1. **Purpose:** This procedure describes the use of external radiation dose monitoring through personnel dosimetry.

2. **Scope:** The Radiation Safety Staff will follow this procedure when implementing the dosimetry program to ensure radiation safety and regulatory compliance.

3. **Definitions:**

3.1 ALARA – An acronym for "As Low As Reasonably Achievable" which is a guiding principle for the radiation safety program. In the absence of specific restrictions, radiation exposure will still be restricted as much as reasonable.

3.2 Committed Effective Dose Equivalent (CEDE) – the sum of the products of the committed dose equivalents for each of the body organs or tissues that are irradiated multiplied by the weighting factors (W_T) applicable to each of those organs or tissues ($H_{E,50} = \Sigma W_T H_{T.50}$).

3.3 Declared Pregnant Worker (DPW) – A participant who has voluntarily chosen to disclose their pregnancy and provides the necessary information to the RSS for the issuance of a fetal dosimeter.

3.4 Deep Dose Equivalent (DDE) – the external whole-body exposure dose equivalent at a tissue depth of 1 cm (1000 mg/cm^2).

3.5 Dose – a generic term that will refer to "effective dose equivalent" (EDE) unless otherwise specified.

3.6 Dosimetry Coordinator (DC) – a worker in each department who receives and distributes dosimeters to participants and fulfills other delegated dosimetry duties as outlined below.

3.7 Dosimetry Participant (Participant) – a radiation worker who has their radiation dose monitored as part of the overall dosimetry program.

3.8 Dosimetry Provider – an individual or organization that provides, processes, and evaluates individual dose monitoring equipment to determine the radiation dose delivered to the equipment.

3.9 Effective Dose Equivalent (EDE) – the sum of the products of the dose equivalent to the organ or tissue (H_T) and the tissue weighting factors (W_T) applicable to each of the body organs or tissues that are irradiated ($H_E = \Sigma W_T H_T$).

3.10 High Radiation Area - any area with dose rates greater than 100 millirem (1 millisievert) in one hour 30 centimeters from the source or from any surface through which the ionizing radiation

3.11 Lens Dose Equivalent (LDE) – the external exposure dose equivalent to the lens of the eye at a tissue depth of 0.3 centimeters (300 mg/cm^2).

3.12 Minor – An individual less than 18 years of age.

3.13 Monitoring Period – the duration that a given participant's dosimeter should be worn. Typically, this will be one quarter or one month.

3.14 Radiation Area – any area with radiation levels greater than 5 millirem (0.05 millisievert) in one hour at 30 cm from the source or from any surface through which the radiation penetrates.

3.15 Radiation Safety Staff (RSS) – radiation safety professionals, working as part of the University of Missouri's Environmental Health & Safety (EHS) Department, responsible for safety and compliance of all radioactive material and radiation-generating equipment on campus and at university healthcare facilities.

3.16 RAM – radioactive material.

3.17 Shallow Dose Equivalent (SDE) – the dose equivalent at a tissue depth of 0.007 centimeter (7 mg/cm^2), which applies to the external exposure of the skin of the whole body or the skin of an extremity.

3.18 Subaccount – a group of participants as defined by the dosimetry provider; they have the same DC and generally receive the same dosimeter(s) per participant. They have the same radiation risk as evaluated by the RSS.

3.19 Total Effective Dose Equivalent (TEDE) – the sum of the effective dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

4. Procedure Details:

4.1 General dosimetry requirements

4.1.1 Dosimeters shall be issued to participants who are likely to receive, in 1 year from external sources to the body, a dose greater than 10% of the limits found in 10 CFR 20.1201(a) and shown in Figure 1. [10 CFR 20.1502(a)(1)].

4.1.2 Participants may not exceed an annual TEDE of 5 rem (0.05 Sv) OR an annual LDE of 15 rem (0.15 Sv) OR a SDE of 50 rem (0.5 Sv) to the skin of the whole body or to the skin of any extremity, as shown in Figure 1.

