OCCUPATIONAL DOSE ASSESSMENT

INSPECTABLE AREAS: Access Control to Radiologically Significant Areas
Radiation Monitoring Instrumentation

CORNERSTONE: Occupational Radiation Safety

EFFECTIVE DATE: January 1, 2016

INSPECTION BASIS: In the radiation safety area, dose is the basic measure of risk from occupational radiation exposures. The ability to provide for adequate protection of the worker rests on effective risk assessment, which is dependent on the application of monitoring and dosimetry techniques appropriate for the exposure situation. Title 10 of the Code of Federal Regulations (10 CFR) Part 20, "Standards for Protection against Radiation," Subpart F, "Surveys and Monitoring," contains provisions for individual monitoring of external and internal exposures, as well as requirements for the calibration and accuracy of dosimetry equipment.

In addition, 10 CFR 20.1202, "Compliance with Requirements for Summation of External and Internal Doses," has requirements for summing external and internal exposures to determine the total effective dose equivalent. This inspectable area verifies aspects of the Occupational Radiation Safety Cornerstone for which there are no indicators to measure performance.

LEVEL OF EFFORT: Inspect Biennially

PROGRAM APPLICABILITY: 2515 App A

71124.04-01 INSPECTION OBJECTIVES

01.01 Determine the accuracy and operability of personal monitoring equipment.

01.02 Determine the accuracy and effectiveness of the licensee's methods for determining total effective dose equivalent.

01.03 Verify that occupational dose is appropriately monitored.

71124.04-02 INSPECTION REQUIREMENTS

02.01 Inspection Planning.

a. Inspectors should review the results of radiation protection program audits related to internal and external dosimetry (e.g., licensee's quality assurance (QA) audits, self-assessments, or other independent audits).

b. Inspectors should review the most recent National Voluntary Laboratory Accreditation Program (NVLAP) accreditation report on the licensee or, if dosimetry is provided by a vendor, review the vendor's most recent results to determine the status of the licensee's or contractor's accreditation.

c. Inspectors should review licensee procedures associated with dosimetry operations, including issuance/use of external dosimetry (routine, multibadging, extremity, neutron, etc.), assessment of internal dose (operation of whole body counter, assignment of dose based on derived air concentration (DAC)-hours, urinalysis, etc.), and evaluation of and dose assessment for radiological incidents (distributed contamination, hot particles, loss of dosimetry, etc.).

d. Inspectors should verify that the licensee has established procedural requirements for determining when external and internal dosimetry is required.

02.02 Source Term Characterization. (1 sample)

a. Source Term

Verify the licensee has characterized the radiation types and energies being monitored. The licensee should have knowledge of the gamma (photon) spectrum, the beta spectrum and average beta energy of the beta spectrum, the hard-to-detect (HTD) component of beta/gamma activity, and the alpha transuranic component of the source term. In addition, verify that the neutron spectrum has been determined.

b. Scaling Factors

Verify scaling factors have been developed for use in scaling HTD radionuclide activity and alpha radionuclides in internal dose assessments.

02.03 External Dosimetry. (1 sample)

a. NVLAP Accreditation

Verify that the licensee's personnel dosimeters that require processing are processed by a NVLAP accredited processor. Verify that the approved irradiation test categories for each type of personnel dosimeter used are consistent with the types and energies of the radiation present, and the way that the dosimeter is being used.

b. Passive Dosimeters (e.g. TLD, OSL)

1. Evaluate the onsite storage of dosimeters before their issuance, during use, and before processing/reading.

2. Evaluate whether personnel dosimeters stored at the plant during the monitoring period are stored in a low dose rate area alongside control dosimeters.

3. If the licensee does not require issued dosimetry to be stored on site during the monitoring period, verify that guidance is provided to radworkers with respect to care and storage of dosimeters.

c. Active Dosimeters (Electronic Alarming Dosimeters)

1. Verify that routine calibrations are being performed according to manufacturer's recommendations.

2. Determine if and how bias has been determined to correct the response of the electronic alarming dosimeter (EAD) as compared to TLD/OSL. Verify that the correction factor is based on sound technical principles.

3. Verify that correlations between EADs and passive dosimeter measurements are being performed, and that substantial discrepancies (i.e., that may indicate that the assigned deep-dose equivalent was not measured for the part of the body receiving the highest exposure) are investigated.

Verify that the correct dose is recorded in the individual's dose records.

