CHAPTER 8

BIOASSAY PROCEDURES

8-1 BIOASSAY

a. Bioassays are procedures which estimate the amount of radioactive material deposited in the body, either by direct measurement, using sensitive x-ray detectors placed over the chest (lung counting) and/ or other organs, or by detection of radioactivity in the excreta (feces and urine). Therefore, a number of factors must be known in addition to the quantity and isotopic distribution of the material to make an accurate estimate of the dose.

Chemical form
Route of intake
Elapsed time from intake
Organ(s) containing the material
Distribution pattern
Organ(s) mass(es)
Biological half-life
Particle size of the original material
Decay scheme of the radioisotope

Complex mathematical models have been developed that take each of these into account.

b. Three methods are used to determine the amount of material present in the body. Each method has specific advantages and disadvantages and the specific methods in any given situation will be determined by the health physicists.

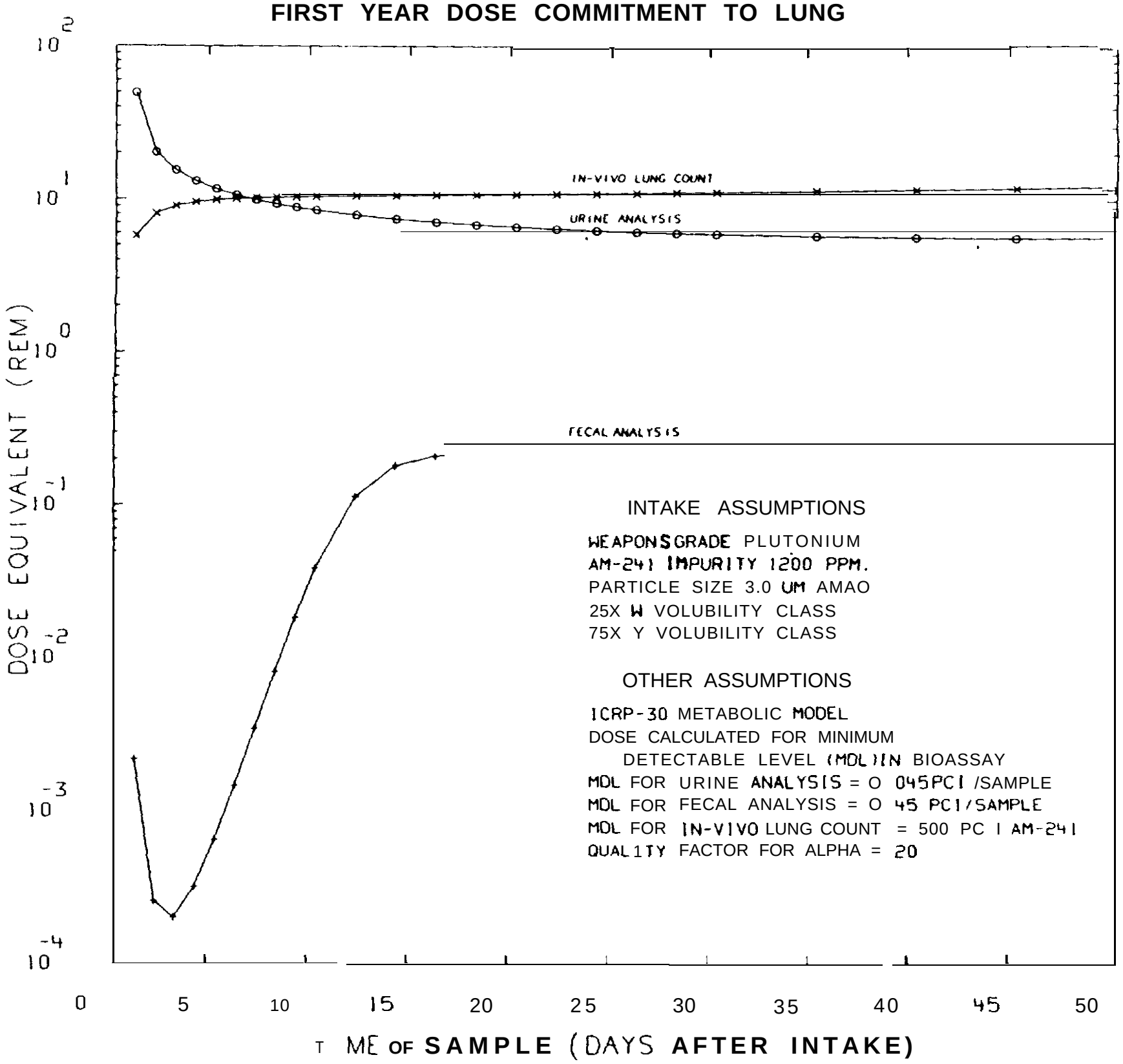
(1) Fecal Sampling. Fecal sampling is an effective bioassay method which has the advantage that samples can be evaluated in the field. Samples should not be taken until at least 48 hours after exposure to permit passage of the contamination through the intestinal tract and should be submitted in well-sealed plastic bags. Low energy gamma radiation sensors such as the FIDLER can be used to estimate the plutonium content. For more definitive results, chemical separation and low level counting techniques must be used. Fecal sampling is especially effective during the first few days, but can be done at any time during the first year after exposure. Figure 8-1 may be used to estimate the first year dose commitment to the lungs based on contamination detected in feces.