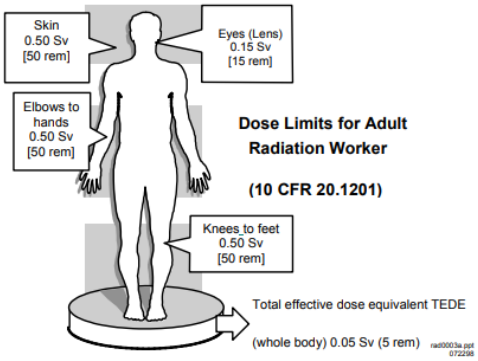

Figure 1. Annual Occupational Exposure Limits

4.1.3 DCs shall notify the RSS if a minor needs to become a participant. Minors are not eligible to become participants without prior approval by the RSS. Annual doses to minors from external sources shall remain less than 100 mrem DDE, 150 mrem LDE, or 500 mrem SDE [10 CFR 20.1502(a)(2)].

4.1.4 DPWs may not exceed 500 mrem to the embryo/fetus during the entire pregnancy and shall wear dosimeters if they are likely to receive 100 mrem DDE during their entire pregnancy [10 CFR 20.1208(a), 10 CFR 20.1502(a)(3)].

4.1.5 Participants entering a high or very high radiation area must wear dosimetry [10 CFR 20.1502(a)(4)].

4.1.6 Per the MU NRC RML commitments Item 10D, persons handling greater than or equal to 1 millicurie of gamma or high-energy beta emitters shall wear extremity monitors unless dose estimates performed by EHS RSS can verify likely doses are below 10% of any applicable limit in 10 CFR 20.

4.1.7 The RSS will perform a dosimetry evaluation to determine if RWs need dosimetry based on anticipated RAM or X-Ray uses. A dosimetry evaluation must be performed prior to actual first use of any new radiation source. Evaluations need not be made for every individual; evaluations can be made for employees with similar job functions or work areas.

4.1.8 Anyone assigned a dosimeter must receive radiation safety training, regardless of the radiation source, as outlined in the Radiation Safety Manual listed on the EHS department website.

4.2 Dosimetry Provider Responsibilities

4.2.1 Personnel monitoring devices such as film badges, optically stimulated luminescence (OSL) dosimeters, or thermoluminescent dosimeters (TLDs) must be evaluated by a provider that is National Voluntary Laboratory Accreditation Program-approved, as required by [10 CFR 20.1501(d)].
The dosimetry provider must process returned dosimeters in a reasonable timeframe to allow prompt communication of dose data with participants and oversight bodies.

4.2.2 Participant dose information must be made available to the RSS as needed for NRC reporting requirements.

4.2.3 The dosimetry provider must comply with other RSS requests as needed for regulatory compliance.

4.3 RSS Responsibilities

4.3.1 RSS are responsible for maintaining overall radiation safety, including monitoring the recorded doses of all dosimetry participants.

4.3.2 Prior to any new use of radiation, whether RAM or radiation-generating machines, RSS will perform a dosimetry evaluation to determine if personnel monitoring is needed.

4.3.2.1 Dosimetry evaluations should be performed by the RSS during the initial RAM permit application and during each renewal period of a RAM permit.

4.3.2.2 When determining the need for personnel dosimetry, RSS will evaluate factors such as:

4.3.2.2.1 Radiation source (radionuclides, device inventory, etc.)

4.3.2.2.2 Room layout and wall/floor materials

4.3.2.2.3 Participant orientation and distance to radiation source

4.3.2.2.4 Estimated activities used per procedure and frequency of procedures performed annually

4.3.2.2.5 Radiation use procedures

4.3.2.2.6 Worker information

4.3.2.3 The results of this evaluation will be recorded in the HP Review document for the relevant RAM or X-ray use permit and/or special conditions of the permit.

