

# NRC INSPECTION MANUAL

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## INSPECTION PROCEDURE 71124 ATTACHMENT 04

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### OCCUPATIONAL DOSE ASSESSMENT

Effective Date: January 1, 2020

PROGRAM APPLICABILITY: IMC 2515 App A

CORNERSTONE: Occupational Radiation Safety

INSPECTION BASES: See IMC 0308 Attachment 2

#### SAMPLE REQUIREMENTS:

Sample Requirements		Minimum Baseline Sample Completion Requirements		Budgeted Range	
Sample Type	Section(s)	Frequency	Sample Size	Samples	Hours
Source Term Characterization	03.01	Biennial	1 per site	1 per site	20 +/- 4 per site
External Dosimetry	03.02	Biennial	1 per site	1 per site	
Internal Dosimetry	03.03	Biennial	1 per site	1-3 per site	
Special Dosimetric Situations	03.04	Biennial	1 per site	1-3 per site	

#### 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.
- 01.02 Verify that occupational dose is appropriately monitored.
- 01.03 To conduct a routine review of problem identification and resolution activities per Inspection Procedure (IP) 71152, "Problem Identification and Resolution."

#### 71124.04-02 GENERAL GUIDANCE

Review the results of radiation protection program audits related to internal and external dosimetry. 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." Consider reviewing documents such as licensee's quality assurance (QA) audits, self-assessments, or other independent audits.

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.

Review the licensee procedures associated with dosimetry operations. Inspectors should consider 1) issuance/use of external dosimetry (routine, multibadging, extremity, neutron, etc.); 2) assessment of internal dose (operation of whole body counter, assignment of dose based on DAC-hours, urinalysis, etc.); and 3) evaluation of and dose assessment for radiological incidents (distributed contamination, hot particles, loss of dosimetry, etc.).

Review licensee procedures for determining when external and internal dosimetry is required. 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.

For each sample, conduct a routine review of problem identification and resolution activities using Inspection Procedure (IP) 71152, "Problem Identification and Resolution." Per IP 71152, it is expected that routine reviews of PI&R activities should equate to approximately 10 to 15 percent of the resources estimated for the associated baseline cornerstone procedures, this is a general estimate only based on the overall effort expected to be expended in each strategic performance area. It is anticipated that the actual hours required to be expended may vary significantly from attachment to attachment, depending on the nature and complexity of the issues that arise at the particular facility. Overall, an effort should be made to remain within the 10 to 15 percent estimate on a strategic performance area basis. Inspection time spent assessing PI&R as part of the baseline procedure attachments should be charged to the corresponding baseline procedure.

## 71124.04-03 INSPECTION REQUIREMENTS

### 03.01 Source Term Characterization Sample

**Verify the licensee has adequately characterized the types and energies of radiation being monitored, to include the proper application of scaling factor techniques, when characterizing radioactive source terms.**

#### Specific Guidance

- a. The licensee should know the following components and spectra of their source term(s) for 1) gamma (photon), 2) beta, 3) average beta energy, 4) hard-to-detect (HTD) nuclides, 5) alpha/transuranic, and 6) neutron. Knowledge of the radiation types and energies being monitored are critical to the correct selection and use of dosimeters.

Additionally, the plant source term may have evolved over time from the various changes that licensees have made to their facilities and operations. 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 accounted for, including the proper characterization of the monitored radiation fields.

- b. Consider if scaling factors have been developed for use in scaling hard-to-detect radionuclide activity and alpha radionuclides in internal dose assessments. If applicable, 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.

### 03.02 External Dosimetry Sample

**Verify the licensee processes, stores and uses external dosimetry such that assigned occupational doses are representative of actual plant exposures.**

#### Specific Guidance

- a. Obtain the NVLAP certification documentation and determine if the dosimeters are processed by a NVLAP accredited processor and consider if 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.

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.

- b. Passive Dosimeters (e.g. thermoluminescent dosimeter (TLD), optically stimulated luminescence (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. Evaluate whether personnel dosimeters stored at the plant during the monitoring period are stored in a low dose rate area alongside control dosimeters.
  - 3. For issued dosimeters not stored on-site during the wear period, guidance should be provided to workers on acceptable storage conditions.
- c. Active Dosimeters (e.g. Electronic Alarming Dosimeters)
  - 1. Determine if and how bias has been determined to correct the response of the electronic alarming dosimeter (EAD) as compared to TLD/OSL and consider if the correction factor is based on sound technical principles.

