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OFFICE OF STANDARDS DEVELOPMENT
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HEALTH PHYSICS SURVEYS IN URANIUM MILLS

A. INTRODUCTION

Section 40.32, "General Requirements for Issuance of Specific Licenses," of 10 CFR Part 40 of the Commission's regulations states that the Commission will approve an application for a specific license to operate a uranium mill if the applicant is qualified by reason of training and experience to use the source material for the purpose requested in such manner as to protect health and minimize danger to life and property and if the applicant's proposed equipment, facilities, and procedures are adequate to protect health and minimize danger to life and property.

The following sections of 10 CFR Part 20, "Standards for Protection Against Radiation," of the Commission's regulations deal with the protection of mill workers: § 20.201, which requires adequate surveys, § 20.101, which limits worker exposure to external radiation, § 20.103, which limits exposure to airborne radioactive material in restricted areas, § 20.202, which requires personnel monitoring for radiation in certain instances, § 20.203, which requires posting of warning signs and controlled access to areas with high radiation levels, § 20.401, which requires records of radiation surveys and personnel monitoring reports, and § 20.405, which requires reports of over-exposures.

This guide describes health physics surveys acceptable to the NRC staff for protecting uranium mill workers from radiation and the chemical toxicity of uranium while on the job. The guidance can also be applied, in part, to other types of uranium recovery facilities since many of the processes used in uranium recovery facilities that have the potential for exposing employees to radioactivity are similar to operations conducted at uranium mills. The guide

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This regulatory guide and the associated value/impact statement are being issued in draft form to involve the public in the early stages of the development of a regulatory position in this area. They have not received complete staff review and do not represent an official NRC staff position.

Public comments are being solicited on both drafts, the guide (including any implementation schedule) and the value/impact statement. Comments on the value/impact statement should be accompanied by supporting data. Comments on both drafts should be sent to the Secretary of the Commission, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Attention: Docketing and Service Branch, by OCT 20 1980

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does not cover surveys to prevent the release of radioactive material to unrestricted areas or surveys to measure exposure of the public to radioactive materials in effluents, with the exception of surveys of the skin and clothing of workers leaving the mill and surveys of equipment and packages leaving the mill.

B. DISCUSSION

Regulatory Guide 3.5, "Standard Format and Content of License Applications for Uranium Mills," outlines the type of information that applicants for a uranium mill license should include in their application and suggests a uniform format for presenting that information. This regulatory guide describes health physics (radiation protection) surveys acceptable to the NRC licensing staff that an applicant may describe as recommended in Section C.5, "Operations," in Regulatory Guide 3.5.

The contents of this guide are based to a significant extent on the health physics survey programs now being required by the NRC licensing staff. The contents of this guide are also based to a large extent on the International Atomic Energy Agency (IAEA) "Manual of Radiological Safety in Uranium and Thorium Mines and Mills" (Ref. 1).

The subjects of respiratory protection and uranium bioassay are not included in this guide. Those subjects are covered in Regulatory Guides 8.15, "Acceptable Programs for Respiratory Protection," 8.22, "Bioassay at Uranium Mills," and Draft Regulatory Guide OH 941-4, "Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Mills Are As Low As Is Reasonably Achievable." Guidance on quality assurance programs can also be obtained from Regulatory Guide 4.15, "Quality Assurance for Radiological Monitoring Programs (Normal Operations)--Effluent Streams and the Environment."

C. REGULATORY POSITION

1. SURVEYS

1.1 Surveys for Airborne Uranium Ore Dust

Surveys for airborne uranium ore dust are necessary (1) to demonstrate compliance with the weekly intake limits for workers specified in paragraphs

20.103(b)(2) as well as the quarterly intake limits for workers specified in paragraph 20.103(a) of 10 CFR Part 20; (2) to meet the posting requirements for airborne radioactivity areas in § 20.203(d); (3) to determine whether precautionary procedures such as process or other engineering controls, increased surveillance, limitation on working times, provision of respiratory protective equipment, or other precautions should be considered to meet paragraphs 20.103(b)(1) and (b)(2); and (4) to determine whether exposures to radioactive materials are being maintained as low as is reasonably achievable as stated in paragraphs 20.1(c) and 20.103(b)(2).

