irradiation, but if the number lost is large enough, there will be observable harm resulting in a loss of tissue function. Such effects require a “threshold” radiation dose to be exceeded before an effect is observed, and generally the severity of the effect once this threshold is exceeded increases with dose. These “deterministic” effects include skin erythema, sterility, opacities of the lens of the eye and depression of the blood forming process. The effects may occur early, within hours or days following exposure; or late, occurring months or years after exposure. The **Table A3.1** summarizes the threshold doses of observed deterministic effects.

Table A3.1. Estimated Threshold Doses for Acute Radiation Effects a, b

Effect	Organ	Dose
Temporary sterility	Testis	150 mGy (15 rad)
Depression of blood cell forming process	Bone Marrow	500 mGy (50 rad)
Reversible skin effects (e.g., erythema)	Skin	1000-2000 mGy (100 – 200 rad)
Permanent sterility	Ovaries	2500-6000 mGy (250 – 200 rad)
Temporary hair loss	Skin	3000-5000 mGy (300 – 500 rad)
Permanent sterility	Testis	3500 – 6000 mGy (350 – 600 rad)
Cataracts	Lens of the eye	2000 – 10,000 mGy (200 – 1000 rad)

a. Institute of Medicine, *Potential Radiation Exposure in Military Operations*, National Academy Press, Washington DC, 1999.

b. Report 60--1990 *Recommendations of the International Commission on Radiological Protection*.

ICRP Publication 60. Annals of the ICRP 21(1-3), 1991.

A3.3. Risk of Neoplasia and Hereditary Effects. For cells that have been altered or modified and can still reproduce, the potential outcomes are very different. Despite highly effective defense mechanisms, the reproduction of radiation-modified cells may result, after a prolonged and variable delay called the latency period, in the manifestation of a malignant condition or cancer. The probability of cancer usually increases with increments in dose, probably with no threshold, and in a way that is roughly proportional to dose, at least for doses well below the thresholds for deterministic effects. For the purposes of radiation protection, the risk of stochastic effects is assumed proportional to dose without threshold, this is also referred to as the linear-no threshold hypothesis. The severity of cancer is not affected by dose. This kind of effect is called “stochastic” in that it is random or of a statistical nature. If the damage occurs in a cell whose function is to transmit genetic information to later generations (i.e., sperm or ovum), any resulting effects, which may be of many different kinds and severity, are expressed in the progeny of the exposed individual. This type of stochastic effect is called “hereditary”. The nominal risks for radiation induced fatal cancers for the general population are given in **Table A3.2**. In addition, non-fatal cancers occur. Therefore, typical ratios for total cancers (fatal plus non-fatal) are given in **Table A3.2**. Note that these values should not be used to interpret individual risks, which are dependent on numerous factors such as age, sex, heredity and environment.

Table A3.2. Nominal Risks at Low Doses and Low Dose Rates for Low-LET Radiation Expressed as Severe Hereditary Disorders and Fatal Cancers (Lifetime)c

Effect	Nominal risk per milliseivert (100 mrem)	Ratio: total cancer to fatal cancers
Hereditary	10×10^{-6} (all generations) ^e	-
<i>Cancer</i>	<i>Fatal probability</i>	
Leukemia (active marrow)	5×10^{-6}	1.01
Bone Surfaces	0.5×10^{-6}	1.4
Breast (females only)	4×10^{-6}	2.0
Lung	8.5×10^{-6}	1.05
Thyroid	0.8×10^{-6}	10
Colon	8.5×10^{-6}	1.8
Oesophagus	3×10^{-6}	1.05
Skin	0.2×10^{-6}	500
Stomach	11×10^{-6}	1.1
Liver	1.5×10^{-6}	1.05
Bladder	3×10^{-6}	2.0
Ovaries	2×10^{-6}	1.4
Other (combined remaining)	5×10^{-6}	1.8

