

Frequently Asked Questions Regarding Dosimeter (Badge) Readings for Personnel Who Perform or Assist with X-Ray and Fluoroscopy Procedures

1) How and where can I obtain or review my dosimetry results?

Answer: Radiation Safety Services e-mails dosimetry results to the designated contact for each dosimetry group, for review by the group supervisor. If you do not receive your results from your Dosimetry Contact or Dosimetry Supervisor, they are available upon request from Radiation Safety Services, or you can access them by following the instructions at <https://ehs.umich.edu/wpcontent/uploads/2018/09/ViewingIDR.pdf>.

2) The reported result for my dosimeter is “SL” or “M.” What does that mean?

Answer: It means your dosimeter result for the wear period was very low.

- “SL” stands for “selected level,” which means your dosimeter recorded less than 10 mrem during the wear period (monthly or quarterly).
- “M” stands for “minimal,” which means the dose recorded by your dosimeter did not exceed the minimum reportable dose for that type of dosimeter. For a whole-body dosimeter (chest, over-apron, or under-apron), the minimum reportable dose is 1 mrem; for a ring dosimeter, the minimum reportable dose is 10 mrem.

3) What is a background radiation dose?

Answer: It is the radiation dose that all of us receive from background sources such as cosmic rays from outer space, radioactive isotopes in the soil, radioactive isotopes in our bodies and the food we eat, and radon gas. The background radiation dose is about 300 mrem/year in Ann Arbor.

4) What are the occupational dose limits for radiation exposure?

Answer: The National Council on Radiation Protection and Measurements (NCRP) recommends dose limits to minimize the risks of cancer, cataracts, skin damage, and other adverse health effects from occupational radiation exposure. The recommended dose limits were established (and are periodically revised) to ensure that the risks from occupational radiation exposure are comparable to the occupational risks of working in a “safe” occupation (e.g., retail or office work). The U.S. Nuclear Regulatory Commission (NRC) adopted its current annual dose limits from the NCRP recommendations in 1991. The State of Michigan revised its *Ionizing Radiation Rules Governing the Rules of Radiation Machines* in 2016, to make occupational dose limits consistent with existing Federal dose limits and recommendations by the Conference of Radiation Program Control Directors (CRCPD):

	Annual dose limit (mrem/year)
Whole body (primary risk: cancer)	5,000
Lens of eye (primary risk: cataracts)	15,000
Skin and other organs except eye	50,000

Extremity (arms below elbows and legs below knees)	50,000
Embryo/fetus of pregnant worker	500 mrem per gestation period and 50 mrem/month
Member of the general public	100

Note: To convert traditional units of mrem to the International System unit of mSv, divide by 100 (e.g., the whole-body occupational dose limit of 5,000 mrem = 50 mSv and background radiation dose of 300 mrem = 3 mSv)

5) The dosimetry report lists DDE, LDE and SDE. What are these?

Answer: These are estimates of the radiation dose at different depths of your tissues and organs.

- **Deep dose equivalent (DDE)** is the dose equivalent at a tissue depth of 1 cm (i.e., the minimum depth of internal organs) and is used to compute your whole-body dose (see answer to Question 6 below). The whole-body dose should be compared to the deep dose equivalent or effective dose equivalent limit (5,000 mrem/year).
- **Lens dose equivalent (LDE)** is the dose equivalent at a tissue depth of 0.3 cm (i.e., to the lens of the eye) and should be compared to the lens dose limit (15,000 mrem/year).
- **Shallow dose equivalent (SDE)** is the dose equivalent at a tissue depth of 0.007 cm (i.e., to the dermis) and should be compared to the skin and extremity dose limits (50,000 mrem/year).

6) How is my whole-body dose estimated from my dosimetry results?

