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IONIZING RADIATION PROTECTION

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This instruction implements Air Force Policy Directive (AFPD) 48-1, *Aerospace Medicine Enterprise*, and Department of Defense Instruction (DoDI) 6055.08, *Occupational Ionizing Radiation Protection Program*. It also implements the requirements of North Atlantic Treaty Organization (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. This instruction applies to Department of Defense (DoD) personnel, Air Force Reserve Command (AFRC) units, Air National Guard (ANG) units, and all tenants (including Department of Energy (DOE) personnel and prime contractors) of AF installations IAW host-tenant support agreements, and other civilian contractors as specified herein. This instruction is a companion to AFI 40-201, *Managing Radioactive Materials in the US Air Force*, and establishes the requirements outlined in Air Force Manual (AFMAN) 48-125, *Personnel Ionizing Radiation Dosimetry*. It serves as a reference for AFI 91-108, *Air Force Nuclear Weapons Intrinsic Radiation* (INRAD) and 91(b) Radioactive Material Safety Program. Ionizing radiation protection roles and responsibilities in this AFI apply to all ionizing radiation

threats including those encountered by nuclear capable units and weapons storage areas unless stated otherwise in DoD publications or AF 91-series publications. This instruction specifies the requirements for the protection of AF personnel and their dependents as well as the public from exposure to ionizing radiation resulting from AF activities. It defines responsibilities for the protection, monitoring and medical follow-up of military personnel for the full spectrum of military operations. This instruction applies to uniformed AF personnel, AF civilians and individuals living on AF installations who might be exposed to radiation. This instruction does not apply to employees working under government contract or private contractors performing work under government contracts, except when complying with Base Contracting requirements. Contractors are solely responsible for compliance with Occupational Safety and Health Administration (OSHA) standards and the protection of their employees unless otherwise provided by law or regulation to be specified in the contract. This AFI does not prohibit providing workplace sampling and survey information to contractors, based on local arrangements. This publication may be supplemented at any level. Requirements are tiered signifying the appropriate waiver authority to the requirement and is indicated in parentheses [T-0, T-1, T-2, or T-3] following the sentence/paragraph that drives the requirement, IAW AFI 33-360, *Publications and Forms Management*. Requests for waivers must be submitted through the chain of command to the appropriate Tier waiver approval authority IAW AFI 33-360. Ensure that all records created as a result of processes prescribed in this publication are maintained IAW Air Force Manual (AFMAN) 33-363, Management of Records, and disposed of IAW Air Force Records Information Management System (AFRIMS) Records Disposition Schedule (RDS). 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 the AF Form 847 from the field through the appropriate chain of command. 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 AF. See Attachment 1 for a Glossary of References and Supporting Information. This publication requires the collection and or maintenance of information protected by the Privacy Act (PA) of 1974. The Systems of Records Notice (SORN) for the Master Radiation Exposure Registry is F044 AF SG O. The authority to collect and or maintain the records prescribed in this publication is DoDI 6055.08.

(FEW) This supplement implements AFI 48-148, *Ionizing Radiation Protection* and AFI 40-201, *Managing Radioactive Materials in the US Air Force*. It establishes responsibilities, policies, and procedures to minimize occupational and environmental exposures to ionizing radiation. This instruction applies to all Air Force military and civilian personnel working at F. E. Warren Air Force Base (FEWAFB), supported sites, outside agencies and contractors bringing radioactive material or devices on to FEWAFB, and contractors on FEWAFB whose duties require work with sources of ionizing radiation or work in areas where exposure to ionizing radiation may occur. Requirements apply to each unit where radioactive material (RAM) or radiation producing devices are used, and to each respective unit Radiation Safety Officer (RSO). This instruction implements the “as low as reasonably achievable” (ALARA) concept for radiation protection as required by AFI 48-148. This instruction does not apply to exposure of patients during diagnostic or therapeutic medical procedures. This instruction is directive in nature. Persons subject to the Uniform Code of Military Justice (UCMJ) may be punished under Article 92, UCMJ for violating or not performing the requirements of this operating instruction. Ensure that all records created as a result of processes prescribed in this publication are

maintained in accordance with Air Force Manual (AFMAN) 33-363, *Management of Records*, and disposed of in accordance with the Air Force Records Information Management System (AFRIMS) Records Disposition Schedule (RDS). Comply with AFI 33-332, *Air Force Privacy And Civil Liberties Program*, for documents containing privacy act information. Comply with AFI 16-1404, *Air Force*ictect*Information Security Program* for documents containing For Official Use Only information. Refer recommended changes and questions about this publication to the Office of Primary Responsibilities (OPR) using the AF Form 847, *Recommendations for Change of Publication*; route AF Form 847 from the field through the appropriate functional's chain of command. See attachment 1 for Glossary of References and Supporting Information.

SUMMARY OF CHANGES

This instruction has been revised and must be reviewed in its entirety. Major changes include the document being tiered to adhere to AFI 33-360. Requirements are tiered signifying the appropriate waiver authority to the requirement and is indicated in parentheses [T-0, T-1, T-2, or T-3] following the sentence/paragraph that drives the requirement, IAW AFI 33-360.

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Chapter 1

PROGRAM OVERVIEW

1.1. Purpose. This instruction addresses the concerns associated with exposure to ionizing radiation, regardless of source, and seeks to keep exposures as low as reasonably achievable (ALARA). Specific USAF requirements for USAF Radioisotope Committee regulated and 91(b) radioactive materials are found in AFIs 40-201 and 91-108, respectively.

1.2. Applicability. The requirements outlined in this instruction apply to all AF, or AF-led, installations with operations that involve:

1.2.1. Possession or use of radioactive material (RAM) as specified in AFIs 40-201 and 91-108;

1.2.2. Possession or use of radiation producing devices (hereafter referred to as radiation sources), including situations where radiation emissions are incidental to use;

1.2.3. Use of RAM or radiation devices by contractors, as specified by contract. Note: Contractors are solely responsible for the health and safety of their personnel as specified in their contract;

1.2.4. Avertable general public and occupational doses.

1.2.5. The requirements outlined in this instruction apply at Air Force installations overseas, including both enduring and non-enduring locations, so long as the requirements do not conflict with applicable provisions from any of the following: international agreements, the Overseas Environmental Baseline Guidance Document (OEBGD), country-specific Final Governing Standards (FGS), Geographic Combatant Command policy, and environmental annexes to operational orders (OPORDS), operational plans (OPLANS) or other operational directive.

1.3. Objectives of the AF Radiation Protection Program.

1.3.1. Prevent radiation induced deterministic effects (i.e., cataracts, skin erythema) for which a threshold dose is believed to exist. The adherence to federal dose limits eliminates these effects.

1.3.2. Limit the risk of stochastic effects (i.e., cancer, leukemia) for which the probability of occurrence is proportional to dose. The risks of stochastic health effects 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.

1.3.3. Ensure workers are properly trained on the risks of radiation, methods to minimize exposure, and the ALARA principle.

1.3.4. Perform health risk assessments, adopt controls, and document radiation exposure.

1.4. Types of Radiation Exposure. For the purposes of this instruction, there are four categories of radiation exposure:

1.4.1. Occupational exposures are routine exposures incurred as a necessary part of supporting the military mission. Common practices resulting in potential occupational exposures include, but are not limited to: industrial radiography, depleted uranium munitions handling, research involving nuclear materials or radiation sources, well-logging, soil density testing, diagnostic radiology, nuclear medicine, radiation therapy and activities involving maintenance of nuclear weapon systems.

1.4.2. Medical exposures are exposures incurred by individuals as part of their own medical diagnosis and treatment. Note: Occupational exposure to medical staff or incidental radiation exposure to the general public from medical sources are not medical exposures.

1.4.3. Public exposure encompasses all exposures other than occupational and medical exposures. Public exposures of concern, for the purposes of this instruction, include those resulting indirectly from AF occupational and medical practices, terrestrial radon exposure, and from accidents.

1.4.4. Incident or contingency type exposures. Incident or contingency type exposures are 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.

1.5. Practices and Interventions. Activities that may result in radiation exposure can be broadly divided into two categories: practices and interventions (reference International Commission on Radiological Protection (ICRP) Publication 60, *1990 Recommendations of the International Commission on Radiological Protection*).

1.5.1. Radiation Protection Policy for Practices. Routine and controlled operations that incur radiation exposure are considered practices. This instruction considers all AF activities involving the routine use of radiation sources or RAM in medicine, research, industry and training to be practices.

1.5.1.1. Justification: Any proposed activity causing exposure to persons should yield a sufficient benefit to society or the military to justify the risks incurred by the radiation exposure.

1.5.1.2. Optimization: The magnitude of individual doses and the number of people exposed shall be kept ALARA. Economic, military, and social factors shall be taken into account. [T-0]

1.5.1.3. Dose Limits: The dose to an individual resulting from a combination of all relevant practices shall not exceed the limits specified in this instruction. [T-1]

1.5.2. Radiation Protection Policy for Interventions. Interventions encompass two broad types of activity operations that seek to reduce existing exposures not part of a controlled practice; and activities conducted to mitigate threats and hazards greater than that posed by radiation exposure, or otherwise conduct operations necessary to achieve higher objectives, including those of national security.

1.5.2.1. Justification: A proposed intervention should do more good than harm. The action should take into account the goals of military objectives or humanitarian assistance in context with risk management.

1.5.2.2. 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 shall be maintained ALARA. [T-0]

1.5.2.3. Dose Guidance: Dose limits do not apply for interventions. Instead, dose guidance is utilized in context with surveillance and protection of forces. See Attachment 7 for additional guidance.

1.6. (Added-FEW) FEWAFB Radiation Protection Program Goals.

1.6.1. **(Added-FEW)** Minimize exposure to ionizing radiation, regardless of source, and keep exposures as low as reasonably achievable.

1.6.2. **(Added-FEW)** Maximize mission effectiveness by ensuring all workers are properly trained on the risks of radiation and methods to minimize exposures.

1.6.3. **(Added-FEW)** Assess and control risks, and document worker exposures for the Individual Longitudinal Exposure Record.

Chapter 2

ROLES AND RESPONSIBILITIES

2.1. Assistant Secretary of the Air Force (Installations, Environment and Logistics) (SAF/IE).

2.1.1. Appoints a voting representative and alternate to the Air Force Radiation Safety Committee (AF-RSC).

2.1.2. Provides guidance, direction, and oversight on all matters pertaining to the formulation, review, and execution of Environment, Safety, and Occupational Health (ESOH) policies, plans, programs, and budgets.

2.1.3. Provides oversight to USAF/SG whose executive is located in AFMSA/SG3.

2.2. Assistant Secretary of the Air Force (Acquisition) (SAF/AQ).

2.2.1. Appoints a voting representative and alternate to the AF-RSC.

2.2.2. Ensures adequate acquisition procedures exist governing the life-cycle management of sources of radiation not covered by AFI 40-201 or AFI 91-108.

2.2.3. Ensures the AF-RSC is informed regarding the acquisition of new systems and upgrades that utilize sources of radiation not covered by AFI 40-201 or 91-108 prior to fielding.

2.3. Deputy Chief of Staff of the Air Force (Logistics, Installations, and Mission Support) (AF/A3/7).

2.3.1. Appoints a voting representative and alternate to represent Civil Engineer and Security Forces to the AF-RSC.

2.3.2. Ensures adequate procedures exist for governing radiation safety as they pertain to logistics, maintenance, civil engineering, and security.

2.3.3. Provides consultation on ionizing radiation matters associated with accidents/incidents/attacks involving RAM, radiation sources or weapons of mass destruction.

2.4. The Surgeon General (AF/SG).

2.4.1. Establishes AF policy for controlling radiation hazards and sets limits for exposure to radiation. Ensures compliance with relevant federal policies and accepted scientific practice.

2.4.2. Appoints an AF/SG Health Physics Consultant and an AF/SG Medical Physics Consultant, who can be one individual if qualified for both positions.

2.4.3. Receives reports from the Consultants, through the Associate Corps Chief for Bioenvironmental Engineering on matters that require SAF visibility.

2.5. Assistant Surgeon General, Healthcare Operations (AF/SG3).

2.5.1. Oversees the use of sources of radiation not covered by AFIs 40-201 or 91-108 to ensure they are used in accordance with all Federal, DoD and AF requirements.

2.5.2. Establishes the AF-RSC that will serve as the focal point for ionizing radiation issues and specific, medical non-ionizing radiation issues (magnetic resonance imaging, medical lasers). Chairs, or delegates someone to chair, the AF-RSC (preferably from AFMSA/SG3P). Authorizes the Chief, Radiation Health (AFMSA/SG3PB) to act in the Chairperson's absence.

2.5.3. Appoints the Chief, Radiation Health (AFMSA/SG3PB) to be the Executive Secretary (AF-RSCES) of the AF-RSC. The AF-RSCES is authorized to conduct business on behalf of the AF-RSC such as setting the RSC agenda, preparing for and conducting RSC meetings, etc.

2.5.4. Appoints a voting representative and alternate from the Radioisotope Committee Secretariat (RICS) to the AF-RSC. The voting representative is the Executive Secretary of the AF-RSC.

2.5.5. Appoints a voting representative and alternate from Bioenvironmental Engineering (AFMSA/SG3PB) to the AF-RSC.

2.5.6. Appoints the AF/SG Consultant on Medical Physics as a voting representative to the AF-RSC. The Consultant on Medical Physics serves as the liaison for the Air Force Medical Physics Working Group (AF-MPWG) to the AF-RSC.

2.5.7. Appoints a voting representative and alternate from Medical Readiness (AFMSA/SG3X) to the AF-RSC.

2.5.8. Appoints a voting representative to the DoD Ionizing Radiation Working Group.

2.6. The Civil Engineer (AF/A7C). Appoints a voting representative and an alternate to the AF-RSC to provide consultation on ionizing radiation matters associated with accidents/incidents/attacks involving RAM, radiation sources or weapons of mass destruction.

2.7. All MAJCOM Surgeons. Appoint a voting representative and an alternate to the AF-RSC to provide consultation on research/development, training, health risk surveillance, and medical readiness issues.

2.8. AFIA/SG.

2.8.1. Appoints a voting representative to the AF-RSC. Resources and prioritizes inspections according to AFI 90-201, The Air Force Inspection System.

2.8.2. Maintains a Bioenvironmental Engineer (BE) qualified in health physics (43E3G) who is trained to conduct inspections of organizations possessing radiation sources covered by this AFI.

2.8.3. Conducts special emphasis inspections (SEIs) as requested by the AF-RSC. Reports on trends associated with findings from routine inspections on a quarterly basis.

2.8.4. Conducts inspections to assess AF compliance with this instruction, AFI 40-201, AFI 90-201 and AFI 91-108.

2.9. 711 HPW/CC.

2.9.1. Appoints a voting representative and an alternate to the AF-RSC to provide consultation on research/development, training, and technical matters.

2.9.2. Through USAFSAM, resources and maintains a consultative service capable of addressing the full spectrum of radiation issues facing the AF. Such shall be capable of publishing technical reports as requested by the AF-RSC.

2.10. Director, USAFSAM/OEH. Provides and manages the following services.

2.10.1. Radiation Dosimetry Laboratory. Serves as the office of primary responsibility for AFMAN 48-125 and manages the Air Force Personnel Dosimetry Program.

2.10.1.1. Maintains the AF Master Radiation Exposure Registry (MRER). The MRER will archive comprehensive dosimetry records for the lifetime of the AF Master Materials License, for all military personnel and for other personnel who use AF dosimetry services. Records will include negative and positive results of bioassays, administrative dose assignments (including copies of documents supporting dose assignments), and supplementary occupational dose equivalent information (e.g., dosimetry information resulting from off-duty employment). [T-0]

2.10.1.2. Data from classified operations will be included to the fullest extent possible. An individual's assessed dose shall not be, in most circumstances, classified. Where classification is deemed necessary, see **paragraph 6.5.4.2** for further guidance.

2.10.1.3. Immediately notifies the installation radiation safety officer (IRSO), AFMSA/SG3PB (Radiation Health), and MAJCOM BEE with dosimetry results indicating personnel received a dose exceeding the values in Table A4.1. [T-1]

2.10.1.4. Provides operational reach back support to installations for radiation dosimetry to include consultation and supply of emergency dosimeters.

2.10.2. Radioanalytical Services.

2.10.2.1. Maintains a capability suitable for the collection of environmental and bioassay samples, conducts in-vivo monitoring, and performs radio analyses of samples. The capability shall support both operational requirements and medical-legal documentation of individual internal exposures during peacetime, combat and non-combat military operations, and war. [T-2]

2.10.2.2. Processes, analyzes and interprets bioassay and environmental samples IAW the most current and scientifically effective analytical procedures.

2.10.2.3. Maintains complete records of all bioassay samples, sample analysis results, and estimation of internal dose for the lifetime of the AF Master Materials License, including estimates below detection limits of the analytical method. [T-2]

2.10.2.4. Provides 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. [T-2]

2.10.2.5. Reports negative or positive occupational bioassay sample results to the Radiation Dosimetry Laboratory for inclusion in the individual's occupational dosimetry record (MRER). [T-2]

2.10.3. Health Physics Consulting.

2.10.3.1. Appoints a voting representative and an alternate to the AF-RSC to provide consultation on the areas pertaining to radiation programs under USAFSAM. [T-2]

2.10.3.2. Provides technical advisory 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.

2.10.3.3. Publishes technical reports as requested by the AF-RSC.

2.10.4. Air Force Radiation Assessment Team (AFRAT). Provides operational health physics support during nuclear or radiological contingencies and is supported by the Health Physics Section, Radioanalytical Laboratory and Radiation Dosimetry Laboratory.

2.11. Air Force Safety Center.

2.11.1. Appoints a voting representative to the AF-RSC to provide consultation on radiation programs related to nuclear weapon systems.

2.11.2. Consults with USAF/SG3 on ionizing radiation exposures to personnel from nuclear weapon systems and nuclear weapons testing.

2.12. Air Force Radiation Safety Committee (AF-RSC).

2.12.1. Provides direction on uses of radiation, not otherwise covered in AFIs 40-201 (e.g. machine generated radiation) and 91-108, and grants authority to the AF-RSCES to conduct all business on its behalf (reference **Attachment 8**). Note: Issues related to the AF Master Materials License, or directed energy, to include non-medical lasers, are addressed by other groups.

2.12.2. Serves as the primary AF point of contact for communications with Federal, state, and Host Nation regulatory authorities regarding radiation issues, not otherwise covered in AFIs 40-201 and 91-108. Note: HQ AFSEC is the single point of contact for 91(b) material.

2.12.3. Provides recommendations to field units, prior to procurement and fielding of new sources of ionizing radiation covered by this AFI, to ensure safe operating procedures exist, the ionizing radiation hazard has been fully characterized, and the exposures to operators, maintainers, and personnel are kept ALARA using administrative controls, engineering controls, or personal protective equipment.

2.12.4. Provides recommendations to field units prior to procurement and fielding of new ionizing radiation detectors or dosimeters to ensure the devices are appropriate for the desired use, proper calibration requirements exist, and adequate training requirements are identified.

2.12.5. Recommends policies to AF/SG for keeping radiation exposure ALARA.

2.12.6. Identifies new or special inspection needs and reports them to AFIA/SG.

2.12.7. Establishes the Air Force Medical Physics Working Group (AF-MPWG) via the Associate Corps Chief for Bioenvironmental Engineering and the AF/SG Consultant for Medical Physics. The AF-MPWG reports on medical physics issues to the AF-RSC and to

the Associate Corps Chief for Bioenvironmental Engineering for planning purposes of the Bioenvironmental Engineering Corporate Board (BCB).

2.12.8. Meets as often as necessary, but not less than once a year, and delegates action items to voting representatives or other technical representatives. A quorum of at least 50% of the appointed representatives is required for each meeting.

2.12.9. Publishes and makes available minutes to all members.

2.12.10. Provides final resolution for allegations concerning the safe and regulatory compliant use of radiation, not otherwise covered in AFIs 40-201 and 91-108.

2.12.11. Is comprised of the members identified in **Table A8.1**, but may add members as deemed necessary.

2.13. AF-RSC Executive Secretariat (AF-RSCES).

2.13.1. The AF-RSCES is led by the Chief, Radiation Health (AFMSA/SG3PB). The AF-RSCES manages the affairs and executes the decisions of the AF-RSC and maintains AF policy pertinent to ionizing and medical non-ionizing radiation safety.

2.13.2. In collaboration with relevant AF/SG Consultants determines whether individuals are qualified by training, education, and experience to use sources of radiation covered by this AFI.

2.13.3. Prior to making a recommendation to procure and field new sources of ionizing radiation covered by this AFI, ensure safe operating procedures exist, ionizing radiation hazards are fully characterized, and exposures to operators, maintainers, and personnel are kept ALARA using engineering controls, administrative controls, or personal protective equipment. Equipment procured through the Air Force Diagnostic Imaging and Radiotherapy Board (AFDIRB) is outside the scope of the AF-RSC.

2.13.4. Prior to making a recommendation to procure and field new ionizing radiation detectors or dosimeters, ensure the devices are appropriate for the desired use, proper calibration requirements exist, and adequate training requirements are identified.

2.13.5. In collaboration with AFLOA/JACE provides provisional interpretation of federal regulations, DoDIs, and AFIs until a final ruling can be obtained from the AF-RSC or applicable federal or state agency.

2.13.6. Conducts visits and responds to incidents and mishaps within the scope of this AFI. As necessary, accompanies AFIA/SGO during inspections where SEIs are being addressed.

2.14. AFLOA/JAC. Provides legal counsel to both the AF-RSC and to the AF-RSCES, as appropriate, on all legal and policy requirements affecting or otherwise applying to AF implementation of the radiation safety program. Specific tasks include:

2.14.1. Director, AFLOA/JAC (JAC) serves as chief counsel to both the AF-RSC and to the AF- RSCES. That office may appoint a qualified attorney from within AFLOA/JACE, military or civilian, to provide legal counsel to the AF-RSC and the AF-RSCES on an as needed basis.

2.14.2. Attends all scheduled meetings of the AF-RSC.

2.14.3. Collaborates with AF-RSCES to obtain and provide accurate interpretations of all statutes, regulations, instructions, and guidance documents affecting implementation of the AF radiation protection program for all AF components covered by this AFI.