The concentration value in Appendix B to Part 20 for airborne uranium ore dust in restricted areas is 75 micrograms of natural uranium per cubic meter of air* (from paragraph 4 of the Note to Appendix B)** or, if gross alpha counting of the air sample is performed, the concentration value is 1×10^{-10} microcuries per milliliter of air. This value applies to the alpha emissions of uranium-238, uranium-235 (negligible), uranium-234, thorium-230, and radium-226. If chemical separation and counting or spectrometric procedures are used to determine the alpha emission rate from uranium alone, the concentration value is 5×10^{-11} microcuries of uranium per milliliter of air. The uranium ore dust concentration value is applicable to areas where ore dust is handled prior to chemical separation of the uranium from the ore. Where the ore crushing and grinding circuits, chemical leaching areas, and yellowcake areas are physically isolated from each other, the ore dust value obviously applies to the ore handling areas.

Where ore handling and yellowcake processing are not physically isolated from each other, it is necessary to have some knowledge of the source of the airborne material to determine whether the uranium ore dust limit applies. For example, in a mill that produces little ore dust because of a wet ore grinding process but has significant emissions from yellowcake processing equipment, the natural uranium concentration of 200 micrograms of natural uranium per cubic meter of air (or 1×10^{-10} microcuries per milliliter) may be applicable throughout the plant. In order to determine if uranium ore dust concentrations are sufficiently low to allow use of this limit for natural uranium,

*Uranium concentrations are expressed preferentially in mass units instead of radiological units because (1) uranium concentrations are usually measured in terms of mass, and (2) the intake limit is usually based on the mass of uranium in the kidney to avoid effects of chemical toxicity.

**Micrograms of uranium can be converted to microcuries by using the specific activity of natural uranium: 6.77×10^{-7} microcuries per microgram.

paragraph 5 of the Note to Appendix B to Part 20 must be consulted. If uranium ore dust is present in quantities below 7.5 micrograms of uranium per cubic meter of air (i.e., below 10% of the ore dust limit), uranium ore dust may be considered to be not present, and the value for natural uranium of 200 micrograms per cubic meter may be used instead of the uranium ore dust limit of 75 micrograms per cubic meter.

An acceptable sampling program for airborne uranium ore dust includes monthly grab samples of 60-minutes duration in worker-occupied areas in which ore is actively handled. The quantity of air sampled and the method of analysis should allow a lower limit of detection (LLD) of at least 7.5 micrograms per cubic meter or 5×10^{-12} microcuries of natural uranium per milliliter of air. However, if any area has been designated as an "airborne radioactivity area," as defined in paragraph 20.203(d), sampling frequency should be increased to weekly and, in addition, an investigation of the cause of the high levels should be made. Where practicable, engineering controls should be adopted to prevent ore handling areas from becoming airborne radioactivity areas. Outdoor areas such as the ore pad should be sampled quarterly. Sample analysis should usually be completed within two working days after sample collection. Unusual results should be reported promptly to the Radiation Safety Officer (RSO).*

Only ore dust samples representative of the air inhaled by the workers present are acceptable to the NRC staff. Samples taken between the source and the worker are considered representative. Samples should be taken while normal ore handling is taking place. The state of operation of major equipment during sampling should be recorded. In large rooms, several locations should be sampled.

During the first year of operation, new mills will need a much more extensive air sampling program than operating mills to determine what locations provide concentrations representative of the concentrations inhaled by workers.

