



Radiation Protection

A Refresher for Auditors

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Quick Review of Radiation Safety to Maintain Exposure As Low As Reasonably Achievable (ALARA)

- Radiation is energy given off by matter that travels in the form of waves, rays, or other particles.
- Ionizing Radiation: Alpha, Beta (Through conversion of an atom, molecule, or substance into an ion or ions typically by removing one or more electrons breaking chemical bonds of the atom).
- Indirect Ionizing Radiation: X and Gamma Rays (Through interaction with an electron resulting in its release from an atom resulting in ionization).
- Neutrons (Through transfer of energy from the neutron interaction with a proton removing the proton from the hydrogen atom resulting in ionization through the movement of the proton and its interaction with electrons).
- Non-Ionizing Radiation: Radio Waves, Microwaves, Visible Light (Not enough energy to create permanent damage beyond heating of the molecule).



Quick Review of Radiation Safety to Maintain Exposure ALARA

Radiation Areas:

- Minimize time around a source of radiation
- Maximize distance from the source of radiation
- Use shielding when in a radiation area

Conform to the Site Requirements for Wearing Dosimetry to Track Your Dose.

Contamination Areas:

- When entering/exiting a contamination area, don and doff personal protective equipment (PPE) appropriately to prevent contamination to the body and prevent the spread of contamination.
- Perform hand and foot/whole body frisk using a current calibrated and source checked instrument as required by the site.



Quick Review of Radiation Safety to Maintain Exposure ALARA

- Review and ensure that you understand the information provided on the Radiation Work Permit (RWP) prior to signing and ensure it is current.
- If you have questions about the RWP, ask the Radiological Control Technician (RCT) for clarification.
- The RWP will provide PPE requirements, dose rate in the area to be visited, contamination type and contamination levels in the area to be visited, dosimetry requirements, limitations for your access to the area, as well as other relevant information.
- Pay attention to barriers and obey postings in the area. If you have questions, ask the RCT or Escort.
- Be cognizant of labeling on containers and what the information on the labels convey.



Quick Review of Radiation Safety to Maintain Exposure ALARA

Controlled Area is an area where procedural controls are required to restrict radiation exposure.

To keep exposures ALARA, a radiological site has access restrictions and written documentation to follow. There are warning signs, shielding, warning lights and interlocking doors where applicable.

Compliance in the following functional areas is synonymous with good Radiation Protection and maintaining exposure ALARA.



Auditor's Review of Radiation Protection Functional Areas

Functional Area: Radiation Protection Program

- Review site's radiological inspections over the past year, including self assessments and those by the Radioactive Material License (RML) issuing authority.
- Confirm that the site's written Radiation Protection Program (RPP) reflects their current licensed activities.
- Confirm that workers are provided with notifications and reports pertaining to their occupational exposures.



Auditor's Review of Radiation Protection Functional Areas

Functional Area: Control of Radioactive Material

- Confirm through interviews and site documentation that the radioactive waste on site is within the limits of the RML.
- Confirm that a good contamination control program is in place by observing engineered as well as administrative controls at the site.
- Confirm that radiological contamination surveys are performed throughout the site where applicable to verify the effectiveness of the contamination control program.



Auditor's Review of Radiation Protection Functional Areas

Functional Area: Radiation Protection Training

Confirm that the training program incorporates the basics of radiation safety and site-specific facts including:

- Doffing and donning of Personal Protective Equipment (PPE)
- Understanding radiological survey data
- Postings and labeling
- Radiation Work Permits
- Alarm acknowledgement
- Entering and exiting radiological areas
- Frisking requirements
- Use of Radiological Procedures
- Emergency Response
- Radiation Worker responsibilities



Auditor's Review of Radiation Protection Functional Areas

Functional Area: Respiratory Protection/Airborne Sampling

- Review evidence of monitoring for airborne radioactivity in work area.
- Review evidence of performing perimeter environmental air sampling.
- Confirm use of Respiratory Protection, fit testing and applied protection factors.



Auditor's Review of Radiation Protection Functional Areas

Functional Area: Radiation Detection Instrument Usage

- Review instrument calibration records.
- Review frequency of calibrations.
- Observe records for instrument response checks.
- Observe use of detector for correct distance from surface and survey speed.
- Ensure instruments are being used appropriately for contamination type.
- Ensure instruments are used properly for dose rate surveys.