(2) Urine Sampling. Urine sampling is a less sensitive indicator of plutonium exposure; only a tiny fraction of the amount inhaled is excreted through urine. This fraction also depends on volubility of the plutonium in the original aerosol. Samples taken during the first five days after the exposure will not reflect the quantity of plutonium inhaled due to the time required for movement through the body. Urine samples taken up to 200 days after the exposure can be used for analysis. Urine samples must be processed in a chemistry laboratory before quantification is possible, but screening for very high levels can be done in the field. Samples should be submitted in plastic or glass bottles with well-sealed tops.

(3) Lung Counting. Lung counting is the direct measurement of emitted x-rays and gamma radiation from the body with a sensitive low energy photon detector. Probably, lung counting is the most accurate method of determining internal exposure. Lung counters are used at National Laboratories, commercially, and at some hospitals and universities. Most lung counters are immobile systems using large shielded rooms (special trailer mounted systems can be obtained through the Department of Energy (DoE) in a few days), and the patient must be sent to the facility. Plutonium is retained in the lung for a very long time.

8-2 BIOASSAY PROCEDURES

a. Administration of a bioassay program for effected civilians may be the responsibility of the state or Federal agency or effected country. The guidelines in Table 8-1 are provided to assist the response force or civilian authorities conducting initial screening in advising individuals contaminated when requested to provide urine or fecal samples for analysis. Advisors explain that sample analysis will determine if the individual received a detectable radiation dose when contaminated. The bioassay procedures used will be established by health physicists responding to the accident. When bioassay samples are collected, every effort should be made to keep samples and their containers free of contamination from the environment, clothing, or skin. Since tritium



Use of Chart.

1. Enter chart with the time of sample.
2. Draw vertical line to curve for sample type.
3. Draw horizontal line to Dose Equivalent scale.
4. Divide thevalueobtained from theDose Equivalent scale by the MDL for the sample type and multipiy this value by the contamination level of the sample in picocuries to get the estimated first year dose to the lung.

Example: Measurement of a fecal sample taken 5 days after the accident read 1000 pCi.

1. Steps 1-3 give a Dose Equivalent Scale value of 4×10^{-4}.
2. The MDL for fecal samples is .45 pCi.
3. $\frac{4 \times 10^{-4}}{.4} \times \frac{1000}{5} = .889$ rem (The estimated first year dose to the lung.)

Analysis of a sample taken from the same person (same first year dose) 10 days after the accident would be expected to read only 20 pCi, assuming the individual inhaled contamination only on the day of the accident.

Figure 8-1. Estimated First-Year Dose Commitment to the Lungs.