1.2 Surveys for Airborne Yellowcake

Studies show that yellowcake, a mixture primarily of ammonium diuranate and uranium oxides, is composed of soluble (biological halflife in the lung is

*The title "Radiation Safety Officer" is used by many licensees and, in this guide, will apply to the person responsible for conducting health physics survey programs; other titles are equally acceptable.

less than 50 days) and insoluble (biological halflife in the lung is greater than 50 days) components (Refs. 2, 3, and 4). For simplicity and added protection, it should generally be assumed that yellowcake is entirely soluble for compliance with weekly limits. Intake of soluble uranium must be limited on a weekly basis in addition to the quarterly intake limit for combinations of radionuclides because paragraph 20.103(a)(2), in connection with footnote 4 of Appendix B to Part 20, imposes a weekly intake limit of 9.6 milligrams for soluble uranium (i.e., equivalent to breathing at a rate of 1.2 cubic meters per hour for 40 hours in air containing 200 micrograms of natural uranium per cubic meter or 1×10^{-10} microcuries of natural uranium per milliliter of air). This special provision for soluble uranium is for protecting the kidneys from the chemical toxicity of uranium. The basis for Part 20 limits for soluble natural uranium is that the chemical toxicity limit is always more restrictive than the radiological limit.

Thus, surveys for airborne yellowcake are necessary to demonstrate compliance with the weekly limit in paragraph 20.103(a). Surveys are also necessary to establish the boundaries of airborne radioactivity areas and to determine whether precautionary procedures such as process or other engineering controls, increased surveillance, limitation on working times, provisions of respiratory equipment, or other precautions should be considered in compliance with paragraph 20.103(b).

Surveys for yellowcake are more extensive than ore dust surveys; yellowcake is a greater potential inhalation hazard than uranium ore dust because of its concentrated form. The lung, bone, and kidney are the organs primarily subject to radiation from uranium. In addition, yellowcake is a chemical toxicity hazard to the kidney. If the kidney is adequately protected from yellowcake, no organ dose limits will be exceeded according to the dosimetric models forming the basis for the Commission's regulations.

The recommended survey program for yellowcake uses a combination of (1) area air sampling and (2) breathing zone sampling during operations that may involve considerable intake such as those that require a special work permit.

Area air sampling for yellowcake should be performed weekly in airborne radioactivity areas and monthly in areas where yellowcake is present but not in sufficient quantity for the area to be designated an airborne radioactivity area. The increased surveillance of airborne radioactivity areas should be performed to meet the requirement in paragraph 20.103(b)(2) for such areas.

Samples should be representative of the air inhaled by the workers. The state of operation of major equipment during sampling should be noted. The quantity of air sampled and the method of analysis should allow an LLD of at least 20 micrograms of uranium per cubic meter of air (10% of the Appendix B concentration). Breathing zone sampling for specific jobs should be used to monitor intakes of individual workers doing jobs that are likely to involve more than 10 MPC-hours* in any one job. An example of a job during which such breathing zone sampling may be used is maintenance of yellowcake drying and packaging equipment. Sample analysis should usually be completed within one working day after sample collection. Unusual results should be reported promptly to the RSO, and an investigation of the causes should be made.

1.3 Surveys for Radon-222 and Its Daughters

In uranium mills, significant concentrations in air of radon and its daughters may occur near ore storage bins and crushing and grinding circuits or in enclosed locations where large quantities of ore are found, particularly dry ore.

NRC regulations permit measurements of concentrations of either radon-222 itself or the radon daughters. However, at uranium mills, measurements of daughters are considered by the staff to be more appropriate. Radon daughter measurements are both easier to obtain and more relevant in terms of hazard to the worker.

Monthly measurements of radon-222 daughter concentrations should be made where radon-222 daughters routinely exceed 10% of the limit or 0.03 working level (i.e., the daughter concentrations are present according to paragraph 5 of the Note to Appendix B to Part 20). If radon-222 daughter concentrations are normally greater than 0.08 working level (25% of limit), the sampling frequency should be increased to weekly. Quarterly sampling for radon-222 daughters should be made where previous measurements have shown the daughters are not generally present in concentrations exceeding 0.03 working level (10% of the limit) but where proximity to sources of radon-222 daughters might allow them to be

*MPC is the acronym for maximum permissible concentration.

present. For example, quarterly measurements might be appropriate for a shop area attached to the crushing and grinding circuit building.