4.3.2.4 The DC or Permitted Individual (PI) is responsible for notifying the RSS if changes in radiation uses occur. If changes are substantial, the RSS will redo the dosimetry evaluation.

4.3.3 If the need for dosimetry is determined, the RSS will assist with setting up a new subaccount code or working with the DC to have dosimeters ordered for a new RW.

4.3.3.1 Dosimetry Subaccounts should be divided based on departments and/or employees with similar exposures that can be reasonably managed by a single DC.

4.3.4 The Radiation Safety Officer (RSO) will review all dose reports as they are received and generate quarterly ALARA reports as part of the ALARA Program described in the Radiation Safety Manual.

4.3.5 RSS will maintain an online database of participant dose history. Paper and digital dose reports will also be available upon request. Annual dose reports (NRC Form 5) and cumulative dose reports (NRC Form 4) are accessible via the EHS website [10 CFR 19.13].

4.3.6 RSS will provide previous employer dose history reports upon request. These requests will be furnished within 30 days after the exposure of the individual or 30 days from the time of the request, whichever is longer [10 CFR 19.13(c)(2)].

4.3.7 RSS will oversee the application process for new dosimetry participants.

4.3.7.1 New participants can apply for dosimetry monitoring online (instructions can be found on the EHS website).

4.3.7.2 Applications will be reviewed and approved by both the appropriate DC and RSS.

4.3.8 RSS is responsible for ordering new dosimeters from the dosimetry provider once the dosimetry application has been approved.

4.3.9 Participant removals and edits can be accomplished by emailing the RSS who will process these requests through the dosimetry provider.

4.4 Participant Responsibilities

4.4.1 All dosimetry program participants must receive basic radiation safety training, with additional training requirements depending on job function.

4.4.2 Participants are responsible for wearing their dosimeters correctly and returning them via their DC.

4.4.2.1 Dosimeters should remain in the participant's workspace but not near radiation sources. Dosimeters should not be taken home.

4.4.2.2 Participants must wear the dosimeter for the entire duration of activities involving radiation exposure in the correct orientation and position as assigned by the RSS.

4.4.2.2.1 All whole-body dosimeters should have the plastic tab labeled 'remove' taken off before use.

4.4.2.2.2 All dosimeters must have the labeled face with the participant's name pointing towards the radiation source.

4.4.2.2.3 Chest dosimeters should be worn towards the midpoint of the abdomen. They can be worn on either side of the body and attached to a pocket or lapel.

4.4.2.2.4 Collar dosimeters should be worn along the collarbone.

4.4.2.2.5 All dosimeters should be worn outside of lead protective garments unless otherwise specified by the RSS.

4.4.2.2.5.1 Note: fetal dosimeters should be worn underneath lead.

4.4.2.2.6 Ring dosimeters should be worn on the participant's dominant hand and can be worn on whichever finger fits best. Make sure the label faces away from the palm so the dosimeter is directly exposed to the radiation source.

4.4.2.2.7 Ring dosimeters should be worn underneath gloves.

4.4.3 If an RW has multiple dosimeters due to work in multiple departments or external workplaces, they should not be used interchangeably. Only use and store dosimeters at their specific workplace or department.

4.4.4 If an RW is assigned dosimetry from the university and plans to receive a diagnostic or therapeutic treatment with RAM (radiopharmaceuticals), then the RW must inform the RSS prior to the treatment. The RSS can advise the RW on how to continue to monitor occupational exposure without interference from the personal treatment or scan.

4.4.5 Participants will not automatically receive a copy of their dose history. This information is available online (instructions are available on the EHS website).

4.4.6 Individuals who no longer work at the University of Missouri and desire a copy of their dose records must contact the RSS for a termination report.

4.4.7 RWs who are pregnant have the option of declaring their pregnancy.

4.4.7.1 If a pregnant RW chooses to declare their pregnancy to the RSS, then the DPW will have their exposure limits reduced during the gestational period. The RSS will also monitor exposures monthly.