2.15. Wing or Installation Commanders, as appropriate. Ensures the Wing or 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:

2.15.1. Appoints, in writing, a qualified individual to be the IRSO. Qualifications for IRSOs are listed in **Attachment 2**. [T-1]

2.15.2. Ensures tenant organization and unit radiation safety programs (including nuclear capable units, units supporting nuclear capable units, and units with 91(b) material not in current nuclear weapons or components) are fully integrated into the Wing or Installation radiation safety program. [T-2]

2.15.3. Affords Air Force Inspection Agency (AFIA) the opportunity to inspect radiation use activities and the premises and facilities where radiation producing devices are used or stored. Upon receiving notice from AFIA, Commanders shall make records kept by the unit, pursuant to federal and DoD requirements and AFIs, available for inspection. [T-0]

2.16. Organization or Unit Commanders, as appropriate.

2.16.1. Designate, in writing, a Unit RSO (URSO) when in possession of RAM or radiation sources. Units possessing only equipment with magnesium-thorium components not covered by permits generally do not require URSOs. Additionally, designates, in writing, a Permit Radiation Safety Officer (PRSO) when required by AFI 40-201 or AFI 91-108. Unit RSO and Permit RSO can be the same individual with approval from the IRSO. Consults with the IRSO for guidance on PRSO requirements. [T-2]

2.16.1.1. **(Added-FEW)** Appointment letters must include the rank, name, and telephone number. A copy of the appointment letter should be sent to the appointed individual and to the IRSO.

2.16.1.2. **(Added-FEW)** Update unit and permit RSO appointment letters as necessary. Ensure the most qualified personnel are appointed.

2.16.1.3. **(Added-FEW)** Ensure unit and permit RSOs conduct radiation safety training for all individuals working where radioactive material or radiation producing devices are used or transferred.

2.16.1.4. **(Added-FEW)** Prohibit unauthorized use of radioactive materials, radiation-producing devices, and lasers. Use of such devices must be coordinated, evaluated and approved by the IRSO prior to use.

2.16.1.5. **(Added-FEW)** Ensure all radioactive material, radiation-producing devices, and lasers are transferred from the unit with the coordination of the IRSO. This includes any items known to contain radioactive materials or lasers, or any materials with associated documents stating radioactive materials or lasers are present when they are not.

2.16.1.6. **(Added-FEW)** Notify IRSO no less than 30 days prior to ordering devices or equipment that contains or is expected to contain radioactive material or lasers for evaluation and approval.

2.16.2. Provides facilities, equipment, and resources for radiation protection and safety. The nature and extent of which must be commensurate with the ALARA concept and the radiation hazards of the workplace. [T-0]

2.16.3. Implements policies, procedures, and a radiation protection program to ensure the requirements of this instruction are met. [T-1]

2.16.4. Ensures implementation of AF radiation dosimetry and/or bioassay program, as necessary. [T-2]

2.16.4.1. **(Added-FEW)** Appoint in writing a (unit) Area Thermoluminescent Dosimeter (TLD) Manager if any unit personnel are enrolled in the TLD program.

2.16.5. Ensures personnel receive education and training IAW this instruction. [T-3]

2.16.6. Ensures reports are made and records are maintained IAW this instruction. [T-1]

2.16.7. Ensures workers incidentally exposed to ionizing radiation in their workplace (not otherwise directly related to or required by their work) receive the same level of protection as if they were members of the public. [T-1]

2.16.8. Integrates risk management into operations, activities, and planning during establishment, review, and approval of procedures involving ionizing radiation exposure IAW established policy (DoDI 6055.1, *DoD Safety and Occupational Health (SOH) Program)* and (AFI 90-802, *Risk Management*). [T-3]

2.16.9. Notifies the IRSO before making changes regarding RAM or radiation sources (i.e., the amount or types of RAM; new or altered radiation sources; special operations; or construction of new facilities). The IRSO shall also be notified prior to any change in facilities affecting source or device security requirements, increased potential for personnel exposures, the location of RAM or radiation sources, or the potential for release of RAM. [T-1]

2.16.10. Executes the specific requirements for 91(b) material as outlined in AFI 91-108, as required. [T-3]

2.16.11. Ensures workers are properly trained on the risks of radiation, methods to minimize exposure, and the ALARA principle. [T-0]

2.17. Organization, Unit, and/or Wing Commanders During Contingencies, and Deployed AF AOR Commanders.

2.17.1. Appoints, in writing, a qualified individual to be the deployed IRSO, as appropriate. Qualifications for IRSOs are listed in **Attachment 2**. Ensures all practices meet the requirements of this AFI. [T-2]

2.17.2. Manages interventions, as defined in this instruction, using RM and the guidance in this AFI. [T-2]

2.17.3. Includes the Deployed Medical Commander (DMC) or deployed Senior Medical Officer (SMO) in the operations and planning staff for all tasks with radiation safety

implications. Conveys intelligence regarding the nature and extent of actual or potential radiological hazards to the DMC or deployed SMO. [T-3]

2.17.4. Requests additional expertise and support, as necessary, from higher headquarters and from host nation radiation protection experts. [T-3]

2.17.5. Establishes or confirms a dose IAW the guidance in **Table A6.2**, for public interventions, and **Table A7.1**, for operations involving interventions. [T-3]

2.17.6. Implements control measures necessary to contain the radiological hazard as indicated in AFI 10-2501, *Air Force Emergency Management (EM) Program Planning and Operations*.

2.17.7. Ensures facilities, equipment, and protective clothing are decontaminated to the levels designated in **Table A4.2**, **Table A7.2**, and **Table A7.3**, as applicable or IAW host nation agreement. [T-2]

2.17.8. Ensures workers are properly trained on the risks of radiation, methods to minimize exposure, and the ALARA principle. [T-0]

2.18. MTF Commanders.

2.18.1. Ensures either measured or estimated radiation dose received by personnel during occupational practices and/or contingency operations is available to the monitored individual. [T-1]

2.18.1.1. Ensures dose determination records are forwarded to USAFSAM/OEH for incorporation into the MRER (to include locally performed bioassays). [T-1]

2.18.1.2. Maintain and ensure accessibility to all radiation exposure data for organizations or units conducting classified operations. [T-1]

2.18.2. Ensures collection of bioassay and laboratory specimens as necessary to assess internal exposures from ingested or inhaled RAM or contaminated wounds IAW NATO Allied Engineering Publication-49, *NATO Handbook for Sampling and Identification of Radiological Agents (SIRA)*. Samples shall be forwarded to USAFSAM/OEH for analysis and interpretation. [T-1]

2.18.3. Ensures compliance through designation of appropriate staff and resources IAW the responsibilities and requirements, to include staffing qualifications, as specified in **Chapter 4** and **6**.

2.18.4. Ensures medical follow-up of personnel receiving significant exposures IAW **Chapter 6**. [T-1]

2.18.5. Ensures workers are properly trained on the risks of radiation, methods to minimize exposure, and the ALARA principle. [T-0]

2.18.6. Coordinates with Bioenvironmental Engineering & IRSO to ensure installation personnel's potential workplace radiation hazards are referenced in the appropriate DOEHRS similar exposure group (SEG). [T-0]

2.18.7. See **paragraph 4.2.1** of additional responsibilities for MTF Commanders.

2.19. Deployed Medical Commander (DMC) or Deployed Senior Medical Officer (SMO).

2.19.1. Consults with personnel possessing specialized expertise. These may include: nuclear medicine physicians, diagnostic radiologists or radiation oncologists, BEs, health physicists, medical physicists, occupational health physicians, and preventive medicine physicians. If local expertise is not available, contact USAFSAM and/or the Health or Medical Physics Consultant to the AF/SG. [T-3]

2.19.2. Applies the framework for radiation protection presented in **Chapter 6**, including justification and optimization of exposures. [T-1]

2.19.3. Applies the principles of risk management (RM) to manage all hazards faced by personnel, including the short and long-term health risks from radiation exposure. [T-2]

2.19.4. Recommends to the AF component of a Joint Task Force (JTF) a dose IAW the guidance in **Table A7.1** for all operations considered interventions. [T-1]

2.19.5. Ensures exposure control measures are implemented for adherence to applicable dose limits or dose guidance. [T-2]

2.19.6. Ensures a personnel dosimetry and bioassay program IAW **Chapter 3** and **6** are established, as necessary. Ensures dose records and local bioassay determinations are entered into deployment medical record DD Form 2766, *Adult Preventive and Chronic Care Flowsheet*. [T-1]

2.19.7. Ensures there is an active environmental surveillance and radiation survey program. The program must provide for evaluation of radiological hazards, assessment of individual doses and exposures, and implementation of protective measures. [T-2]

2.19.8. Provides diagnostic and treatment services for radiation injury, to include psychiatric casualties and internal radioactive contamination, IAW AF Manual 44-161, *Treatment of Nuclear and Radiological Casualties*; NCRP Report 161, *Management of Persons Contaminated with Radionuclides*; and NATO Manual AMedP-6(B), *NATO Handbook on the Medical Aspects of NBC Defensive Operations, Part I - Nuclear,* or as otherwise consistent with accepted practice. [T-2]

2.19.9. Ensures workers are properly trained on the risks of radiation, methods to minimize exposure, and the ALARA principle. [T-0]

2.20. Installation Radiation Safety Officer (IRSO). Qualifications for the IRSO are covered in **Attachment 2**.

2.20.1. Ensures the overall coordination of installation radiation safety activities to include INRAD and 91(b) material safety. Provides direct support and information to the installation commander on radiation health and safety issues and effectiveness of measures to control radiation hazards to comply with Federal, DoD and AF requirements (ref: AFI 40-201, AFI 91-108, AFMAN 48-125). [T-1]

2.20.1.1. Joint Basing: At locations where Air Force Wing is not lead agent and is a tenant unit on a Joint Base (JB), lead Service will appoint IRSO. In these cases, it is unlikely an AF member will be appointed as IRSO to manage the entire installation radiation protection program per the host service's guidelines. The AF Wing commander must designate a Wing RSO to execute IRSO responsibilities for Wing-owned personnel and operations. The Wing RSO is equivalent to IRSO and must meet same requirements

(see Appendix 3). If the host appoints an IRSO, designation of an AF Wing RSO is optional. [T-2]

2.20.1.2. Overseas Locations: IAW **paragraph 1.2.5** of this Instruction, USAF activities overseas shall also follow applicable laws and regulations of either the United States or the host nation. Host nation laws and regulations shall take precedence according to the terms of an applicable Treaty or Status of Forces Agreement (SOFA) (or similar document) with the host nation. Radiation safety standards and requirements followed by USAF organizations overseas will always be at least as stringent as those followed by USAF organizations within the United States. [T-1]

2.20.2. Establishes and manages the overall installation radiation safety program IAW Chapter 3. The program must include periodic, but at least annual, reviews of procedures and practices, facility design and classification, training, exposure control, monitoring, and surveillance activities. IRSOs shall provide oversight of permitted activities IAW AFI 40-201. This includes, but is not limited to, ensuring primary and alternate PRSOs are correctly identified on existing USAF Radioactive Material Permits and verifying the accuracy of RAM inventories. Reports deviations from this AFI and the base instruction or supplement to AFI 48-148, as applicable, to the Installation Commander, AFMSA/SG3PB or AFSEC/SEW, and through the MAJCOM/SGPB, as applicable. [T-1]

2.20.3. Assists commanders with the development of installation radiation safety operating instructions or radiation safety manuals, as appropriate.

2.20.4. Conducts public dose assessments and radon exposure monitoring described in **Chapter 5**. [T-1]

2.20.5. Works with Civil Engineers (CE) to ensure adequate design of facilities that will contain radiation sources. [T-2]

2.20.6. Manages the distribution and recordkeeping requirements of the personnel dosimetry and bioassay program for both occupational exposures and interventions.

2.20.6.1. Forwards unit personnel's off-duty or moonlighting radiation dose records to USAFSAM/OEH for inclusion into the MRER. [T-0]

2.20.6.2. Coordinates with Bioenvironmental Engineering to ensure installation personnel's potential workplace radiation hazards are referenced in the appropriate DOEHRS SEG. [T-0]

2.20.7. Oversees routine radiological decontamination and site remediation activities.

2.20.8. Publishes an installation radiation safety instruction or supplement, if desired, detailing local procedures for complying with this instruction. Annually reviews the installation instruction and updates it through the base publication process if changes are needed. [T-1]

2.20.9. IRSOs supporting nuclear capable units shall issue radiation dosimeters to all members of the 2W2 (Nuclear Weapons Specialist) career field assigned to nuclear capable units unless they are assigned to duties that do not have the potential for intrinsic radiation exposure (i.e., administrative positions). 2W2 personnel shall be monitored for gamma and neutron dose IAW AFI 91-108. [T-1]

2.20.10. Ensures discrepancies in radiation dosimetry reports due to lost or damaged radiation monitoring devices are corrected in the MRER in coordination with the AF Dosimetry Center. Corrections shall be accomplished within 30 days of identification. [T-1]

2.20.11. Briefs the Installation Commander at least annually regarding the results of the review, as described in **paragraph 2.20.3** of this regulation. (Note: Providing this briefing to the Environmental, Safety, Occupational Health Council satisfies this requirement.) [T-1]

2.20.12. Document radiation source incidents and environmental radon exposures in DOEHRS. [T-2]

2.20.13. Ensures workers are properly trained on the risks of radiation, methods to minimize exposure, and the ALARA principle. [T-0]

2.20.14. **(Added-FEW)** Approve contractor and outside agency use of Air Force Radioisotope Committee Secretariat (RICS) permitted (or equivalent) licensed radioactive materials at FEWAFB and 90 MW supported sites.

2.20.15. **(Added-FEW)** Ensure unit and permit RSOs possess the necessary qualifications.

2.20.16. **(Added-FEW)** Provide training materials on radiation safety and intrinsic radiation to unit and permit RSOs.

2.20.17. **(Added-FEW)** Coordinate requests for the acquisition, transport, disposal or recycling of radioactive material, radiation-producing devices, and lasers.

2.20.18. **(Added-FEW)** Maintain a master inventory of generally licensed devices or AF-permitted radioactive material on the installation. Load this inventory into the Radioactive Material Management Information System (RAMMIS).

2.20.19. **(Added-FEW)** Maintain a list of unit RSOs. Update this list each year during the base program review or when changes are identified.

2.21. Unit Radiation Safety Officer (URSO) and Permit Radiation Safety Officer (PRSO). The qualifications for URSOs and PRSOs are covered in **Attachment 2**. PRSO responsibilities are further prescribed in AFI 40-201.

2.21.1. Provides technical support to organization or unit commanders on radiation protection issues. Keeps organization and unit commanders, and the IRSO, informed about radiation health and safety issues and effectiveness of measures to control radiation hazards. [T-1]

2.21.2. Establishes and manages the organization or unit radiation safety program IAW **Chapter 3**, as applicable. The program must include review of procedures and practices, facility design review and classification, training, exposure control activities, and routine monitoring and surveillance activities. [T-2]

2.21.3. Provides commanders assistance in developing organization specific radiation safety operating instructions and radiation safety manuals. [T-3]

2.21.4. Maintains and manages records as required by this AFI. [T-2]

2.21.5. Ensures workers are properly trained on the risks of radiation, methods to minimize exposure, and the ALARA principle. [T-0]

2.21.6. Forwards unit personnel's off-duty or moonlighting radiation dose records to IRSO for inclusion into the MRER. [T-0]

2.21.7. **(Added-FEW)** Complete and submit USAF radioactive material permit applications, amendments, and termination requests through the installation RSO IAW AFI 40-201.

2.21.8. **(Added-FEW)** Routinely inspect all areas where radioactive materials or radiation-producing devices are used or stored to ensure no changes have occurred and that they remain in accordance with requirements of USAF Radioactive Material Permits, Air Force Instructions and other directives.

2.21.9. **(Added-FEW)** Develop operating instructions (OI), as needed or as required by the IRSO, to help keep exposures ALARA and ensure a quality assurance program for radiation safety is implemented. Submit the OIs to the IRSO for coordination and approval.

2.21.10. **(Added-FEW)** Ensure that personnel involved with the use of radioactive material and devices are qualified to use them.

2.21.11. **(Added-FEW)** Immediately notify the IRSO of all accidents or incidents involving radiation. Aid the IRSO in evaluating and investigating such exposures.

2.21.12. **(Added-FEW)** Notify IRSO no less than 30 days prior to ordering devices or equipment that contain or is expected to contain radioactive material or lasers for approval and evaluation.

2.21.13. **(Added-FEW)** Immediately notify the IRSO prior to disposal, or recycling of any radioactive material, radiation-producing equipment, and lasers. The IRSO will coordinate the transport of these items.

2.22. Base Civil Engineer (BCE).

2.22.1. Designs facilities IAW **paragraph 3.2** of this instruction. [T-3]

2.22.2. In response to major accidents/incidents, enemy attack and terrorist use of improvised explosive devices (IED), weapons of mass destruction involving nuclear or radiological materials, Explosive Ordnance Disposal (EOD) or Emergency Management, with guidance from the IRSO shall: [T-1]

2.22.2.1. Mitigate and remediate radiological hazards, as necessary, to keep exposures ALARA and within guidance presented in **Attachment 7** and **8**, respectively. [T-2]

2.22.2.2. Assists in conducting radiation surveys to evaluate or confirm the extent and nature of the radiological hazards. [T-2]

2.22.2.3. Use portable X-Ray systems, if warranted, to diagnose and determine presence of hazardous devices inside closed packages and munition. [T-3]

2.22.3. Mitigates structures where exposures to radon or radon progeny exceed the remedial action level specified in **Chapter 5**. Incorporate radon reduction measures in the construction of new facilities at medium and high risk installations as required in current DoD and AF policy. [T-1]

2.22.4. Manage and control radioactive wastes generated during remedial actions or interventions. Ensures wastes are disposed of via the Air Force Radioactive Recycling and Disposal (AFRRAD) Office IAW AFIs 40-201, 91-108 and 32-7086. [T-1]

2.22.5. Conducts training IAW AFI 10-2501, *Air Force Emergency Management (EM) Program Planning and Operations*, and include all subjects identified in **Chapter 6**.

2.22.6. **(Added-FEW)** The Base Civil Engineer will ensure the IRSO, unit RSOs, and permit RSOs with a vested interest review plans for new construction or modification of facilities that involve the use of radioactive material or radiation producing devices.

2.22.7. **(Added-FEW)** Provide expert advice to generating units, the IRSO, and AFRRAD on all applicable federal, state and local environmental regulations (primarily RCRA) pertaining to the identification, handling, storage, treatment, transport and disposal of 91(b) mixed waste as hazardous waste (reference 42 U.S.C., Ch. 82, Sec. 6901 et seq., RCRA).

2.23. Workplace Supervisors.

2.23.1. Ensures workplace adherence to the requirements of this AFI. [T-2]

2.23.2. Ensures protection of Airmen and AF civilians from occupational exposures. Contractors shall comply with this instruction regarding the use and control of radiation devices and are solely responsible for the health and safety of their personnel as specified in their contract. [T-1]

2.23.3. Ensures protection of the public from non-occupational exposures from workplace practices. [T-1]

2.23.4. Ensures personnel are trained on radiation hazards in the workplace and appropriate protection requirements. [T-2]

2.23.5. Ensures radiation safety procedures are current and adhered to by workers. [T-2]

2.23.6. Ensures declared pregnant workers notify Public Health of their pregnancy status. [T-1]

2.23.7. Notifies the IRSO and URSO of changes in practices or procedures involving radiation sources, potential violations of this instruction, unsafe work practices involving radiation sources, or accidents or incidents involving radiation. [T-1]

2.23.8. Ensures workers are properly trained on the risks of radiation, methods to minimize exposure, and the ALARA principle. [T-0]

2.23.9. **(Added-FEW)** For workplaces monitored on the TLD program, ensure the TLD badge, when not worn during work, is stored at the approved storage location. Storage in areas other than the designated rack (for example, desk drawers, clothing, vehicle glove compartments, etc.) is prohibited as such actions may affect monitoring results.

2.23.10. **(Added-FEW)** Ensures individuals and permittees identify items containing radioactive materials and coordinate with the IRSO prior to shipment. The radionuclide, activity, chemical and physical form, item nomenclature, and stock number shall be provided to the IRSO.

2.24. Radiation Worker.

2.24.1. Follows applicable rules and procedures for radiation protection and safety specified by organizational management and this AFI.

2.24.2. Uses issued dosimeters and personal protective equipment correctly and IAW AFMAN 48-125, *Personnel Ionizing Radiation Dosimetry*.

2.24.3. Complies with commander-directed radiation protection and dose assessment programs as well as radiological health surveillance.

2.24.4. Provides the URSO and/or IRSO information on past and current work relevant to ensure comprehensive effective protection and safety for themselves and others. Provides off duty or moonlighting dosimetry data to the URSO and IRSO. (IAW 10 CFR 20.2104). [T-1]

2.24.5. Performs operations in a manner that maintains doses ALARA.

2.24.6. Receives information, instruction, and training concerning protection and safety to conduct work IAW this AFI.

2.24.7. Notifies workplace supervisors of changes to procedures or operations that could affect exposure, potential violations of this instruction, unsafe work practices involving radiation sources, or accidents or incidents involving radiation.

2.24.8. An active duty pregnant female shall, on becoming aware she is pregnant, notify her Commander, workplace supervisor, and the Public Health office. A non-military or civilian member is encouraged to notify her Commander, workplace supervisor, and Public Health office of her pregnancy. Note: It is important to remember that it is the decision of a civilian woman whether or not she declares her pregnancy. [T-1]

2.25. Base Contracting.

2.25.1. Monitor and review contracts on projects in which contractor(s) requires the use of devices that contain radioactive materials (RAM), e.g., soil density gauges, radiography cameras, or use of radiation producing devices (RPD), e.g., portable x-ray machines. [T-1]

2.25.2. Ensures IRSO reviews scope of work to assess radiation protection requirements prior to contractor(s) bringing RAM containing devices or RPDs onto the installation. [T-1]

2.26. (Added-FEW) Bioenvironmental Engineering.

2.26.1. **(Added-FEW)** Will conduct radiation surveys and/or evaluations of all radioactive material shipments and receipts.

2.26.2. **(Added-FEW)** Will monitor and maintain a log of radiation survey results of all radioactive material shipments and receipts. The log of shipments and receipts will be maintained for 3 years.

2.26.3. **(Added-FEW)** Aid the IRSO during overexposure investigations. Ensure privacy act information is safeguarded IAW AFI 33-332. Mark/safeguard the report/listing/statements as FOUO-PA IAW AFI 33-332 Chapter 2 and AFI 31-401, Atch 2. Any disclosure to unauthorized personnel must be reported as PII Breach per AFI 33-332 Chapter 9.

2.27. (Added-FEW) Traffic Management Office (TMO) or Cargo Movement.