Radon-222 daughter samples should be taken so as to be representative of worker exposures. Samples should be taken near locations where workers are most often present. The state of operation of major equipment during sampling and the time of day the sample was taken should be recorded.

The lower limit of detection for radon-222 daughter measurements should be 0.03 working level so that concentrations defined as being present in paragraph 5 of the Note to Appendix B to Part 20 can be detected. The lower limit of detection (LLD) for a single measurement is defined as:

$$LLD = 4.66S$$

where S is the standard deviation of the normal background, i.e., alpha emitters on a filter after radon daughters have decayed away.*

However, measured values less than the lower limit of detection, including negative values, should still be recorded on data sheets. The lower limit of detection is set high enough to provide a high degree of confidence that any measured value above the LLD truly represents radon daughters and is not a "false positive" value. However, the most accurate annual average for an area is still obtained by averaging all measured values, including values obtained that are below the lower limit of detection.

The modified Kusnetz method for measuring radon daughter working levels is a suitable method for uranium mills. The procedure consists of sampling radon daughters on a high efficiency filter paper for 5 minutes and, after a delay of 40 to 90 minutes, measuring the alpha activity on the filter. The original Kusnetz method used a rate meter to measure alpha activity. In the modified Kusnetz method, the rate meter is replaced by a scaler. This improves the sensitivity to a practical lower limit of 0.03 working level for a 1-minute count on a 10-liter (0.01 cubic meter) sample. This is about a factor of 10 lower than that originally obtained using the original Kusnetz method. A 4-minute count gives a lower limit of about 0.003 working level (Ref. 1).

*This definition of LLD was chosen to be consistent with the NRC position previously stated in Tables 1 and 3 of Regulatory Guide 4.8, "Environmental Technical Specifications for Nuclear Power Plants." The basis for the definition is given in Reference 5. The definition is also used in other Regulatory Guides, among them 4.14, "Radiological Effluent and Environmental Monitoring at Uranium Mills," and 8.14, "Personnel Neutron Dosimeters."

High efficiency membrane or glass fiber filters should be used to minimize loss of alpha counts by absorption in the filter. However, a corrective factor to account for alpha absorption in the filter paper should still be used. Care should be taken to avoid contamination of the alpha counter.

The modified Kusnetz method is discussed in more detail in References 1 and 6. Other acceptable methods discussed in Reference 1 are the original Kusnetz method with greater than 10 liters of air sampled, the modified Tsivoglou method, and the Rolle method. The modified Tsivoglou method is slightly more accurate but is also more complicated than the modified Kusnetz method. The Rolle method is quicker than the Kusnetz method, but is less sensitive. Alpha spectroscopy yields acceptable results, but the instruments are expensive and fragile and lack portability. Recently "instant working level" meters have been developed, which have the advantage of speed. These are also acceptable if an LLD of 0.03 working level can be achieved.

1.4 Surveys for External Radiation and Action Levels for External Radiation

Most, but not all, mill workers receive external gamma radiation doses of less than 1 rem per year (Ref. 1). Gamma radiation exposure rates are generally below 1 milliroentgen per hour in contact with incoming ore and are about 1.2 milliroentgens per hour in contact with fresh yellowcake (Ref. 1). During the buildup of the uranium daughters thorium-234 and protactinium-234 in fresh yellowcake, the radiation levels increase somewhat for several months following yellowcake production.

Gamma radiation surveys should be performed semiannually throughout the mill at locations representative of where workers are exposed in order to allow determination of radiation area boundaries in accordance with paragraph 20.203(b) and to determine external radiation dosimetry requirements, in accordance with § 20.202. At new mills a gamma radiation survey should be performed shortly after plant operation starts.

