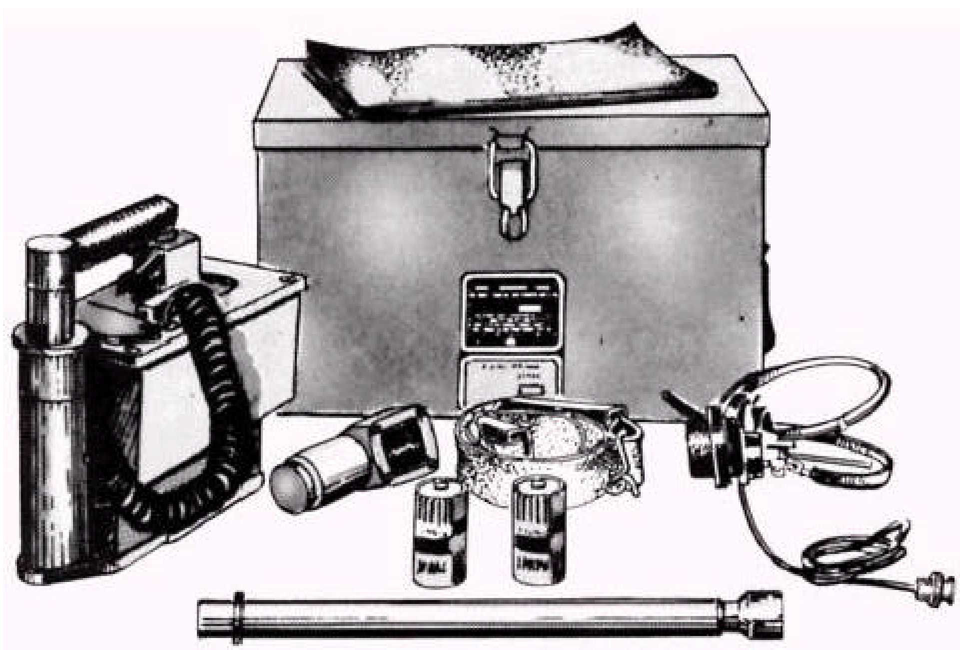
Radiation Detection Instrumentation at the Department of Energy



Office of Worker Safety and Health Policy
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INTRODUCTION

Throughout the Department of Energy's (DOE) history, various types of instrumentation have been used to detect and quantify radiation levels and radiation doses to individuals. These include classic radiation detection instruments such as hand-held dose rate meters, contamination monitors, continuous air monitors, area monitors, etc., as well as dosimeters used to measure the dose received by individuals.

Currently, there are ongoing initiatives to reevaluate past radiation exposures received by individuals. These are based on historical records of surveys from radiation detection instruments and personnel dosimetry records. These radiation dose reevaluations employ current dosimetry models to best estimate lifetime radiation exposures.

This handout provides an overview of historical and current radiation monitoring and personnel dosimetry capabilities used by the DOE. The handout describes the purpose and process of radiation dose assessment and should help the reader understand the capabilities and limitations of measuring radiation dose.

1. INSTRUMENTATION AT DOE FACILITIES

To understand the terminology used in discussing radiation instrumentation monitoring, we need to understand that there are two kinds of monitoring typically being discussed: (1) monitoring the intensity of the radiation field per unit time and (2) monitoring the total radiation dose received by an individual.

Information on the intensity of the radiation fields encountered in the work environment and individual radiation doses is essential for establishing adequate radiological controls. It permits the calculation of stay times for personnel in radiological areas. Also, it provides an objective means for restricting access to specified areas for personnel in the interest of the "As Low as Reasonably Achievable" (ALARA) principle.

The difference between monitoring the intensity of the radiation fields and monitoring the total radiation dose received by an individual may be compared to automobile speedometers and odometers (mileage indicators). The dose rate, or survey meter measures the intensity of radiation fields and is like the speedometer that indicates the speed of an automobile in miles per hour. Dosimeters measure the individuals' total exposure, in millirem (mrem), without regard to time, like the odometer that measures total distance traveled in miles.

2. DOSIMETRY AT DOE FACILITIES

Dosimeters are devices that are worn by an individual to estimate dose received by the individual. In general, they are passive devices that either physically or chemically change when exposed to ionizing radiation and can be read at a later time. Various types of dosimeters have been used at DOE sites over the years. Prior to 1970, the state of the art were film dosimeters, which employ a simple film housed in an enclosure impervious to visible light that can be penetrated by various forms of radiation. The film can subsequently be developed and read to estimate the dose received. In general, most film badge devices offered a minimum detectable level of approximately 30 mrem.

Due to technological breakthroughs and discoveries, most dosimetry is now accomplished using Thermoluminiscent (TLD) Dosimeters, which use the electron trapping capabilities of various crystals to measure dose received by the individual wearing the TLD. Due to this new technology, minimum detectable levels are in the 5-10 mrem. range, marking a great improvement from the old film badge methods.

Historical and current dosimetry at DOE sites

Historical Timeframe	*Dosimeter*	*Min. Detectable Level*
1950-1970	Film	Approx. 30 mrem
1970-Present	TLD	Approx. 5-10 mrem

3. **ALTERNATE METHODS FOR RADIATION DOSE ASSESSMENT**

Purpose of Using Alternate Methods for Dose Assessment

Sometimes it is necessary to use alternate methods to evaluate an individual's or a group's previous exposure to radiation. Typically this is needed because individual radiation monitoring data are unavailable, incomplete or are of questionable quality.