2.27.1. **(Added-FEW)** Notify the IRSO and/or BE of any radioactive materials, radiation-producing devices, or lasers received or requested to be shipped.

2.27.2. **(Added-FEW)** Allow BE to survey radioactive materials and devices prior to packaging shipments and prior to issuing materials or items to owning unit.

2.28. (Added-FEW) Defense Logistics Agency (DLA) Disposition Services.

2.28.1. **(Added-FEW)** Shall not accept any radioactive materials.

2.28.2. **(Added-FEW)** Shall return any radioactive materials, or items with radioactive listed on the item documentation, to the sender. Immediately notify the IRSO of any instances where radioactive materials are transferred to DLA Disposition Services.

Chapter 3

RADIATION PROTECTION FOR OCCUPATIONAL PRACTICES

3.1. Organization and Administration. Every organization or installation that uses non-exempt quantities of RAM (defined in AFI 40-201), radiation producing devices (RPD), or has the potential for exposures to residual RAM associated with AF operations shall implement a radiation safety program commensurate with the scope of the program and its potential health hazards. Critical program elements are found in this chapter and are generic to all AF practices involving potential exposure to ionizing radiation. Specific Technical Orders (T.O.s) or instructions should be referred to for additional detailed information on radiation protection for unique practices (e.g., T.O. 33B-1-1, *Non-destructive Inspection*). [T-1]

3.1.1. Installation Radiation Safety.

3.1.1.1. IRSO: The IRSO has overall responsibility and authority over the installation or USAF owned operations requiring a radiation safety program, as described in **paragraph 2.20**. [T-1]

3.1.1.2. URSO or PRSO. Nuclear capable units and units with 91(b) material will appoint URSOs in accordance with AFI 91-108. This individual shall be directly responsible to senior management of the organization, 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. [T-3]

3.1.1.3. Radiation Safety Committee (RSC).

3.1.1.3.1. RSCs shall be established when directed by federal standard (e.g. 10 CFR 33.13 or 35.24) or when specified as a permit condition issued by the AF Radioisotope Committee Secretariat. [T-0]

3.1.1.3.2. RSCs should be established for facilities, organizations, or installations with extensive radiation protection program requirements. Examples include medical facilities to which a health or medical physicist (43EXG) is assigned, an installation with many diverse operations involving radioactive material permits, and activities with large radiation sources (e.g. irradiators, radioactive waste facilities). [T-3]

3.1.1.3.3. RSCs shall be composed of senior management, the IRSO, organization or URSO and other individuals knowledgeable and responsible for RAM and radiation sources. The RSC shall meet at a frequency appropriate to evaluate the purpose, safety, and compliance of the radiation safety program and regulatory requirements.

3.1.1.3.4. RSCs established as a condition of an AF RAM permit shall meet quarterly. [T-1]

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

3.1.2.1. Commanders, organization and URSOs, and workplace supervisors shall institute a radiation safety policy that defines the goals of the radiation safety program, the organization and administrative controls required for use of RAM and radiation sources, and state a commitment to the radiation protection policy for practices. [T-1]

3.1.2.2. Commanders, organization and URSOs, 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, readily available to all users of radiation sources, and annually reviewed and updated, as necessary. They shall describe the safety controls and procedural safeguards necessary to limit exposure and actions to be followed in the event of a mishap or emergency. [T-1]

3.2. Facility Design, Layout and Area Classification.

3.2.1. Facility Design.

3.2.1.1. Facilities in which non-exempt quantities of RAM, nuclear weapons or components, 91(b) material, or radiation producing devices are used shall be designed so that exposures from normal operation of the facility are ALARA and do not result in exposures that exceed applicable limits as provided in Attachment 3. Where appropriate, facilities shall also be designed so as to prevent or mitigate radiation mishaps. [T-1]

3.2.1.2. Consideration shall be made, but not limited to: site selection, facility layout, equipment and system design, shielding, ventilation (including fume hoods and glove boxes), RAM waste management, monitoring and surveillance requirements, and access controls (References: 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*, and NCRP Report No. 151, *Structural Shielding and Evaluation Megavoltage X- and Gamma-Ray Radiotherapy Facilities*). [T-1]

3.2.1.3. New AF facilities designed for use of RAM or radiation producing devices shall be constructed so that a member of the public will not likely receive more than 0.02 mSv (2 mrem) deep-dose equivalent in any one hour and 1 mSv (100 mrem) total effective dose equivalent (TEDE) in a calendar year from the normal operation of the facility. [T-0]

3.2.1.4. The planning and design of new or significantly modified facilities shall include a review by a qualified expert (as defined in Attachment 2) to ensure appropriate radiation safety features are incorporated. Where local expertise is unavailable, contact USAFSAM for assistance. [T-1]

3.2.1.5. Administrative controls and personal protective equipment shall not be used as a substitute for engineering controls and appropriate facility design. [T-3]

3.2.1.6. Consideration shall be given to decommissioning requirements during the design phase if facilities are to be used for unsealed RAM, accelerators producing photons with energies greater than 13 MeV, or neutron sources. [T-1]

3.2.2. Classification of Areas.

3.2.2.1. Restricted Areas. Restricted areas shall be established, as required, to control radiation exposures, spread of contamination, or access to RAM. The IRSO will maintain a list of restricted areas, to include: the classification of the area, the location, and the owning organization. Restricted areas shall: [T-1]

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 the IRSO or personnel having approval of the unit or organization 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 where 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 be designated a radiation area. All such areas shall: [T-0]

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 temporary areas, medical x-ray facilities, and rooms otherwise exempted IAW 10 CFR 20.1903.

3.2.2.3. High Radiation Areas. Any area accessible to individuals where 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: [T-0]

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 temporary areas, medical x-ray facilities, and rooms otherwise exempted 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 where radiation levels could result in an individual receiving an absorbed dose in excess of 5 Gy (500 rad) in 1 hour at 1 meter from a radiation source shall be designated a very high radiation area. All such areas shall: [T-0]

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 temporary areas, medical therapy facilities, and facilities otherwise exempted IAW 10 CFR 20.1903.

3.2.2.4.3. Adhere to the requirements of 10 CFR 20.1602. [T-0]

3.3. Training.

3.3.1. General: All personnel (military, civilians and in-house contractors) who have the potential to be occupationally exposed to 1 mSv (100 mrem) in a year 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 IRSO. Training should address the following topics, as applicable: [T-0]

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 (i.e., internal versus external);

3.3.1.4. Health risks posed by this exposure including: deterministic and stochastic effects, somatic and genetic effects, and effects on the unborn fetus, as appropriate; and

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. RAM permit requirements, as appropriate; and

3.3.1.10. Other occupation specific hazards and the related skills and procedures that are required for working with the RAM or radiation-producing devices of concern (e.g., depleted uranium awareness training).

3.3.1.11. Intrinsic radiation safety training shall be given to all nuclear weapons specialists (2W2) assigned to nuclear weapons capable units or to units with 91(b) materials. Such shall occur within 90 days of assignment with a refresher given every 15 months thereafter. The IRSO and URSO can expand the scope of this training as appropriate (e.g. handlers, loaders, security forces). The content of training is provided at the AFMSA Radiation Programs website located on AFMS Knowledge Exchange; **https://kx2.afms.mil/kj/kx5/radiationprograms/Pages/home.aspx**.

3.3.2. Training Plan: A written training plan shall be developed by the unit, organization, or IRSO. The training program shall be reviewed and revised as necessary to reflect changes in practices in the workplace. [T-2]

3.3.3. Record keeping. Training programs presented, course curricula, and attendance shall be maintained for a period of three (3) years unless otherwise specified. Training shall be documented on personnel's AF Form 55, Employee Safety and Health Record, or other AF sanctioned training database. [T-0]

3.3.4. **(Added-FEW)** The unit RSO shall provide the IRSO documentation showing their personnel have completed radiation safety training. This may be accomplished by forwarding a training log, or electronic printout showing completion dates for the specific course.

3.4. Radiation Exposure Control.

3.4.1. Dose Limits. Occupationally exposed personnel shall not exceed dose limits specified in Table A4.1. [T-0]

3.4.2. Reference Levels. Personnel should not receive a dose in excess of 25% of the applicable annual dose limits in a quarter, or 10% of the applicable annual dose limits in a month without proper justification and optimization of the procedure.

3.4.3. Investigation Levels. IRSOs, or the RSC where applicable, shall ensure the local program includes documented acceptable dose threshold levels based upon historical dosimetry and bioassay results, and/or surveillance (see **paragraph 3.5.2**). IRSOs shall conduct an investigation into causative factors and identify corrective measures when this threshold level is exceeded. Refer to AFMAN 48-125 for additional information. [T-1]

3.4.3.1. **(Added-FEW)** FEWAFB Personnel dosimetry investigation action levels are determined by the IRSO and serve to determine surveillance and control requirements. Investigation Action Levels are maintained by the IRSO and are reviewed and updated annually based on trend analysis.

3.4.4. Exposure Control. Workers shall use the following techniques under the judgment and discretion of the IRSO to ensure dose limits are not exceeded and exposures are ALARA (reference NCRP Report No. 127). [T-1]

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. 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.

3.4.4.2.2. Personal protective clothing is not warranted 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 AFI 48-137, *Respiratory Protection Program*.

3.4.4.3. Contamination Control: In the absence of superseding 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 labeled as contaminated. An exemption is granted to routine low-level contamination by short-lived radionuclides (half-life less than 120 days) used in nuclear medicine departments. Contact USAFSAM/OEH for additional guidance.

3.4.4.3.2. Always prevent or keep radioactive contamination 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 for areas that can be classified as high or very high radiation areas under **paragraph 3.2.2**. For additional information, consult USAFSAM/OEH and refer to NCRP Report No. 88, *Radiation Alarms and Access Controls Systems*, 2 September 1986.

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

3.4.4.6. Change of Duty or Curtailment: 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 limits are not exceeded. Such changes in duty shall remain in effect until the individual's projected dose will be less than the prescribed limits. This situation is most frequently encountered for the pregnant worker who has declared her pregnancy. Based on the exposure information and workplace assessment of the IRSO, the female worker's PCM (if military) or health care provider (if civilian) will determine any restrictions to the worker's duties involving occupational radiation exposure. The following guidelines are prudent for declared pregnant workers: [T-1]

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 or 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 compounding radiopharmaceuticals, dosing patients, and working in the hot lab.

3.4.4.6.4. Female nuclear weapons specialists (2W2) who declare pregnancy should be restricted from duties requiring contact with or occupancy in rooms where Hydrogen-3 (tritium) vapors/oxides are present. If operational requirements of the unit make it necessary for pregnant females to work in those areas, then the unit commander shall review the exposure potential. The unit commander shall consult AFSEC/SEW, the IRSO, and/or the worker's PCM to discuss the potential for exposure and risk. [T-1]

3.5. Radiation Dosimetry, Reporting and Record Keeping.

3.5.1. Personnel Monitoring Criteria. Individuals who are occupationally exposed to ionizing radiation as part of their duties must be provided dosimetry and bioassays as described in AFMAN 48-125 when any of the following apply: [T-0]

3.5.1.1. Exposures are measured or calculated to exceed 1 mSv (100 mrem) TEDE in a year, 2% of a CEDE based ALI, or 2% of the occupational limits listed in **Table A4.1**.

3.5.1.2. Dosimetry services may be provided to individuals not meeting the above criteria. If the type of radiation to which the individual could be exposed is detectable by the AF personnel monitoring program, at the discretion of the IRSO, dosimetry services may be provided in the following cases:

3.5.1.2.1. Monitoring would be helpful in demonstrating compliance with ALARA;

3.5.1.2.2. Monitoring is desirable to evaluate potential exposure conditions to relieve worker concern;

3.5.1.2.3. Requested by the individual.

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

3.5.1.4. Members of the 2W2 career field assigned to a nuclear capable unit except those assigned to duties not having the potential for INRAD exposure (i.e., administrative positions). These individuals shall be monitored for both gamma and neutron dose IAW AFI 91-108.

3.5.1.5. Pregnant occupational radiation workers must be monitored throughout their gestational period. Note: Contractors will only be provided dosimetry when legally required, as specified in the contract. The contract, IAW 29 CFR 1910.1096, should state the contractor's employer (not the USAF) will provide dosimetry. The AF always has the responsibility to control exposures due to licensed radioactive material IAW 10 CFR 20.1201. The IRSO may determine that a contractor can receive personal dosimetry if any of the above criterion is met and their employer is not able to provide the service. [T-0]

3.5.2. Reference Levels. Any dosimeter and/or bioassay result which indicates a dose in excess of 25% of the applicable annual dose limit, received for a quarterly monitoring period, or 10% of the applicable annual dose limits if monitored monthly, shall be investigated within 10 days following discovery. If an investigation determines excessive exposure occurred, a report must be submitted to AFMSA/SG3PB and USAFSAM/OEH through the MAJCOM BEE within 30 days. The report shall include: [T-1]

3.5.2.1. Name, SSAN, occupational dosimetry code, and AFSC of the individual(s) involved;

3.5.2.2. Description of circumstances surrounding the exposure;

3.5.2.3. Estimates of each individual(s) dose equivalent, to include a detailed discussion of how this value was determined;

3.5.2.4. Cause of the exposure;

3.5.2.5. Corrective actions taken to prevent recurrence;

3.5.2.6. Statement signed by the individual(s) involved either supporting or contesting the investigation report;

3.5.2.7. Results of any medical examinations;

3.5.3. Overexposures. Any dosimeter and/or bioassay result exceeding the applicable limit in **Table A4.1** shall be considered an overexposure and immediately investigated. [T-0]

3.5.3.1. Notification:

3.5.3.1.1. When a dosimeter and (or) bioassay indicates an overexposure may have occurred, USAFSAM/OEH will immediately notify the IRSO by telephone and follow up with an email or faxed letter within three (3) hours. [T-1]

3.5.3.1.2. The individual shall be removed, when warranted, from all duties involving potential radiation exposure until an investigation of the incident can be completed. [T-1]

3.5.3.2. Reporting:

3.5.3.2.1. The IRSO shall investigate suspected overexposures, with a written report of the investigation submitted through the MAJCOM BEE to USAFSAM/OEH and AFMSA/SG3PB within 10 duty days after notification. The written report must include those elements required in **paragraph 3.5.2**. [T-1]

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

3.5.4. Record Keeping.

3.5.4.1. Cumulative History of Occupational Exposure. Upon written request by the individual, IRSO, or other authorized organizations and individuals, USAFSAM/OEH shall provide a copy of all AF Forms 1527-2, *Cumulative History of Individual Occupational Exposure to Ionizing Radiation*. All requests other than those made to official AF use must have a release signed by the individual for whom the report pertains. [T-1]

3.5.4.2. Previous or Concurrent Occupational Dose. The IRSO shall make a reasonable effort to collect dosimetry records for individuals having either past or present non-AF employment involving radiation exposure. AF 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 IRSO or URSO. The IRSO shall ensure these results are forwarded to USAFSAM/OEH for incorporation in the MRER. The individual bears ultimate responsibility for ensuring any non-AF dosimetry results become part of the MRER. [T-1]

3.5.5. Administrative Doses. Assignment of administrative doses are required for lost or damaged dosimeters or for those individuals with exposures other than the purpose for which it was intended. Exposure information from recovered dosimeters shall replace administrative dose estimates. Assigned doses must be estimated by the IRSO using the procedures in AFMAN 48-125. The IRSO shall ensure the assigned dose replaces the administrative dose in MRER within 30 days. [T-1]

3.6. Monitoring and Surveillance Programs and Instrumentation.

3.6.1. Types of Surveys: Surveys shall be conducted in areas where the potential exists for exposure to external radiation fields, airborne contamination, or surface contamination. Two types of surveys are common: routine surveys conducted on a fixed, periodic basis at common locations to determine changes or trends in the radiation environment and non-routine surveys performed to evaluate new or expected changes in a radiation field. [T-0 - 10 CFR 20.1501]

3.6.1.1. Routine surveys shall be performed by a qualified expert (see Attachment 2) following requirements of this instruction. [T-2]

3.6.1.2. Non-routine surveys shall be performed by a qualified expert on any new or substantially modified facility where a radiation source is used or if the characteristics of the radiation source have significantly changed. New survey measurements must be taken after any modification of the facility impacting the shielding or RAM control, replacement or change of the radiation source, and/or a significant change in practice or the uses of the radiation source. 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. This includes nuclear weapons storage and maintenance facilities, as well as facilities housing 91(b) materials. [T-2]

3.6.2. Instrumentation: Instrumentation used to perform surveys, shall be appropriate to the type(s) of radiation and emitted energy(ies). IRSOs shall consult with USAFSAM/OEH on instrumentation requirements prior to performing intrinsic radiation, atmospheric radiation, high energy (>13 MeV) accelerator surveys or other mixed radiation environments. [T-1]

3.6.2.1. Instrumentation shall be calibrated annually, or at a frequency specified in the applicable USAF RAM Permit or Technical Order (T.O.), using National Institute of Standards and Technology (NIST) traceable radiation sources. [T-0]

3.6.2.2. Instrument performance shall be checked before each use, IAW manufacturer's recommendations, as applicable. [T-1]

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 the applicable AF RAM permit, T.O. or AF Files Disposition Instruction, whichever is most stringent. Specific record keeping requirements for radiation protection programs can be found in AFI 40-201, paragraph 3.15. [T-0]

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. [T-1]

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 be recycled, when feasible, or be reduced in volume and treated, when feasible, to render it less hazardous. [T-1]

3.7.2. Radioactive Waste Storage: All waste pending disposition shall be stored in a restricted area, in clearly marked containers. See AFI 40-201 for guidance. [T-2]

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, etc.). Medical surveillance of overexposures shall be evaluated on a case-by- case basis by the MAJCOM/SG in coordination with AFMSA/SG3PB. [T-3]

3.9. (Added-FEW) Radiation Exposure Incidents.

3.9.1. **(Added-FEW)** Workers shall immediately notify their supervisor whenever a suspected overexposure occurs. The unit RSO, in coordination with the IRSO, will obtain a signed, narrative statement from the exposed worker and witnesses immediately. Ensure privacy act information is safeguarded IAW AFI 33-332. Supervisors will mark/safeguard any statements as FOUO-PA IAW AFI 33-332 Chapter 2 and AFI 31-401, Atch 2. Any disclosure to unauthorized personnel must be reported as PII Breach per AFI 33-332 Chapter 9. The statement will include:

3.9.1.1. **(Added-FEW)** Name, rank, and SSAN (last four) of exposed worker.

3.9.1.2. **(Added-FEW)** Radiation source - include activity (power settings if X-ray).

3.9.1.3. **(Added-FEW)** Brief description of event.

3.9.1.4. **(Added-FEW)** Length of exposure.

3.9.1.5. **(Added-FEW)** Distance from source.

3.9.2. **(Added-FEW)** The exposed worker will report immediately to the 90 MDG for physical examination. The physician will complete a referral to Public Health to generate an AF Form 190, Occupational Illness/Injury Report.

3.9.3. **(Added-FEW)** The IRSO will make appropriate notifications and coordinate an investigation.

Chapter 4

RADIATION PROTECTION REQUIREMENTS FOR MEDICAL USES OF RADIATION

4.1. Introduction.

4.1.1. This chapter applies to all USAF Medical Treatment Facilities (MTFs) worldwide (i.e., CONUS, OCONUS, overseas enduring and non-enduring AF locations, and Joint DoD installations where the AF is the lead service) that acquire, possess, install, calibrate, maintain, evaluate, use, or dispose of sources of radiation used for diagnosis, therapy, or for medical research. Any exceptions to this policy must be approved by the Associate Corp Chief for Bioenvironmental Engineering in consultation with the AF/SG Consultant for Medical Physics. [T-1]

4.1.2. Operations involving Joint DoD or Joint AF-Veterans Affairs MTFs must have an Memorandum of Agreement (MOA) which shall include specific instructions and/or guidance regarding the scope of medical physics support and required services. Coordination of all proposed MOAs must be coordinated through the Associate Corps Chief for Bioenvironmental Engineering in consultation with the AF/SG Consultant for Medical Physics. If the AF is the lead service, coordination through the designated Regional Consulting Medical Physics Office (reference **Attachment 5**) is also required. [T-3]

4.1.3. This chapter describes radiation protection requirements that are applicable to medical practices to ensure patient, practitioner, and public radiation doses are ALARA, while obtaining clinical objectives. Responsibility for complying with the requirements in this chapter rests with the MTF commander or duly appointed individual(s) who possess appropriate training, skills, credentials, and resources to ensure compliance.

4.2. Responsibilities.

4.2.1. MTF Commander.

4.2.1.1. If the MTF maintains qualified medical physicists (reference **paragraph 4.3.3**):

4.2.1.1.1. The MTF shall ensure qualified organizational medical physicists are directly responsible to the organization to which they are assigned, and appropriate staff is maintained to provide medical physics services to support those MTFs within their host organization's region of responsibility (reference **Attachment 5**). [T-1]

4.2.1.1.2. The MTF shall provide resources to support the training of active duty medical physics trainees. If qualified active duty or civil service medical physicists are not available for all diagnostic imaging and/or radiation therapy modalities, qualified contracted medical physics services shall include a contract provision to provide clinical training to active duty medical physicists to a fully-qualified status. [T-3]

4.2.1.2. If the MTF does not maintain qualified medical physicists:

4.2.1.2.1. The MTF shall designate annual consulting (TDY) funds for medical physics services in accordance with the following:

4.2.1.2.1.1. It is the responsibility of the equipment gaining MTF to fund consulting medical physics services, to include acceptance testing and associated annual surveys.

4.2.1.2.1.2. The specific equipment that requires medical physics acceptance testing and annual surveys by a qualified medical physicist, specified in **paragraph 4.3.3**, includes the following: mammography, computed tomography, computed radiography, digital radiography, teleradiology systems, magnetic resonance imaging, high level fluoroscopy systems (including interventional radiography), single photon computed tomography (SPECT) systems, and positron emission tomography (PET) or PET/CT systems.

4.2.1.2.1.3. If a qualified AF medical physicist is not available, a contract physicist should be hired based upon the qualification requirements stated in **paragraph 4.3.3**. Final reports of testing performed by non AF medical physicists must be forwarded to the designated regional consulting medical physics office for review (reference **Attachment 5**). [T-2]

4.2.1.2.2. An estimate for the clinical physics testing services for the scope of the MTF (i.e., diagnostic imaging, nuclear medicine, and other users of radiation imaging devices) can be provided by the designated regional consulting medical physics office (reference **Attachment 5**) or the AF/SG Consultant for Medical Physics.