If the semiannual survey reveals any areas accessible to personnel where the gamma exposure rates are high enough that a major portion of the body of an individual could receive a dose in excess of 5 millirems in any hour or a dose in excess of 100 millirems in any 5 consecutive days, the area must be designated a "radiation area," as defined in paragraph 20.202(b)(2), and surveys of this area should be made quarterly. For example, if the maximum time any individual worker spends in a room in a 5-day period is 40 hours, the room will be a radiation area if the exposure rate exceeds 2.5 milliroentgens per hour. Surveys performed for this purpose should be representative of where workers sometimes stand so that their whole-body radiation exposures can be estimated. Thus, measurements should generally be made at about waist height and 12 inches from surfaces (see § 20.204(a) and Item 6(a) of Regulatory Guide 10.6, "Guide for the Preparation of Applications for Use of Sealed Sources and Devices for the Performance of Industrial Radiography"). Use of surface "contact" exposure rate measurements are not required for establishing radiation area boundaries or estimating personnel whole-body exposures because these exposures would not be representative of the exposures workers would receive.

The existence of a radiation area in a mill should be considered an action level. If a radiation area exists, the cause of the elevated gamma radiation levels should be investigated, and actions to reduce the radiation levels should be taken if practicable.

A list of the radiation levels in each area of the plant should be prepared after each survey. The number of areas on the list should be held to a manageable number. In general, a minimum of 20 survey locations is necessary to characterize the radiation levels in the mill.

To determine the need for personnel monitoring, quarterly radiation exposures expected for each category of plant worker should be calculated from the measured radiation levels and predicted occupancy times. If the calculated quarterly radiation gamma ray exposure for any individual worker exceeds 0.31 rem, § 20.202 of 10 CFR Part 20 requires that the worker wear a personnel radiation dosimeter (e.g., film badge or TLD). In addition, personnel monitoring should be used for at least a 1-year period to verify the survey results even if predicted levels are below 0.31 rem. If external radiation doses to any worker exceed 0.31 rem per quarter, an investigation of the causes should be made and corrective actions taken if appropriate.

In addition to gamma surveys, beta surveys should be made every two years to estimate extremity and skin exposures for workers who work for long periods in close proximity to yellowcake. This survey does not require more frequent measurements of yellowcake beta levels since those beta levels are fairly constant. The beta dose rate from a uranium metal slab in which equilibrium with protactinium-234 and thorium-234 has been reached is about 240 millirems per hour. The dose level from fresh yellowcake will be below this because of lower uranium density, self-shielding by oxygen and other elements, and lower concentrations of protactinium-234 and thorium-234 that have not regained equilibrium. In addition, rubber gloves will largely eliminate the beta dose to the hands if used. Extremity monitoring is required by paragraph 20.202(a) for any worker whose hand dose would exceed 4.68 rems in a quarter.

It should be noted that commercially available film badge and TLD services often cannot measure beta radiation in the mixed beta-gamma field of a uranium mill (see, for example, Tables A-11 and A-12 of Reference 7). Workers' beta doses should be estimated from survey instrument measurements rather than from such dosimetry data.

1.5 Surveys for Surface Contamination

NRC regulations provide no specific limit on surface contamination levels in restricted areas. However, yellowcake or ore dust lying on surfaces can become resuspended in the air if they are disturbed. Thus, surface contamination presents a potential source of hazardous airborne material; it can become resuspended and contribute to the intake of radionuclides, which is limited by paragraph 20.103(a).

In ore-handling areas, surface contamination is not a serious problem because of the very low specific activity of the ore. In fact, cleanup attempts by methods such as sweeping are likely to produce a more serious hazard through resuspension in the air than if the ore dust were allowed to remain where it lies. When necessary, cleanup may be performed by hosing down the ore dust into floor sumps or by using vacuum suction systems.

In leaching and chemical separation areas there is usually little dust and little difficulty with surface contamination during normal operations.