4. As part of the problem identification and resolution review in 02.06 below, select three to five (as available) dosimetry occurrence reports or corrective action program documents for adverse trends related to EADs, such as interference from electromagnetic frequency, dropping or bumping, failure to hear alarms, etc. Determine if the licensee has identified any adverse trends and implemented appropriate corrective actions.

02.04 Internal Dosimetry. (1 sample)

a. Routine Bioassay (in vivo)

1. Review procedures used to assess dose from internally deposited nuclides using whole body counting equipment. Verify that the procedures address methods for determining if an individual is internally or externally contaminated, the release of contaminated individuals, the determination of entry route (ingestion, inhalation), and assignment of dose.

2. If whole body counting is used to routinely verify, or quantify, the intakes of radionuclides (i.e., following the entry into a high airborne radioactivity area, or following the use of respiratory protection equipment), verify that the frequency of such measurements is consistent with the biological half-life of the potential nuclides available for intake.

3. If the licensee uses a method other than whole body counting for screening intakes (e.g., passive monitoring using portal monitors), evaluate the minimum detectable activity (MDA) of the instrument. Determine if the MDA is adequate to determine the potential for internally deposited radionuclides sufficient to prompt additional investigation.

4. Select three to five whole body counts, and verify that the system used in each had sufficient counting time/low background to ensure appropriate sensitivity for the potential radionuclides of interest. Verify that the appropriate nuclide library was used. Verify that any anomalous count peaks/nuclides indicated in each output spectra received appropriate disposition. If the licensee relies solely on whole body counting for assessing internal dose, verify that HTD nuclides are accounted for in the dose assessment.

b. Special Bioassay (in vitro)

1. For licensees with a routine in vitro (urinalysis and/or fecal analysis) bioassay program in place, review procedures used to assess dose from internally deposited nuclides of radionuclides (tritium, fission products, and activation products). Verify that the procedures address collection and storage of samples, the determination of entry route (ingestion, inhalation) and assignment of dose.

2. Select one to two, as available, internal dose assessments obtained using in vitro monitoring. Review and assess the adequacy of the dose assessments, beginning with sample collection through assignment of dose. Review the counting lab's QA program or, if a vendor lab is used, the licensee's audits of the lab. Verify that the lab participates in an analysis cross-check program and that out-of-tolerance results are evaluated and resolved appropriately.

c. Dose Assessments Based on Airborne Monitoring

1. Review and assess the adequacy of the licensee's program for dose assessments based on air sampling and DAC-hr monitoring.

Verify that flow rates and/or collection times for fixed head air samplers or lapel breathing zone air samplers are adequate to ensure that appropriate lower limits of detection (LLDs) are obtained.

2. Review the adequacy of procedural guidance used to assess dose when, if using respiratory protection, the licensee applies protection factors.

3. Review one to two dose assessments performed using air sampling and DAC-hr monitoring, if available. Verify that the licensee's DAC calculations are representative of the actual airborne radionuclide mixture, including HTD radionuclides, as appropriate.

d. Internal Dose Assessments

Review and assess the adequacy of the licensee's internal dose assessments for any actual internal exposure (limit these assessments to no more than two intake events with similar radionuclide mixes) assessed. Determine if the affected personnel were properly monitored with calibrated equipment and if the data were analyzed and internal exposures properly assessed in accordance with licensee procedures.

02.05 Special Dosimetric Situations. (1 sample)

a. Declared Pregnant Workers

1. Verify that the licensees inform workers, as appropriate, of the risks of radiation exposure to the embryo/fetus, the regulatory aspects of declaring a pregnancy, and the specific process to be used for (voluntarily) declaring a pregnancy.

2. Select one to two individuals (as available) who have declared their pregnancy during the current assessment period, and verify that the licensee's radiological monitoring program (internal and external) for declared pregnant workers is technically adequate to assess the dose to the embryo/fetus. Review the exposure results and monitoring controls employed by the licensee and with respect to the requirements of 10 CFR Part 20.

b. Dosimeter Placement and Assessment of Effective Dose Equivalent for External Exposures (EDEX)

1. Review the licensee's methodology for monitoring external dose in situations in which non-uniform fields are expected or large dose gradients will exist (e.g., diving activities and steam generator jumps).

Verify that the licensee has established criteria for determining when alternate monitoring techniques (i.e., use of multi-badging or determination of effective dose equivalent for external exposures (EDEX) using an approved method) are to be implemented.

