

**NC DEPARTMENT OF ENVIRONMENT & NATURAL RESOURCES  
NORTH CAROLINA RADIATION PROTECTION**

**APPROPRIATE PERSONNEL MONITORING**

I. Introduction

Personnel monitoring is the use of a device that is sensitive to radiation and produces a quantifiable response to determine an approximate dose received by the individual wearing or carrying the device. Common examples are film badges, thermoluminescent dosimeters, and pocket ion chambers. Personnel monitoring is necessary for estimating the dose received by an individual. An estimation of dose provides a means of complying with the North Carolina Regulations For Protection Against Radiation (NCRFPAR) Section .1600, and a means of following the principle of keeping radiation exposure as low as reasonably achievable (ALARA).

The purpose of this document is to provide guidance as to what the Agency considers appropriate personnel monitoring for determining dose from external sources of radiation.

The terms "dose" and "exposure" are often used interchangeably to describe radiation energy which is imparted to matter. "Exposure," however, is defined only for photons; "dose" (or absorbed dose) describes the energy imparted to matter by ionizing radiation for unit mass of material. In most cases, "dose" is the proper term for this discussion.

II. Applicability

A. Applicable Rules

NCRFPAR requires registrants to monitor exposures to radiation at levels sufficient to demonstrate compliance with the occupational dose limits of Section .1600. As a minimum as stated in Rule .1614:

- (1) Each registrant shall monitor occupational exposure to radiation and shall supply and require the use of individual monitoring devices by:
  - (a) adults likely to receive, in one year from sources external to the body, a dose in excess of 10 percent of the limits in Rule .1604(a).
  - (b) minors and declared pregnant women likely to receive, in one year from sources external to the body, a dose in excess of 10 percent of any of the applicable limits in Rules .1609 or .1610, and
  - (c) individuals entering a high or very high radiation area.

Rule .1604 specifies the limits which apply for occupational dose as follows:

- (a) The registrant shall control the occupational dose to individual adults, except for planned special exposures as provided in Rule .1608, to the following dose limits:
  - (1) an annual limit, which is the more limiting of:
    - (A) the total effective dose equivalent being equal to five rems (0.05 Sv); or
    - (B) the sum of the deep-dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 50 rems (0.5 Sv); and
  - (2) the annual limits to the lens of the eye, to the skin, and to the extremities which are:
    - (A) an eye dose equivalent of 15 rem (0.15 Sv), and
    - (B) a shallow-dose equivalent of 50 rems (0.50 Sv) to the skin or to each of the extremities.

NCRFPAR requires that the monitoring equipment be accredited by the National Voluntary Laboratory Accreditation Program for Personnel Dosimetry.

Interpretation of some specific circumstances which are not clearly defined in the rules follows. Unusual problems may best be addressed by direct inquiry or application to the Agency.

#### B. Who Should Be Monitored

1. Appropriate personnel monitoring equipment shall be used by each individual who enters a high radiation area or a very high radiation area and each individual who uses or operates any source of radiation and is likely to exceed the levels specified in Rule .1614. These persons must be monitored and their occupational doses kept within the limits of the NCRFPAR Section .1604. Radiation received as a patient from healing arts procedures is not included in these limits.
2. The standard applies to all individuals exposed to radiation. Licensed practitioners of the healing arts and veterinary medicine are also required to be monitored if they are exposed to radiation at levels that exceed the amounts specified in Rule .1614 and Rule .1604. No exemption can be granted solely on the basis of licensure to practice medicine. Therefore, a self-employed practitioner who is the only user or operator of radiation machines is required to be monitored if their exposures are likely to exceed the specified limits.
3. Persons performing any activity in which an individual may receive a radiation dose of 500 millirem in one year shall be monitored. [Section .1604] Special

cases exist for operating room and emergency room staff, floor nurses and other personnel who infrequently enter a restricted area. These nurses or other staff need not be monitored if the radiation safety officer (RSO) has instituted adequate training and controls ensuring that these workers cannot exceed 500 millirem in one year. The controls may include establishing a portion of a room as the radiation area and performing periodic room surveys to estimate dose rates and total doses.