In the precipitation circuit and the yellowcake drying and barrelling areas, surface contamination can be a problem because of the concentrated nature of the yellowcake. The IAEA recommends (in Reference 1) a limit for surface contamination on walls, floors, benches, clothing, etc., of 10^{-3} μCi/cm^2 (220,000 dpm/100 cm^2), which is equivalent to almost 2 mg/cm^2 of natural uranium. Based on experience, the IAEA concluded that if surface contamination levels are kept below this value, the contribution to airborne radioactivity from surface contamination will be well below applicable limits. The British National Radiological Protection Board also recommends a limit of 10^{-3} μC/cm^2 for uranium contamination in active areas of plants (Ref. 8), based on calculations using resuspension factors rather than experience. The NRC staff considers these levels acceptable to meet the ALARA concept in uranium mills. The levels are low enough to ensure little contribution to airborne radioactivity, yet not so low that the cost of meeting them in uranium mills is too high. Such an amount of surface contamination is readily visible because of the low specific activity of uranium and does not require a survey instrument for detection. Daily visual inspections should be made for locating yellowcake contamination on surfaces.

Visible yellowcake should be cleaned up promptly, especially where contamination will be disturbed and resuspended on walkways, railings, tools, vibrating machinery, and similar surfaces. Spills should be cleaned up before the yellowcake dries so that resuspension will be lessened. Surfaces on which yellowcake may settle should be painted in contrasting colors to make the yellowcake more visible.

In rooms where work with uranium is not performed, such as eating rooms, change rooms, control rooms, and offices, a lower level of surface contamination should be maintained. These areas should be spot-checked weekly for removable surface contamination using smear tests and for total contamination using instrument measurements. The areas should be promptly cleaned if surface contamination levels exceed 25% of the values in Table 1.

TABLE 1

SURFACE CONTAMINATION LEVELS
FOR URANIUM AND ASSOCIATED DECAY PRODUCTS
(REFERENCES 9 AND 10)

Average (total)	5,000 dpm alpha per 100 cm^2	Averaged over no more than 1 m^2
Maximum (total)	15,000 dpm alpha per 100 cm^2	Applies to an area of not more than 100 cm^2
Removable	1,000 dpm alpha per 100 cm^2	Determined by smearing with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the smear

1.6 Surveys for Contamination of Skin and Personal Clothing

Contamination of skin and personal clothing should be controlled to prevent the spread of contamination to unrestricted areas (i.e., the workers' cars and homes). Alpha radiation from uranium on the skin or clothing is not a direct radiation hazard because the alpha particles do not penetrate the dead layer of the skin. Rather, uranium is primarily a hazard if it is inhaled or swallowed.

Visual examination for yellowcake is not sufficient evidence that the worker's skin or clothing is sufficiently free of contamination to permit the workers to leave the work environment. Normally such contamination can be adequately controlled if workers wash their hands before eating, shower before going home, and do not wear street clothes while working with yellowcake in the mill. Prior to leaving the restricted area, all mill employees should either shower or monitor themselves after changing clothes. An alpha survey instrument should be available at the exit of the employee change room. If clothing is not changed, clothing should be monitored. In addition, the licensee should perform at least quarterly using an alpha survey instrument an unannounced spot survey for alpha contamination on workers leaving the mill. The licensee should adopt an action level of 1000 dpm per 100 square centimeters. If levels exceed this action level, additional showering or decontamination should be done, and an investigation of the cause of the contamination should be made. These levels are considered by the NRC staff to meet the ALARA concept in a uranium mill.

1.7 Surveys of Equipment Prior to Release to Unrestricted Areas.

Surface contamination surveys should be conducted before potentially contaminated equipment is released to unrestricted areas. If contamination is detected, the equipment should be decontaminated until additional efforts do not significantly reduce contamination levels. The applicant may propose and justify total and removable contamination limits below which release of the equipment to unrestricted areas is permitted. The surface contamination levels listed in Table 1 are acceptable to the licensing staff and need not be justified by the applicant (Refs. 9 and 10).