2. Review one to two dose assessments performed using multi-badging during the current assessment period. Verify that the assessment was performed consistently with licensee procedures and dosimetric standards.

c. Shallow Dose Equivalent

Review one to two SDE dose assessments (as available) for adequacy. Evaluate the licensee's method (e.g., VARSKIN or similar code) for calculating SDE from distributed skin contamination or discrete radioactive particles.

d. Neutron Dose Assessment

1. As appropriate, evaluate the licensee's neutron dosimetry program, including dosimeter type(s) and/or survey instrumentation.

2. As available, select one to two neutron exposure situations (e.g., independent spent fuel storage installation operations or at-power containment entries) and verify that (a) dosimetry and/or instrumentation is appropriate for the expected neutron spectra, (b) there is sufficient sensitivity for low dose and/or dose rate measurement, and (c) neutron dosimetry is properly calibrated. Verify that interference by gamma radiation has been accounted for in the calibration. Verify that time and motion evaluations are representative of actual neutron exposure events, as applicable.

e. Dose of Record

For the special dosimetric situations reviewed in this section, determine how the licensee assigns dose of record for total effective dose equivalent, SDE, and LDE. This should include assessment of external and internal monitoring results, supplementary information on individual exposures (e.g., radiation incident investigation reports and skin contamination reports), and radiation surveys and/or air monitoring results when dosimetry is based on these techniques.

02.06 Problem Identification and Resolution. (1 sample)

Verify that problems associated with occupational dose assessment are being identified by the licensee at an appropriate threshold and are properly addressed for resolution in the licensee corrective action program. In addition, verify the appropriateness of the corrective actions for three to five problems documented by the licensee involving occupational dose assessment.

71124.04-03 INSPECTION GUIDANCE

03.01 Inspection Planning.

The results of the reviews should be used to gain insights into overall licensee performance in the area of dose assessment and focus the inspector's activities consistent with the principle of "smart sampling."

Unless there is a documented prospective evaluation that individual monitoring was not required (i.e., planned exposure or intakes would not meet any of the criteria in 10 CFR 20.1502(a) or (b)), the fact that monitoring was provided is considered de facto evidence that the licensee had previously determined the monitoring was required by 10 CFR 20.1502.

03.02 Source Term Characterization.

a. Source Term

Knowledge of the types and energies of radiation being monitored are critical to the correct selection and use (calibration and/or dose assessment) of dosimeters. Additionally, with power uprates, increased frequency of at-power containment entries, and expansion of ISFSI facilities, changes in water chemistry, etc., the source term may have changed over the years. Information Notice 2014-05 reminds licensees of their responsibility for ensuring that all applicable factors that may affect the accuracy of a dosimetry evaluation have been considered and taken into account, including the proper characterization of the radiation fields that are to be monitored.

b. Scaling Factors

Review the licensee's 10 CFR Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste," analyses to determine appropriate scaling factors for HTD and alpha-emitting radionuclides.

03.03 External Dosimetry.

a. NVLAP Accreditation

Obtain the NVLAP certification documentation to verify the dosimeters are processed by a NVLAP accredited processor.

Relevant test categories are Categories I (accident photons), Category II (Photon mixture), Category III (betas), and Category IV (photon/beta mixtures), Category V.C (moderated Cf-252 neutrons and photons), and possibly Categories V.A (neutron/photon mixtures) and possibly Category V.B (unmoderated Cf-252 neutrons and photons). Note: The test categories for low energy photon exposure is not important for the radiation spectrum in nuclear power plants.

Additional guidance is provided in American National Standards Institute (ANSI) N13.11-2009, “Personnel Dosimetry Performance - Criteria for Testing,” and Information Notice 2014-05, “Verifying Appropriate Dosimetry Evaluation.”

b. Passive dosimeters (e.g. TLD, OSL)

1. Storage of dosimeters prior to issuance and after the monitoring period (prior to processing) should be in a low dose rate area.

2. Dosimeters in use that are stored in racks on-site during non-wear periods should be in a low dose rate area with control dosimeters.

3. For issued dosimeters not stored on-site during the wear period, guidance should be provided to workers on acceptable storage conditions (e.g., to avoid hanging from rear view mirrors, excessive heat (cars/trucks), and storage on granite countertops).

c. Active Dosimeters (Electronic Alarming Dosimeters)

1. Routine calibrations should be performed according to manufacturer’s recommendations to verify dose rate points and dose integration accuracy. Commonly, irradiations are performed to Cs-137 over a dose range of intended use; e.g., from 1 mrem to 1 rem.