4. Each registrant shall conduct operations so that members of the public do not exceed the total effective radiation dose of 100 millirem per year.
5. It is the responsibility of each registrant to keep the total occupational doses of individuals as low as reasonably achievable or below the limits specified in NCRFPAR Section .1604. Where an individual is working at more than one facility, the transfer of information from dosimetry records among those facilities in which the individual is working is necessary. The summation of doses from all facilities in which an individual works cannot exceed the applicable limits. Any violation may result in a citation to all facilities. [Rule .1604 (f)]
6. Radiation monitoring shall be provided to radiation workers in a veterinary medicine facility, as required in NCRFPAR Section .1614 and the operational control provisions for veterinary x-ray systems in Section .0603, and .0610.

Pregnant women and members of the general public, especially minors and fertile women are discouraged from holding animals during radiography procedures.

When an animal must be held in position during radiography, mechanical supporting or restraining devices shall be used; except if the animal must be held by an individual, that individual shall be protected with appropriate shielding devices, such as protective gloves and apron, and shall be so positioned that no part of the individual's body will be struck by the useful beam. The exposure of any professional staff or ancillary personnel used for this purpose shall be monitored and permanently recorded. Exposures shall comply with Rules .1604 and .1609. [Rule .0610(c)(3)]

For individuals not occupationally exposed, monitoring may be accomplished with properly calibrated pocket dosimeters with an appropriate range (0-200 mR) and energy response.

7. Any occupational dose to minors should be carefully evaluated. The applicable limit for minors is 500 millirem annually for whole body.

### III. Types of Monitoring

#### A. External Exposure

Monitoring devices used to measure external dose give the integrated dose in a time period, not the dose rate. The dosimeters will register radiation exposure from the time they are dispensed until they are read. Therefore, a control dosimeter is often used to estimate and subtract exposure from background or handling. The control badge must be stored in a radiation free area, away from radiation sources.

Monitoring devices should be convenient and comfortable for wearing on the person. Effects from leakage or fading must be minimal for the period from exposure to processing (or reading). They must also have minimal sensitivity to environmental factors such as light, heat, dust, and humidity.

The most widely used devices are film badges and thermoluminescent dosimeters (TLDs). The registrant must confirm that the dosimetry supplier is accredited by the NVLAP (National Voluntary Laboratory Accreditation Program) of the National Institute for Standards and Technology in the appropriate category. [Rule .1613 (c)]

1. Film Badges

Film badges are acceptable for x-, gamma, beta, and neutron radiation and provide the advantage of a permanent record of exposure (i.e., the film) that can be re-evaluated by the dosimetry service should questions arise. In order to measure and differentiate the energy levels, special films and filters are selected for the badge. The maximum acceptable exchange interval for film badges is one month, as fading or fogging of film may become significant after this time.

2. TLDs

TLDs are also acceptable and used extensively for x-, gamma, beta, and neutron dosimetry. TLDs offer a greater linear range than film and are generally less sensitive to environmental effects. They may be used for intervals up to three months.

3. Pocket Ion Chambers

A less frequently used device is the pocket ion chamber, which is a pencil-sized chamber containing an electrometer. These devices may be used as backup monitors or for special circumstances, but are not acceptable to determine routine occupational exposures pursuant to rule .1604 and NVLAP accreditation is not available for them.

B. Placement and Wearing of Personnel Monitoring Devices

1. Personnel monitoring devices must be worn in a manner which can best measure the radiation field to which the individual is exposed. Generally the chest or trunk exposure typified the whole body, and badges can be placed at

the neck or collar or at the waist. However, if beam geometries are such that exposure or scatter will preferentially expose the back or side, the monitoring badge should be placed accordingly.