4.2.1.2.3. The MTF shall maintain a radiation safety program and implement appropriate quality control (QC) programs for the various diagnostic imaging, nuclear medicine, and radiation therapy modalities offered at the MTF. The designated regional consulting medical physics office can provide consultation regarding these programs. [T-1]

4.2.1.2.4. New diagnostic imaging and/or radiation therapy systems shall not be used clinically until acceptance testing has been performed. In addition, commissioning of radiation therapy systems must be performed by a qualified radiation therapy medical physicist prior to clinical use. [T-1]

4.2.1.2.4.1. Human test subjects or volunteers shall not be used for device/system evaluation. An exception may be granted by AFMSA/SG3PB, but only after a medical physics acceptance test has been performed and appropriate participant consent forms signed and approved by the MTF/ Chief of Hospital Services (SGH), in consultation with the MTF Radiology flight commander and the regional medical physicist. [T-0]

4.2.2. Physicians. Radiologists, radiation oncologists, nuclear medicine physicians, and other qualified physicians that clinically use radiation devices and/or RAM shall:

4.2.2.1. Control all aspects of the conduct and extent of the examinations; [T-1]

4.2.2.2. 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 radiation. [T-1]

4.2.2.3. Ensure the procedures used are appropriate and optimized for the clinical problem presented. [T-1]

4.2.3. Credentialed Providers.

4.2.3.1. Cognizant of all of their patient's radiation procedures (i.e., diagnostic imaging, nuclear medicine, and/or radiotherapy) and maintains such information in the patient's medical record.

4.2.3.2. Considers the patient's history regarding recent radiation procedures performed external to the facility as an important aspect of medical care, especially for females of child-bearing age.

4.2.3.2.1. If a patient is pregnant or becomes pregnant prior to, or immediately after, a radiological procedure (e.g., x-ray of the pelvic region and/or nuclear medicine study), the provider shall immediately consult with a radiologist and/or regional consulting medical physics office regarding the calculation of the dose to the conceptus. [T-2]

4.2.3.3. In addition, potential high-dose exposure, from multiple-computed tomography or high-level fluoroscopy procedures, should be reviewed/evaluated by the radiologist and/or regional consulting medical physics office. [T-1]

4.2.4. Medical Physicists. Qualified organizational medical physicists, as defined in paragraph 4.3.3, shall be directly responsible to the organization to which they are assigned, and support those MTFs within their host organization's region of responsibility (reference **Attachment 5**).

4.2.4.1. Chief, Medical Physicist shall:

4.2.4.1.1. Oversee quality control (QC) programs and provide guidance on quality assurance (QA) practices for the MTF to which the medical physicist is assigned, and provide consultation on and review of QC programs and QA practices to clinics utilizing radiation for imaging within the consulting medical physics office's region of responsibility. [T-2]

4.2.4.1.1.1. Provide medical physics education and training. [T-2]

4.2.4.1.1.1.1. Oversee the training of medical physics trainees to a fully-qualified status for diagnostic imaging and/or radiation therapy medical physics. Training curricula shall follow the guidance provided by the American Association of Physicists in Medicine (AAPM) and the American Board of Radiology (ABR).

4.2.4.1.1.2. Provide medical physics lectures to support the Radiology Residency Training Programs.

4.2.4.1.1.3. Provide radiation safety and dose/image quality overview training to all fluoroscopy x-ray users, including non-radiology users. The training shall also include the guidance found in applicable AF/SG NOTAMs (e.g., SGNOTAM 10-002).

4.2.4.1.1.4. Support other AF training programs (e.g., technologists training programs in diagnostic imaging and nuclear medicine) related to the medical use of radiation as requested and upon availability.

4.2.4.1.1.5. Oversee technologists who perform nuclear medicine and diagnostic

radiology QC and QA tasks. This is focused on periodic review of the data collection and associated analysis, and the appropriateness of the QC program.

4.2.4.1.2. Provide or supplement diagnostic medical physics contract services in support of the requirements in the Mammography Quality Standards Act, 21 CFR Parts 16 and 900. Note: For mammography support, diagnostic medical physicists must meet all qualifications specified in 21 CFR Part 900. [T-0]

4.2.4.1.3. Provide or supplement acceptance testing services for all new diagnostic imaging and radiation therapy medical systems. [T-1]

4.2.4.1.4. Consult on patient radiation protection requirements and dosimetry review programs, including those involving exposure to the conceptus and from advanced imaging modalities (i.e., computed tomography, interventional radiography, and nuclear medicine studies). This includes supporting regional sites in addition to the primarily assigned facility. [T-1]

4.2.4.1.5. Create and maintain a repository of QC reports for each diagnostic medical x-ray system at each MTF within their region of responsibility as deemed appropriate by the regional consulting medical physics office. This is to include annual entrance skin exposure (ESE) calculations. [T-2]

4.2.4.1.6. If a designated regional consulting medical physics office is unable to support a requirement for an MTF within their region of responsibility, the designated office shall first coordinate with other AF consulting medical physics offices to determine if support can be provided to the requesting MTF. If support can't be provided from within the AF or it is more cost effective to utilize a local contract medical physicist for the requested services, it is the responsibility of the requesting MTF to locate qualified support external to the AF (**paragraph 4.3.3.4**). All MTFs utilizing contracted medical physics services shall send a copy of the final report(s) to their designated regional medical physics office for review, which must be completed within 30 duty days from receipt of report. The testing physicist can approve (full/partial) clinical use of the device based on testing results prior to final report review by the regional consulting medical physics office.

4.2.4.1.7. Consultative medical physics support for expeditionary and sustainment locations will be coordinated with the AF/SG Medical Physics Consultant and provided by a designated regional medical physics office.

4.2.4.1.7.1. A copy of all testing reports, regardless of which military service provides the medical physics support, shall be forwarded to the AF/SG Medical Physics Consultant NLT 45-duty days post system test by the supporting bioenvironmental engineer.

4.2.4.1.7.2. For sustainment locations, the equipment should be checked in the AOR by a qualified individual prior to clinical use. Requirements found in **paragraph 4.7.1** are applicable at sustainment locations where the AF is the lead service.

4.2.4.1.7.3. A copy of all testing reports, regardless of which military service provides the medical physics support, shall be forwarded to the AF/SG Medical

Physics Consultant for review.

4.2.4.1.8. Provide semi-annual reports to the AF/SG Medical Physics Consultant regarding status of the regional support mission. Details of the report will be established by the AF Medical Physics Working Group (AF-MPWG) and used by the AF-RSC and the decision making processes for the Bioenvironmental Engineering Corporate Board (BCB). [T-1]

4.2.4.1.8.1. Each MTF shall directly report any medical ionizing radiation or MRI related injury, IAW the FDA (i.e., 21 CFR) and/or accrediting body requirements (i.e., The Joint Commission or the Accreditation Association for Ambulatory Health Care), through their local MTF/SGH, and provide a copy of the report to AFMSA/SG3PB. [T-0]

4.2.4.1.8.2. Urgent matters, such as equipment defects that may exist at multiple locations or situations that could result in patient injury, shall be reported to AFMSA/SG3PB and the AF/SG Consultant for Medical Physics. [T-1]

4.2.5. Medical Equipment Repair Centers (MERC). Regional MERCs will support the collection of beam exposure data for entrance skin exposures (ESE) calculations IAW AFI 41-201, *Managing Clinical Engineering Programs*, and perform diagnostic imaging equipment acceptance testing. [T-1]

4.2.5.1. Beam exposure data shall be collected annually for each radiographic and fluoroscopic unit, including new equipment under warranty or service contract. The data shall be provided to the regional consulting medical physics office for review, and the ESE calculations will be compared to the most recent National Evaluation of X-Ray Trends (NEXT). [T-3]

4.2.5.2. Reports. The final ESE report will be maintained at the regional consulting medical physics office. A copy of the final ESE report shall be maintained by the regional MERC or local Biomedical Equipment Technician (BMET) office together with the appropriate survey report. An additional copy of the final ESE report will be forwarded to the radiology clinic's NCOIC. Radiology shall maintain this report, together with determined technique charts, for each diagnostic imaging unit and make such available during AFIA/SGO inspections. [T-3]

4.2.6. Coordination and Funding Requirements for Medical Physics Services

4.2.6.1. Regional Medical Physics Offices shall have access to the Medical Equipment Web application managed by Medical Logistics Division Air Force Medical Operations Agency/Clinical Engineering Branch. The web application will provide information on any AFDIRB approved equipment procurement packages for diagnostic and nuclear medicine imaging equipment and radiation therapy equipment. This site can be used for regional support planning purposes by the regional consulting medical physics offices. [T-3]

4.2.6.2. The equipment gaining MTF shall notify the designated regional consulting medical physics office of the equipment installation schedule for diagnostic or nuclear medicine imaging systems, radiation therapy equipment, and/or related construction (for room shielding calculations and/or evaluations) in a timely manner (3 months minimum

in advance of equipment installation), and provide any updates regarding the schedule. This is for procurement and other types of equipment purchase packages.

4.2.6.2.1. The equipment gaining MTF shall notify the regional consulting medical physics office of any major repairs or upgrades (e.g., automatic exposure control device, tube head, and software upgrade) of equipment requiring evaluation. No diagnostic or nuclear medicine imaging system and no radiation therapy equipment shall be used clinically until acceptance testing has been completed by or confirmation is obtained from the regional consulting medical physics office that any repairs/upgrades on the device/system do not require testing.

4.2.6.2.2. Physics testing of clinical imaging devices and systems by a qualified diagnostic imaging medical physicist includes evaluation of radiation dose and/or image quality per Federal and American Association of Physicist in Medicine (AAPM) guidelines and/or American College of Radiology (ACR) accreditation requirements. The types of acceptance testing performed by manufacturers and the MERC or local BMET for the indicated systems may include some equivalent tests, but overall evaluation, specifically for dose and image quality, is not equivalent to clinical medical physics testing requirements. MERC and local BMET acceptance testing is used for clinical qualification whereas medical physics testing is used for clinical use. For assistance in determining requirements, contact the designated regional consulting medical physics office found in **Attachment 5**.

4.2.6.3. It is the responsibility of the equipment gaining MTF to fund consulting medical physics services, to include acceptance testing and associated annual surveys.

4.2.6.3.1. The specific equipment that requires medical physics acceptance testing and annual surveys by a qualified medical physicist, specified in **paragraph 4.3.3**, includes the following: mammography, computed tomography, computed radiography, digital radiography, teleradiology systems, magnetic resonance imaging, high level fluoroscopy systems (including interventional radiography), single photon computed tomography (SPECT) systems, and positron emission tomography (PET) or PET/CT systems.

4.2.6.3.2. If a qualified AF medical physicist is not available, a contract physicist should be hired based upon the qualification requirements stated in **paragraph 4.3.3**. Final reports of testing performed by non AF medical physicists must be forwarded to the designated regional consulting medical physics office for review (reference **Attachment 5**). [T-2]

4.2.6.4. A list of the average and typical range of fees for specific contracted medical physics services (i.e., equipment testing only) is available in the AAPM annual salary survey report; a copy of the current list can be obtained for planning purposes from the regional consulting medical physics offices or from the AF/SG Medical Physics Consultant.

4.2.6.4.1. AF medical physicists may be able to provide additional services to the regional sites during site visits such as training (radiation safety, quality control program, etc.), testing of other diagnostic and/or nuclear medicine imaging systems, and audits of programs (i.e., radioactive material permit program compliance,

modality specific quality control programs, and radiation safety program review) in addition to the equipment testing services. These medical physics services are typically not provided by contracted services, and if so, would be at an additional fee.

4.3. Qualifications.

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

4.3.1.1. The use of machine produced radiation for the purposes of diagnosis or treatment of disease or injury shall only be prescribed by Doctors of Medicine or Osteopathy who are properly licensed by the United States or one of its territories/possessions or are certified by an appropriate certifying agency.

4.3.1.2. The Chief of Radiology may recommend to the Credentials Committee that other healthcare providers (physician assistants, nurse practitioners, physical therapists, occupational therapists, etc.) be granted privileges for ordering radiographic exams, consistent with their training and abilities. 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. All users of RAM for medical permitted activities must meet qualifications for that use as defined in 10 CFR 35. Additionally, they must be approved as an authorized user for the specific use identified on the RAM permit, and comply with associated permit conditions and AFI 40-201, Managing Radioactive Materials in the U.S. Air Force. [T-0]

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.

4.3.1.5. Variances to the above qualification requirements may be authorized by the MTF's SGH in consultation with the Chief of Radiology for contingency, emergency or life-threatening situations.

4.3.2. Operator Qualifications.

4.3.2.1. Physician Performance. Eligible physicians include radiologists and other physicians (e.g., cardiologists, urologists, dentists) granted radiology privileges based on the needs of patients serviced by the MTF.

4.3.2.2. Technologist Performance. The application of radiation for diagnosis or treatment shall only be performed by technologists working under the supervision of an eligible physician or technologist (Diagnostic Imaging 4RXXX) who are trained and who have demonstrated proficiency in the use of the specific radiation source, or in the administration and use of the prescribed RAM. Such proficiency shall be IAW the American Society of Radiologic Technologists (ASRT) Position Statements and Scopes of Practice for technologists, assessed through national-performance-oriented evaluation procedures developed by the American Registry of Radiologic Technologists (ARRT), or by didactic training and practical experience equivalent to training programs and examination requirements of recognized credentialing organizations (ARRT or equivalent). Generally, technologists are the largest population responsible for

implementing and following the requirements of this chapter. Technologists shall strive to ensure patient doses are ALARA while ensuring diagnostic and therapeutic objectives are achieved. [T-1]

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 and training and/or proficiency requirements for imaging technologists;

4.3.2.3.3. Requirements for continuing education and demonstration of proficiency; and

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

4.3.2.4. All individuals who operate medical devices that produce ionizing radiation must undergo initial and annual ALARA training when the potential to exceed 1 mSv (100 mrem) per year exists. This training can be provided by radiology or the regional consulting medical physics office contingent upon the training curriculum being pre-approved by the regional consulting medical physics office. [T-0]

4.3.3. Qualifications for Medical Physicists. Medical Physicists hereafter refers to any active duty (i.e., AFSC shreds: 43E3M or select 43E3G/43EA) or civilian (i.e., civil service and contract) personnel that are determined to be qualified as diagnostic imaging and/or radiation therapy medical physicists per the following standards:

4.3.3.1. Board Certified Diagnostic Imaging Medical Physicist. A diagnostic imaging medical physicist shall be considered qualified to provide diagnostic imaging physics services for nuclear medicine and diagnostic imaging modalities, except mammography, if the individual is board certified in diagnostic radiologic physics by the American Board of Radiology (ABR) or the American Board of Medical Physics (ABMP). [T-1]

4.3.3.1.1. Board certified nuclear medical physicists are deemed qualified for handling RAM in nuclear medicine for equipment testing purposes. An individual's diagnostic medical physics training should have included the techniques and practices of handling nuclear medicine RAM; if not, then the individual shall perform a practicum approved by a qualified medical physicist, prior to performing tests. [T-0]

4.3.3.1.2. Active duty, board certified, diagnostic imaging medical physicists that have not performed clinical medical physics tasks for 36 consecutive months due to a career broadening assignment should undergo a peer review period with a diagnostic board certified medical physicist to become reacquainted with all modalities within six (6) months of a clinical assignment.

4.3.3.1.3. Civilian or contract, board certified, diagnostic imaging medical physicists shall have in their duty requirements and/or contract a requirement to train or support the training program of active duty medical physics trainees toward ABR certification. The Chief of Medical Physics, if board-certified in the appropriate subfield, shall manage the training program. [T-1]

4.3.3.2. Non-Board Certified Diagnostic Medical Physicist. A non-board certified, government employed, medical physicist or equivalently trained individual (e.g., not a contractor) may be considered qualified to perform surveys in specific diagnostic modalities, except mammography, if they have obtained a preceptor statement from a board certified diagnostic imaging medical physicist confirming that the individual has been trained and is qualified to perform surveys independently in the specified modalities. A copy of this preceptor statement shall be forwarded to and maintained in a file by the designated regional consulting medical physics office. [T-1]

4.3.3.2.1. The minimum requirements for preceptorship completion shall include the performance of three (3) surveys for the particular modality (e.g., x-ray, type of fluoroscopy system, computed radiography system, digital radiography system, computed tomography system, magnetic resonance imaging system) within the past 36 months under the supervision of a qualified diagnostic medical physicist as specified in **paragraph 4.3.3.1**. [T-1]

4.3.3.2.2. Government employed individuals obtaining qualifications via the preceptorship path shall complete either of the following within 36 months from the date of the preceptor statement: 1) achieve ABR board certification in diagnostic radiologic physics or 2) provide documentation of maintenance of qualifications to the designated regional consulting medical physics office; the minimum requirements consist of three surveys for each modality that was approved on the preceptor statement and 50 hours or more of CME in radiologic physics. The AF/SG Medical Physics Consultant may require the individual to be requalified by a board-certified diagnostic medical physicist if board certification is not achieved after the first maintenance of qualifications cycle (i.e., 36 months). Note: All nuclear medical physics trainees shall complete a practicum, approved by a qualified medical physicist, on the methods and techniques of handling RAM prior to equipment testing. Individuals with previous nuclear medicine technology training satisfy this requirement. [T-1]

4.3.3.3. Mammography Qualified Medical Physicist. For mammography surveys, individuals are considered to be qualified if they satisfy the standards as specified in the Mammography Quality Standards Act (MQSA) and have forwarded a copy of their State and/or FDA approved documentation to the designated regional consulting medical physics office.

4.3.3.4. Contracted Diagnostic Imaging Medical Physics Services. For contracted diagnostic and nuclear medicine physics services, a board certified diagnostic imaging medical physicist is preferred and will be deemed qualified. [T-1]

4.3.3.4.1. MTFs should consult with the designated regional consulting medical physics office and/or the AF/SG Consultant for Medical Physics regarding the availability of active duty medical physicists prior to pursuing contracted medical physics services.

4.3.3.4.2. Contracted medical physics services for mammography surveys must be performed by a MQSA qualified individual (reference **paragraph 4.3.3.3**). [T-0]

4.3.3.4.3. Contract diagnostic imaging medical physicists that are not board certified will not be deemed qualified; however, they can perform surveys under the supervision of a board certified diagnostic medical physicist with the final report cosigned by the certified physicist. The final survey report must be reviewed by the designated regional consulting medical physics office. [T-1]

4.3.3.5. Radiation Therapy Medical Physicist. A qualified radiation therapy medical physicist shall be an individual board certified by the ABR or ABMP in therapeutic radiologic physics. This policy is mandatory for active duty, civil service, and contract personnel. [T-1]

4.3.3.5.1. Individuals proposed to work in AF MTFs as authorized medical physicists as defined in 10 CFR 35.51 must be approved and listed on the RAM permit issued by the RICS prior to providing clinical services. [T-0]

4.3.3.5.2. All primary civil service and/or contract radiation therapy medical physics positions at AF MTFs shall be filled by board certified medical physicists. [T-1]

4.3.3.5.2.1. For secondary therapy medical physics positions, board eligible civil service and contract physicists must work under the supervision of a qualified radiation therapy physicist. Note: Board eligible is defined as a person who has passed the ABR Part 2 exam in therapeutic radiological physics and is eligible, in good standing, for part 3, oral exam. [T-1]

4.3.3.5.2.2. Non-board eligible individuals, i.e., reference board-eligible in **paragraph 4.3.3.5.2.1**, are not considered radiation therapy medical physicists and cannot function in that capacity. These individuals are considered medical physics assistants or junior physicists. They can provide radiation therapy support only under the direction of an on-site qualified radiation therapy medical physicist. Employment and/or training of these individuals shall not supersede the training and sustainment of available active duty medical physics trainees. MTFs shall consult with the AF/SG Consultant for Medical Physics regarding the availability of active duty medical physicists prior to pursuing civilian and/or contract medical physicists. [T-1]

4.3.3.5.2.3. Supervisory and oversight responsibilities for non-military, including secondary and non-board eligible, medical physicists must be stated in a Memorandum of Understanding/Agreement. For clinics that employ government and contract medical physicists, a clear scope of responsibility and chain of command must be established by the radiation oncology flight commander in coordination with the MTF's chief medical physicist provided that individual is qualified in radiation therapy physics. The lead radiation therapy medical physicist shall be board certified. [T-2]

4.3.3.5.3. Active duty radiation therapy medical physics trainees shall perform clinical physics duties under the direction of a qualified radiation therapy physicist. [T-1]

4.3.3.5.4. Active duty board-certified radiation therapy medical physicists that have not performed clinical medical physics tasks for 36 consecutive months due to career-broadening assignments should undergo a peer-review period with a radiation therapy

board-certified medical physicist to become re-acquainted with all modalities within 6 months of a clinical assignment.

4.3.3.5.5. Civilian or contract, board certified, radiation therapy medical physicists shall have in their duty requirements and/or contract a requirement to train or support the training program of active duty medical physics trainees toward ABR certification. The Chief of Medical Physics, if board-certified in the appropriate subfield, shall manage the training program. [T-1]

4.4. General.

4.4.1. Nuclear Medicine and Radiation Therapy Clinics using Byproduct Material. All AF MTFs offering nuclear medicine or radiation therapy clinical services involving byproduct materials shall adhere to the applicable requirements of 10 CFR Parts 19, 20, 35 and conditions of their USAF RAM permit as specified in AFI 40-201. [T-0]

4.4.2. Medical X-ray and Dental X-ray Clinics. All medical and dental x-ray systems used shall adhere to the most current requirements of 21 CFR, Parts 1020.30 through 33. A self-inspection of the radiation safety program shall be conducted annually. [T-0]

4.4.3. Dosimetry Systems.

4.4.3.1. 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 36 months by radiology personnel. [T-0]

4.4.3.2. Dosimetry systems used in external beam radiation therapy shall have been calibrated by the NIST or by an 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 calibration. A record of each dosimetry system calibration, intercomparison, and comparison shall be maintained for 36 months. [T-0]

4.4.3.3. Each facility shall maintain two (2) 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. [T-1]

4.5. 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 and consistent with clinical objectives. Each MTF shall have and implement written operating and safety procedures. These procedures, including any restrictions of the operating technique required for the safe operation of the particular system, shall be made available to each individual operating a radiation producing machine. These procedures shall be reviewed annually and approved by the appropriate clinic chief, MTF radiation safety office, or regional consulting medical physics office. Specific requirements shall include, but are not limited to: [T-2]

4.5.1. The useful beam shall be limited to the smallest area practical and consistent with the objectives of the radiological examination or treatment. [T-2]

4.5.2. The tube potential, filtration and source-to-skin distance (SSD) employed in medical diagnostic procedures should be as large as practical, consistent with study objectives. [T-2]

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

4.5.2.2. The operator should use the maximum SSD consistent with medical requirements of the procedure. For diagnostic procedures, other than dental procedures, distances less than 30 cm should not be used. Note: For new systems, one must be aware of variable source to image distance options which could result in excessive wear on the x-ray tube. [T-2]

4.5.3. Protection of the conceptus during radiological examination or treatment of women known to be pregnant shall be given special consideration, as described in paragraph 4.6. [T-1]

4.5.4. Exposure techniques shall be appropriately modified for pediatric patients. [T-2]

4.5.5. 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 clinical diagnostic information or proper treatment. In addition: [T-2]

4.5.5.1. 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. [T-2]

4.5.5.2. 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 shield must be placed between the source of x-rays and the patient. If there is no shield available, a posterior-anterior (PA) view should be used. [T-2]

4.5.5.3. 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 PA projections).