How Alternate Methods to Evaluate Radiation Doses are Used.

Historical radiation doses may be assessed by evaluating all appropriate data relevant to an individual's radiation exposure. Examples of data which may be used include:

- Internal dosimetry data (results of urinalysis, in vivo measurements, etc.)
- External dosimetry data (film badge readings, thermoluminiscent dosimetry results, etc.)

- Workplace monitoring data (air sample results and area radiation measurements)
- Workplace characterization data (solubility studies, particle size measurements, and inventories of radioactive materials present)
- Process descriptions for each work location
- Co-worker data

Assessing Historical Radiation Doses When There is Little or No Monitoring Data Available

If an individual's radiation doses were not monitored or there is uncertainty about the monitoring methods used, the assessment of radiation dose could require extensive data gathering and analysis. This may include:

- Determining specific characteristics of the monitoring procedures
- Identifying events that were monitored or where a worker should have been monitored
- Identifying the types and quantities of radioactive materials involved
- Evaluating the locations and activities of exposed persons
- Identifying comparable exposure circumstances for which data is available to make assumptions
- Conducting a variety of complex analyses to understand the data compiled or estimated

Additional Sources of Information that may be used for Dose Assessment

In cases where individual monitoring data are limited, the following sources of information may also be used. Many of these do not directly involve dose records, but tangential information on where certain activities were conducted or where former employees may have been involved in work:

- Employment histories and workplace monitoring records from DOE and its contractors, including Atomic Weapons Employers, and the Former Worker Screening Program
- Completed dose assessments from NIOSH and other records from health research on DOE worker populations
- Interviews and records of job functions and workplace conditions provided by workers/former workers
- Co-workers of employees, or other witnesses with information relevant to the employee's exposure, such as knowledge of any radiological incidents involving the employee
- Labor union records verifying employment history, job functions and employee concerns from unions representing employees at facilities of DOE or Atomic Weapons Employers

The system of occupational radiation protection used by DOE and all other Federal agencies in the United States is based on maintaining radiation doses well below an annual limit. Accordingly, for purposes of protecting workers, neither DOE nor any other Federal agency has ever instituted a lifetime dose limit. As a result, records of the lifetime doses for most of the oldest workers are not readily available and must be reconstructed from the records of annual doses as well as records of workplace and personal monitoring.

In the decades spanning a worker's career, the methods of radiological monitoring and determination of dose have continually improved. Therefore DOE applies the latest technologies and models to the historical radiation exposure data in order to generate lifetime doses. Once the lifetime doses have been estimated, they are compared to tables of data relating radiation dose to the occurrence of various health risks in order to determine the probability of any adverse health effects.

4. RADIATION DETECTION INSTRUMENTS

Most radiation detection instruments used at DOE facilities fall into one of several categories:

- area radiation monitors
    - fixed position
    - portable (dose rate meters)
- air monitors
    - continuous monitors
    - grab samplers
- contamination monitors
    - area
    - personnel

The most common radiation detection instruments typically are either gas-filled detectors, (such as Geiger-Mueller detectors or proportional counters), or scintillation detectors, where a material that produces scintillation light when exposed to ionizing radiation is used, or the use of semiconductor materials to detect radioactivity. Although there is an uncertainty associated with each instrument, during calibration, instruments are typically required to be calibrated to within +/-10% of a reference value.

Below is a listing of some common instruments found in use at DOE sites.

Popular Radiation Detection Instruments

Instrument Type	*Model*	*Min. Detectable Level*
Radiation Monitor-Beta/Gamma	Eberline RO-2	0.2 mr/hr.
Radiation Monitor-Neutron	Ludlum 12-4	1 mr/hr
Contamination Monitor-Beta/Gamma	Ludlum Model 3 with g-m pancake probe	1000 dpm/probe area
Contamination Monitor-Alpha	Ludlum Model 3 with Alpha scintillation detector	20 dpm/probe area
Personnel Contamination Monitor-Beta/Gamma	Eberline PCM-1	5000 dpm/100cm^2
Personnel Contamination Monitor-Alpha	Eberline PCM-1	1000 dpm/100cm^2
Air Monitor-Beta/Gamma	Eberline AMS-4	Dependent on isotope and flow rate
Air Monitor-Alpha	Eberline Alpha 7	Dependent on isotope and flow rate

This table illustrates that radiation detection instruments have been available and used at DOE which are capable of:

- controlling radiation doses to workers and the public,
- establishing criteria for access controls,
- ensuring radiation doses are As Low As Reasonably Achievable,
- providing sufficient information to workers to enhance their confidence in the safe work conditions at the facility, and
- demonstrating compliance with radiation safety regulations.

Eberline RO-20

Ludlum Model 3

5. ADDITIONAL SOURCES OF INFORMATION

The following useful sources provide more detail on Radiation Detection Instrumentation at DOE:

1. Health Physics Instrument Committee (HPIC) web site.
   url: http://www.ornl.gov/doehpic/hpic/hpic.htm

2. DOE EH-52Web site.
   url: http://tis.eh.doe.gov/whs/rhmwp/

3. DOE Occupational Exposure Annual Reports
   url: http://rems.eh.doe.gov/annual.htm

4. NIOSH Website
   url: http://www.cdc.gov/niosh/homepage.html

5. Knoll, G. F. Radiation Detection and Measurement, Second Edition. New York, NY: John Wiley & Sons, Inc.; 1989.

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