A bias is normally established for EADs to adjust readings to account for a geometric bias 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). A conservative factor of about 5% is 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).

2. Consider if correlations between EADs and passive dosimeter measurements are being performed, and if substantial discrepancies are investigated

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 as described in 03.03.c.1 above. 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.

EADs used for underwater diving may be subject to different (lower) energy radiation due to scattering (water). This may also impact the passive dosimetry response.

d. Neutron Dose Assessment

1. As appropriate, evaluate the licensee's neutron dosimetry program, including dosimeter type(s) and/or survey instrumentation.
2. Situations to consider include independent spent fuel storage installation operations and at-power containment entries. Consider whether (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; (c) neutron dosimetry is properly corrected for the associated spectrum; (d) interference by gamma radiation has been accounted; and (e) time and motion evaluations are representative of actual neutron exposure events, as applicable.

03.03 Internal Dosimetry Sample

**Evaluate the adequacy of the licensee's internal dose assessments for actual internal exposures.**

Specific Guidance

- a. Consider whether the affected personnel were properly monitored with calibrated equipment and if data were analyzed and internal exposures properly assessed in accordance with licensee procedures.

b. In Vivo Bioassay

1. Review procedures for assessing internal dose that address methods for 1) determining if an individual is internally or externally contaminated; 2) whether the contamination was ingested or inhaled; 3) the release of contaminated individuals; and 4) assignment of dose. 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 the beta contamination monitor alarms.
2. Prompt whole body counts (WBCs), as well as follow-up WBCs can be used to determine if residual contamination levels follow the retention functions in NUREG/CR-4484 inhalation or ingestion models. Contamination removal from skin may occur by showering and skin layer sluffing.

If the licensee routinely uses whole body counting (WBC) to verify, or quantify, the intakes of radionuclides, consider if the frequency of such measurements is consistent with the biological half-life of the potential nuclides available for intake. Be especially mindful of instances following personnel entry into a high airborne radioactivity area, or following the use of respiratory protection equipment.

3. If the licensee uses a method other than whole body counting for screening intakes, consider if the minimum detectable activity (MDA) is adequate to determine the potential for internally deposited radionuclides sufficient to prompt additional investigation. 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 annual limit on intake (ALI), or 100 mrem committed effective dose equivalent (CEDE). This review should include any potential HTD contribution to CEDE as this will not be detected by passive monitoring.
4. Consider if whole body counts provide sufficient counting time/low background to ensure appropriate sensitivity for the potential radionuclides of interest; if the appropriate nuclide library was used; and if any anomalous count peaks/nuclides indicated in each output spectra received appropriate disposition. WBC systems and gamma spectroscopy systems commonly have different radionuclide libraries for different exposure conditions and/or analytical needs. Selectively review the radionuclide libraries and consider if the licensee has analytical capabilities for fission products, natural occurring radioactive materials, and failed fuel conditions.
5. If the licensee relies solely on whole body counting for assessing internal dose, consider if HTD nuclides are accounted for in the dose assessment and review the licensee's methodology for determining HTD scaling factors.

c. In Vitro Bioassay

1. For licensees with an in vitro bioassay program, determine if procedures used to assess dose from internally deposited radionuclides address collection and

storage of samples; whether the contamination was ingested or inhaled; evaluation of results (including HTDs); and assignment of dose.

The licensee's sample collection procedures should ensure the following:

- (1) 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,
  - (2) A sample of adequate size for each type of analysis requested, including adequate amounts to allow verification or additional analysis if needed,
  - (3) Containers that are free of external and internal contamination,
  - (4) 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
  - (5) Accurate and unambiguous identification of samples. In addition, the licensee should specify the required lower limits of detection (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. Labs should participate in an analysis cross-check program and out-of-tolerance results should be evaluated and resolved appropriately.
- d. Dose Assessments Based on Airborne Monitoring
1. Assess the adequacy of the licensee's program for dose assessments based on air sampling and derived air concentration (DAC)-hour monitoring.
  2. Consider if flow rates and/or collection times for fixed head air samplers or lapel breathing zone air samplers are adequate to ensure that appropriate LLDs are obtained.
  3. Review the adequacy of procedural guidance used to assess dose when, if using respiratory protection, the licensee applies protection factors.
  4. For dose assessments performed using air sampling and DAC-hr monitoring, consider if the licensee's DAC calculations are representative of the actual airborne radionuclide mixture, including HTD radionuclides, as appropriate.