4.5.6. 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, and guidance in spot film recording of critical detail and simulation in radiation therapy. Last image hold should be utilized whenever possible. System users shall understand the various dose mode options in multiple dose mode systems, and review those features annually in reference to exposure output data provided by the regional consulting medical physics office.

4.5.7. Intensifying screens, computed radiography imaging plates, digital imaging detectors, and other image recording devices shall be tested annually for uniform response and artifact evaluation. Defects identified shall be reviewed by the interpreting radiologist or medical physicist for corrective action. Imaging screens/plates/detectors shall be replaced as deemed necessary by the interpreting radiologist or medical physicist. [T-2]

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

4.5.8.1. If a patient must be held in position, then mechanical supports or immobilization aids must be used when feasible. [T-3]

4.5.8.2. If mechanical devices cannot be used, the individual selected to hold the patient should be a willing adult (21 years of age or older) relative who is not an occupational radiation worker. If no willing adult family member is available, the next best option is to have a properly shielded non radiation safety worker position the patient. Only if this is not feasible, a monitored occupational radiation worker may hold the patient. Diagnostic Imaging (4RXXX) technologists may hold the patient when consistent with ALARA objectives as determined by the RSO.

4.5.8.3. Pregnant women or persons under 18 years of age should not be permitted to hold patients.

4.5.8.4. If a patient must be held by someone, the individual holding the patient 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. [T-3]

4.5.9. Only individuals whose presence is necessary shall be in diagnostic x-ray, fluoroscopy or low-energy (< 150 kV) radiotherapy rooms during exposures. These personnel shall be protected with appropriate shielding for the specific situation (e.g., leaded aprons, leaded gloves and/or portable shields). [T-2]

4.5.10. Individuals, other than the patient, shall not be in linear accelerator vaults or high dose rate brachytherapy vaults during machine use. [T-0]

4.5.11. Protective devices, including lead aprons, gloves, and shields (including those items at dental, cardio-lab, angiography and operating rooms) shall be stored properly and checked initially and 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) for dental and medical clinics. Additional checks of defects may be performed using x-ray imaging (fluoroscopy recommended). Each MTF must develop proper procedures for disposal of rejected lead protective material. [T-2]

4.5.12. The machine operator shall stand behind a barrier, if provided, and shall observe the patient during diagnostic or therapeutic procedures. The operator shall be able to see, speak to, and hear the patient. [T-1]

4.5.13. Radiographic film shall 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. [T-3]

4.6. Exposure of Fertile Women to Radiation for Treatment or Diagnosis. Due to the increased radiation exposure risks to the conceptus (including all embryonic and fetal development stages), the possibility of pregnancy shall be addressed for any woman of reproductive capacity when considering any nuclear medicine procedure and/or any radiographic examination involving the lower abdomen. [T-0 – DoDI 6055.08, NUREG 1556, v13]

4.6.1. Before any medical procedure involving radiation is performed, the patient shall be asked if she is pregnant; if the patient is pregnant or there is a possibility that she could be pregnant, the attending physician shall be immediately informed. Before any therapeutic procedure, a pregnancy test shall be given to all fertile women no sooner than 48 hours preceding the treatment. Any inconclusive pregnancy test or statement made by the patient

as to the potential of being pregnant should delay treatment until a conclusive negative pregnancy test can be obtained. Note: A pregnancy test cannot detect the presence of an embryo until several days post implantation. [T-0]

4.6.2. 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 during pregnancy. In practice, the timeliness of medical needs should be the primary consideration in deciding the timing of an examination.

4.6.3. Radiographic and nuclear medicine examination and/or waiting 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 technologist before the examination. [T-2]

4.6.4. In the event of a conceptus exposure (i.e., the fetus or embryo is exposed to radiation) the responsible clinic shall:

4.6.4.1. Have a qualified medical physicist (**Attachment 5**) determine by measurement or modeling the estimated dose to the conceptus. These calculations shall be reported to the patient's physician who will interpret them to the patient. [T-2]

4.6.4.2. Adhere to the requirements of paragraph 4.14. [T-2]

4.7. Quality Control (QC). A QC program provides adequate confidence that a diagnostic x-ray or nuclear medicine clinic will produce consistently high quality images with minimum dose to the patients and medical staff. Similarly, a radiation therapy QC 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.

4.7.1. Diagnostic Imaging Clinics and Other Clinics Utilizing Radiation Sources. All clinics, utilizing radiation sources (i.e., non-radioactive materials) for the purposes of medical or dental imaging shall implement a QC program, approved by the regional consulting medical physics office, 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: [T-3]

4.7.1.1. Acceptance Tests. Medical physics testing shall be based on national standards and guidance as appropriate (i.e., ACR credentialing standards, AAPM task group reports, manufacturer QC instructions, NEXT data, abide all pertinent federal regulations (e.g., 21 CFR 1020), AF Instructions (e.g., AFI 41-201 and AFI 48-148), and manufacturer QC instructions). [T-0]

4.7.1.1.1. A qualified diagnostic imaging medical physicist, defined in **paragraph 4.3.3**, shall perform acceptance testing (including image quality and dose assessment, as appropriate), prior to clinical use or any major component change, on the following equipment: mammography imaging devices, computed tomography systems, high-level fluoroscopy systems, magnetic resonance imaging systems, computed radiography devices, digital radiography systems, nuclear medicine imaging systems, interventional radiology systems, and cardiac catheterization systems. Note: Acceptance testing for picture archiving systems (PACS), telemedicine systems (for radiation related applications such as teleradiology and teledental systems), and

diagnostic review workstations are performed by Air Force Clinical Engineering (AFMOA/SGALE). Annual compliance testing should be performed by medical physicist or qualified MERC/local BMET. [T-2]

4.7.1.1.2. A qualified MERC technician or local BMET, in coordination with the regional consulting medical physics office, may perform acceptance testing of computed tomography, computed radiography, and digital radiography systems located at regionally supported sites, sustainment sites, and expeditionary locations. Final reports must be forwarded to the designated regional consulting medical physics office for review. [T-3]

4.7.1.1.3. All other diagnostic x-ray systems shall receive acceptance testing, prior to clinical use, by a qualified MERC technician or local BMET as defined in AFI 41-201. Acceptance testing for clinical use authorization shall not be performed by the vendor or their representative. Systems having undergone a significant component change (e.g., a new x-ray tube) shall be retested as appropriate prior to clinical use. [T-2]

4.7.1.1.4. Final acceptance testing reports shall be placed in the Equipment Data File (EDF) at the owning MTF for the duration of system use. [T-3]

4.7.1.1.5. Radiology Flight Commanders or the Radiology Services NCOIC shall ensure technique charts are provided to the regional medical physics office for preparation of ESE charts. They shall also ensure compliance with the QC programs and equipment testing requirements. [T-2]

4.7.1.2. Compliance Inspections.

4.7.1.2.1. Qualified medical physicist shall perform an annual evaluation of the equipment specified in **paragraph 4.7.1.1.1**. These inspections should have a focus on dose and image quality. [T-2]

4.7.1.2.2. Radiological compliance inspections shall be conducted at least annually on all diagnostic and dental x-ray systems. [T-2]

4.7.1.2.2.1. Inspection results shall be maintained IAW AFI 41-201. A copy of each inspection report shall be forwarded to the equipment custodian. It is the responsibility of the equipment custodian to ensure the report is forwarded along with appropriate technique factors to the regional consulting medical physics office for computation of the ESE data as appropriate and IAW with **paragraph 4.2.5**. [T-3]

4.7.1.3. Preventive Maintenance. Maintenance shall be performed in accordance with requirements of AFI 41-201. It is recommended that MERC/local BMET, the manufacturer, or a qualified third party contractor perform preventive maintenance on all diagnostic imaging devices to include those listed in **paragraph 4.7.1.1.1**. Any service contract should provide for additional site visits when problems occur. [T-2]

4.7.1.3.1. The medical physicist should be informed of any major work/upgrades performed on the imaging devices listed in **paragraph 4.7.1.1.1**.

4.7.1.4. Contracted Mobile Imaging Services. Contracted mobile imaging services used on AF installations shall provide the MTF with recent QC data associated with the

specific scanner prior to clinical use. This data shall be reviewed and acceptable to the MTF radiologist and/or regional consulting medical physics office. At minimum, patient and staff dose evaluation, image quality tests, and public exposure evaluation about the mobile unit (i.e., exposure for x-ray systems and Gauss line for magnetic resonance imaging systems) must be evaluated by a qualified medical physicist or qualified MERC/local BMET prior to clinical use. [T-2]

4.7.1.5. Quality Control Program. Each clinic, including deployed AF locations, AF lead Joint Basing locations, and contracted mobile imaging services used on AF installations, shall establish a QC program for each diagnostic imaging modality in coordination with, and approved, by the MTF radiologist and/or regional consulting medical physics office. These programs shall be based on national standards and guidance as appropriate (e.g., ACR credentialing standards, AAPM task group reports, NEXT data, manufacturer's QC instructions) and abide all pertinent Federal regulations (e.g., 21 CFR 1020). [T-0]

4.7.2. Nuclear Medicine Clinics. All nuclear medicine clinics shall implement a QC program approved by the regional consulting medical physics office 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: [T-2]

4.7.2.1. Acceptance Tests. Testing shall be based on national standards and guidance as appropriate (e.g., AAPM task group reports, ACR credentialing standards, manufacturer's QC instructions) and abide by all pertinent Federal regulations (e.g., 10 CFR 35). Final acceptance testing reports shall be placed in the local BMET EDF at the owning MTF for the duration of system use. [T-2]

4.7.2.1.1. A qualified diagnostic or nuclear medical physicist shall perform acceptance testing of all nuclear medicine imaging modalities (e.g., gamma cameras, positron emission tomography (PET), PET/CT imaging systems) prior to clinical use. [T-2]

4.7.2.2. Radioactive Materials. Radioactive materials must be acquired and used IAW AFI 40-201.

4.7.2.3. Compliance Inspections. Annual evaluations of imaging devices should be performed by a qualified diagnostic imaging or nuclear medicine medical physicist as specified in **paragraph 4.3.3**. [T-2]

4.7.2.4. Preventive Maintenance. Maintenance shall be performed in accordance with requirements of AFI 41-201. It is recommended that the manufacturer or a qualified third party contractor perform preventive maintenance on gamma cameras and PET systems twice a year. The service contract should provide for additional site visits when problems occur. The medical physicist should be informed of any work performed on these imaging devices. [T-3]

4.7.2.5. Contracted Mobile Imaging Services. Contracted mobile imaging services (e.g., gamma cameras and PET imaging systems) used on AF installations shall provide the MTF with recent QC data associated with the specific scanner prior to clinical use. This data shall be reviewed and approved by the MTF radiologist and/or regional consulting medical physics office. At minimum, image quality tests and public exposure evaluation about the mobile unit must be performed by a qualified nuclear medicine technologist

and approved by the MTF radiologist or regional medical physics consulting office prior to clinical use. [T-2]

4.7.2.5.1. The MTF's RAM permit must be amended by the permittee for authorized use location and possibly authorized RAM use prior to clinically using the mobile system. These requests must be submitted to and approved by the USAF RICS IAW AFI 40-201 prior to radioactive material procurement. [T-0]

4.7.2.6. Quality Control Program. The clinic shall establish QC programs for each nuclear medicine imaging device and therapy modality in coordination with, and approved by, the MTF Nuclear Medicine Flight Commander and regional consulting medical physics office. These programs shall be based on national standards and guidance as appropriate (e.g., AAPM task group reports, ACR credentialing standards, manufacturer's QC instructions) and abide all pertinent Federal regulations (e.g., 10 CFR 19, 20, 35). [T-0]

4.7.3. Radiation Therapy Clinics. All radiation therapy clinics shall implement a QC program approved by a qualified radiation therapy medical physicist with the objective to minimize staff dose while obtaining optimal clinical objectives. As a minimum, the program shall consist of the following elements: [T-1]

4.7.3.1. Acceptance and Commissioning Tests. Testing shall be based on national standards and guidance as appropriate (e.g., AAPM task group reports, manufacturer's QC instructions) and abide all pertinent Federal regulations (e.g., 10 CFR 35, 21 CFR 1020). Specific testing requirements for external beam radiation therapy systems can be found in **paragraph 4.11** and **4.12** **Final acceptance testing and commissioning reports.** Final acceptance testing and commissioning reports shall be maintained by the therapy medical physics office for the duration of system use. [T-2]

4.7.3.1.1. A qualified radiation therapy medical physicist shall perform acceptance testing and commissioning of all radiotherapy systems (e.g., linear accelerators and associated on-board imaging devices, brachytherapy systems, simulators, treatment planning systems, radiation oncology information management systems, diode or TLD dosimetry systems). [T-0]

4.7.3.2. Radioactive Materials. RAM (i.e., brachytherapy sources and teletherapy units) must be authorized by the USAF RIC/S IAW AFI 40-201. [T-1]

4.7.3.3. Compliance Inspections. Annual evaluations of radiation therapy devices/systems should be performed by a qualified radiation therapy medical physicist IAW **paragraph 4.11** and **4.12** and should follow guidance provided by the AAPM. [T-1]

4.7.3.4. Preventive Maintenance. Maintenance shall be performed in accordance with the requirements of AFI 41-201. It is recommended that the manufacturer (preferred) or a qualified third party contractor perform preventive maintenance on radiation therapy devices and systems at least annually and when requested by the radiation therapy physicists. All work performed on these devices/systems must be reported to the radiation therapy medical physicist prior to clinical use. [T-2]

4.7.3.5. Contracted Mobile Imaging Services. Contracted mobile services that are used or support AF radiation therapy clinics must comply with **paragraph 4.7.1.4** and/or **paragraph 4.7.2.5**. [T-2]

4.7.3.6. Quality Control Program. The clinic shall establish QC programs for each modality in the therapy treatment chain. These programs shall be based on national standards and guidance as appropriate (e.g., AAPM task group reports) and abide all pertinent Federal regulations (e.g., 10 CFR 35). Specific requirements for external beam radiation therapy systems can be found in **paragraph 4.7.3.1**; **4.7.3.4**; **4.11**; and **4.12**. [T-2]

4.8. Specific Radiation Safety Requirements for Fluoroscopy. In addition to the general requirements specified under paragraph 4.5, the following requirements shall be applied to the 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 medical physicist shall use this data to provide patient ESE calculations 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. [T-2]

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, dose area product (if available), cumulative absorbed dose (if available), physician, procedure type, and specific unit should be recorded in the patient's medical record and a log maintained for each unit for general fluoroscopy, angiography, and cardiac catheterization lab. This data should be monitored by a radiologist or qualified user, medical physicist, or technologist on a monthly or quarterly basis to identify equipment, procedural, or personnel issues resulting in higher than average exposures (i.e., average exposure values are listed in AAPM Report No. 58, *Managing the Use of Fluoroscopy in Medical Institutions*).

4.8.1.4. Tight collimation, short irradiation times, and minimal use of magnification shall be employed and consistent with clinical objectives. Always position the image intensifier as close to the patient as possible while maximizing the distance between the x-ray tube and the patient. Note: For newer systems, a variable source-to-image distance option may be available. Review the operator's guide and/or consult with the regional medical physicist. [T-2]

4.8.1.5. Medical fluoroscopy shall be performed only by or under the immediate supervision of a physician granted x-ray user privileges. 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. [T-2]

4.8.1.6. Leaded protective aprons shall be worn in the fluoroscopy room by all medical and support staff during all fluoroscopy procedures. Note: Radiation PPE normally ranges from 0.25-1 mm lead equivalent; a qualified expert (e.g., medical physicist or

bioenvironmental engineer, as defined in the Glossary) shall specify and recommend all protective shielding for the specific modality. [T-2]

4.8.1.7. Leaded gloves of at least 0.25 mm lead equivalence should be worn by physicians during near beam work. The physician shall not place hands in the direct beam, even with lead glove protection. If not using gloves, a ring dosimeter must be worn. It is recommended that ring dosimeters be worn when using lead gloves (i.e., ring dosimeter worn on finger inside of leaded glove). [T-2]

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 paragraph 4.5, the following additional requirements are applicable to portable fluoroscopic and radiographic procedures, with the exception of microampere orthopedic units.

4.8.2.1. All unessential personnel, if possible, shall stand at least 2 m (approximately 6 ft) from the patient, the x-ray tube and the useful beam during procedures. [T-3]

4.8.2.2. Portable equipment should be used only for examinations when it is not practical or of necessary expediency to transfer patients to locations of fixed radiographic or fluoroscopic units. [T-2]

4.8.2.3. The operator and any individual within 2 m (approximately 6 ft) of the patient or the x-ray tube shall wear protective devices (i.e., lead aprons, thyroid shields) during any exposure. [T- 1]

4.8.3. Specific Radiation Safety Requirements for Cardiac and Fluoroscopically Guided Procedures. In addition to the general requirements specified under **paragraph 4.5**, the following additional requirements are applicable during cardiac and interventional radiography procedures and pain management procedures:

4.8.3.1. During serial (cine) radiography, the number of frames per second and the duration of the procedure should be kept to a minimum, consistent with clinical objectives. The total number of cine frames should be recorded in the patient's medical record and a maintained log for each unit.

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

4.8.3.3. Avoidance of serious x-ray-induced skin injuries to patients during fluoroscopically-guided procedures. (reference 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, clinics performing fluoroscopically guided procedures shall: [T-0]

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 effects. [T-2]

4.8.3.3.2. Assess the impact of each procedure's protocol for the potential of radiation injury to the patient. [T-2]

4.8.3.3.3. Modify the protocol, as appropriate, to minimize the cumulative absorbed dose to any irradiated area of the skin to accomplish the clinical tasks and to avoid cumulative doses that would induce unacceptable adverse effects. Use equipment that aids in minimizing absorbed dose. [T-2]

4.8.3.3.4. Obtain assistance from a qualified diagnostic medical physicist as needed, in implementing these protocols to ensure the clinical image quality/dose objectives of the procedure are not adversely affected. [T-2]

4.8.3.3.5. Report, IAW AFI 44-119, *Medical Quality Operations;* the Safe Medical Devices Act of 1990 (SMDA); and 21 CFR Parts 803 to 807a, 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 malfunction should report to their Medical Device User Facility Reporting individual. Note: 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 exposure. Providers performing these procedures may not be in direct contact with the patients following the procedure and may not observe the symptoms when they occur. Cumulative dose information therefore should be recorded in the patient's medical record and on the appropriate form in the AF Form 2100A series. Patients should be informed via 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. [T-0]

4.9. Specific Radiation Safety Requirements for Mammography Procedures. In addition to the general requirements specified under **paragraph 4.5**, the following requirements are applicable during mammography procedures:

4.9.1. All mammography services offered by AF clinics shall adhere to the requirements of the *Mammography Quality Standards Act*, Title 21 CFR Parts 900. [T-0]

4.9.2. Mammography imaging technologists shall meet the Federal standards of the MQSA (Public Law 102-539), and follow the American Society Radiation Technologists' Position Statements and Active Practice Standards for technologists. [T-0]

4.10. Specific Radiation Safety Requirements for Computed Tomography Procedures. In addition to the general requirements specified under **paragraph 4.5**, the following requirements are applicable to computed tomography procedures.

4.10.1. The slice thickness and collimator pitch 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 performed only when necessary to provide critical diagnostic information.