4.4.7.2 Only RWs should declare a pregnancy. Non-RWs do not need to declare pregnancy.

4.4.7.3 If a pregnancy is declared, the DPW will be assigned a fetal dosimeter with limits of 50 mrem/month and 500 mrem for the entire gestation period from the point of declaration [10 CFR 20.1208].

4.4.7.4 If a pregnancy is not declared, the RSS will not enforce additional dose restrictions or assign a fetal dosimeter.

4.4.7.5 If discretion is desired, DPWs can choose to work directly with the RSS rather than the DC to declare pregnancy and order fetal dosimeters.

4.4.7.6 The RSS is available for consultation regarding DPW status. Further information regarding prenatal radiation exposure can be found in NRC Regulatory Guide 8.13.

4.4.7.7 To wear a fetal dosimeter, place the dosimeter at abdominal height. If shielding such as lead aprons are worn, place the fetal dosimeter under the shielding.

4.4.7.8 Fetal dosimeters are monthly dosimeters and should be exchanged on a monthly basis. Dose reports will be reviewed by the RSO once received from the dosimetry provider. The DPW will only be notified if fetal dose limits are exceeded.

4.5 Dosimetry Coordinator (DC) Responsibilities

4.5.1 The DC is the main point of contact for the dosimetry program in their department or subaccount. The DC will maintain a working knowledge of all RWs in their area to build and maintain a current roster of dosimetry program participants. This will be accomplished by:

4.5.1.1 Assisting new participants with completing dosimetry applications and approving their applications for review by RSS.

4.5.1.2 Informing RSS of any participants that need to be removed from the subaccount or have their dosimeter information otherwise altered.

4.5.1.3 Informing RSS of any change in departmental or billing contact information.

4.5.2 DCs will be provided training materials and working guides through the EHS department website with specific instructions for adding new participants and maintaining compliance with the broader radiation safety program.

4.5.3 The DC is responsible for receiving mail from the RSS and distributing dosimeters to participants in their subaccount.

4.5.4 The DC is responsible for collecting used dosimeters and returning them to the RSS via campus mail or other means when the monitoring period is concluded.

4.5.4.1 For ease of use and completeness, RSS recommends the use of badge boards, mail slots, or any other organizational aid to assist in collecting all dosimeters.

4.5.4.2 Dosimeters will be batched and shipped by the RSS to the Dosimetry provider for evaluation.

4.5.5 The DC acknowledges that dosimetry equipment fees must be paid through departmental invoicing to the RSS which may include late and lost fees for missing dosimeters. Return schedule and late and lost fees will be listed on the RSS website.

4.5.6 Loss or damage to dosimetry equipment during a monitoring period will be reported to the RSS for replacement with spare dosimeters if possible.

4.5.7 A DC may request an updated dosimetry evaluation based on significant changes to the use of radiation in their subaccount such as new equipment, materials, or procedures.

4.5.8 Participant and subaccount level dose data may be requested from the RSS as needed.

4.5.9 DCs are not responsible for maintaining a dose history for their participants. However, DCs may be asked to assist the RSS in estimating missing dose information or participating in over-dose investigations.

4.5.10 DCs are not responsible for dose history requests from outside organizations, and such requests may be forwarded to the RSS for follow-up.

5. References:

5.1 Schiager, K. J., McDougall, M. M., Christman, R. E. A., Party, E., Ring, J., Carlson, D. E., & Barkley, W. E. (1996). Consensus radiation protection practices for academic research institutions. *Health physics*, *71*(6), 960-965.

5.2 NUREG-1556 Volume 9, Rev. 3

5.3 NRC License 24-00513-32 Tie Down Document as of Amendment 126 6/6/2022

5.4 NRC Reading Room Glossary https://www.nrc.gov/reading-rm/basic-ref/glossary/

5.5 University of Missouri EHS Radiation Safety Manual https://ehs.missouri.edu/rad/rsm

6. Revisions

6.1 Rev 01 – 2023-10-24 – New SOP.