Personnel Monitoring Devices

Purpose of Measuring Occupational Exposure

● Provides information that leads to identification of undesirable practices and of unexpected sources of high exposure

● Permits prompt application of controls to limit exposure

● Provides information regarding exposure of the individual, permitting a comparison with long-term limits

● Guides long term controls required to reduce exposure

Different types of devices

● There are several different types of devices available for measuring both instantaneous radiation dose and cumulative radiation dose.

● Each has specific applications

● Each has advantages and disadvantages

Monitoring Requirements

- "Personnel monitoring for external exposure shall be performed on all occupationally exposed individuals who may receive >10% of the applicable MPD during the normal course of their duties or through accidental exposure."
- Personnel monitoring is not required where the nature of the work performed or the nature of the radiation sources is such that personnel exposures are below the limits recommended for uncontrolled areas and where there is very small potential for accidental exposure above these limits.
- Occasional visitors to controlled areas, including messengers, servicemen, and deliverymen should be regarded as non-occupationally exposed persons since it is most improbably that they will receive in one year a dose equivalent exceeding the

non-occupational limit of 0.5 Rem during their brief time in controlled areas. They therefore do not need to be badged.

- Long term visitors to controlled areas should be regarded as occupationally exposed persons if it is likely that they will receive a dose equivalent exceeding 0.5 Rem per year. They should be monitored according to the criteria of "Occupationally Exposed Persons" above.
- The ideal personnel monitoring device must accurately measure the biological dose in Rems received by parts of the body considered to be most vital from the standpoint of chronic low level exposure, i.e., bone marrow and gonads.
- Measurement must be independent of type and energy of radiation producing the dose. Records must be continuously maintained and preserved in accordance with CFR 20.401(c) until NRC authorizes disposition

EXPOSURE RECORDS

Title 10, Part 19 addresses notification and reporting practices to occupational personnel

Title 10, Part 20 of the Code of Federal Regulations outlines procedures for maintaining exposure records

Reportable exposure records include:

- Those dealing with whole body or finger measurements
- Results of any measurements, analyses, or calculations of radioactive material deposited or retained in the body

Exposure records must be furnished to:

- Any currently employed occupational worker who requests it- on an annual basis
- Any formerly employed occupational worker who requests it- within 30 days
- The individual and the NRC/State in the case of an overexposure- within 30 days

Principles & Characteristics of Monitoring Devices

Personnel monitoring devices are designed to measure the accumulated external exposure or dose that a person receives over some time interval. These devices are integrating, unlike dose rate meters or surveying instruments, which give an instantaneous readout.

General Principles of Monitoring Devices

- These devices must be compact and light enough to be worn at all times during working hours.
- They also must be inexpensive since so many are used at an institution and they are changed every month.

General Characteristics of Personnel Monitors

- Should be reliable and accurate
- Should be sensitive to the type of radiation being monitored
- Should be inexpensive, portable, and easy to understand its operation

MONITORING DEVICES

FILM BADGES:

Personnel monitoring usually performed through use of Film Badges for whole body exposures and TLD ring badges for extremity exposure

- Most popular type of monitoring device
- Contains photographic emulsion mounted in plastic and then over-wrapped in light-tight paper
- Measures whole body exposure
- Distinguishes type of radiation to which wearer is exposed
- Plastic case has cutaway portion to permit entry of β- particles
- Contains 3 small metallic filters- usually Cu, Cd, and Al, placed in different portions of case to help distinguish among higher energy photons
- Each metal attenuates photons of different energy values
- When radiation is absorbed in film emulsion, some Ag halide grains are altered. These grains, which form the latent image, respond differently to developers and are reduced to Ag metal at much faster rate than unaffected grains. Optical density of Ag is proportional to radiation exposure.
- Metal filters reduce photon energy to levels which are optimal for photographic emulsions.
- Film density is compared to that of films exposed to standard doses of radiation of similar energy to estimate absorbed radiation dose.

Advantages

- Provides permanent record of individual exposure
- Relatively inexpensive
- Requires no technical knowledge of user
- Film can be re-read at later date

Disadvantages

- Takes 3-5 weeks for results of previous month
- Not very accurate (qualitative vs quantitative)
- Not very sensitive at low levels (<40 mR)
- Fair reproducibility
- Affected by heat, e.g., sunlight; ruined by washing machine cycle
- Image changes as f(t)- develop within 1 month

Thermoluminescent Dosimeters

TLD ring badges are very important for individuals involved in eluting generators, preparing kits, and injecting patients.

Monitoring Devices: TLD

● The thermoluminescent dosimeter depends on thermoluminescent phosphors, such as lithium fluoride, that trap electrons freed by radiation exposure.

● The trapped electrons release light when the application of heat frees the electrons, returning them to stable energy states. The process can be repeated many times.

● Instead of reading the blackness (optical density) of a film, the amount of light released versus the heating of the individual pieces of thermoluminescent material is measured as a "glow curve" which is then related to the radiation exposure.

● Lithium fluoride in the form of powder compressed into pellets has advantages over film badges by being tissue equivalent, by having an exposure range from a few hundredths of a millisievert to over 100 Sv (10000 rem), by exhibiting little fading over time in storage at room temperature and by being free of many of the problems associated with film.

● In the badge, a pellet is placed behind each of the filters so that radiation energy information is obtained as well as consistent readings. The ability to reuse the pellets is also an advantage.

● If the lithium is enriched with Li-6, the lithium fluoride becomes very sensitive to thermal neutron interaction and a pair of pellets (one enriched and the other not enriched) can provide neutron exposure information.

POCKET DOSIMETERS

Pocket dosimeters are useful in those situations in which large exposures are expected on an infrequent schedule.

- The original pocket dosimeters used an extremely sensitive fiber electrometer type voltmeter and a small volume of air to measure the total amount of radiation to which the instrument has been exposed. A reading may be made at any time by merely looking at a source of light through the eyepiece end of the instrument.
- The more modern ones are completely electronic and much less prone to breakage.

Advantages

- Reusable
- Easy to read exposure value
- Immediate reading of cumulative radiation exposure

Disadvantages

- More expensive initially than other devices
- More fragile than other devices

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