Answer: When you wear a protective apron, your actual whole-body dose is less than the dose recorded by the over-apron (collar) dosimeter. There are published methods to estimate whole body dose, and the State of Michigan authorizes the following method¹ (Michigan *Ionizing Radiation Rules*, R 333.5057):

- When a single (over-apron) dosimeter is worn and located at the neck (collar) outside the protective apron, the effective dose equivalent shall be the reported deep dose equivalent.
- When a single (over-apron) dosimeter is worn and located at the neck (collar) outside the protective apron, and the cumulative reported dose for the year exceeds 25% of the annual limit (i.e., 1,250 mrem), the effective dose equivalent shall be the reported as the over-apron deep dose equivalent x 0.3.
- When over- and under-apron dosimeters are worn, the effective dose equivalent shall be reported as the sum of the under-apron deep dose equivalent x 1.5 and the over-apron deep dose equivalent x 0.04.

Examples: Estimates of whole-body effective dose equivalent using methods recommended by the State of Michigan:

- Your reported deep dose equivalent (DDE) is “SL” each quarter for the entire year.

Answer: Your effective whole-body dose is at most the selected level (SL) dose of 9 mrem times 4 quarters per year, or 36 mrem.

- You are a nurse and wear a single dosimeter on your collar. Your cumulative over-apron dose for the year is 1,500 mrem.

Answer: Your over-apron dose exceeds 25% of the annual limit, so your effective dose equivalent = 0.3 x



over-apron, or $0.3 \times 1500 = 450$ mrem.

- You are a radiologic technologist who works in interventional radiology. Your cumulative over apron dose for the year is 1,000 mrem and your cumulative under-apron dose is 30 mrem.

Answer: Your effective dose = $1.5 \times \text{under-apron dose} + 0.04 \times \text{over-apron dose}$, or $1.5 \cdot 30 + 0.04 \cdot 1000 = 85$ mrem.

- You are an interventional radiologist. Your cumulative over-apron dose for the year is 5,000 mrem and your cumulative under-apron dose is 150 mrem.

Answer: Your effective dose = $1.5 \times \text{under-apron dose} + 0.04 \times \text{over-apron dose}$, or $1.5 \cdot 150 + 0.04 \cdot 5000 = 425$ mrem.

The above results should be compared with the 300 mrem from background radiation that each of us receives per year and the occupational effective dose equivalent limit of 5,000 mrem per year. Notice that even the interventional radiologist, who likely performs many hours of fluoroscopic imaging in her/his job, receives an effective dose equivalent (425 mrem/year) that is much less than the occupational dose limit.

7) What are ALARA I and ALARA II?

Answer: ALARA stands for “As Low As Reasonably Achievable,” which is a safety principle and regulatory philosophy for minimizing radiation doses. The goals of ALARA are to 1) keep occupational doses as far below regulatory limits as practicable in order to maintain a safe working environment, and to 2) keep patient doses as low as possible without sacrificing image quality and affecting the physician’s ability to make a diagnosis. ALARA investigation levels are established by the University of Michigan Radiation Policy Committee as a part of the ALARA Program.

ALARA I investigation levels are used to inform a worker that their recorded dose exceeded a small percentage of the applicable regulatory dose limit. Other than informing the worker (and their Dosimetry Supervisor), no action is taken by Radiation Safety Services and no response is required by the worker.

ALARA II investigation levels are used to inform a worker that their dosimetry results exceeded a larger percentage of the applicable regulatory dose limit. In addition to informing the worker (and their Dosimetry Supervisor), Radiation Safety Services may perform an investigation and make recommendations to reduce the probability of recurrence (e.g., minimize fluoroscopy time, maximize distance between worker and patients, and use portable shielding).

The following are examples of ALARA I and II investigation levels:

ALARA I investigation level for whole body dose is 500 mrem, which is 10% of the annual dose limit of 5,000 mrem.

ALARA II investigation level for whole body dose is 1,500 mrem, which is 30% of the annual dose limit of 5,000 mrem.

8) What does it mean to receive an ALARA I notification letter, and what do I need to do?

Answer: The ALARA I letter is simply a notification that your cumulative dose for the calendar year exceeds the ALARA I investigation level. There is no response required by you, but you and your supervisor should consider ways to keep your dose as low as reasonably achievable. For example:



- minimize fluoroscopy imaging time
- maximize distance between you and the patient
- use portable shielding
- optimize x-ray/fluoroscopy machine settings

9) What does it mean to receive an ALARA II notification letter, and what do I need to do?

