Guide for Demonstrating that Members of the Public will not Receive Doses Exceeding Allowable Limits

This generic guide provides a basic understanding of the requirements for determining doses to the general public. Consult with your regulatory agency for specific requirements of your license.

I. Introduction

Your license requires that:

- Radiation doses in unrestricted areas not exceed **2mrem (0.02mSv) in any one hour**
- Doses to members of the public not exceed **100mrem (1mSv) in a year**

Your license requires surveys, calculations and/or environmental monitoring to be used to demonstrate compliance with the dose limits. A member of the public (MOP) dose compliance study provides documentation of compliance with both regulatory limits. This procedure describes methodologies for use by portable gauging device license applicants and license holders conducting MOP studies.

II. Dose Limit for Unrestricted Areas

For portable gauging device operations, there are three situations that must be addressed in order to demonstrate compliance with the 2mrem in any one hour dose limit for unrestricted areas:

- Storage of portable gauging devices in transport vehicles;
- Use and storage of portable gauging devices at temporary job sites; and
- Storage of portable gauging devices at the permanent facility.

Section A demonstrates compliance with the unrestricted area dose limit for shipment of portable gauging devices to and from temporary job sites and their use and storage at job sites.

Section B's Method 1 describes the procedure followed when a survey meter is available to conduct radiation measurements. Compliance with the unrestricted area dose limit can also be demonstrated without direct measurements. Section B's Method 2 describes the procedure followed when a survey meter is unavailable. The selected box indicates the method used.

A. Transport Vehicles and Temporary Job Sites

Security procedures, approved by the regulatory agency and incorporated into the license, describe the measures taken by operators to restrict public access to portable gauging devices while in transport vehicles or at temporary job sites. During transport and storage at temporary job sites the procedures require a minimum of two independent physical controls, which comprise of tangible barriers, that must be used to prevent public access to the device. While in use, the portable gauging device must always be under the direct supervision of the operator to prevent unauthorized access. Adherence to these procedures ensures compliance with the 2mrem in any one hour public dose limit.

B. Permanent Facility

Method 1. Physical Surveys

Your license requires prevention of unauthorized public access to gauges at the permanent facility. Portable gauging devices are stored in an approved storage area and are kept locked in their transport cases and secured using a minimum of two independent physical controls, comprising of tangible barriers. All portable gauging devices will be appropriately secured from public access, unless they are kept under the physical control and personal supervision of an operator.

A radiation detection instrument is used to measure ambient radiation levels in the unrestricted areas around the permanent storage area while all inventoried portable gauging devices were in storage. This survey evaluates the "worst case scenario" – where radiation emitted by the portable gauging devices are at their highest levels. Survey results revealing dose rates below 2mrem per hour demonstrate compliance.

The following information should be attached:

- Date of the survey and the name of the individual(s) performing the measurements
- Information about the instrument used to perform the survey (manufacturer and model number, the types of radiation detected by the instrument, its minimum and maximum range, and the date it was last calibrated)
- Diagram of the permanent facility identifying the restricted area, adjacent unrestricted areas, nearby MOP workstations, and the locations where all recorded measurements are taken
- Information about the type and number of portable gauging devices present during the survey and a description of their placement within the storage area (e.g., contained in transport cases, stacked against back wall, etc.)
- Results of survey(s) of unrestricted area radiation levels, with results keyed to facility diagram

Note: If surveys note radiation levels > 2mrem/hr, attach a description of controls in place to further restrict access to the storage area (e.g., establishment of expanded restricted area around the storage area, using barricades and/or posted notices).

Method 2. Calculations

Radiation levels in unrestricted areas can be calculated using information provided by portable gauging device manufacturers. Prior to shipment, the manufacturer lists the Transport Index (TI) number on the RADIOACTIVE YELLOW II label on the transport case's exterior surface. The TI indicates the radiation levels at 1 meter (3.3 feet) from the case per hour when it contains a portable gauging device. The TI value was used as the basis for the calculations. If the TI is less than 2, then radiation levels in all directions around the portable gauging device when it is stored in its transport case are 2mrem per hour (or less) at 1 meter, so that is the boundary of the restricted area. Additional distance and shielding provided by the storage area lowers the dose rate even further. Storing the portable gauging device in its case and then in a cabinet, locker, room, etc. prevents unauthorized access to within a meter or more, so no MOP can receive 2mrem in any one hour.

B. Permanent Facility Method 2: Calculations

When calculating for two or more stored portable gauging devices, each case's TI is added together. Although this method is overly conservative it should not cause the 2mrem limit to be exceeded.

