CHAPTER 6

RESPIRATORY AND PERSONNEL PROTECTION

6-1 GENERAL

This chapter addresses protective clothing and respiratory protection including protection factors, protective action guide and resuspension factors.

6-2 RESPIRATORY PROTECTION

Plutonium and uranium particulate are the most serious source of airborne radioactivity at an accident site. These particulate may be present in the cloud and smoke from a breached or burning weapon, but settle to the ground shortly thereafter. The radioactive particles may become resuspended in the air by surface winds and by soil disturbing operations including vehicular traffic. Resuspension is highly dependent upon specific conditions (for example, type and condition of soil or surface, vegetation, moisture present, and time since deposition) and is difficult to measure and predict. Respiratory protection prevents airborne contamination from entering the lungs and is provided by self contained breathing apparatus (SCBA), or respirators which filter particulate out of the ambient air. Respiratory protection devices adversely affect productivity and effectiveness, and their use is not recommended except when airborne contamination is present or expected. In hot climates, respiratory protection devices can result in heat injuries, including death, and a heat injury prevention program as discussed in paragraph 14-5 should be implemented when temperatures exceed 70°F.

a. Protection Factors (PF). The amount of protection from inhaling airborne particulate contaminants provided by a given device is called its protection factor. Protection factors vary primarily as a function of anthropometrical data, mask fit and mask design. Protection factors are determined by dividing the ambient air concentrations (AAC) of a contaminant by the inhaled concentration (IC) or amount of contaminant which enters the mask; thus PF = AAC/IC. A test facility/ chamber using probe equipped test masks in a chamber containing a nontoxic contaminant is required for quantitative tests to determine the PF for each individual. A deployable fit test facility may be obtained through JNACC. PF's of up to 2,000 can be achieved with properly fitted respirators. If the mask passes a qualitative smoke test around the edges of the mask it is assumed a PF above the nominal value is achieved. Demand type SCBA (air supplied on inhalation) cause negative mask pressure during inhalation and provide no more protection from contaminants than a respirator. . Pressure demand SCBA (i.e., always under positive pressure) provide a nominal PF of 10,000.

b. Protective Action Guidelines (PAG). PAG are developed to identify protective devices to limit exposure to the lungs from inhalation of contaminants to agreed upon limits. The guidelines provided are intended for use until health physics personnel at the scene can develop situation specific instructions. In deriving the guidelines, a PF of 100 was assumed and the maximum permissible concentration (MPC) of activity in the air being inhaled was based on a MPC for radiation workers of 40 picocuries/ cubic meter (pCi/ m^3) per 40 hour week. This calculation assumes possible exposures at this rate over the period of a year and is approximately ten (10) times greater than the one (1) pCi/ m^3/ 168 hour week MPC for the general public. Radiation dose is a function of level of activity and exposure time. Therefore, if exposure time of workers is being tracked, a person could be permitted to enter an area of higher activity without adequate respiratory protection for a shorter period of time without exceeding dose limits. The time versus dose approach should be applied in emergencies as appropriate, that is, if a person suffers heat stroke the respirator should be removed immediately to meet the urgent medical requirement to cool the person since the short unprotected exposure during evacuation from the area for treatment will limit the amount of contaminant which is inhaled. Table 6-1 provides respiratory protection guidelines to use when air sampling data provides a basis for assessing airborne contamination levels. Calculated activity levels should be corrected for background activity before entering the table.

TABLE 6-1. Recommended Respiratory Protection Levels for Emergency Workers as a Function of Airborne Contamination

Airborne Alpha Activity dpm/ m^3 above background	Respiratory Protection
Below 100 dpm/ m^3	No respiratory protection needed.
100-10,000 dpm/ m^3	Full-face respiratory (M-series Protective Mask or civilian equivalent)
Above 10,000 dpm/ m^3	Pressure demand SCBA or limited entry restricted to essential personnel wearing a full-face respiratory. Source of contamination should be fixed as soon as possible.