2. When only a portion of the body is exposed, extremity monitors are warranted where hand and forearm dose may be the controlling limit. Extremity monitoring shall be provided whenever an adult is likely to exceed a shallow-dose equivalent of 50 rems to the skin or to each of the extremities as specified in the rule .1604. The monitoring device shall be worn on the dominant hand. Some specific cases where extremity monitoring are required as follows:

Rule .0806(b): Personnel monitoring or wrist dosimetric devices shall be provided to, and shall be used by:

- a. for analytical x-ray equipment workers using systems having an open beam configuration and not equipped with a safety device; and
  - b. for personnel maintaining analytical x-ray equipment if the maintenance procedures require the presence of a primary x-ray beam when any local component in the analytical system is disassembled or removed.
3. A monitoring device should only be worn during occupationally-related activities. Badges should not be worn during exposure to medical procedures as a patient or in recreational activities with possible natural radiation exposure (e.g., flying or exposure to elevated natural background). The badges should be stored carefully in a radiation free area when not in use. They must not be placed where environmental extremes could alter their reliability, i.e., closed automobiles, and they should not be washed or dry cleaned. Marking or writing on the film packets should be avoided because they are pressure sensitive. A name plate or covering placed over the open window will distort data.
  4. Control badges should be stored in a moderate environment and away from radiation fields, preferably the same storage location for all badges. The control badges must be returned with the personnel badges in order to utilize them most accurately.
  5. Area badges or monitors are devices placed in a work area or station to monitor ambient radiation levels. Data from these can be used to evaluate shielding, scatter, exposure outside the controlled area, or levels within the work area. This is valuable information to the implementation or modification of safety procedures.
  6. Each monitored individual must have an assigned monitoring device(s). They may not be interchanged among personnel or used as area monitors during any

one period. Each badge must be returned for processing at the appropriate time interval.

7. When a protective apron is worn, an individual shall wear the badge at the collar outside the apron to estimate head and eye exposures. An additional badge may also be worn under the apron to estimate whole body exposures.

C. Declared pregnant women and dose to an embryo/fetus

The registrant shall ensure that the dose to an embryo/fetus during the entire pregnancy, due to occupational exposure of a declared pregnant woman, does not exceed 50 millirem. Recordkeeping requirements for doses to an embryo/fetus are provided in Rule .1640. Badges may be processed on a weekly or twice per month schedule if exposure varies. Internal exposure should only be permitted with medical guidance, careful monitoring, and informed consent.

IV. Reporting and Recordkeeping

Reports from personnel monitoring processors should be made in a timely manner to registrants to ensure that monitoring results are available for consideration of dose limits.

Each registrant shall maintain records of doses received by all individuals for whom monitoring was required pursuant to Rule .1604.

The registrant shall make entries of the records specified in Rule .1640(b) at least annually.

The registrant shall maintain the records on the agency form for recording occupational radiation doses, in accordance with the instructions provided with the form, or in clear and legible records containing all the information required by the agency form for recording occupational radiation doses.

The registrant shall maintain records sufficient to demonstrate compliance with the dose limit for individual members of the public required by Rule .1611. These records may include such things as survey results, monitoring results, calculations and other documents pertaining to the determination of doses to individual members of the public.

Records of exposure history shall be maintained and made available for inspection by the Agency. Records must be preserved and retained until the Agency authorizes disposition or transfer to the Agency upon a request to terminate the certificate of registration. [Rule .1640(g)]

For industrial radiography, pocket ion chambers or self-reading dosimeters must be recharged at the start of a work shift and readings recorded at least daily before recharging. All other registrants who use these devices are encouraged to follow similar procedures. Records must be maintained.

If you suspect there has been an excessive exposure, a radiation incident or have questions concerning personnel monitoring, you can contact our agency. The address is:

DENR/DEH  
North Carolina Radiation Protection  
1645 Mail Service Center  
Raleigh, North Carolina 27699-1645  
Phone: (919) 571-4141  
Fax: (919) 571-4148