Note that if used for underwater diving, EADs may be subject to different (lower) energy levels due to scattering in the water medium. This may also impact dosimetry of record (e.g., TLDs).

2. A bias is normally established for EADs such to adjust readings to account for a geometric bias and a conservative factor. These two correction factors are normally a geometry correction and a conservative factor (conservative with respect to TLD/OSL measurements).

The geometry correction factor is typically a 5 – 10% positive bias to account for the fact that the EAD physical size and geometry is larger than the passive dosimeter. The EAD batteries and electronics provides some self-shielding, since the instrument response is directionally dependent (i.e., when the exposure angle is not perpendicular to the face of the EAD).

The second factor is a conservative factor (~5%) commonly used to ensure the real-time dose tracking used for worker exposure control is conservative (i.e., the EAD measurements will be higher than the TLD/OSL dose measurements normally used for dose of legal record).

These two factors of a conservative bias and a geometry bias may be better understood if a field comparisons of RO-2 surveys and electronic dosimeter and TLD/OSL evaluations are performed.

3. The evaluations of discrepancies between active and passive dosimeters may identify the cause of differences in measured values, such as due to passive dosimeter handling, storage, or processing errors, or due to electronic dosimeter misuse or other causes. Justifiable differences can occur even for the same exposure conditions, even if the active and passive dosimeters were co-located on the monitored individual. For example, the active dosimeter may have been calibrated with a positive bias to compensate for its inherent geometric under-response in field conditions (e.g., geometry factors such as its larger size and electrical components that can shield the internal detector). In addition, an additional positive bias may have been applied to the active dosimeter to ensure conservative exposure measurement for dose control purposes. Investigations may indicate that that one or both of the dosimeters were not used correctly, or were not working correctly, or that one or both of the dosimeters may have been subject to unexpected radiation exposure, or that the required dosimeter was not appropriately placed at the highest exposed part of the whole body.

4. Discuss the corrective action program entries with dosimetry staff, and review the corrective actions and any improvements in dosimetry performance.

03.04 Internal Dosimetry.

a. Routine Bioassay (in vivo)

1. Methods of assessing internal dose are provided in RG 8.34. “Monitoring Criteria and Methods to Calculate Occupational Radiation Doses.” Also see guidance in RG 8.9, “Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program,” and ANSI N13.30-1996, “Performance Criteria for Radiobioassay.”

   A common method for determining the location of personnel contamination is identifying the contaminated area via a hand held frisker and identifying the zone where beta contamination monitor alarms. Prompt whole body counts, as well as follow-up whole body counts can be used to determine if the residual contamination level follows the retention functions in NUREG/CR-4484 inhalation or ingestion models, and contamination removal from skin via showering and dead skin layer sluffing off.

2. No guidance provided.

3. Some licensees have procedures for the use of personnel contamination monitors in lieu of routine WBCs. Review licensee evaluations to determine if the passive monitoring can identify intakes exceeding the evaluation level defined in RG 8.9 of 2% of an ALI, or 100 mrem CEDE. This review should include any potential HTD contribution to CEDE as this will not be detected by passive monitoring.

4. WBC systems and gamma spectroscopy systems commonly have different radionuclide libraries for different exposure conditions and / or analytical needs. Selectively review the radionuclide libraries to verify that the licensee has analytical capabilities for fission products, natural occurring radioactive materials, and failed fuel conditions.

b. Special Bioassay (in vitro)

1. In addition to the references cited above in section 03.04.a., Regulatory Guide 8.26, “Applications of Bioassay for Fission and Activation Products,” and Regulatory Guide 8.32, “Criteria for Establishing a Tritium Bioassay Program,” provide relevant guidance for in vitro monitoring programs.

Verify that the licensee’s sample collection procedures ensure the following:

(a) collection and preservation of samples in a manner such that the loss of activity on the walls of the container is minimal and sample contamination is prevented,

(b) a sample of adequate size for each type of analysis requested, including adequate amounts to allow verification or additional analysis if needed,

(c) containers that are free of external and internal contamination,

(d) precautions to ensure the integrity of the container and prevent leakage from the container and/or cross-contamination of samples during the shipment and storage of samples, and

(e) accurate and unambiguous identification of samples. In addition, the licensee should specify the required LLDs and the reporting requirements, including standard error or confidence interval estimates, and alert the service laboratory of potentially “highly contaminated” samples, samples that may contain additives and/or preservatives, or samples that may contain extremely insoluble material.