TABLE 8-1. Guidelines **for Bioassay Sampling.**

Suspected Radioactive Material	Feces Optimum Sampling Time After Exposure	Urine Optimum Sampling Time After Exposure	Sample Quantity
Plutonium	**2** days	2-3 weeks	24 hours total
Uranium	2 days	24 hours	24 hours total
Tritium	N/A	4-8 hours	1 voiding .

contamination cannot be detected by CCS monitoring, anyone suspected of having been exposed to tritium should follow the guidelines in Table 8-1. A bioassay program is recommended for all individuals without respiratory protection and found to be contaminated. This program will determine if any dose was received and provides assurance to those who did not receive a dose that their health was not effected. To provide similar assurance to all people in the contaminated area, bioassays may be appropriate even for people who weren't found to be contaminated; moreover, some people never in contaminated areas will request tests to ensure they were not effected by the accident.

(1) Bioassay Priorities. If a nuclear weapon accident occurs near a populated area, obtaining bioassay samples from large numbers of people may be necessary.

NOTE: Since it is virtually impossible for a significant amount of plutonium to be incorporated into the body without gross contamination of skin or clothing also occurring, initial alpha monitoring which identifies contaminated personnel also can provide a method for assuring that those with the greatest possibility of radiation exposures which may affect their health are given priority treatment.

Table 8-2, applicable only to people not wearing respiratory protection, provides recommended guidelines for the assignment of priorities for bioassay analysis. Response force personnel will normally be equipped with protective clothing and respirators, when required. Bioassays for response force personnel will be performed in accordance with Service regulations and as directed by the On-Scene Commander.

Personnel falling in the HI priority category in Table 8-2 may have had a substantial plutonium intake. Conversely, exposure to airborne contamination which produces a surface contamination level in the LO category will be less likely to result in a significant deposition in the lungs, To ensure alpha meter readings provide a valid guide for assignment of priorities, individuals should be asked, during screening, if they have bathed or changed clothes since the time of possible contamination. A record must be made and retained for future reference of all personnel screened and the results of both alpha meter screening and bioassays. Use of the Radiation Health History and Bioassay Screening Forms contained in Appendix 5-E should be considered.

(2) Nasal Smears. If initial alpha meter screening indicates probable plutonium inhalation, a nasal smear shall be collected for analysis by specialized teams when they arrive on-site. Contamination on a wipe (Q-Tip) from inside the nasal passage is a possible indicator of plutonium inhalation. Due to the biological half-life of nasal mucus, a nasal smear is a reliable indicator only if collected during the first hour after t he exposure. When medical personnel collect nasal smears, the Q-tip must be free from any gels or other material that will prohibit alpha particle counting.

b. Personnel Exposure and Bioassay Records. Documentation should be maintained on all personnel who enter the radiological control area, or who may have been contaminated prior to establishment of a radiological control area. Examples of forms used for recording data on personnel working in the radiological control area, or who may have been exposed to contamination downwind from the accident, are contained in Appendix 5-E. To ensure appropriate follow-up actions are completed on all exposed, or potentially exposed people, a copy of all CCS logs, other processing station records, bioassay data, and other documentation identifying people who were or were not contaminated should be provided to the Joint Hazard Evaluation Center for consolidation into a single data file. This data file is subject to Privacy Act regulations, and must be retained as part of the permanent accident records. Therefore, procedures for handling data obtained on non-DoD personnel should be coordinated with the OSC'S legal officer. Data obtained on DoD personnel will be needed to satisfy Service-specific requirements contained in AR 40-14, Control and Recording Procedures for Occupational Exposure to Ionizing Radiation; NAVMED P-5055, Radiation Health Protection Manual; AFR 161-8, Control and Recording Procedures Occupational Exposure to Ionizing Radiation; AFR 161-28, Personnel Dosimetry Program and the USAF Master Radiation Exposure Registry, references (q), (r), (s), and (t). These records shall be retained and become part of the individual's permanent medical record.

TABLE 8-2. Guidelines for Assignment of Priorities for Collection and Processing of Bioassays.

Priority	Alpha Contamination Level on Clothing or Skin	
	60 cm^2 probe	17 cm^2 probe
HI	Above **300,000** Cpm	Above **75,000 Cpm**
MED	**50,000-300,000** cpm	**12,500-75,000 cpm**
LO	Below 50,000 cpm	Below 12,500 cpm