The following information is attached:

- Diagram of the permanent facility identifying the restricted area, adjacent unrestricted areas, and distance to MOP workstations
- Information about the type and number of portable gauging devices present and a description of their placement within the storage area (e.g., contained in transport cases, stacked by wall)
- Copies of manufacturer-provided documentation providing information on portable gauging device dose rates and/or TI numbers for the portable gauging devices being evaluated
- Results of calculations demonstrating estimated radiation levels in unrestricted areas, with results keyed to the facility diagram

Note: If calculations note radiation levels > 2mrem/hr, attach a description of controls in place to further restrict access to the storage area (e.g., establishment of expanded restricted area around the storage area, using barricades and/or posted notices).

III. Annual Public Dose Limit

"Total effective dose equivalent" (TEDE) describes the dose from summation of internal and external radiation doses. However, there is little possibility of internal exposures during routine operations so internal doses can be ignored for portable gauging device MOP studies. Thus, for portable gauging device licensees demonstrating compliance with the 100mrem annual MOP dose limit, the individual's external dose ("deep dose equivalent" or DDE) is equal to the total dose (TEDE).

Licensees must demonstrate compliance with the annual dose limit with measurements or calculations showing that the MOP likely to receive the highest dose from the licensed operations does not exceed the 100mrem limit. Different methods of using this regulatory approach are described below. The selected box indicates the method used in this study.

Method 1. Radiation Level Data

Survey measurements and calculations can be used to demonstrate that the radiation levels resulting from licensed operations are not likely to cause any MOP to exceed the annual public dose limit.

Radiation levels generated by gauges present in the workplace can be determined by direct measurement with survey instruments, or from indirect information, such as radioactive material package transport index values (describing radiation levels at 1 meter from a package's exterior surface). The radiation level data can then be used with the inverse square law to calculate the DDE.

Method 1: Radiation Level Data (Continued)

Use either radiation survey instrument measurements or Transport Index (TI) values with the inverse square law to calculate the DDE.

Occupancy factors are addressed by selecting one of two options.

The first and most conservative scenario assumes a MOP is continuously present in the unrestricted area (24 hours/day, 365.25 days/year = 8766 hours).

The second is more realistic (but still very conservative) assumes the individual located in the unrestricted area is present during all business hours (8 hours/day x 40 hours/week x 50 weeks/year = 2,000 hours).

Inverse Square Law: $I_2 = \frac{I_1 R_1^2}{R_2^2}$

Where: I_1 = intensity (radiation dose rate) at distance R_1
I_2 = intensity (radiation dose rate) at distance R_2.
R_1 = distance from RAM with dose rate I_1
R_2 = distance from RAM where dose rate I_2 is calculated

Notes: A. This formula has two limitations:

(a) it only applies to gamma-emitters

(b) the closest distance should be at least five source diameters.

B. If using transport package exterior radiation levels, set R_1 = 1 inch.

Example of an Inverse Square Law Calculation Using Survey Meter Measurements

Assume a lab contains a variety of sealed sources. The sources may be treated as a single point source by positioning them together for the measurement. Assuming a collective source diameter of 12 inches, a radiation measurement (I_1) is taken at a distance equal to at least five source diameters from the grouped sources, which serves as R_1 in the inverse square formula. The intensity at 10 feet is the unknown value being sought (the distance to the nearest unrestricted area).

I_1 = 0.1mrem/hr
I_2 = ?mrem/hr
R_1 = 60 in. (5 x 12 in.)
R_2 = 120 in. (10 ft.)

$I_2 = \frac{0.1 \times (60)^2}{(120)^2}$

I_2 = .025mrem/hr

A 2,000 hour occupancy factor yields:
.025 mrem/hr x 2,000 hours
= 50mrem = DDE

Example of an Inverse Square Law Calculation Using a Package Transport Index

A shipping case used to store a portable nuclear density gauge bears a Radioactive Yellow II label that shows its TI = 0.6. The nearest MOP workstation is located 24 feet away.

I_1 = 0.6 mR/hr
I_2 = ? mrem/hr
R_1 = 3.3 ft. (1 meter)
R_2 = 24 ft.

$I_2 = \frac{0.6 \times (3.3)^2}{(24)^2}$

I_2 = .011 mrem/hr

A 2,000 hour occupancy factor yields:
.011 mrem/hr x 2,000 hours
= 22mrem = DDE

Method 2. Using Dosimetry Data to Determine Maximally Exposed Individual MOP

If annual occupational doses for workers exceed 100millirem, the MOP that is likely to receive the highest dose from the licensed operations may be used to demonstrate compliance with the annual public dose limit. The "maximally exposed individual MOP" may be a person that does not operate portable gauging devices but works at the same site where they are used or stored. It could also be an employee working in a management, clerical, or maintenance position at the permanent facility, or an employee or a regular customer that has routine contact with the operators when they are working.