2. No guidance provided.

c. Internal Dose Assessments Based on Airborne Monitoring

Note that requirements in this section may overlap requirements in Inspection Procedures 71124.01 and 71124.03. Avoid duplication of effort to the extent possible.

03.05 Special Dosimetry Situations.

a. Declared Pregnant Workers

See the guidance in Regulatory Guide 8.36, “Radiation Dose to the Embryo/Fetus,” Regulatory Guide 8.13, “Instruction Concerning Prenatal Radiation Exposure,” and Regulatory Guide 8.34, “Monitoring Criteria and Methods to Calculate Occupational Radiation Doses.

b. Dosimeter Placement and Assessment of Effective Dose Equivalent for External Exposures (EDEX)

See the guidance on several NRC-approved methods for assessing EDEX contained in Regulatory Issue Summary (RIS) 2003-04, “Use of the Effective Dose Equivalent in Place of the Deep Dose Equivalent in Dose Assessments,” dated February 13, 2003; RIS 2004-01, “Method for Estimating Effective Dose Equivalent from External Radiation Sources Using Two Dosimeters,” dated February 17, 2004; RIS 2009-09, “Use of Multiple Dosimetry and Compartment Factors in Determining Effective Dose Equivalent From External Radiation Exposures,” dated July 13, 2009; and Regulatory Guide 8.40, “Methods for Measuring Effective Dose Equivalent from External Exposure.”, dated July 2010.

c. Shallow Dose Equivalent

SDE must be the dose averaged over the 10 square centimeters of skin receiving the highest exposure. This should combine contributions from distributed skin contamination, gamma contributions from clothing contamination (if significant), as well as Discrete Radioactive Particles (DRPs), into one dosimetric quantity. If licensees are keeping track of DRP dose separately from SDE, then they are not meeting the intent of the 2002 rule change to SDE evaluation. See the Federal Register notice dated April 5, 2002 (67 FR 16304), for a more detailed discussion.

Verify that the licensee has established procedures for wound monitoring, and dose assessment from imbedded sources. Verify that clear criteria have been established for releasing from the site personnel with imbedded radioactive particles.

d. Neutron Dose Assessment

See guidance on neutron dosimeters in ANSI N13.52-1999 (Reaffirmed August, 2010), “Personnel Neutron Dosimeters (Neutron Energies Less Than 20 MeV).”

e. Dose of Record - See guidance in Regulatory Guide 8.7, “Instructions for Recording and Reporting Occupational Radiation Exposure Data” and ANSI N13.6-2010, “Practice for Occupational Radiation Exposure Records Systems.”

03.06 Problem Identification and Resolution.

See IP 71152, “Identification and Resolution of Problems,” for additional guidance.

71124.04-04 RESOURCE ESTIMATE

For planning purposes, it is estimated to take 20 hours, on average (with a range of 16 to 24 hours) to perform the requirements of this attachment.

71124.04-05 COMPLETION STATUS

Inspection of the minimum sample size will constitute completion of this procedure in the RPS. The minimum sample size for this attachment is five, defined as the sum of all the inspection requirements.

If any of the sample inspection requirements cannot be completed, the procedure should be closed in accordance with IMC 0306, “Planning, Tracking and Reporting of the Reactor oversight Process (ROP).” For example, if certain steps could not be completed due to sample unavailability, the procedure attachment should be declared “Complete – full sample not available” with a comment addressing the specific steps or activities that could not be completed.

END

Attachment 1 – Revision History for IP 71124.04

Commitment Tracking Number	Accession Number Issue Date Change Notice	Description of Change	Description of Training Required and Completion Date	Comment and Feedback Resolution Accession Number (Pre-Decisional, Non-Public Information)
N/A	12/02/09 CN 09-030	Conducted four year search for commitments and found none. This new procedure is being issued as a result of the 2009 ROP IP Realignment. It supersedes inspection requirements in IP 71121 and 71122.	Yes 09/09/2009	ML092810401
N/A	ML15344A332 02/19/16 CN 16-007	Major revisions to the IP 71124.04 procedure attachment were made in response to the 2013 ROP Enhancement Project. The revisions clarified the existing inspection requirements and enhanced the inspection guidance section. The revision also changed how samples are counted.	N/A	ML15344A337