SPECIAL ENVIRONMENTAL SURVEILLANCE PROGRAM FOR UF_6 CONVERSION AND URANIUM FUEL FABRICATION PLANTS IN THE UNITED STATES

Shum, Edward Y. S. and Crow, William T.
U.S. Nuclear Regulatory Commission
Office of Nuclear Material Safety and Safeguards

INTRODUCTION

In 1977, the U.S. Environmental Protection Agency (EPA) issued regulations setting forth environmental protection standards for uranium fuel cycle facilities. The regulations require that radioactivity in normal effluent releases, radon and its daughters excepted, from uranium fuel cycle plants be limited so that no member of the public will receive an annual exposure resulting in a dose equivalent of more than 25 millirems to the whole-body, 75 millirems to the thyroid or 25 millirems to any other organ. The U.S. Nuclear Regulatory Commission (NRC) is responsible for assuring that uranium fuel cycle plants licensed by the NRC meet these radiation protection standards. The enforcement of the standards has revised the conventional method of environmental monitoring requirements of these facilities. The following sections describe the general procedure and special environmental program required to demonstrate compliance with the EPA standards for two types of nuclear facilities, uranium hexafluoride conversion and uranium fuel fabrication plants. The current status of compliance for these plants is also discussed.

GENERAL PROCEDURE FOR DEMONSTRATION OF COMPLIANCE

The EPA standards require assessment of realistic doses received by individuals living near the plant. The general procedure for demonstration of compliance is to perform a dose calculation using measured effluent release data and applying environmental pathway models for dose calculations. For the uranium hexafluoride conversion and uranium fuel fabrication plants, the critical pathway of dose to man is from direct inhalation. The liquid pathway is not a realistic pathway, since there is no nearby resident using surface water in streams where the plants' liquid effluents discharge. Most of the dose received is expected from the air pathway. Table 1 summarizes the current release rate of radionuclides in air effluents from these facilities in the United States. At present there are two uranium hexafluoride conversion facilities and seven fuel fabrication plants in the United States. The release rates in Table 1 vary substantially because of differences in the types of processes, operational rates and effluent treatment systems. Also included in Table 1 are the distances from the plant to the nearest resident who is expected to be highest exposed from the plant's release. For dose calculation purposes, the critical organs from the intake of uranium are either the lung or the bone depending on the solubility classification of uranium. Table 2 summarizes the air concentrations of uranium of different solubility classification and particle size which, if breathed for one year, would result in a bone or lung dose of 25 mrem. The permissible concentrations were derived using 50-year committed dose conversion factors generated from the ICRP

Task Group Lung Model, and 80% occupancy time and inhalation rate of 8,000 m^3/yr for an adult. As shown in Table 2, the permissible uranium concentrations could vary by order of magnitude depending on the solubility classification and the particle sizes which are highly important in dose calculation.

SPECIAL MONITORING PROGRAM REQUIRED

To demonstrate compliance with the EPA standards, measurement has to be made of uranium solubility and particle size to provide sufficient information for dose assessment unless the plant meets the standard by conservative calculation. The measurements of solubility and particle size of uranium in stack effluents from plant releases are generally difficult and expensive, since plants typically have multiple stacks. The preferred method of measurement is to take samples for analysis from the location of the nearby residence. The cascade impactor is normally used to determine the activity median aerodynamic diameter (AMAD) of the particle size. High volume air samplers are used to collect air particulates for the solubility test and the dissolution rates in simulated lung fluids are determined in terms of the ICRP Task Group Lung Model. In addition to these measurements, continuous air sampling is conducted at the nearby residence to measure annual average concentration of uranium rather than relying on measurements of all plant effluents and applying a meteorologial model such as the Gaussian plume model to calculate the uranium concentration at the residence. This is necessary at plants which have multiple stacks and when the nearest resident is so close to the plant that the normal Gaussian plume model cannot be applied.

For analyzing air particulates, the conventional method of gross alpha analysis of the air filter cannot be used since the method is not capable of measuring air concentrations as low as 10^{-15} to 10^{-16} microcuries per milliliter. The collected air samples must be composited and analyzed either by the fluorimetric method or by gamma spectroscopy. At one facility, residences are located directly across a street within 50 meters from the plant and there are more than 30 small discharge stacks. The points of maximum impact from the plant's discharge must be determined by measuring the isopleths of uranium deposition around the plant under typical weather conditions. The above special monitoring program was not required before the more restrictive standards became effective.