Sum of fatal cancer risk for whole body irradiation ^d	50×10^{-6} (1 in 20,000) per milliseivert	
Baseline cancer mortality	0.15 (1 in 6.7) to 0.25 (1 in 4)	

- a. The nominal risks are average values for a population comprised equally of males and females.
- b. LET means linear energy transfer; low-LET radiation refers to sparsely ionizing radiations such as gamma rays, x-rays and beta particles.
- c. Report 62--Radiological Protection in Biomedical Research, (Also includes Addendum 1 to ICRP Publication 53, Radiation Dose to Patients from Radiopharmaceuticals, and a Summary of the Current ICRP Principles for Protection of the Patient in Diagnostic Radiology), May, 1993.
- d. For infants and children, the nominal risk is likely 2-3 times higher than 50×10^{-6} . For adults over 50 at the time of exposure, the risk is 5-10 times less. e. A doubling dose of 1 Gy (100 rad) is assumed.

A3.4. Effects Following Irradiation In-Utero. The potential effects on the conceptus following irradiation depend on the time of irradiation relative to conception. When the number of cells in the conceptus is small, and their nature is not yet specialized, the effect of damage to these cells is likely a failure to implant or the undetectable death of the conceptus. Irradiation in the first three weeks following conception is not likely to result in deterministic or stochastic effects in the live-born child, despite the heart and central nervous system development in the third week. During the rest of the period of organogenesis, malformations may be caused in the organ(s) under development at the time of irradiation. These effects are deterministic in nature, with a threshold estimated to be 0.1 Gy (10 rad). Two additional effects of irradiation on the developing fetus include severe mental retardation and cancers that may develop in childhood or in adult life. The periods of sensitivity after conception for these described effects is summarized in [Table A3.3](#)

Table A3.3. Types of Effects Following Irradiation In-uteroa

Time After Conception	Effect	Normal Incidence in live-born
First three weeks	No deterministic or stochastic effects in live-born children	-
3 rd through 8 th weeks	Potential for malformations of organs ^b	0.06 (1 in 17)
8 th through 25 th weeks	Potential for mental retardation, probability: 1 to $4 \times 10^{-4}/\text{mSv}^c$	5×10^{-3} (1 in 200)
4 th week throughout pregnancy	Cancer in childhood or adult life, probability: 28 to $130 \times 10^{-6}/\text{mSv}^d$	1×10^{-3} (1 in 1000)

- a. Report 60--1990 *Recommendations of the International Commission on Radiological*

Protection.

ICRP Publication 60. Annals of the ICRP 21(1-3), 1991.

- b. Malformations of organs appears to be deterministic effect, with a threshold dose in man, estimated from animal experiments to be 0.1 Gy.
- c. The risk of severe mental retardation is associated with an observed shift in IQ of 30 IQ units per Sv to the brain during the 8th through 15th week after conception, with lesser shifts from the 16th through 25th week). At absorbed doses on the order of 0.1 Sv, no effect would be detectable in the general distribution of IQ in an irradiated group.
- d. The risk of fatal cancers expressed in childhood or in adult life for individuals irradiated in utero may be similar to the risk of individuals irradiated in the first decade of life, which is somewhat larger than that for the population as a whole.

Attachment 4

DOSE AND CONTAMINATION LIMITS FOR PRACTICES

Table A4.1. Annual Dose Limits for Practices 1, 3

Application	Occupational	Declared Pregnant Females	Minors (16 - 18 years) ⁴	General Public
Total Effective Dose Equivalent ² Deep-dose Equivalent + Committed Dose Equivalent	50 mSv (5 rem) in a single year, and 500 mSv (50 rem) to any tissue, except lens of the eye	5 mSv (500 mrem) for remainder of pregnancy to the embryo/fetus, avoiding substantial variation from a uniform monthly exposure rate	5 mSv (500 mrem) per year 50 mSv (5 rem) to any tissue, except lens of the eye	1 mSv (100 mrem) in a year ⁵
Annual Dose Equivalent				
The lens of eye ⁶	150 mSv (15 rem)		15 mSv (1.5 rem)	
The skin ⁶	500 mSv (50 rem)		50 mSv (5 rem)	
The hands and feet	500 mSv (50 rem)		50 mSv (5 rem)	

Table A4.2. 1 Acceptable Surface Contamination Levels (dpm/100 cm²).