Auditor's Review of Radiation Protection Functional Areas

Functional Area: Posting/Labeling/Entry/Exit Control

- Observe radiological labels to ensure they are durable, legible and identify the hazard.
- Observe radiological postings to ensure all are properly marked, placed, and legible.
- Contamination Area: \geq removable contamination limit.
- High Contamination Area \geq 100 times removable contamination limit.
- Radiation Area > 5 millirem/hr. @ 30 cm.
- High Radiation Area > 100 millirem/hr. @ 30 cm.
- Very High Radiation Area > 500 Rad/hr. at 1 meter.
- Airborne Radioactivity Area = Area exceeding the DAC or \geq 12 DAC hrs.
- Ensure radiological boundaries are properly established.



Auditor's Review of Radiation Protection Functional Areas

Functional Area: Radiological Work Planning and Controls (WP&C)

- Review procedures and supporting documentation for WP&C.
- Verify dose to work force is maintained per regulatory/administrative limits.
- Verify dose to individual members of the public do not exceed 100 mrem/year.
- Verify use of administrative and engineered controls
 - Proper use of PPE
 - Containment
 - Decontamination
 - Ventilation
 - RWPs.



Auditor's Review of Radiation Protection Functional Areas

Functional Area: Radiological Surveys

- Procedure for performing surveys.
- Selection of appropriate instrument/detector for survey.
- Speed of survey (2 to 3 inches per second and close to surface of item being surveyed with care not to contaminate detector).
- Smear surveys over 100 cm² area (for determining removable contamination).
- Use of appropriate system to analyze smear (gas flow, scintillation, etc.).
- Use of Large Area Wipes.
- Documentation of surveys (Instrument Efficiency, Correction Factors, etc.).



Auditor's Review of Radiation Protection Functional Areas

Functional Area: External/Internal Dosimetry

- Dosimetry procedures
- External dose monitoring (Thermoluminescent Dosimeters (TLD)s, Electronic Personnel Dosimeters (EPD), Pencil Dosimeters, etc.)
- Dosimeter processing (National Voluntary Laboratory Accreditation Program (NVLAP), etc.)
- Internal dose monitoring (Bioassay, whole body monitoring, etc.)



Auditor's Review of Radiation Protection Functional Areas

Functional Area: Radiological Incidence Response

- Early (Emergency) Phase
- Intermediate (Control) Phase
- Late (Recovery) Phase
- Protective Actions (Primarily Evacuation and Sheltering)
- Dose limits for emergency workers (25 rem whole body for life saving)
- Emergency Response procedures
- Drills, Alarms and training in protocols for response



Auditor's Review of Radiation Protection Functional Areas

Functional Area: Requirements vs. Procedures

Radiological Protection Documents/Procedures should cover:

- Radiological Protection Program
- ALARA Program
- Instrument use
- Instrument Calibration
- Radiological Surveys
- Posting Requirements
- Radiological Control Access
- Air Sampling
- Radiological Monitoring
- Personal External Radiation Monitoring
- Internal/External Dosimetry
- Radiation Work Permits



Auditor's Review of Radiation Protection Functional Areas

Functional Area: Records

Records maintained for 3 years after generation of record or employee termination as applicable:

- Calibration Records
- Survey Records
- Source Leak Test Records
- Waste Disposal Records
- Maintenance Records
- Training Records

Records maintained until after facility termination:

- Operating and Emergency Procedures
- Dosimetry records

Records of audits are maintained and retained for 3 years



Auditor's Review of Radiation Protection Functional Areas

Functional Area: ALARA

- ALARA audits conducted.
- Radiation Protection Program demonstrating a good radiation protection culture through meeting the functional area requirements.



Findings and Observations Past 6 Years DOECAP Audits

Findings:

- In 2017, 1 facility had 1 finding.
- In 2019, 1 facility had 4 findings.

No findings have been documented since 2019.

Observations:

- In 2017, 1 facility had 2 observations.
- In 2019, 1 facility had 3 observations and 3 other facilities each had 1 observation.
- In 2020, there were 3 observations.
- In 2021, 1 facility had 2 observations and 2 other facilities each had 1 observation.

