# Radiological Effect of Aerosols From Decommissioning and Decontamination

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## 1. Introduction

According to the US Department of Energy`s (DOE) announcement, decommissioning and decontamination (D&D) of nuclear power plants (NPPs) activities can cause additional problems for inhalation of radioactive aerosols. During D&D, various cutting technics are used to cut metals. These activities generate airborne species called aerosols that cause a negative effect on health [1].

Inhalation is the major route of internal exposure of workers to radioactive aerosols. The particle size distribution will determine whether any part of the inhaled particles to be deposited in the compartment of the respiratory tract. Therefore, the internal doses from radioactive aerosols are strongly dependent on the particle size distribution [2]. This study presents the importance of measuring the aerodynamic diameter distribution for the risk assessment of worker`s internal dose in the nuclear facility.

## 2. The generation of radioactive aerosol during the D&D process

During D&D, radioactive aerosols are produced by cutting the metal in large-scale components and melting the metal during recycling to achieve a reduction in volume. The cutting metal process produces radioactive aerosols by the mechanical comminution of metals and the vaporization of metals. The radioactive aerosols have very different characteristics depending on the cutting process specifications such as a cutting tool, the thickness of material, and atmosphere condition (Table 1).

The distribution of aerosols is essential parameters needed for assessment of inhalation exposures. Therefore, it is essential to analyze the aerodynamic diameter distribution of aerosols for the D&D process.

Table 1. Characterization of aerosols produced during metal cutting processes [1]

| Cutting tool | Material | MMAD (μm) | Concentration (mg/m$^3$) |
|---|---|---|---|
| Oxy-Acetylene Torch | Stainless steel pipe | 0.1~0.3 | 15±11 |
| Plasma Torch | | 0.2~0.3 | 60±80 |
| Cut Rod | | 0.4~0.8 | 53±30 |

(MMAD = Mass Median Aerodynamic Diameter)

In laboratory experiments, a plasma torch is used to cut metal plates of different thicknesses and measure various parameters. Mostly, the size distribution of aerosol measurements is performed using impactor. For an impactor, all particles collected at a given stage have an aerodynamic diameter greater than the cut-off diameter of that stage.

## 3. Inhalation of aerosol into the human respiratory model for internal dosimetry

### *3.1 Human Respiratory Tract Model(HRTM)*

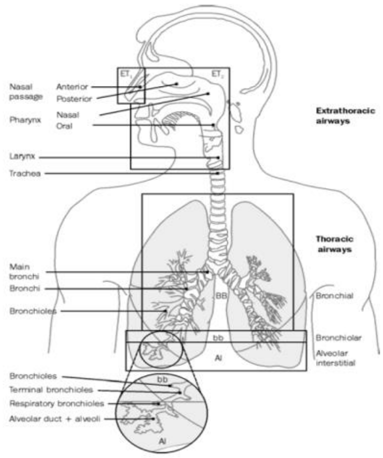


Fig. 1. The human respiratory tract is showing the various regions used within the HRTM [3].

The International Commission on Radiological Protection (ICRP) developed a human respiratory tract model (HRTM) for the assessment of internal dose by aerosol inhalation (Fig 1). ICRP provides information and guidance to the worldwide nuclear community to inform radiological protection practices.

The activity median aerodynamic diameter (AMAD) is an aerodynamic diameter for which 50% of the radioactivity in the cumulative size distribution. AMAD is a key parameter to predict internal dose from inhaling radioactive aerosols. It is used as a means to simplify the actual distribution of aerosol for internal dosimetry. The task group on lung dynamics of ICRP concluded that respiratory tract deposition was mainly related to the median of the distribution: AMAD and the breathing characteristics of the person.

Inhalation dose increased with decreasing particulate size. Committed effective doses due to inhalation of 0.01 μm sized particulates were higher than doses due to 100 μm sized particulates [4]. The aerosol particles of about 0.1 to 1 μm in size receive both aerodynamic and thermodynamic effects in the respiratory tract. Therefore, these particles in the respiratory region have a lower deposition fraction.

### *3.2 Internal exposure of workers depends on the aerosol diameter*

Measurements of airborne particulate in a wide range of nuclear workplaces have shown that activity is distributed on airborne particulate such that the AMAD is in the region of 5 μm [5]. However, the AMAD can affect the effective dose more than tens or hundreds of times (Fig 2). Thus, when the radiation dose is evaluated without consideration of aerosol characteristics precisely, it will be significantly distorted.

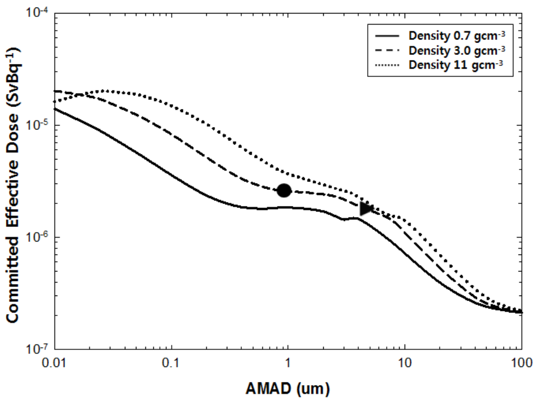


Fig. 2. Committed effective dose due to inhalation of airborne particulates by particulate mass density [4].

Internal radiation dose through radioactive aerosol inhalation depends on the particulate properties, such as size, shape, density, and absorption type. In order to the accurate assessment of worker exposure, for this reason, it is taken into consideration that both site-specific materials and the site-specific particulate properties.

## 4. Conclusion

It is significant to understand the distribution of radioactive aerosols according to their aerodynamic diameters, radioactive isotopes, chemical forms for the evaluating the worker's internal exposure.

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