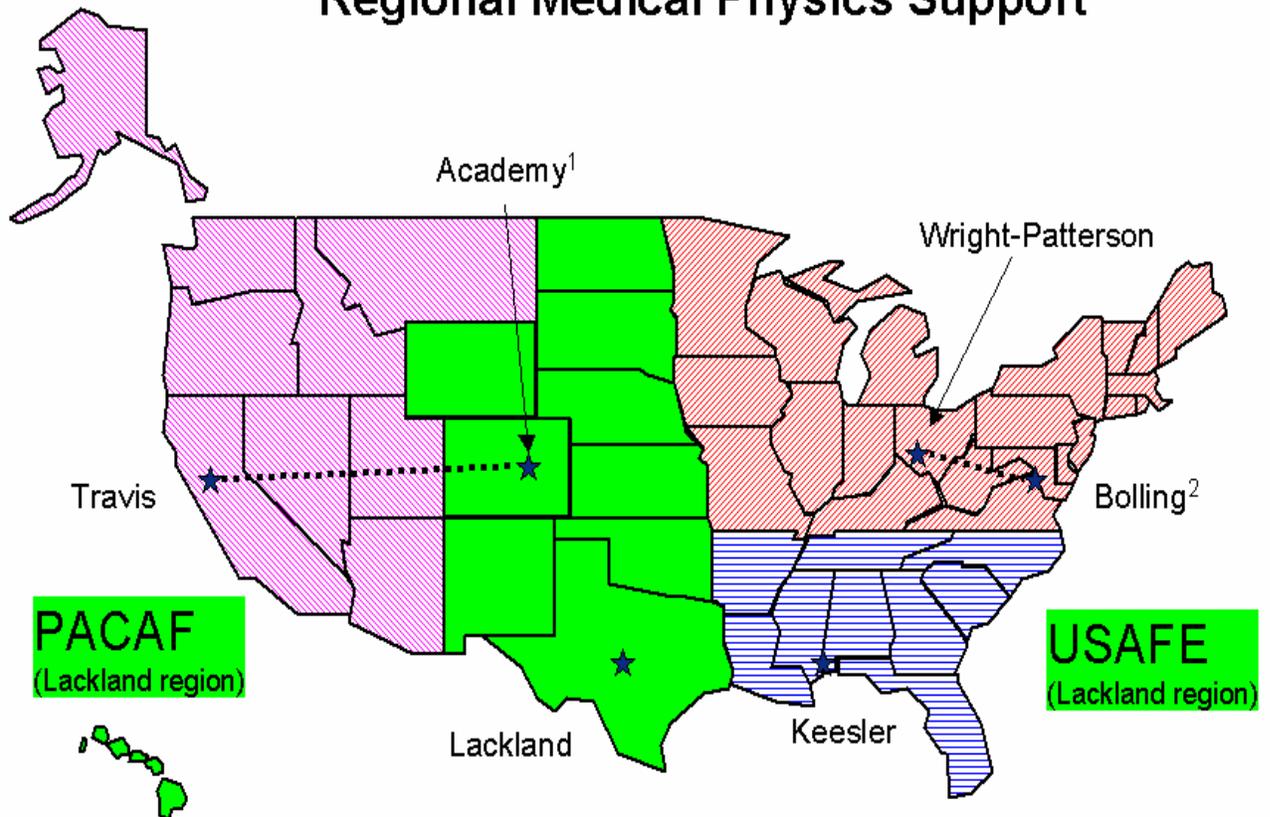
Nuclide	Removable ^{2, 3}	Total (Fixed + Removable) ^{2, 4, 6}
U-nat, ²³⁵ U, ²³⁸ U, and associated decay products	1,000 dpm/100 cm ² (0.17 Bq/cm ²)	5,000 dpm/100 cm ² (0.83
Transuranics, ²²⁶ Ra, ²²⁸ Ra, ²³⁰ Th, ²²⁸ Th, ²³¹ Pa, ²²⁷ Ac, ¹²⁵ I, ¹²⁹ I	20 dpm/100 cm ² (0.0033 Bq/cm ²)	100 dpm/100 cm ² (0.017 Bq/cm ²)
Th-nat, ²³² Th, ⁹⁰ Sr, ²²³ Ra, ²²⁴ Ra, ²³² U, ¹²⁶ I, ¹³¹ I, ¹³³ I	200 dpm/100 cm ² (0.033 Bq/cm ²)	1,000 dpm/100 cm ² (0.17 Bq/cm ²)

Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except ^{90}Sr and others noted above ⁵	1,000 dpm/100 cm ² (0.17 Bq/cm ²)	5,000 dpm/100 cm ² (0.83 Bq/cm ²)
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Attachment 5

REGIONAL MEDICAL PHYSICS SUPPORT

Regional Medical Physics Support



¹ USAF Academy can provide additional support to Travis Region

² Bolling can provide additional support to Wright-Patterson Region

*Contact AFMSA/SG3PB (Radiation Programs) at DSN 425-0035 or (703) 588-0035, or send email to USAF.RIC@pentagon.af.mil. After duty hours, Bolling AFB DC Command Post, DSN 297-4011 or (202) 767-4011

Attachment 6

GENERAL PUBLIC INTERVENTION LEVELS

A6.1. REMEDIAL ACTION LEVELS.

Table A6.1. Remedial Action Levels from Natural Sources of Radiation

Exposure to Radon Decay Products	$> 3.5 \times 10^{-3} \text{ Jhm}^{-3}/\text{year}$
Exposure to Radon	$> 4 \text{ pCi/l}$ average Rn concentration

A6.2. GENERIC INTERVENTION LEVELS **Table A6.2** Generic and Operational Intervention Levels for Protection of the Public¹

Protective Action	Generic Intervention Level (GIL) (Dose avertable by taking protective action)	Operational Intervention Level (OIL) Following a Large Reactor Accident ²
Sheltering	10 mSv (1 rem) (Not recommended for more than 2 days)	
Evacuation	50 mSv (5 rem) (Not recommended for more than 1 week)	1 mSv/h (100 mrem/hr) ambient dose rate in plume 1 mSv/h (100 mrem/hr) ambient dose rate from deposition
Iodine Prophylaxis ³	100 mGy (10 rad) for adults 50 mGy (5 rad) for children and infants	0.1 mSv/h (10 mrem/hr) ambient dose rate in plume
Temporary Relocation	30 mSv (3 rem) in first 30 days 10 mSv (1 rem) in following 30 days	0.2 mSv/h (20 mrem/hr) ambient dose rate from deposition
Permanent Resettlement	1 Sv (100 rem) in lifetime	

¹I15, Vienna, (1996)

2. GILs are difficult to apply in an emergency since because they cannot be promptly measured in the field and do not address facility or environmental conditions. However, they could be used to develop, as part of planning, *operational intervention levels* (OILs). These can easily be measured during an emergency e.g., ambient dose rate in plume or from deposition, marker radionuclide concentration in deposition or foodstuff and on which the need for protective action can be rapidly ascertained. The values provided were derived for a large nuclear reactor accident.

3. Dosage and periodicity should follow FDA guidance specified in “Guidance for Potassium Iodide as a Thyroid Blocking Agent in Radiation Emergencies”, U.S. Department of Health and Human Services Food and Drug Administration Center for Drug Evaluation and Research (CDER), (<http://www.fda.gov/cder/guidance/3698dft.pdf>), Dec 2000

Attachment 7

OPERATIONAL DOSE GUIDANCE FOR INTERVENTIONS

Table A7.1. OPERATIONAL DOSE GUIDANCE (NATO Standardization Agreement 2473).