No observations have been documented in 2022.

Total Findings over 6 years: 5 Total Observations over 6 years: 18

Total findings since 2019: 0 Total Observations in 2022: 0



Findings and Observations

Why So Few Findings In Radiation Protection?

- [10 CFR 20.1101](#) regulations require annual radiation safety program audits be conducted to review the licensee's radiation safety program.
- Performance-based reviews are routinely performed at the sites.
- Self audits are performed routinely.
- The nuclear industry is highly regulated and assessed multiple times per year by the agreement state and/or NRC as applicable, EPA, OSHA, as well and through in-house Management Assessments and Quality Assurance Assessments.
- Radiological/Nuclear facilities are among the most highly regulated facilities with continuous oversight covering regulatory requirements for all functional areas, safety systems, and the environment.
- Findings are tracked and corrected.
- Continuous oversight and strict regulatory requirements result in reduced number of findings and observations.



Additional Radiation Safety Information



Radiation Safety Extras

Background Radiation:

- Background Radiation varies, but typical levels per year are in the range of the following:
- Air ~ 228 millirem (Inhalation of air with radon daughters).
- Food and water ~ Potassium 40/Carbon 14 ~ 28 millirem.
- Soil ~ 21 millirem (varies based on amount of natural U-238 in soil).
- Cosmic radiation ~ 33 millirem (varies with altitude).
- Medical X-rays ~ 300 millirem (varies with number of X-rays performed).
- Building materials, air travel, cigarettes ~ 13 millirem.

TOTAL Average of ~ 623 millirem per year background exposure.



Radiation Safety Extras

Dose Limits:

RADIATION WORKER

- Whole body dose 5000 millirem/yr.
- Extremity dose 50,000 millirem/yr.
- Skin dose 50,000 millirem/yr.
- Internal Organ (committed to organ) 50,000 millirem/yr.
- Lens of the eye 15,000 millirem/yr.
- Embryo/Fetus of worker 500 millirem total

PUBLIC DOSE LIMIT

100 millirem/yr.



Radiation Safety Extras

Effects From Various Radiation Exposures

- Exposure to low levels of radiation does not cause immediate health effects however as exposure levels increase so do cancer risks over one's lifetime. The lower the dose, the lower the risk of cancer in a lifetime.
- Stochastic Effects ((chronic) long term low dose exposure). At low radiation doses (10,000 millirem/year or less), the risk of cancer is so small that it cannot be distinguished from risk due to exposure from chemicals, genetics, smoking or diet.
- There is approximately a 4% increase in cancer risk for every 100,000 millirem of chronic dose received or 0.00004% increase for every 1,000 millirem chronic exposure.
- Due to the rapid rate of cell division in a developing fetus, radiation exposure is limited to 500 millirem.



Radiation Safety Extras

Deterministic Effects ((Acute) short term high dose exposure to whole body)

- 50,000 millirem received in minutes - short term blood cell decrease.
- 50,000 to 100,000 millirem – some observable health effects, blood system quickly recovers.
- 100,000 millirem to 200,000 millirem – nausea and fatigue.
- 200,000 millirem to 300,000 millirem – nausea and vomiting within 24 to 48 hours. Medical attention needed.
- 300,000 millirem to 500,000 millirem – nausea, vomiting, diarrhea within hours. Loss of hair and appetite within one week. Medical attention needed to survive. 50% of people who receive such a dose will die without medical attention.
- 500,000 millirem to 1,200,000 millirem – death within a few days.
- >10,000,000 millirem - death within a few hours.



Radiation Safety Extras

Effects of Acute high dose to focused areas of the body:

- 25,000 millirem, temporary sterility in men.
- 40,000 millirem to the eyes can cause cataracts.
- 100,000 millirem to 500,000 millirem localized to an area with hair can cause hair loss.
- 200,000 millirem or more to a local area of the skin can cause skin reddening.
- 400,000 millirem, permanent sterility in men.
- 1,000,000 millirem or more to the abdomen can cause a breakdown of the intestinal lining leading to internal bleeding and possible death.
- 1,400,000 millirem locally to ovaries, sterilization.
- 1,500,000 millirem or more locally to the skin can cause reddening and blistering.