Justification for how the maximally exposed individual was identified must be documented; i.e., why the person is likely to receive the highest radiation dose compared to other members of the public. Next, assign the individual a personnel monitoring device (film badge, TLD or OSLD). Provide instructions on when (during working hours) and where (on the torso, waist or chest level) the badge must be worn, and on proper use (protect badge from excessive heat, light, moisture or chemicals, store with control badge in low background area when not being worn). In general, at least one year of monitoring should be conducted to provide adequate measurement data and to account for seasonal fluctuations in workloads. If the dosimetry reports show that the monitored person received < 100millirem for the year, compliance with the annual public dose limit has been demonstrated, because if the MOP likely to receive the highest dose from the licensed operations is receiving < 100millirem, then so are all other members of the public. It is not necessary to wait for a full year of dosimetry records to begin drawing conclusions from the collected data. As dosimetry reports arrive, the recorded dose can be extrapolated to gain an estimate of the annual exposure, which can serve as a MOP study "in-progress" until the year of monitoring is completed. The study can then be updated to reflect the results of a full year of monitoring.

If this method is employed attach the following:

- Description of the maximally exposed individual MOP (name, title) and justification for why the individual was selected
- Facility diagram identifying all restricted areas, adjacent unrestricted areas, and where the monitored MOP's workstation is located
- Copies of the dosimetry reports used in the study. Prior to submitting the reports, be sure to delete all personal information (e.g., social security numbers, last names, birth dates).

Method 3. Environmental Monitoring Data

If the maximally exposed individual MOP is a worker at the permanent facility, a third approach is available. A film badge/TLD/OSLD can be mounted at the person's work station to record radiation levels, which can then be related to the dose received by the person working in the area. If environmental monitoring demonstrates that the annual workplace continuous exposure to the ambient radiation levels results in a total dose less than 100mrem, then it can be concluded that no MOP would be likely to exceed the annual

public dose limit from the licensed operations. If environmental monitoring indicates that continuous occupancy would result in exposures that would exceed the public dose limit, then the use of realistic occupancy factors might be used to demonstrate compliance. The maximally exposed individual MOP's annual occupancy time can be determined by review of the person's time cards, interviews of the person and his/her co-workers, etc. Note: An environmental badge is not the same type of badge used for personnel monitoring, so it is important to specify to the dosimetry supplier what type of monitoring is planned when ordering badges. In addition, posted badges must be protected from adverse environmental conditions such as excessive heat, light and moisture.

One or more badges should be posted in the unrestricted areas adjacent to restricted areas (or in the restricted area on a wall adjacent to unrestricted areas) for at least 12 months. Badges should be posted where the highest radiation exposure is expected and where exposure to non-regulated sources of radiation (e.g., medical patients injected with radionuclides) will not contribute to the measurements. If the results for the monitoring period total < 100mrem, use continuous occupancy for the dose determination. If the results for the monitoring period exceed 100mrem, it may be possible to demonstrate compliance with the annual dose limit by applying a more realistic (but still very conservative) occupancy factor, such as 2,000 hours for a work year.

Example: The total dose measured by the environmental badge = 280mrem; the dose received by a MOP working 2,000 hours in the area that the badge was posted is:

280mrem/8,766 hrs = .032mrem/hr x 2,000 hrs = 64mrem

Using a 2,000 hour occupancy factor means that any annual dose from environmental monitoring that totals < 438mrem will demonstrate compliance

Example: 438mrem/8,766 hrs = .049mrem/hr x 2,000 hrs = 99.9mrem

If the results for the 12 month monitoring period total > 438mrem, compliance may still be demonstrated by using an even more realistic occupancy factor, provided the number can be legitimized by supporting documentation (e.g., employment records).

Example: Environmental badges total 680mrem for the 12 month monitoring period; time sheets indicate that a conservative estimate of the most time spent by any MOP in the monitored area is 25 hours a week, 50 weeks a year = 1,250 hours.

680mrem/8,766 hrs = .078mrem/hr x 1,250 hrs = 97mrem

Attach an annotated diagram of the facility identifying restricted areas, adjacent unrestricted areas, and the location of posted badges.

Method 4. Occupational Worker Dosimetry Data

If measurements show that all of a licensee's portable gauging device operators receive less than 100mrem annually, then by extrapolation, no MOP receives 100mrem annually, because operators receive higher exposures from portable gauging devices than any MOPs.