Total Cumulative Doses ¹	Radiation Exposure Status Category	Recommended Protection and Surveillance Actions ²	Increased Risk of Long Term Fatal Cancer ⁵
0 to 0.5 mSv (0 to 0.05 rad)	0	None	Negligible
0.5 to 5 mGy (0.05 to 0.5 rad)	1A	Record individual dose Initiate periodic environmental monitoring	1:4,000
5 to 50 mGy (0.5 to 5 rad)	1B	Record individual dose Continue monitoring Initiate radiation survey Prioritize tasks Establish dose control measures during operations	1:400
50 to 100 mGy (5 to 10 rad)	1C	Record individual dose Continue monitoring Update radiation survey Continue dose control measures Execute priority tasks only ³	1:200
100 to 250 mGy (10 to 25 rad)	1D	Record individual dose Continue monitoring Update radiation survey Continue dose control measures Execute critical tasks only ⁴	1:80
250 to 750 mGy ⁶ (25 to 75 rad)	1E	Record individual dose Continue monitoring Update radiation survey Continue dose control measures Execute critical tasks only ⁴	1:30

Table A7.2. Military Contamination Limits for 7-day Operations¹

Commander Dose	Maximum Contamination Limits ² 7 day mission duration
	Equipment and Protective Clothing ⁴

Guidance	High Toxicity Alpha Emitter ³	Beta and Low Toxicity Alpha Emitters ³
Category 1A 0.05 - 0.5 rad	5 Bq/cm ² (30x10 ³ dpm/100cm ²)	50 Bq/cm ² (300x10 ³ dpm/100cm ²)
Category 1B 0.5 - 5 rad	50 Bq/cm ² (300x10 ³ dpm/100cm ²)	500 Bq/cm ² (3000x10 ³ dpm/100cm ²)
Category 1C 5 - 10 rad	100 Bq/cm ² (600x10 ³ dpm/100cm ²)	1000 Bq/cm ² (6000x10 ³ dpm/100cm ²)
Category 1D 10 - 25 rad	250 Bq/cm ² (1500x10 ³ dpm/100cm ²)	2500 Bq/cm ² (15000x10 ³ dpm/100cm ²)
Category 1E ⁶ 25 - 75 rad	750 Bq/cm ² (4500x10 ³ dpm/100cm ²)	7500 Bq/cm ² (45000x10 ³ dpm/100cm ²)

Table A7.3. Military Contamination Limits for 3-Month Operations¹

Commander Dose Guidance	Maximum Contamination Limits ² 3 month mission duration	
	Equipment and Protective Clothing ⁴	
	High Toxicity Alpha Emitters ³	Beta and Low Toxicity Alpha Emitters ³
Category 1A 0.05 - 0.5 cGy	0.5 Bq/cm ² (3x10 ³ dpm/100cm ²)	5 Bq/cm ² (30x10 ³ dpm/100cm ²)
Category 1B 0.5 - 5 cGy	5 Bq/cm ² (30x10 ³ dpm/100cm ²)	50 Bq/cm ² (300x10 ³ dpm/100cm ²)
Category 1C 5 - 10 cGy	10 Bq/cm ² (60x10 ³ dpm/100cm ²)	100 Bq/cm ² (600x10 ³ dpm/100cm ²)
Category 1D 10 - 25 cGy	25 Bq/cm ² (150x10 ³ dpm/100cm ²)	250 Bq/cm ² (1500x10 ³ dpm/100cm ²)
Category 1E 25 - 75 cGy	75 Bq/cm ² (450x10 ³ dpm/100cm ²)	750 Bq/cm ² (4500x10 ³ dpm/100cm ²)