CURRENT COMPLIANCE STATUS

Table 3 summarizes the current compliance status of the EPA standards for these plants. At present, all of the facilities are in compliance.

Table 1
Annual Routine Releases of Uranium from UF_6 and Fuel Fabrication Facilities

Facility	Release Rate (Ci/yr) from Stacks	Major Uranium Compounds	Nearby Resident from Plant (m)
A. UF_6 Conversion Facilities			
1. Allied Chemical Corp.	2.8×10^{-1}	U_3O_8, UO_3, UO_2F_2, UF_4	430 meter
2. Kerr-McGee Corp.	1.4×10^{-1}	U_3O_8, UO_3, UO_2F_2, UF_4	800 meter
B. Fuel Fabrication Facilities			
1. Exxon Nuclear Co. (UF_6 to UO_2 & pelletizing)	3.9×10^{-5}	UO_2F_2, UO_2, U_3O_8, $(NH_4)_2U_2O_7$	3,350 meter
2. Westinghouse Electric Corp. (UF_6 to UO_2 & pelletizing)	1.7×10^{-3}	UO_2F_2, UO_2, U_3O_8, $(NH_4)_2U_2O_7$	1,100 meter
3. General Electric Co. (UF_6 to UO_2 & pelletizing)	8.5×10^{-4}	UO_2F_2, UO_2, U_3O_8, $(NH_4)_2U_2O_7$	600 meter
4. B & W Co. (Apollo) (UF_6 to UO_2)	9.4×10^{-4}	UO_2F_2, UO_2, U_3O_8, $(NH_4)_2U_2O_7$	50 meter
5. B & W Co. (Lynchburg) (pelletizing)	8.3×10^{6}	UO_2	800 meter
6. Combustion Engineering, Inc. (UF_6 to UO_2)	5.6×10^{-5}	UO_2F_2, UO_2	630 meter
7. Combustion Engineering, Inc. (pelletizing)	4.3×10^{-5}	UO_2	800 meter

Table 2
Permissible Air Concentrations of Uranium in Compliance with EPA Standards Under Various Solubility Classification and Particle Sizes

Uranium Solubility Classification	Permissible Concentration of Uranium (μC/ml)	
	Bone (25 mrem)[b]	Lung (25 mrem)
1. Y Compounds[a]		
A. AMAD[c] = 0.3 micron	7.1E-13[d]	6.0E-15
B. AMAD = 1.0 micron	1.0E-12	9.3E-15
C. AMAD = 5.0 micron	1.7E-12	2.0E-14
2. W Compounds		
A. AMAD = 0.3 micron	4.2E-13	5.9E-14
B. AMAD = 1.0 micron	4.2E-13	9.3E-14
C. AMAD = 5.0 micron	3.4E-13	2.0E-13
3. D Compounds		
A. AMAD = 0.3 micron	1.0E-13	3.5E-12
B. AMAD = 1.0 micron	1.0E-13	5.5E-12
C. AMAD = 5.0 micron	8.1E-14	1.3E-11

[a] Solubility classification based on ICRP Task Group Lung Model.
[b] Dose calculation based on 80% occupancy time and inhalation rate of 8,000 m^3/yr for an adult.
[c] AMAD = Activity median aerodynamic diameter.
[d] E-13 = 10^{-13}

Table 3
Current Compliance Status of EPA Standards for the UF_6 Conversion and Fuel Fabrication Facilities in the United States

Types of Facility	Nearby Resident from Plant	Maximum Critical Organ Dose to the Nearby Resident	
		Lung (mrem)	Bone (mrem)
A. UF_6 Conversion Facilities			
1. Allied Chemical Corporation	430 meter	24.0	9.0
2. Kerr-McGee Corporation	800 meter	6.0	4.0
B. Fuel Fabrication Facilities			
1. Exxon Nuclear Co.	3,350 meter	<1	<1
2. Westinghouse Electric Corp	1,100 meter	3	<1
3. General Electric Co.	600 meter	1	<1
4. B&W Co. (Apollo)	50 meter	6	1
5. B&W Co. (Lynchburg)	800 meter	<1	<1
6. Combustion Engineering, Inc. (Hematite)	630 meter	<1	<1
7. Combustion Engineering, Inc. (Windsor)	800 meter	<1	<1