4.10.3. The user shall be familiar with the relationship between patient dose (i.e., both the maximum value and its distribution) and the exposure scanning technique factors (i.e., kVp, mAs per slice, slice thickness and collimator pitch). Special attention shall be given to pediatric patients; patient size shall be matched to appropriate dose-reducing exposure settings, and inappropriate provider referrals should be prohibited. [T-2]

4.10.4. A qualified diagnostic medical physicist shall measure the radiation output of computed tomography systems on an annual basis, and compute the dose for all applicable clinically used exposure scanning techniques, 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 (reference AAPM Monograph 20, 1991 AAPM Annual Summer School Proceedings held at University of California, Santa Cruz). Qualified MERC/local BMET personnel approved by the regional consulting medical physics office may perform the radiation output measurements and provide the data to the consulting physicist for dose calculation. [T-2]

4.11. Specific Requirements for External Beam Radiation Therapy Systems Using Energies Less Than 500 keV. In addition to the general requirements specified under **paragraph 4.5**, the following requirements are applicable to radiation therapy systems operated at a potential less than 500 keV:

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. [T-2]

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 kVp. In such cases, the holder shall wear protective gloves and lead apron of not less than 0.5 millimeters lead equivalency at 100 kV. [T-2]

4.11.1.3. A copy of the current operating and emergency procedures shall be maintained at the therapeutic radiation machine control console. [T-2]

4.11.2. Record Keeping. The clinic 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 medical physicist responsible for performing the calibration. [T-3]

4.11.3. Periodic QC Checks.

4.11.3.1. Periodic QC checks shall be performed on therapeutic radiation machines IAW written procedures established by a qualified radiation therapy medical 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: [T-1]

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; and

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 limit set by the radiation therapy medical physicist shall be investigated and corrected before the system is used for patient irradiation. [T-2]

4.11.3.3. Whenever a QC check indicates a significant change in the operating characteristics of a system, as specified in the radiation therapy medical physicist's QC check procedures, the system shall be recalibrated as required. [T-2]

4.11.3.4. The clinic shall have the radiation therapy medical physicist review and sign the results of each radiation output QC check within 1 month of the date that the QC was performed. [T-2]

4.11.3.5. The clinic shall maintain a record of each QC check for five (5) years. The record shall include: the date of the QC 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 QC check. [T-2]

4.12. Specific Requirements for External Beam Radiation Therapy Systems using Energies Greater Than 500 keV. In addition to the general requirements specified under **paragraph 4.5**, the following requirements are applicable to radiation therapy systems operated at a potential energy of 500 keV and above, and for electron or proton therapy systems:

4.12.1. Radiation Therapy Medical Physicists: The services of a qualified radiation therapy medical physicist shall be required in facilities having therapeutic radiation machines with energies of 500 kVp and above. The radiation therapy medical physicist shall be responsible for: [T- 1]

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 QC check review;

4.12.1.5. Consultation with the radiation oncologist in treatment planning, as needed; and

4.12.1.6. Performance of calculations/assessments regarding medical events. If the radiation therapy medical physicist is not a full time employee of the MTF, the operating procedures required by **paragraph 4.12.2** shall also specifically address how the radiation therapy medical physicist is to be contacted for problems or emergencies, as

well as the specific actions, if any, to be taken until the radiation therapy medical 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. [T-1]

4.12.2.2. Therapeutic radiation machines, when not in operation, shall be secured to prevent unauthorized use. [T-1]

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. [T-1]

4.12.2.4. If a patient must be held in position during treatment, mechanical supporting or immobilization devices shall be used. [T-2]

4.12.2.5. A copy of the current operating and emergency procedures shall be maintained at the therapeutic radiation machine control console. [T-1]

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 **paragraph 4.12** shall be performed by a qualified radiation therapy medical physicist meeting the requirements in **paragraph 4.3.3.5**. [T-1]

4.12.3.2. Acceptance testing shall be performed IAW manufacturer's recommendations and any additional contractual requirements following installation or reinstallation of the therapeutic radiation machine and prior to clinical use. Commissioning should be accomplished using, AAPM Code of Practice for Radiotherapy Accelerators: Report of AAPM Radiation Therapy Task Group 45 and any updated/new and applicable AAPM reports following installation or reinstallation of the therapeutic radiation machine. Commissioning shall be conducted prior to clinical use of that particular beam or modality. [T-1]

4.12.3.3. Full calibration should include measurement of all parameters specified in 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. Any new applicable AAPM reports associated with equipment testing that is associated with the radiation therapy process should be considered as well. [T-2]

4.12.3.4. The radiation therapy medical physicist shall perform all elements of a full calibration necessary to determine that all parameters are within acceptable limits: [T-1]

4.12.3.4.1. Whenever QC check measurements indicate that the radiation output differs by more than 2% 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 clinic 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 medical physicist responsible for performing the calibration. [T-2]

4.12.4. Periodic QC Checks.

4.12.4.1. Periodic QC checks shall be performed on all therapeutic radiation machines subject to **paragraph 4.12** at intervals not to exceed those specified in "Comprehensive QA for Radiation Oncology: Report of AAPM Radiation Therapy Committee Task Group 40" or more current report. [T-1]

4.12.4.2. QC checks shall include determination of central axis radiation output and a representative sampling of periodic QC checks contained in, Comprehensive QA for Radiation Oncology: Report of AAPM Radiation Therapy Committee Task Group 40. Representative sampling shall include all referenced periodic QC checks in an interval not to exceed 12 consecutive calendar months. [T-1]

4.12.4.3. The clinic shall perform periodic QC checks IAW procedures established by the radiation therapy medical physicist. [T-1]

4.12.4.4. The clinic 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 medical 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 clinical use until the radiation therapy medical physicist has determined that all parameters are within their acceptable tolerances. [T-1]

4.12.4.4.2. If all QC check parameters appear to be within their acceptable range, the QC check shall be reviewed and signed by either the radiation oncologist or radiation therapy medical physicist. [T-3]

4.12.4.4.3. The clinic shall have the radiation therapy medical physicist review and sign the results of each radiation output QC check within one (1) month of the date that the QC was performed. [T-3]

4.12.4.5. Therapeutic radiation machines subject to **paragraph 4.12** shall have safety QC checks listed in Comprehensive QA for Radiation Oncology: Report of AAPM Radiation Therapy Committee Task Group 40 performed at intervals not to exceed one (1) week; these checks shall ensure proper operation of: [T-1]

4.12.4.5.1. Electrical interlocks at each external beam radiation therapy room entrance; [T-1]

4.12.4.5.2. Proper operation of the "BEAM-ON", interrupt and termination switches; [T-1]

4.12.4.5.3. Beam condition indicator lights on the access doors, control console, and in the radiation therapy room; [T-1]

4.12.4.5.4. Viewing systems; and [T-1]

4.12.4.5.5. Electrically operated treatment room door(s) from inside and outside the treatment room. [T-1]

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 QC 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. [T-1]

4.12.4.7. The clinic shall promptly repair any system identified above that is not operating properly. [T-1]

4.12.4.8. The clinic shall maintain a record of each QC check for five (5) years. The record shall include: the date of the QC 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 QC check. [T-1]

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; [T-2]

4.12.5.2. Records of all surveys, calibrations, and periodic QC checks of the therapeutic radiation machine required by **paragraph 4.11** and **4.12**, as well as the name(s) of person(s) who performed such activities; [T-2]

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; and [T-2]

4.12.5.4. Signature of person authorizing the return of therapeutic radiation machine to clinical use after service, repair, or upgrade. [T-2]

4.13. Report and Notification of a Medical Event.

4.13.1. An AF MTF shall report all diagnostic imaging and radiation therapy medical events as specified in **paragraph 4.13.3** and **4.13.4**. A medical event 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 use of radiation for medical applications results in: [T-1]

4.13.1.1. A medical event related to the medical application of radioactive materials occurs when a dose 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 20% or more;

4.13.1.1.2. The fractionated dose delivered exceeds the prescribed dose, for a single fraction, by 50% 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% or more of the prescribed fraction size.

4.13.1.2. Medical events related to external beam radiotherapy occur when:

4.13.1.2.1. The total dose delivered differs from the prescribed dose by 10% or more;

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

4.13.1.2.3. The treatment is delivered to the wrong individual;

4.13.1.2.4. The wrong treatment modality is used; or

4.13.1.2.5. The treatment is delivered to the wrong site or target volume.

4.13.1.3. Medical events related to diagnostic imaging procedures (i.e., sections 4.8 and 4.10, related to fluoroscopy and computed tomography, respectively), occur when:

4.13.1.3.1. The imaging procedure is delivered to the wrong individual;

4.13.1.3.2. The imaging procedure is delivered to the wrong body region;

4.13.1.3.3. Prolonged fluoroscopy results in cumulative dose exceeding 15 Gy (1500 rads) to a single field.

4.13.1.3.4. An unintended event where a physician determines that actual damage has occurred to an organ or a physiological system of an individual due to or suspected to be due to exposure to diagnostic radiation from a computed tomography scanner. The key is for actual damage to have occurred, e.g. patient reports skin reddening or their hair falling out. Examples of computed tomography medical events are excessive doses (i.e., cumulative CTDIvol) on the order of 0.5 Gy for an organ or physiological system.

4.13.1.4. The Joint Commission (TJC) tracks certain events, defined as sentinel events, to ensure they are adequately analyzed and any undesirable trends or decreases in performances are identified early and mitigated. Regarding radiation therapy, TJC currently classifies the following as reviewable sentinel events: radiotherapy delivered to the wrong body region or 25% above the planned dose; for fluoroscopy medical events, a sentinel event occurs when the cumulative dose exceeds 15 Gy to a single field. TJC requires the accredited organization to report any of these sentinel events. Reporting and coordination of follow-up actions for sentinel events is performed by the Patient Safety Manager or as directed by the SGH IAW AFI 44-119. The local and/or regional medical

physics office should support the SGH's patient safety function within the MTF. Additional guidance on sentinel events can be found on TJC's website. Healthcare organizations are also required to notify the Food and Drug Administration (FDA) and device manufacturer within 10 days of an adverse incident caused by a medical device per the Safe Medical Device Act of 1990; this reporting is for an actual device malfunction and not due to operator use. An adverse incident occurs when a medical system is involved in an event with the potential to cause serious harm or death. Reporting of adverse events at the MTF is accomplished through the MDSS Squadron/Logistics IAW AFI 41-201 and may be facilitated by the SGH's patient safety program. NRC reporting criteria and time limits for events involving radioactive materials for US NRC-licensed materials are detailed in AFI 40-201.

4.13.1.4.1. For fluoroscopy medical events, refer to AF/SG NOTAM 10-002, Recognition and Reporting of Injury Due to Fluoroscopy, Mar 2010.

4.13.2. The clinic 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. [T-1]

4.13.3. The clinic shall notify the responsible MTF's SGH, or their 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 physician utilizing radiation for medical purposes, qualified medical physicist, and referring physician or clinic, 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 event. The clinic will then telephonically report the medical event to the AFMSA/SG3PB (Radiation Program) within seven (7) calendar days. [T-1]

4.13.4. The clinic shall submit a written report to AFMSA/SG3PB (Radiation Health) through the responsible MAJCOM/SGP within 15 calendar days after discovery of the medical event. [T-1]

4.13.4.1. The written report must include: [T-1]

4.13.4.1.1. The clinic's organization and base;

4.13.4.1.2. The name and unit of the prescribing physician, Chief of Radiation Oncology or Diagnostic Imaging, and radiation therapy medical physicist;

4.13.4.1.3. A brief description of the event and its cause;

4.13.4.1.4. The effect, if any, on the individual(s) that received the medical radiation imaging and/or therapy;

4.13.4.1.5. The actions that have been taken or are planned to prevent recurrence;

4.13.4.1.6. The status of notification to the individual (or the individual's responsible relative or guardian) and any information that was provided; and

4.13.4.1.7. The report may not contain personal identifiable information.

4.13.5. Notification.

4.13.5.1. The clinic shall notify the referring physician, or, if unavailable, the responsible referring clinic chief within 24 hours. [T-1]

4.13.5.2. The individual affected by the medical event shall also be notified no later than 24 hours after its discovery, unless the referring physician or clinic chief elects to personally inform the individual or that, based on medical judgment, telling the individual would be harmful. [T-1]

4.13.5.3. The clinic is not required to notify the individual without first consulting the referring physician. However, if the referring physician or the affected individual cannot be reached within 24 hours, the clinic shall notify the individual as soon as possible thereafter.

4.13.5.4. The clinic may not delay any appropriate medical care for the individual, including any necessary remedial care as a result of the medical event, because of a delay in notification. Therefore to meet the requirements of this section, notification may be made 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 clinic shall also provide a written report to the individual within 15 days after discovery of the medical event. A clinic may send either: [T-2]

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 that may affect the individual.

4.13.7. The clinic shall retain a record of a medical event for 50 years per the Air Force records Disposition Schedule (AFRIMS). The record shall contain the information specified in **paragraph 4.13.4.1** [T-1]

4.14. Report and Notification of a Dose to a Conceptus (Embryo/Fetus) or Nursing Child.

4.14.1. A medical or dental clinic shall report any cumulative absorbed dose to a conceptus (i.e., embryo/fetus) 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 RAM to a pregnant individual or nursing mother from studies/treatments where the resultant dose was not specifically approved, in advance, by the requesting physician. [T-0]

4.14.2. The clinic shall notify the responsible MTF's Chief of Hospital Services (SGH), or their designee, and the IRSO within 24 hours, and notify by telephone AFMSA/SG3PB (Radiation Health) no later than seven (7) calendar days after discovery of a dose to the conceptus that requires a report in **paragraph 4.14.1**. [T-2]

4.14.3. The clinic shall submit a written report to AFMSA/SG3PB (Radiation Health) 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 **paragraph 4.14.1** [T-2]

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, chief of the clinic, and responsible medical physicist or RSO;

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 conceptus or nursing child; and

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

4.14.4. Notification.

4.14.4.1. The clinic shall notify the referring physician, or if unavailable, the referring physician's clinic chief and the pregnant individual, 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**, unless the referring physician or chief of clinic personally informs the clinic either that he or she will inform the mother or that, based on medical judgment, telling the mother would be harmful. [T-1]

4.14.4.2. 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.

4.14.4.3. The clinic 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 clinic shall make the appropriate notifications as soon as possible thereafter.

4.14.4.4. The clinic may not delay any appropriate medical care for the conceptus or for the nursing child, including any necessary remedial care as a result of the event, because of any delay in notification.

4.14.5. If notification was made under **paragraphs 4.8.3** or **4.6.4**, the clinic shall also furnish a written report to the mother or responsible relative or guardian within 15 days after discovery of the event. The clinic may send either of the following: [T-2]

4.14.5.1. A copy of the report that was submitted to AFMSA/SG3PB (Radiation Health).

4.14.5.2. A brief description of both the event and the consequences as they may affect the conceptus or nursing child.

4.14.6. A clinic shall retain a record of a dose to a conceptus or a nursing child reported in accordance with this section for 50 years per the Air Force Records Information management System. The record shall contain the information specified in **paragraph 4.14.3.1**. [T-2]

Chapter 5

RADIATION PROTECTION OF THE PUBLIC

5.1. General. Public dose is the dose received by a member of the public from exposure to radiation or radioactive material used in AF practices, or radon which emanates from within Air Force controlled buildings. Public dose does not include occupational dose or doses from other background radiation sources or any medical administration the individual has received.

5.2. Control of Public Exposures from AF Practices. Administrative and engineering controls, policies, or procedures are implemented to control public dose from AF practices. The following requirements are specified for all AF practices that may result in public exposure:

5.2.1. All practices shall be conducted to minimize public dose considering the state of technology, economics of improvements in relation to the state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations. [T-0]

5.2.2. Members of the public shall not occupy vehicles during cargo or vehicle inspections that use scanning systems employing radiation. For waivers, consult with AF-RSCES. [T-2]

5.2.3. All practices shall be conducted in such a manner that a member of the public will not exceed the applicable dose limits specified in Table A4.1. For non-medical practices, the IRSO shall be responsible for the determination, either by measurement or calculation that this dose is not exceeded, and maintain this record permanently using DOEHRS. For medical practices, the PRSO, responsible medical physicist, health physicist or BEE, as appropriate, shall be responsible for this determination. [T-0]

5.2.4. Unrestricted areas. The dose in any unrestricted area resulting from AF 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 IRSO shall be responsible for the assessment, either by measurement or calculation, that these dose limits are not exceeded and maintain this record permanently (i.e., DOEHRS). [T-0]

5.2.5. Control of Visitors.

5.2.5.1. Visitors to any restricted area must be accompanied by persons knowledgeable about the protection and safety measures in the area. [T-1]

5.2.5.2. 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. [T-1]

5.2.5.3. Visitors entering a location defined as "Radiation Area" or "High Radiation Area" or that could incur a deep dose equivalent in excess of 0.10 mSv (10 mrem) shall be provided personal monitoring devices (i.e. a dosimeter). A log of all such monitored individuals shall be maintained and the results communicated to the individual. [T-0]

5.2.6. Public Overexposures. If an individual member of the 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 IRSO. If appropriate, the unit, organization or IRSO should

implement, with commander's approval, protective actions to mitigate further exposures. [T-0]

5.2.6.1. Notification: When a member of the public may have received a dose above the applicable limits in Table A4.1, the IRSO shall be contacted immediately. The IRSO shall contact USAFSAM/OEH to validate the assessment of dose. If the dose is validated, the IRSO shall immediately notify the MAJCOM BEE and AFMSA/SG3PB. AFMSA/SG3PB can be contacted via Andrews AFB's Command Post. [T-1]

5.2.6.2. Reporting: The IRSO, with the assistance of USAFSAM/OEH, shall investigate suspected exposures above the limits specified in Table A4.1, with a written report of the investigation submitted through the MAJCOM BEE to AFMSA/SG3PB within seven (7) days of notification. The written report must include: [T-1]

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

5.2.6.2.2. A brief description of the event;

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

5.2.6.2.4. Why the event occurred; and

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

5.3. Protection of the Public from Avoidable Doses. This section specifies requirements to protect members of the public from two specific sources of radiation: public exposures resulting from radon in AF controlled structures and public exposures that may occur from an incident or accident involving radioactive materials. For each case, interventions may be necessary to protect the public. The radon exposure at which an intervention is merited is referred to as a remedial action level. For incidents or accidents, a protective action or intervention is merited when the dose can be avoided by conducting the intervention or implementing the protective action.

5.3.1. Radon Exposure.

5.3.1.1. Radon measurements must be available for all DoD housing, child development centers, and DoD Education Activity (DoDEA) schools. DoD housing does not include privatized housing. Results will be made available to all occupants of tested facilities. The actions included in this paragraph must be implemented within five years of publication.

5.3.1.2. Radon measurements must be periodically re-evaluated using a risk-based approach in accordance with the *Bioenvironmental Engineer's Guidebook for Radon Management*.

5.3.1.3. New structures should not be tested for one year after construction to allow for foundation settling and testing must occur in accordance with the Bioenvironmental Engineer's Guidebook for Radon Management. It is acceptable to occupy a facility in the absence of initial radon test results.

5.3.1.4. CE will notify the IRSO within 5 days after completion of facility construction or facility mitigation. Recently-mitigated facilities should have radon testing initiated within 90 days after the mitigation system is installed.

5.3.1.5. DoD housing residents will not be required to live in a home or assessed a turndown option for refusing a home with a radon exposure level of 4 pCi/L or higher.

5.3.1.6. DoD housing, child development centers, and DoDEA schools must be mitigated within 3 years if levels are detected from 4-20 pCi/L, within 1 year if levels are detected above 20 pCi/L. Expedited remediation shall be considered for elevated radon levels above 20 pCi/L.

5.3.1.7. Radon testing and mitigation in current privatized housing will be accomplished by the project owner as specified in the applicable project documents.

5.3.1.8. New privatized housing projects will assure radon testing and mitigation is accomplished by the project owner as specified in the applicable project documents.

5.3.1.9. Radon-related guidance published in the Unified Facility Criteria will be followed for construction and renovations in DoD housing, privatized housing, child development centers, and other facilities.

5.3.1.10. Current criteria in the UFC includes 4-740-14, Child Development Centers; UFC 4-711-01, Family Housing, and UFC 4-030-01, Sustainable Development.

5.3.1.11. Installations determined by the USAF School of Aerospace Medicine (USAFSAM) to be low-risk in accordance with the *Bioenvironmental Engineer's Guidebook for Radon Management* are exempt from program requirements.

5.3.2. Uncontrolled Exposures Resulting from Radiological Incidents and Accidents. Members of the 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. 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. [T-0]

Chapter 6

RADIATION PROTECTION OF AF PERSONNEL DURING INTERVENTIONS

6.1. General. This chapter provides guidance for protecting AF 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 industrial, medical, 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. This section also applies to nuclear capable units and units with 91(b) material. The following summarizes the radiation protection considerations described in Joint Publication 3-11, *Operations in Chemical, Biological, Radiological, and Nuclear Environments*, Oct 2013. For specific guidance refer to JP 3-11; AFRRI's *Medical Management of Radiological Casualties, 4th Edition* Jul 2013; and/or *Bioenvironmental Engineering Field Manual*, Aug 2012.

6.2. Radiation Protection Principles and Guidance for Interventions.

6.2.1. There are three basic principles of ionizing radiation protection used to manage the risks associated with ionizing radiation exposure.

6.2.1.1. Justification. No unnecessary exposure should be undertaken.

6.2.1.2. Optimization. The level of individual doses, number of people exposed and likelihood of incurring exposure should be kept ALARA.

6.2.1.3. Limitation. The dose to an individual shall be limited according to appropriate DoD guidance. [T-0]

6.2.2. Applying radiation protection principles should not introduce a higher level or more severe risk to the unit or mission. Complete risk management requires:

6.2.2.1. Information. Personnel must assess risk using an all hazards approach using all available information such as measurements, visual observations, and modeling. [T-0]

6.2.2.2. Justification. Consideration of threshold and random health consequences of radiation exposure needs to be considered. Unnecessary risks to health should not be accepted.

6.2.2.3. Optimization. To minimize the potential effects of exposure, intervention planning should involve efforts to reduce the time in a radiation area, maintaining the maximum distance possible from radiation sources, and using shields between exposed personnel and radiation sources to keep radiation exposures ALARA.

6.2.3. Dose guidance should be developed for a given intervention. Dose limits do not apply for interventions. Instead, the operational exposure guidance (OEG) is applicable. The commander's decision to allow this exposure should be based on the Radiation Exposure Status (RES) category found in JP 3-11 and made in the context of the situation and balance the anticipated benefit with both short and long-term health risks the exposure may cause. The exposure will vary depending on whether the mission is critical, priority, or routine and the severity of the radiological threat (catastrophic, critical, marginal, or negligible). An

OEG should be set for each mission with potential for exposure, for decontamination of personnel or equipment, or for immediate or operational decontamination.

6.2.3.1. Dose due to the ingestion or inhalation of RAM cannot be accurately measured in the field but can be estimated for operational purposes. Depending on the type of RAM 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. [T-0]

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.

6.2.4.1. Experienced volunteers who do not plan on having more children may be preferred. The concern over temporary/permanent sterility is reduced. Also, experienced workers typically can complete an operation in a timelier manner, reducing their dose.

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. [T-1]

6.3. Allowable Contamination Levels.

6.3.1. Recommended contamination levels for clothing or skin and equipment should be managed to levels that are ALARA using methods found in AFMAN 44-161(l) and NUREG 1575, Supplement 1. In some operational environments where thorough decontamination options may be unavailable, skin contamination should not exceed the levels specified in NATO Standardization Agreement 2473 (see **Attachment 7**).

6.3.2. Operational implementation of these contamination standards should follow procedures in Allied Engineering Publication-49, NATO Handbook for *Sampling and Identification of Radiological Agents*ictect*(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 **paragraph 3.3** of this instruction. Depending on the nature of the intervention, training should be provided by medical radiation protection personnel. [T-1]

6.5. Monitoring During Interventions. Implementing 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, environmental sampling, personnel dosimeters, and/or bioassays.

6.5.1. Personnel deployed in known or potential radiation environments shall be provided individual dosimeters if the potential to exceed 1 mSv (100 mrem) exists. [T-0]

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, environmental monitoring data, modeling, dose reconstructions, or other methods consistent with currently accepted scientific practice. [T-0]

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 AF MRER. [T-0]

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 OEG. The RSO 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. [T-0]

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. [T-0]

6.5.5. Reports of dosimetry or bioassay results shall be given promptly to the potentially exposed individual and their commander or delegated representative. [T-0]

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 AF Manual 44-161, *Treatment of Nuclear and Radiological Casualties*, NCRP Report 161, *Management of Persons 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 USAFSAM, and may include, but not be limited to: [T-1]

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 RAM, respectively; and/or

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, there is not a requirement to conduct follow up medical testing and monitoring. Personnel should continue with normally prescribed medical procedures authorized by their Primary Care Provider, such as those testing and monitoring programs included in guidelines for the general population (e.g., routine mammography and pap smears).