Answer: The ALARA II letter is a notification that your cumulative dose for the calendar year exceeds 30% of the annual dose limit (or 75% for extremity dose). Doses at this level are not uncommon for frequent operators of the fluoroscopy equipment in Interventional Radiology and Cardiology. Radiation Safety Services may perform an investigation to determine the potential causes of your doses (e.g., performed many complex procedures involving many minutes of fluoroscopy and/or many digital angiography or cine runs). Elevated under-apron dosimeter readings are almost always the result of improper wear (e.g., mistakenly reversing the positions of the under- and over-apron dosimeters or wearing both dosimeters over the apron).

If you are asked to meet with Radiation Safety Services for an ALARA investigation, please do so in a timely manner and be as cooperative as possible. Radiation Safety Services will help review how you work with radiation and make recommendations to reduce your dose, including:

- minimizing the fluoroscopy imaging time
- maximizing the distance between you and the patient
- keeping your hands out of the x-ray beam
- standing on the detector side of patient (if possible)
- using portable and overhead shielding
- optimizing the x-ray/fluoroscopy machine settings

10) What if my cumulative dose exceeds the annual occupational dose limit? Can I continue to perform x-ray/fluoroscopy procedures?

Answer: With the State regulatory changes in 2016, an individual exceeding the annual dose limit would be restricted from receiving additional occupational radiation exposure. However, exceeding the annual occupational dose limit is expected to be an extremely rare occurrence.

Depending on the time period over which the dose was recorded, Radiation Safety Services will perform an investigation to determine the potential causes of your cumulative dose and may need to submit a report to the State of Michigan. Radiation Safety Services will also recommend methods to reduce your occupational radiation dose (see answer to Question 9, above).

It is important to realize that neither the over-apron nor the under-apron dosimeter results represent your actual whole body occupational dose. The over-apron dosimeter does not account for the attenuation of x-rays by your protective apron, thyroid shield, and eyewear, and the under-apron dosimeter does not account for radiation incident on parts of your body that are not shielded (e.g., head). The annual occupational dose limits focus on the whole-body dose and extremity dose. There are methods to estimate the whole body dose from your dosimeter readings (see answer to Question 6, above).

11) What is the difference between double-badge, single-badge, and chest badge?

Answer: “Whole body” for the purposes of measuring external radiation dose, includes the head, trunk (including male gonads), arms above the elbow, and legs above the knee. The ALARA notification lists the ALARA I and ALARA II investigation levels for workers who wear only a chest dosimeter (no protective apron), an over-apron dosimeter with protective apron (“single badge”), over- and under apron dosimeters with

protective apron (“double badge”), and/or extremity dosimeters (rings). Any dosimeter worn on the torso (chest, over-apron, or under-apron) is used to estimate the wearer’s whole body radiation dose.

12) Who should wear two dosimeters (“double-badge”)?

Answer: Anyone who performs or assists with Interventional Radiology or Cardiology procedures, and some individuals whose duties require routine wearing of protective aprons (subject to certain exceptions by Radiation Safety Services). Radiation Safety Services determines which personnel or job functions at Michigan Medicine require two dosimeters.

13) How can I obtain a dosimeter to monitor the dose to my fetus if I am pregnant or am trying to get pregnant?

Answer: Pregnant employees can voluntarily declare their pregnancy with Radiation Safety Services in order to receive an additional dosimeter to wear on the abdomen (beneath the protective apron) to monitor the external radiation dose to the embryo/fetus. This dosimeter is exchanged monthly and the recorded dose is reported on a monthly basis through the designated contact for the dosimetry group. The fetal dosimeter is obtained by completing a [Declaration of Pregnancy form](#).

14) My occupational dose report (Form 5) for the year reports a dose of “ND.” What does that mean?

Answer: ND means “not detectable.” That is, none of the dosimeters issued to you recorded a dose that exceeded the minimum recordable dose (1 mrem). This includes dosimeters that were issued to you but were unused or unreturned.

15) Where can I obtain more information about occupational radiation dose monitoring at Michigan Medicine?

Answer: See <http://www.med.umich.edu/i/policies/umh/05-03-029.html> and [Dosimetry/Bioassay Webpage](#).