Air sampling data is unavailable until some time after response personnel have arrived on-scene. During the initial response, and when working in areas where available air sampling data may not be applicable. Table 6-2 provides guidelines for protective requirements based on measurements of surface contamination levels. Table 6-2 is based upon surface contamination levels which could produce the airborne contamination levels in Table 6-1 assuming a resuspension factor of 10^{-5} per meter (m-'). Conversions from microcurie per meter squared (μCi/ m^2) to counts per minute (CPM) were made using the equation in Appendix 5 conversion factor charts for measurements on soil. Using Table 6-2 is appropriate during the initial approach to the area when using respirators in uncontaminated areas may create undue public alarm. If contamination levels detected during the initial approach indicate high levels of contamination can be expected, wearing of respirators by people entering the contaminated area is recommended until air sampling data is available to assess the actual airborne hazard. Table 6-2 guidelines should not be used in the downwind area until after the contamination cloud released by the accident has dispersed (several hours after the fire is extinguished or the explosion).

c. Air Sampler Equipment. TF-1 A Air Particles. Commonly referred to as a STAPLEX, the TF-1 A is capable of sampling air for particles down to 0.01 microns in diameter depending on the filter paper used. A flow meter is used to determine rate of air flow. Cellulose filters are used normally and retained for laboratory analysis. Field estimates of airborne contamination can be derived from measurement of filter contamination with field survey instruments.

d. Resuspension Factors. Other than during the initial release of contamination, airborne radioactivity is caused by resuspension. One means of estimating the potential airborne hazard caused by a given level of surface contamination is by using resuspension factors. The resuspension factor is defined as the activity in the air (μCi, pCi, dpm, etc.) per unit volume (usually m^3) divided by the activity on the ground below expressed in the same activity unit per unit area. The dimension of the resuspension factor is then inverse length, usually m^{-1}.

$$RF = \frac{\text{airborne activity}}{\text{ground activity}} = \frac{\text{dpm/ m}^3}{\text{dpm/ m}^2} = m^{-1}$$

The method of computing airborne contamination levels is contained in the air sampling appendix. In theory, the surface is assumed to have an infinite plane of uniform texture with a uniform level of contamination. In practice, the contaminated area has varied levels of contamination, is finite in size, and may contain a variety of surfaces with different resuspension characteristics. For wind speeds below 20 miles per hour (mph), only those surfaces within approximately 200 meters can contribute to the airborne contamination. For wind speeds over 30 mph, surfaces as much as 900 meters

TABLE 6-2. **Protective Devices for Emergency Worker as a Function of Surface Contamination**

FIDLER Determined Contamination μCi/ m^2	Alpha Reading CPM 60cm^2 Probe	Alpha Reading CPM 17cm^2 Probe	Protection
Below 4.5	Below 10,000	Below 2,500	Shoe covers; gloves recommended
4.5-450	10,000-1,000,000	2,500-250,000	Anti-contamination clothing; full-face respirator.
Above 450	Above 1,000,000	Above 250,000	Pressure demand SCBA, or limited entry restricted to essential personnel wearing a full-face respiratory. Source of contamination should be fixed as soon as possible.

away may contribute. Averaging of ground activity levels from these areas may be considered when computing resuspension factors. Resuspension factors may provide a method of roughly estimating airborne contamination levels for use with Table 6-1 in areas where air sampling data is unavailable. When using resuspension factors to estimate airborne contamination levels,the types and levels of contamination on surfaces in the area where the resuspension factor was computed and those in the area of interest should be considered. Resuspension factors may vary from 10^{-5} to 10^{-7} for plutonium newly deposited on soil and up to 10^{-3} on pavement. Resuspension factors are affected by the following:

(1) Soil Disturbing Operations. Mechanical disturbance, such as vehicular traffic may increase resuspension factors by as much as 100 times in the vicinity of the disturbance.

(2) Wind. Resuspension factors vary proportionally to the cube of the wind speed.

(3) Rain or Moisture. Leaching of plutonium into the soil by rain or sprinkling may reduce resuspension factors by 10 to 100 times or more. Surface and airborne alpha contamination levels may not be measurable with an alpha meter for some time after rain or sprinkling due to the shielding action of the moisture.

6-3 PROTECTIVE CLOTHING

Protection from contamination can be provided by any close weave cotton material or disposable suits. The outfit includes: The standard anti-contamination coveralls, boot covers, gloves, mask and hood. The outfit openings should be taped using masking or other appropriate adhesive tape. Disposable suit or the battle dress uniforms or equivalent with a hood and mask may be used provided the outfit openings are taped. For identification, the person’s name and team should be written on tape and placed on their back and chest.