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.

Chapter 7 (Added-FEW)

RADIATION PROTECTION QUALITY ASSURANCE AND MANAGEMENT OVERSIGHT

7.1. (Added-FEW) The IRSO will accomplish a review of the base radiation protection program and perform an Intrinsic Radiation Safety Self-Assessment annually. Results will be presented at the 90 MW Environmental, Safety, and Occupational Health (ESOH) Council and Aerospace Medicine Council annually. The review will include:

7.1.1. **(Added-FEW)** A review of AFI supplements and unit operating instructions to ensure they are current.

7.1.2. **(Added-FEW)** A review of radiation survey results to ensure all required surveys have been performed, documented and appropriate corrective action taken. The review will include all sources in the master inventory, as required in paragraph 2.20.18.

7.1.3. **(Added-FEW)** A review of USAF Radioactive Material Permits used at FEWAFB to ensure currency and compliance with requirements.

7.1.4. **(Added-FEW)** A review and update of the list of unit RSOs to ensure completeness and accuracy.

7.1.5. **(Added-FEW)** A review of the ALARA/INRAD radiation safety training completion by unit RSOs to ensure that training is being performed and documented.

Chapter 8 (Added-FEW)

COMMITMENT

8.1. (Added-FEW) FEWAFB is committed to minimizing exposure to ionizing radiation and keeping exposures as low as reasonably achievable.

8.2. (Added-FEW) Implementing the policies in this instruction will ensure FEWAFB achieves its goal.

THOMAS W. TRAVIS, Lieutenant General,
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Surgeon General

(FEW)

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Attachment 1

GLOSSARY OF REFERENCES AND SUPPORTING INFORMATION

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Abbreviations and Acronyms

AAPM—American Association of Physicists in Medicine

ABC—Automatic Brightness Control

ABH—American Board of Health Physics

ABMP—American Board of Medical Physics

ABR—American Board of Radiology

ACR—American College of Radiology

ADCL—Accredited Dosimetry Calibration Laboratory

AFDIRB—Air Force Diagnostic Imaging and Radiotherapy Board

AFI—Air Force Instruction

AFIA—Air Force Inspection Agency

AFMAN—Air Force Manual

AFMPWG—Air Force Medical Physics Working Group

AFMSA—Air Force Medical Support Agency

AFOSH—Air Force Occupational Safety and Health

AFPD—Air Force Policy Directive

AFRAT—Air Force Radiation Assessment Team

AFRRAD—Air Force Radioactive Recycling & Disposal

AF-RSC—Air Force Radiation Safety Committee

AF-RSCES—Air Force Radiation Safety Committee Executive Secretariat

AFSC—Air Force Specialty Code

AFSEC—Air Force Safety Center

ALARA—As Low As Reasonably Achievable

ALI—Annual Limits of Intake

AOR—Area of Responsibility

ARRT—American Registry of Radiologic Technologists

ASRT—American Society of Radiologic Technologists

BCB—Bioenvironmental Engineering (BE) Corporate Board

BCE—Base Civil Engineer

BE—Bioenvironmental Engineering

BEE—Bioenvironmental Engineer

BMET—Biomedical Equipment Technician

CBRNE—Chemical, Biological, Radiological, Nuclear and high-yield Explosive

CE—Civil Engineer

CEDE—Committed Effective Dose Equivalent

CFR—Code of Federal Regulations

CME—Continuing Medical Education

COCOM—Combatant Command

CONUS—Continental United States

CRCPD—Conference of Radiation Control Program Directors

CT—Computed Tomography

CTDI—Computed Tomography Dose Index

DHS—Department of Homeland Security

(Added-FEW) DLA—Defense Logistics Agency

DMC—Deployed Medical Commander

EDF—Equipment Data File

EM—Emergency Management

EPA—Environmental Protection Agency

ESE—Entrance Skin Exposure

ESEG—Entrance Skin Exposure Guide

ESOH—Environmental, Safety, and Occupational Health

eV—Electron Volt

FDA—Food and Drug Administration

GSU—Geographically Separated Unit

IAW—In Accordance With

ICRP—International Commission on Radiological Protection

HLC—High Level Control

JTF—Joint Task Force

IAEA—International Atomic Energy Agency

INRAD—Intrinsic Radiation

IRSO—Installation Radiation Safety Officer

MAJCOM—Major Command

MERC—Medical Equipment Repair Center

MOA—Memorandum of Agreement

MQSA—Mammography Quality Services Act

MRER—Master Radiation Exposure Registry

MRI—Magnetic Resonance Imaging

MSAD—Multiple Scan Average Dose

MTF—Military Treatment Facility

NARM—Naturally Occurring or Accelerator Produced Material

NATO—North Atlantic Treaty Organization

NCOIC—Non-Commissioned Officer In Charge

NCRP—National Council on Radiation Protection

NEXT—Nationwide Evaluation of X-ray Trends

NIST—National Institutes of Standards and Technology

NRC—Nuclear Regulatory Commission

OCONUS—Outside the Continental United States

ODG—Operational Dose Guidance

OEG—Operational Exposure Guidance

OPR—Office of Primary Responsibility

OSHA—Occupational Safety and Health Administration

pCi/L—picoCurie/Liter

PCM—Primary Care Manager

PET—Positron Emission Tomography

PPE—Personal Protective Equipment

PRSO—Permit Radiation Safety Officer

QA—Quality Assurance

QAP—Quality Assurance Program

QC—Quality Control

RADIAC—Radiation Detection Instrumentation and Calculation

RAM—Radioactive Material

rem—Roentgen Equivalent Man

RES—Radiation Exposure Status

RIC—Radioisotope Committee, see USAF RIC

RICS—Radioisotope Committee Secretariat

RM—Risk Management

RSC—Radiation Safety Committee

RSO—Radiation Safety Officer

SEI—Special Emphasis Investigation

SMDA—Safe Medical Devices Act of 1990

SMO—Senior Medical Officer

SOFA—Status of Forces Agreement

SPECT—Single Photon Emission Computed Tomography

SSD—Source-to-Skin Distance

SSN—Social Security Number

Sv—Sievert

TDY—Temporary Duty

TEDE—Total Effective Dose Equivalent

(Added-FEW) TLD—Thermoluminescent Dosimeter

(Added-FEW) TMO—Transportation Management Office

TO—Technical Orders

URSO—Unit Radiation Safety Officer

USAF RIC—United States Air Force Radioisotope Committee

USAFSAM—United States Air Force School of Aerospace Medicine

WLM—Working Level Month

Terms

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 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 2.58E-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.

91(b) Material—RAM 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 RAM 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 (D)—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.

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—An arbitrary value assigned in a dose report in cases where a dosimeter is not returned for processing at the end of the wear period, is damaged, or which cannot be evaluated due to other factors. Administratively assigned doses must be investigated by the installation RSO as "Abnormal Exposures" IAW AFMAN 48-125.

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, RAM, and radiation in the public interest.

Annual Average Effective Dose Equivalent in the US Population—The following table provides a list of common exposure sources and the annual average dose an individual in the U.S. receives from each source. The rounded annual dose for non-smokers per year is 6.2 mSv, or 620 mrem. It provides a basis for comparison to the limits and dose guidance specified in this instruction. Below is a comparison showing the increase in the annual average exposure based on results from National Council on Radiation Protection and Measurements (NCRP), Report No. 160, Ionizing Radiation Exposure of the Population of the United States (2009), and Report No. 093, Ionizing Radiation Exposure of the Population of the United States, showing recent data indicating an increase of effective dose. This is namely due to medical exposures.

Annual Limit of Intake (ALI)—The derived limit of RAM 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 rem) or a committed dose equivalent of 0.5 Sv (50 rem) to any individual organ or tissue.

Background Radiation—Radiation from cosmic sources; naturally occurring RAM, including radon (except as a decay product of source or special nuclear material); 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 regulated by the NRC or from NARM that the AF regulates through AFI 40-201.

Becquerel (Bq)—The International System of Units (SI) unit of radioactivity is equivalent to one disintegration per second (dps, or Bq). One curie (Ci) is equivalent to 3.7E10 (37 billion) Bq.

Bioassay (Radio-bioassay)—The determination of kinds, quantities or concentrations, and, in some cases, the locations of RAM in the human body, whether by direct measurement (in-vivo counting) or by analysis and evaluation of materials excreted or removed (in-vitro) from the human body.

Byproduct Material—(1) Any RAM (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; (2) the tailings or wastes produced by the extraction or concentration of uranium or thorium from ore processed primarily for its source material content, including discrete surface wastes resulting from uranium solution extraction processes. Underground ore bodies depleted by these solution extraction operations do not constitute "byproduct material" within this definition.

Committed Dose Equivalent ($H_{T,50}$)—The dose to a specific organ or tissue that is received from an intake of radioactive material by an individual over a specified time after the intake. For radiation protection purposes, the specified time is to the age of 70, which is normally taken to be 50 years for a radiation worker and 70 years for a member of the public.

Committed Equivalent Dose and Committed Effective Dose Equivalent ($H_{E,50}$)—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, $H_{T,50}$ 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 public. The committed effective dose, E(), 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: $E(50) = SUM(W_T*H_T(50))$

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

Curie (Ci)—A unit of radioactivity equal to 37 billion Becquerels. See definition of Becquerel.

Declared Pregnant Woman—A woman who is also a radiation worker and has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception. The declaration remains in effect until the declared pregnant woman withdraws the declaration in writing or is no longer pregnant.

Derived Air Concentration (DAC)—The concentration of a given radionuclide in air which, 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 ionizing radiation used in the diagnosis of injury or disease. Includes: x-ray units (fixed, portable, fluoroscopy, computed tomography,

etc.), RAM (capsules, liquids or gases) used in nuclear medicine, and RAM used in a laboratory setting to perform *in-vitro* studies (on blood, urine, cells, etc.).

Deep Dose Equivalent (H_d)—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) which is expressed in units of rem or Sievert (Sv).

Dose Equivalent (H_T)—A quantity used for radiation protection to indicate the biological effectiveness of different radiations to cause stochastic health effects (e.g., cancer). The product of the absorbed dose in tissue (D_T) and the quality factor (Q), and all other necessary modifying factors at the location of interest where $H_T = D_T * Q$. The units of dose equivalent are the rem and Sievert (Sv). (0.01 Sv = 1 rem). The dose equivalent in Sv is equal to the absorbed dose in gray multiplied by the Q; 1 Sv = 100 rem. Its purpose is to have a single unit, regardless of the type of radiation, describing the biological effect due to exposure to radiation on man.

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, w_T. Expressed in unit of Sievert (Sv) or rem (100 rem = 1 Sv).

Electron Volt (eV)—A unit of energy equal to approximately 1.6E-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, w_R. Expressed in units of Sievert (Sv) or rem.

Exposure—In radiation protection, the act or occurrence of being exposed to radiation or RAM. 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 rad).

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—Any area with dose rates greater than 0.1 rem (1 mSv) in one hour, 30 centimeters from the source, or from any surface through which the ionizing radiation penetrates. Areas at licensee facilities must be posted as "high radiation areas" and access into these areas is maintained under strict control.

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.

(Added-FEW) Installation RSO— The individual designated by the 90 MW/CC to manage the base radiation protection program. This individual conducts the base-wide radiation protection program including surveillance of all radioactive material and radiation producing devices. The installation RSO coordinates with and assists the unit and permit RSOs.

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

Investigation Level—1) A dose equivalent value or radionuclide intake activity set by the installation RSO that requires further investigation when exceeded. A 10% default value is recommended for all dose types (e.g., 125 mrem for whole body quarterly badges, 375 mrem for lens of eye quarterly badges, 1250 mrem for extremity quarterly badges, 41 mrem for pregnant women monthly badges), however, at the IRSO discretion, levels can be tailored to each using section's historical dosimetry data in order to promptly identify and correct adverse trends; (2) The CEDE from radioactive material ingested, inhaled, or otherwise taken into the human body or dose equivalent from an external radiation source to which the worker is occupationally exposed which justifies further investigation. Such an investigation generally includes a review of the circumstances associated with the apparently abnormal internal or external personnel dose equivalent, assessment of the consequences and mitigation or prevention of such a personnel dose equivalent of similar magnitude in the future.

Ionizing Radiation—Any electromagnetic or particulate radiation capable of producing ions, directly or indirectly during its passage through matter. It 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 dose equivalent to the lens of the eye from external exposure of the lens of the eye to some radiation source. It is measured at an eye lens tissue depth of 0.3 cm (300 mg/cm^2).

Medical Event—An event that meets the criteria in **paragraph 4.13.1**.

Member of the 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 RAM from regulated and unregulated sources of radiation, whether in the possession of the licensee 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 RAM and released IAW applicable regulations; from voluntary participation in medical research programs; or as a member of the public.

(Added-FEW) Permit RSO— The individual designated by the unit commander to continuously monitor the radiation protection program for a USAF Radioactive Material Permit. Each permittee (unit commander) must appoint a permit RSO to be approved by the installation RSO and the AF Radioisotope Committee (RIC).

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

Prescribed Dose—(1) For brachytherapy, stereotactic radiosurgery, or other radiation therapy procedures involving radioactive material, 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 or a person having knowledge and training to provide advice regarding radiation protection principles, standards and measurements. In general, a BEE 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: A biomedical equipment repair technician is considered a qualified expert to support QC, equipment repair, collection of data and calibration IAW AFI 41-201, Managing Clinical Engineering Programs.
Note: 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.

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 radiation weighting factor, w_T, for a given radiation. The radiation weighting 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 RAM. For the purposes of individual monitoring using personnel dosimetry, three specific quantities of dose equivalent are used:

Deep Dose Equivalent (H_D)—Dose assigned to personnel from external whole-body exposure, it is the dose equivalent at a tissue depth of one cm (1000 mg/cm^2) which is expressed in units of rem or Sievert (Sv). It is the primary dose reported in the AF personnel dosimetry program. The deep dose equivalent is derived from the more general Individual Dose Equivalent, Penetrating, Hp(d). This is defined as the dose equivalent in soft tissue at a depth, d, in the body that is appropriate for penetrating radiations.

Shallow Dose Equivalent (H_S)—Dose equivalent measured at a tissue depth of 0.007 cm (7 mg/cm^2, the average depth of the germinal cell layer) averaged over an area of 1 cm^2. This is otherwise referred to as the shallow or skin dose in the AF 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 where d = 10 mm for strongly penetrating radiation, and d = 7 mm for weakly penetrating radiation.

Lens Dose Equivalent (H_E)—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/cm^2).

Radiation Quality 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 quality factor (Q) 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: $H_T = SUM(Q_R*D_{T,R})$ 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.

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 = 1 cGy).

Radiation—For the purposes of this regulation, unless otherwise specified, ionizing radiation and specific, medical uses of non-ionizing radiation, such as radio- or microwaves, or visible, infrared, or ultraviolet light.

Radiation Area—Any area with radiation levels greater than 5 millirem (0.05 milliSievert) in one hour at 30 centimeters from the source or from any surface through which 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. Health physics and radiation protection are synonyms.

Radiation Safety Committee—An advisory committee for the commander to assess the adequacy of an organization's radiation safety program. Radiation control committee and radiation protection committee are synonyms.

Radiation Safety Officer—The person that the commander designates, in writing, as the person responsible for the installation, organization or unit radiation safety program. It is the same as a radiation protection officer or health physics officer. (Reference **Attachment 2**)

Radiation Safety Program—A program to implement the objectives of radiation safety regulations directives and instructions.

Radiation Source—Any non-exempt quantity of RAM, equipment, or devices which spontaneously generate or are capable of generating ionizing radiation. Examples include nuclear reactors, medical and dental radiographic and fluoroscopic x-ray systems, particle generators and accelerators, certain electromagnetic generators operating at electrical potentials that result in the production of x-rays, x-ray diffraction, industrial radiographic and spectrographic equipment, electron microscopes, electron-beam welding, melting, and cutting equipment, nuclear moisture or density gauges, byproduct, source, and special nuclear materials, natural or accelerator-produced radioactive materials, materials containing induced or deposited radioactivity and radioactive commodities.

Radiation Worker—An individual who may be occupationally exposed in the course of their duties or designated by the IRSO.

Radio-bioassay—See bioassay.

(Added-FEW) TLD— The personnel dosimeter is used to indicate a close approximation of the exposure dose to ionizing radiation to monitor exposures are maintained ALARA. The badge contains a thermoluminescent dosimetry packet. The packet is exchanged monthly or quarterly depending on the area where an individual works and the condition of the individual.

(Added-FEW) Unit RSO— The individual designated by the unit commander to continuously monitor the radiation protection program within the organization. Each unit that operates radiation producing devices or ships, stores or receives radioactive material must appoint a unit RSO.

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.

Rem—The conventional unit of any of the quantities expressed as dose equivalent. The dose equivalent in rem is equal to the absorbed dose in rad 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 and RAM. Restricted area does not include areas used as residential quarters, but separate rooms in a residential building may be set apart as a restricted area.

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.

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 – the average depth of the germinal cell layer) averaged over an area of 1 cm2 usually 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 Sievert is equal to the absorbed dose in gray multiplied by appropriate radiation weighting factors, wR, (1 Sv = 100 rem). One milliSievert (mSv) is 0.001 Sv [(0.1 rem) or (100 mrem)].

Stochastic Effects—Health effects that occur randomly and for which the probability of the effect occurring, rather than its severity, is assumed to be a linear function of dose without threshold. Hereditary effects and cancer incidence are examples of stochastic effects.

Surveys—An evaluation of the radiological conditions and potential hazards incident to the production, use, transfer, release, disposal, or presence of radioactive material or other sources of

radiation. When appropriate, such an evaluation includes a physical survey of the location of radioactive material and measurements or calculations of levels of radiation, or concentrations or quantities of radioactive material present.

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, RAM 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.

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, wT, 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(wT*HT) where HT is the equivalent dose in tissue or organ T and wT is the weighting factor for tissue T. Tissue weighting factors are given in the following table. 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.

Total Effective Dose—This is the sum of the deep dose equivalent, Hd, 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: Et = E(50) +Hd

Unrestricted Area—An area, access to which is neither limited nor controlled (for the purposes of 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 exceed 500 rad (5 Gy) in one hour at 1 meter from the source or from any surface that the radiation penetrates.

[**Note**: For very high doses received at high dose rates, units of absorbed dose (e.g., rad and Gray) are appropriate, rather than units of dose equivalent (e.g., rem and Sievert)].

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

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 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 1.3E5 MeV in a liter of air, equivalent to 2E-5 Joule per cubic meter of air (J/m3). One working level month (WLM, or 3.5E-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 data gather regarding occupational exposures uranium miners, lung cancer probabilities are estimated in the broad range of 1 to 4E-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% equilibrium with the radon.

Attachment 2

TRAINING AND QUALIFICATIONS

A2.1. General. This attachment provides the training requirements and qualifications required for all AF radiation workers and RSOs. In general, the AF has three types of RSOs – IRSOs, URSOs and PRSOs. In some instances, RSOs require additional qualifications that are outlined in other AF publications. Training requirements are outlined in **Table A2.1**.

A2.2. IRSO Qualifications.

A2.2.1. Be a BEE (4E3EX) who meets at least one of the following:

A2.2.1.1. Attended the BE Officer Course prior to 1999 or after 2007; or

A2.2.1.2. Awarded the G shred (i.e., 43E3G); or

A2.2.1.3. Is a certified health physicist; or

A2.2.1.4. Has received 40 hours of RSO training (reference **Table A2.1**) via a formal course.

A2.2.2. In the absence of a BE officer or AF civilian employee or if a unit is geographically separate from one, the IRSO should be a 7-level BE Craftsman (4BO71). The IRSO shall have the training and experience criteria in **paragraph A2.2.1**.

A2.2.3. Contractors cannot be the IRSO. Permittee's listed on a permit issued by the AF Radioisotope Committee Secretariat cannot be an IRSO unless no other individual meets the above qualifications.

A2.2.4. In addition to the qualifications listed in this instruction, IRSOs must meet the qualifications listed in AFI 40-201 or AFI 91-108 if they are applicable to the installation. [T-3]

A2.2.5. Knows the hazards of the sources of radiation on the installation (including INRAD from nuclear weapons and radioactive waste sites).

A2.3. URSO Qualifications.

A2.3.1. URSO qualifications are based upon the RAM, e.g. generally licensed devices (GLD) IAW 10 CFR 31, or radiation sources in the unit. **Table A2.1** lists the training required for URSOs.

A2.3.2. URSO for units conducting non-destructive inspections using radiation sources. In addition to **A2.3.1**, must meet the requirements in T.O. 33B-1-1. [T-2]

A2.4. PRSO Qualifications.

A2.4.1. PRSOs must also meet the training and qualification requirements listed in AFI 40-201 or AFI 91-108 as applicable. [T-2]

A2.4.2. There are three types of permits – non-template, template, and medical permits. Additional training requirements for the RSOs for permits are delineated in AFI 40-201.

A2.4.3. Know the hazards of the sources of radiation relevant to the permit.

A2.5. Radiation Workers. All radiation workers will have the training listed in **Table A2.1**. Initial and annual training can often be provided by the IRSO, URSO, or PRSO depending on scope of use. [T-2]

Table A2.1. Training guidance for radiation safety officers and radiation workers.

Topic/Audience	IRSO[1]	URSO Only[3] Machine Produced	URSO NDI Machine Produced	Radiation Worker	PRSO[2]
Radiation vs. contamination	X	X	X	X	X
Internal vs. external exposure and dose	X			X	X
Biological effects of radiation	X	X	X	X	X
Types and hazards associated with RAM or devices possessed	X	X	X	X	X
ALARA concept	X	X	X	X	X
Training in the principles of time, distance, and shielding to minimize exposure	X	X	X	X	X
Radiation detection and measurement	X	X	X	If required by position	X
Personnel dosimetry	X	X	X	X	X
Applicable regulations	X	X	X	X	X
License/Permit conditions, amendments, renewals	X				X
Locations of use and storage of RAM	X	X[3]			X
Material control and accountability	X	X[3]			X
Annual audit of radiation safety program	X	If required by position	If required by position	If required by position	X
Transfer and disposal	X	X[3]			X
Record keeping	X	X	X	X	X
Prior events involving permitted material	X				X

Managing incidents/mishaps	X	X	X	X	X
Recognition and assurance of radiation warning signs; visibility and legibility	X	X	X	X	X
Inspection by regulatory agencies	X	X	X		X
Requirement for complete and accurate information	X	X	X		X
Employee protection	X	X	X	X	X
Deliberate misconduct	X	X	X	X	X
Emergency response procedures	X	X	X	X	X
Protective action guides	X				
Air monitoring procedures	X				
Bioassay techniques	X				X
Special Requirements	X	X[3]	TO 33B-1-1		AFI 40-201

[1]These are the minimum topics for a 40 hr course to train IRSOs

[2]Specific training requirements for PRSOs are contained in AFI 40-201

[3]Specific GLDs requirements IAW 10 CFR 31 for URSOs

Attachment 3

MEDICAL CONSEQUENCES OF RADIATION EXPOSURE

A3.1. General. Exposure of living cells by 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 large number of cells following irradiation, but if the number lost is substantial, 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 (cataracts) 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.