#### 03.04 Special Dosimetric Situations Sample

**For the following special situations evaluate how the licensee monitors and assigns occupational doses: skin exposures, exposures to the lens of the eye, declared pregnant workers, application of effective dose equivalent for external exposure methodologies, and neutron exposures.**

## Specific Guidance

- a. For declared pregnant workers consider if the licensee informs the worker, as appropriate, of the risks of radiation exposure to the embryo/fetus; the regulatory aspects of voluntarily declaring a pregnancy; and the specific process for voluntarily declaring a pregnancy.
- b. Dosimeter Placement and Assessment of Effective Dose Equivalent for External Exposures (EDEX)
  1. Consider, evaluating the licensee's methodology for monitoring external dose in situations in which non-uniform fields are expected or large dose gradients will exist.
  2. Consider if the licensee has established criteria for determining when alternate monitoring techniques are to be implemented.
  3. When available, review annual dose records of workers that used EDEX monitoring and routine monitoring during the annual period, and verify accurate dose values were assigned per NRC Form 5 requirements.
- c. Shallow Dose Equivalent (SDE)

Consider if clear criteria were established for releasing personnel with imbedded radioactive particles.

Consider evaluating the licensee's methodologies for monitoring and/or calculating SDE. SDE is 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.

## 71124.04-03 REFERENCES

RG 8.7, "Instructions for Recording and Reporting Occupational Radiation Exposure Data"

RG 8.9, "Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program"

RG 8.13, "Instruction Concerning Prenatal Radiation Exposure"

RG 8.26, "Applications of Bioassay for Fission and Activation Products"

RG 8.36, "Radiation Dose to the Embryo/Fetus"

RG 8.32, "Criteria for Establishing a Tritium Bioassay Program"

RG 8.34, "Monitoring Criteria and Methods to Calculate Occupational Radiation Doses"

RG 8.40, "Methods for Measuring Effective Dose Equivalent from External Exposure"

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

NRC, "Revision of the Skin Dose Limit," *Federal Register*, Vol. 67, No. 66, April 5, 2002, pp. 16298-16304 (62 FR 16298).

NRC Information Notice 2014-05, "Verifying Appropriate Dosimetry Evaluation"

ANSI N13.30-1996, "Performance Criteria for Radiobioassay"

ANSI N13.52-1999 (Reaffirmed August, 2010), "Personnel Neutron Dosimeters (Neutron Energies Less Than 20 MeV)"

ANSI N13.11-2009, "Personnel Dosimetry Performance - Criteria for Testing"

ANSI N13.6-2010, "Practice for Occupational Radiation Exposure Records Systems"

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

Commitment Tracking Number	Accession Number Issue Date Change Notice	Description of Change	Description of Training Required and Completion Date	Comment Resolution and Closed Feedback Accession Number (Pre-Decisional, Non-Public Information)
N/A	ML17286A288 12/21/17 CN 17-031	<p>Major editorial revision of IP 71124.04.</p> <p>Section 02 was audited and modified to move guidance to Section 03 and concisely state actions necessary to complete each requirement</p> <p>PI&amp;R was transitioned from an independent sample to a requirement that would be completed as part of each sample. Guidance section updated to reflect resource estimates for routine review of PI&amp;R activities per IP 71152 Section 04.01.</p>	Verbal discussion of changes during 2017 HP Counterpart meeting, 09/06/2017	ML17300A473
N/A	ML19253D047 12/23/19 CN 19-042	Major editorial revisions of IP 71124.04 to conform with IMC 0040 formatting guidance.	Verbal discussion of changes during 2019 HP Counterpart Meeting. 09/04/2019	ML19253D075