Table A3.1. Estimated Threshold Doses for Acute Radiation Effects [1, 2.]

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 – 600 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)

1. Institute of Medicine, *Potential Radiation Exposure in Military Operations, National Academy Press*, Washington DC, 1999.
2. 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.

A3.3.1. 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.

A3.3.2. The nominal risks given in **Table A3.2** are for radiation induced fatal cancers for the general population. In addition, non-fatal cancers occur. Therefore, typical ratios for total cancers (fatal plus non-fatal) are given in **Table A3.2** Note: 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[1] at Low Doses and Low Dose Rates for Low-LET[2] Radiation Expressed as Severe Hereditary Disorders and Fatal Cancers (Lifetime) [3.]

Effect	**Nominal risk per milliSievert (100 mrem)**	**Ratio: total cancer to fatal cancers**
Hereditary	**$10x10^{-6}$ (all generations)[5]**	**-**
Cancer	*Fatal probability*	
Leukemia (active marrow)	$5x10^{-6}$	1.01
Bone Surfaces	$0.5x10^{-6}$	1.4
Breast (females only)	$4x10^{-6}$	2.0
Lung	$8.5x10^{-6}$	1.05
Thyroid	$0.8x10^{-6}$	10
Colon	$8.5x10^{-6}$	1.8
Esophagus	$3x10^{-6}$	1.05
Skin	$0.2x10^{-6}$	500
Stomach	$11x10^{-6}$	1.1
Liver	1.5×10^{-6}	1.05
Bladder	$3x10^{-6}$	2.0
Ovaries	$2x10^{-6}$	1.4
Other (combined remaining)	$5x10^{-6}$	1.8
Sum of fatal cancer risk for whole body irradiation[4]	$50x10^{-6}$ (1 in 20,000) per milliSievert	
Baseline cancer mortality	**0.15 (1 in 6.7) to 0.25 (1 in 4)**	

1. The nominal risks are average values for a population comprised equally of males and females
2. LET is the *linear energy transfer*; low-LET radiation refers to sparsely radiations such as gamma rays, x-rays and beta particles
3. 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
4. For infants and children, the nominal risk is likely 2-3 times higher than $50x10^{-6}$. For adults over 50 at the time of exposure, the risk is 5-10 times less
5. 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 are summarized in **Table A3.3**.

Table A3.3. Types of Effects Following Irradiation In-Utero [1.]

Time After Conception	**Effect**	**Normal Incidence in live-born**
First three weeks	No deterministic or stochastic effects in live-born children	-
3rd through 8th weeks	Potential for malformations of organs[2]	0.06 *(1 in 17)*
8th through 25th weeks	Potential for mental retardation, probability: 1 to $4x10^{-4}$/mSv[3]	$5x10^{-3}$ *(1 in 200)*
4th week throughout pregnancy	Cancer in childhood or adult life, probability: 28 to $130x10^{-6}$/mSv[4]	$1x10^{-3}$ *(1 in 1000)*

1. Report 60, *1990 Recommendations of the International Commission on Radiological Protection.* ICRP Publication 60. Annals of the ICRP 21(1-3), 1991.
2. Malformations of organs appear to be deterministic effect, with a threshold dose in man, estimated from animal experiments to be 0.1 Gy.
3. 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.
4. 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] [T-0].

Application	Occupational	Declared Pregnant Females	Minors (16 - 18 years)[4]	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 conceptus (embryo/fetus) (no more than 50 mrem/month is recommended)	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)	

1. Based on the requirements of Title 10, CFR, Part 20
2. The limits apply to the sum of relevant doses from external exposure in a period of 1 calendar year and the 50 year committed dose from intakes in the same period
3. The mSv is the preferred unit of dose for radiation protection purposes. Current AF instrumentation uses the Gy or R as their basic unit of measure, and the MRER reports doses in rem. For low LET penetrating radiations (x-rays, gamma rays), the following conversions can be applied: 10 mSv = 1 cSv ≈
1 cGy =10 mGy = 1 rad ≈ 1 R
4. Conditions for Minors: No person under the age of 16 years shall be subjected to occupational exposure, and no person under the age of 18 shall be allowed to work in a restricted area unless supervised, and then only for the purposes of training
5. In special circumstances, an effective dose of up to 5 mSv in a single year, provided the average over five years does not exceed 1 mSv per year. AFMSA/SG3PB shall be contacted to obtain this variance. Also, general public shall not be exposed to more than 0.02 mSv (2 mrem) in any one hour
6. Averaged over 1 cm^2, regardless of the area exposed

Table A4.2. Acceptable Surface Contamination Levels[1] (Bq/cm^2 and $dpm/100\ cm^2$).

Nuclide	Removable[2,4]	Total (Fixed + Removable)[2,3]

U-nat, ^{235}U, ^{238}U, and associated decay products	[7] 0.17 Bq/cm^2 (1,000 dpm/100 cm^2)	[7] 0.83 Bq/cm^2 (5,000 dpm/100 cm^2)
Transuranics, ^{226}Ra, ^{228}Ra, ^{230}Th, ^{228}Th, ^{231}Pa, ^{227}Ac, ^{125}I, ^{129}I	0.0033 Bq/cm^2 (20 dpm/100 cm^2)	0.017 Bq/cm^2 (100 dpm/100 cm^2)
Th-nat, ^{232}Th, ^{90}Sr, ^{223}Ra, ^{224}Ra, ^{232}U, ^{126}I, ^{131}I, ^{133}I	0.033 Bq/cm^2 (200 dpm/100 cm^2)	0.17 Bq/cm^2 (1,000 dpm/100 cm^2)
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except ^{90}Sr and others noted above[5]	0.17 Bq/cm^2 (1,000 dpm/100 cm^2)	0.83 Bq/cm^2 (5,000 dpm/100 cm^2)
Tritium and tritiated compounds[6]	1.7 Bq/cm^2 (10,000 dpm/100cm^2)	N/A

Note: This table is extracted from 10CFR835, Appendix D and NUREG-1575, Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual (MARSAME), Supp.1, Table E.1. In general, this table will not apply to contingency operations. For contingency operations follow the COCOM, or equivalent, directives.

1. The values in this appendix, with the exception noted in footnote 5, apply to radioactive contamination deposited on, but not incorporated into the interior or matrix of, the contaminated item. Where surface contamination by both alpha-and beta-gamma emitting nuclides exists, the limits established for alpha-and beta-gamma-emitting nuclides apply independently.
2. As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.
3. The levels may be averaged over one square meter provided the maximum surface activity in any area of 100 cm2 is less than three times the value specified. For purposes of averaging, any square meter of surface shall be considered to be above the surface contamination value if: (1) From measurements of a representative number of sections it is determined that the average contamination level exceeds the applicable value; or (2) it is determined that the sum of the activity of all isolated spots or particles in any 100 cm^2 area exceeds three times the applicable value.
4. The amount of removable radioactive material per 100 cm2 of surface area should be determined by swiping the area with dry filter or soft absorbent paper, applying moderate pressure, and then assessing the amount of radioactive material on the swipewith an appropriate instrument of known efficiency. (Note: The use of dry material may not be appropriate for tritium.) When removable contamination on objects of surface area less than 100 cm2 is determined, the activity per unit area shall be based on the actual area and the entire surface shall be wiped. It is not necessary to use swiping techniques to measure removable contamination levels if direct scan surveys indicate that the total residual surface contamination levels are within the limits for removable contamination.
5. This category of radionuclides includes mixed fission products, including the Sr-90 which is present in them. It does not apply to Sr-90 which has been separated from the other fission products or mixtures where the Sr-90 has been enriched.
6. Tritium contamination may diffuse into the volume or matrix of materials. Evaluation of surface contamination shall consider the extent to which such contamination may migrate to the surface in order to ensure the surface contamination value provided in this appendix is not exceeded. Once this contamination migrates to the surface, it may be removable, not fixed; therefore, a Total value does not apply.
7. Alpha activity

Attachment 5

REGIONAL CONSULTING MEDICAL PHYSICS OFFICES

Note: The AF/SG Consultant for Medical Physics, or Associate Corps Chief for Bioenvironmental Engineering, will identify the medical physics office to support other regions, including OCONUS and deployed locations, as appropriate. [T-3]

Attachment 6

PUBLIC INTERVENTION LEVELS

A6.1. Remedial Action Levels.

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

Exposure to Radon	> 4 pCi/L average radon concentration

A6.2. Department of Homeland Security (DHS) and EPA PROTECTIVE ACTION GUIDE (PAG).

Table A6.2. DHS and EPA Protective Action Guides.

Phase	Protective Action	Protective Action Guide
Early	Limit Emergency Worker Exposure	50 mSv (5 rem) (or greater under exceptional circumstances)[1]
	Sheltering of Public	1 to 50 mSv (5 rem) projected dose[2]
	Evacuation of Public	1 to 50 mSv (5 rem) projected dose[3]
	Administration of Prophylactic Drugs	For potassium iodide, FDA Guidance dose values[4,5,6]
Intermediate	Limit Worker Exposure	50 mSv/yr (5 rem/yr)
	Relocation of Public	20 mSv (2 rem), projected dose first year. Subsequent years: 5 mSv/yr (500 mrem/yr) projected dose
	Food Interdiction	5 mSv/yr (500 mrem/yr) projected dose[7]
	Drinking Water Interdiction	5 mSv/yr (500 mrem/yr) dose
Late	Final Clean-up Actions	Late phase PAG based on optimization

1. In cases when radiation control options are not available or, due to the magnitude of the incident, are not sufficient, doses above 5 rem may be unavoidable
2. Should normally begin at 1 rem; however, sheltering may begin at lower levels if advantageous
3. Should normally begin at 1 rem
4. Provides protection from radioactive iodine only
5. For other information on medical prophylactics and treatment please refer to http://www.fda.gov/cder/drugprepare/default.htm or http://www.bt.cdc.gov/radiation/index/asp or http://www.orau.gov/reacts.
6. Potassium Iodide as a Thyroid Blocking Agent in Radiation Emergencies,'' December 2001, Center Drug Evaluation and Research, FDA, HHS (http://www.fda.gov/cder/guidance/5386fnl.htm).
7. Accidental Radioactive Contamination of Human Food and Animal Feeds: Recommendations for State and Local Agencies,'' August 13, 1998, Office of Health and Industry Programs, Center for Devices and Radiological Health, FDA, HHS (http://www.fda.gov/cdhr/dmqrp/84.html).

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

Note: Reference AFMAN 10-2503, Chemical, Biological, Radiological, Nuclear, and High-Yield Explosive (CBRNE) Operations, for recommended operational exposure guidelines based on the commander's assessment of the mission criticality and acceptable risk level

1. The use of the measurement milliSievert (mSv) is preferred in all cases. For low LET, whole body irradiation (x - rays, gamma rays): 1 cGy =10 mGy = 1 rad ≈ 10 mSv ≈ 1 R
2. All doses should be kept ALARA. This will reduce individual risk as well as retain maximum operational flexibility for future employment of exposed personnel
3. Priority missions are those missions that avert danger to people, prevent damage from spreading, or support the organization's mission essential task list (METL)

4. Critical missions are those missions that are essential to the overall success of a higher headquarters' operation, emergency lifesaving missions, or like missions
5. This is in addition to the 1:5 and 1:4 incidence of fatal cancer among the general population. Increased risk is given for induction of fatal cancer. Total lifetime risk is assumed to be 4 – 7 percent per ~1,000 mSv (100 rad). It must be recognized that higher radiation dose rates produce proportionally more health risks than the same total dose given over longer periods of time
6. NATO STANAG 2083, Commander's Guide on Nuclear Radiation Exposure of Groups, states 125 cGy (125 rad) as the commander's upper dose limit

Table A7.2. Military Contamination Limits for 7-day Operations [1.]

Commander Dose Guidance	**Maximum Contamination Limits[2] 7 day mission duration**	
	Equipment and Protective Clothing[4]	
	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)

1. From NATO Standardization Agreement 2473, Ratification Draft 1. The specified contamination limits are those estimated that would limit the total cumulative dose from inhalation of re-suspended material and ingestion of contamination to less the category Commander Dose Guidance for the operations period
2. Radioactive contamination is removable (assessed with swipes)
3. If the alpha emitter is undetermined, use high-toxicity emitter column. Low toxicity alpha emitters include natural uranium, ^{235}U, and ^{238}U. All other alpha emitters are considered to be high toxicity
4. It is recommended that in Cat 1A, gloves and booties be worn. It is required that in Cat 1B and above, booties, coveralls, gloves and respiratory protection be worn

Table A7.3. Military Contamination Limits for 3 Month Operations [1.]

Commander Dose Guidance	**Maximum Contamination Limits[2] 3 month mission duration**	
	Equipment and Protective Clothing[4]	
	High Toxicity Alpha Emitter[3]	**Beta and Low Toxicity Alpha Emitters[3]**
Category 1A 0.05 – 0.5 cGy	0.5 Bq/cm^2 (3x10^3 dpm/100 cm^2)	5 Bq/cm^2 (30x10^3 dpm/100 cm^2)
Category 1B 0.5 - 5 cGy	5 Bq/cm^2 (30x10^3 dpm/100 cm^2)	50 Bq/cm^2 (300x10^3 dpm/100 cm^2)
Category 1C 5 - 10 cGy	10 Bq/cm^2 (60x10^3 dpm/100 cm^2)	100 Bq/cm^2 (600x10^3 dpm/100 cm^2)

Category 1D 10 – 25 cGy	25 Bq/cm^2 (150x10^3 dpm/100 cm^2)	250 Bq/cm^2 (1500x10^3 dpm/100 cm^2)
Category 1E 25 – 75 cGy	75 Bq/cm^2 (450x10^3 dpm/100 cm^2)	750 Bq/cm^2 (4500x10^3 dpm/100 cm^2)

1. From NATO Standardization Agreement 2473, Ratification Draft 1. The specified contamination limits are those estimated that would limit the total cumulative dose from inhalation of re-suspended material and ingestion of contamination to less the category Commander Dose Guidance for the operations period
2. Radioactive contamination is removable (assessed with swipes)
3. If the alpha emitter is undetermined, use high-toxicity emitter column. Low toxicity alpha emitters include natural uranium, ^{235}U, and ^{238}U. All other alpha emitters are considered to be high toxicity
4. It is recommended that in Cat 1A, gloves and booties be worn. It is required that in Cat 1B and above, booties, coveralls, gloves and respiratory protection be worn

Attachment 8

AIR FORCE RADIATION SAFETY COMMITTEE (AF-RSC)

A8.1. Purpose. The AF-RSC is responsible for providing oversight of sources of radiation not covered by AFI 40-201 or AFI 91-108 to ensure they are operated in accordance with Federal, AF and host nation requirements. The AF-RSC is also responsible for the development and execution of the AF's radiation protection program for both practices and interventions as is outlined in this AFI.

A8.2. AF-RSC Members Organizations and Responsibilities.

A8.2.1. XXX **Table A8.1** indicates the membership and general roles for each member of the AF- RSC. At the request of the AF-RSCES or the AF-RSC Chairman additional advisors can be invited.

A8.2.2. AF-RSC Executive Secretary (AF-RSCES): Organization, scheduling and planning of the AF-RSC meeting, and generation of meeting minutes.

A8.2.3. AF-RSC Chair: Open AF-RSC meetings, and preside over their proceedings. Assist in maintaining the discussion focus of the agenda items, and resolve disagreements. Adjourn meeting once completed.

A8.2.4. AF-RSC Members: Ensure either they or their alternates attend scheduled AF-RSC meetings and are prepared to address agenda items.

Table A8.1. AF-RSC Membership and Responsibilities.

Office	AF-RSC Membership			Responsibilities
	Chair	Voting	Alternate	
AFMSA/SG3P Chair, AF-RSC	1	1		Provides oversight/ leadership of RSC
AF/SG Consultant for Health Physics (Chief, Radiation Health)		1	1	Can act in Chair's absence; develops RSC agenda; provides direction and guidance for Radiation Health; conducts daily ops and ensures completion of RSC action items
Bioenvironmental Engineering (AFMSA/SG3PB)		1	1	Provides career specific input relevant to the safe use of radiation sources
AF/SG Consultant for Medical Physics		1		Liaison for the Air Force Medical Physics Working Group (paragraph 2.10.6) and supports AF-RSC regarding issues specific

				to Chapter 4
Medical Readiness (AFMSA/SG3X)		1	1	Provides guidance on readiness issues with respect to the use of radiation
Assistant Secretary of the Air Force (Installations, Environment and Logistics)		1	1	Provides guidance, direction, and oversight [for] all matters pertaining to the formulation, review, and execution of Environment, Safety, and Occupational Health (ESOH) policies, plans, programs, and budgets
Assistant Secretary of the AF for Acquisition, SAF/AQ		1	1	Ensures the AF-RSC is informed regarding the acquisition of new systems and upgrades that utilize sources of radiation not covered by AFI 40-201 or 91-108 prior to fielding
Deputy Chief of Staff for Logistics, Installations, and Mission Support, USAF/A3/7		1	1	Provides guidance on the management of items covered by this AFI that produce radiation or result in radiation exposure
Surgeon General, USAF/SG				Establishes AF policy for controlling radiation hazards and sets limits for exposure to radiation and ensures compliance with relevant Federal policy and accepted scientific practice
Assistant Surgeon General, Health Care Operations, HQ USAF/SG3				Responsible for the execution of the AF radiation safety program covered by this AFI and for the AF-RSC. Appoints the Chair, RSC
The Air Force Inspection Agency, Medical		1		Conducts inspections to assess compliance

Operations Directorate, AFIA/SG				with AF and Federal requirements and provides reports to the AF-RSC Executive Secretary
The Civil Engineer (HQ USAF/A7C)		1	1	Provides policy guidance for major accidents/incidents, enemy attack, and terrorist use of weapons of mass destruction involving nuclear and radiological materials
Command Surgeons, Air Force Materiel Command (AFMC/SG), Air Force Global Strike Command (AFGSC/SG), Air Combat Command (ACC/SG), U.S. Air Forces in Europe (USAFE/SG), Pacific Air Forces (PACAF/SG); Air National Guard (ANG/SG); AF Reserve (AFRC/SG)		1	1	Provides policy guidance for the acquisition and logistical management of sources of radiation that are not covered by AFI 40-201 or AFI 91-108
Commander, 711th Human Performance Wing (711 HPW/CC)		1	1	Provides advice on research and development matters. Appoints a voting member and alternate to the RSC
HAF AFSEC/SEWN		1		Provides guidance regarding ionizing radiation exposures to personnel from nuclear weapon systems and nuclear weapons testing
AFLOA/JAC		1	1	Ensures legal counsel is provided to both the AF-RSC and to the AF-RSCES to both the AF-RSC and to the AF-RSCES, as appropriate, on all legal and policy requirements affecting or otherwise applying to AF

				implementation of the radiation safety program

A8.3. Business Practices.

A8.3.1. The AF-RSC Chair and the AF-RSCES will establish the detailed procedures for AF-RSC meetings.

A8.3.1.1. A formal AF-RSC meeting will occur at least semi-annually, but more frequently if determined necessary by the Chair or the majority of the committee. AF-RSC meetings are scheduled by the AF-RSCES.

A8.3.1.2. Ad hoc meetings can be called by the Chair on an as needed basis. These meetings are called to address emergent issues that require timely action by the AF-RSC.

A8.3.1.3. Rapid staffing of an action can be approved by the Chair to address emergent issues for which an ad hoc meeting cannot be convened. For a rapid staffing the AF-RSCES will prepare a staffing package that addresses the issue and provides the voting members of the AF-RSC the ability to vote without meeting. All rapid staffing actions will be discussed at the next AF-RSC meeting.

A8.3.1.4. Quorum for a meeting is established by having a least one-half of the voting members present.

A8.3.2. Meetings will be conducted IAW all applicable policies and procedures. The Chair and the AF-RSCES will establish the specific procedures for the conduct of routine meetings, ad hoc meetings and rapid staffing actions.

A8.3.3. Motions and Voting.

A8.3.3.1. Only members and guests recognized by the Chair may speak.

A8.3.3.2. Generally, before any item can be discussed, there should be a motion made and seconded. Once a motion has been seconded, discussion will follow. After discussion, one of four things can happen: [T-3]

A8.3.3.2.1. **(1)** There can be a vote on the motion. In the event of a tie, the Chair casts the deciding vote.

A8.3.3.2.2. **(2)** The motion can be amended (second required). Then there can be discussion on the amendment. The amendment can be voted. If the amendment passes, the motion automatically passes. If the amendment fails, the motion still stands and can be discussed until voted.

A8.3.3.2.3. **(3)** The motion can be tabled (second required). There can be no discussion on a motion to table; a vote must be taken immediately. If the vote is to table, no further discussion can take place on the motion. [T-3]

A8.3.3.2.4. **(4)** There may be no action on the motion; therefore it becomes old business at a future meeting.

A8.3.3.3. Motions must be clear and concise. A motion to "improve practices" would be vague and discussions could meander. However, a motion to "implement x-ray radiation safety practices for a new x-ray device" is specific and could be effectively discussed and acted on. [T-3]

A8.4. Disagreement Resolution. The Chair of the meeting is responsible for maintaining order. On procedural questions, the Chair's ruling will be determinative and final.

A8.5. Record Keeping.

A8.5.1. The AF-RSCES will ensure that appropriate files for each meeting are maintained IAW all applicable requirements. This will include as a minimum, the agenda, meeting minutes, copy of all reference materials, background information, memoranda, standing reports, and presentations applicable to that quarters meeting.

A8.5.2. Committee members are responsible for providing applicable materials to the AF-RSCES as requested.

A8.5.3. Records of AF-RSC meetings, to include agendas, presentations, and meeting minutes, shall be kept for the duration of existence of the AF-RSC. [T-2]