1.8 Survey of Packages Prepared for Shipment

Smear tests of external surfaces of yellowcake packages prepared for shipment should be carried out after packaging. Packages having contamination should be cleaned until the packages meet Department of Transportation requirements for nonexclusive-use vehicles in § 173.397 of 49 CFR Part 173; i.e., removable alpha contamination must be below 22,000 dpm per 100 cm^2 averaged over 300 cm^2.

1.9 Ventilation Surveys

Surveys of the adequacy of ventilation systems for both enclosed and unenclosed areas are discussed in Draft Regulatory Guide OH 941-4, "Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Mills Will Be As Low As Is Reasonably Achievable."

2. INTAKE AND EXPOSURE CALCULATIONS

Uranium Ore Dust and Yellowcake.

In 10 CFR Part 20, paragraph 20.103(a)(1) establishes a quarterly limit on exposure to airborne uranium ore dust, and paragraph 20.103(a)(2) establishes a weekly limit on exposure to soluble uranium.

The intake of uranium ore dust or yellowcake during the weekly or quarterly period being evaluated should be estimated using the following equation:

$$I = b \sum_{i=1}^{n} \chi_i \, t_i \qquad (1)$$

where

I = uranium intake, μg or μCi

t_i = time of exposure to average concentration χ_i, hrs

χ_i = average concentration of uranium in breathing zone air during the time t_i, μg/m^3 or μCi/m^3

b = breathing rate, 1.2 m^3/hr

n = number of exposure periods during the week or quarter

Radon Daughters

In 10 CFR Part 20, paragraph 20.103(a)(1) establishes an annual limit on exposure to radon daughters. This annual exposure should be estimated using the following equation:

$$E = \sum_{i=1}^{n} W_i t_i \qquad (2)$$

where

E = annual radon daughter exposure, working-level months

t_i = time of exposure to W_i, months

W_i = average number of working levels in breathing zone air during the time t_i

n = number of exposure periods during the year

If the licensee's respiratory protection program is being conducted in full conformance with Regulatory Guide 8.15 and the appropriate NRC regional office has been notified that the licensee plans to use respirators, χ_i and W_i values may be divided by the prescribed protection factor in the calculation of I and E.

The preferred method for determining values of t_i is that of actual timing and recording for each exposure. However, t_i values may be derived from a time study of worker occupancy in the various mill areas provided that the elapsed time between the completion of the time study and the intake determination does not exceed 3 months. When nonroutine maintenance or cleanup operations are performed, accurate time records should be kept, and the results of special area or breathing zone samples taken over this period should be used in calculating employee exposures.

3. REPORTS OF OVEREXPOSURES TO AIRBORNE MATERIALS

Overexposure reports to the appropriate NRC regional office are required by § 20.405 if the intake of uranium ore dust or yellowcake exceeds the quantities specified in § 20.103 or if the exposure to radon and its daughters exceeds the working-level values specified in footnote 3 to Appendix B to 10 CFR Part 20. Many uranium mill workers are exposed to a combination of these materials; in such cases, Appendix B to 10 CFR Part 20 specifies the method for determining whether NRC exposure limits have been exceeded. Overexposure reports are also required for combined exposures that exceed NRC limits.

A listing of reportable overexposures for various uranium products follows:

1. Uranium Ore Dust. If during a period of 1 calendar quarter a worker is subjected to an intake of uranium in ore dust greater than 47,250 micrograms (0.03 microcuries)*, a reportable overexposure has occurred.

2. Yellowcake. If during a period of 1 calendar week a worker is subjected to an intake of uranium in yellowcake greater than 9,600 micrograms (0.0048 microcurie) or if during a period of 1 calendar quarter a worker is subjected to an intake of uranium in yellowcake greater than 126,000 micrograms (0.063 microcurie), a reportable overexposure has occurred.

3. Radon Daughters. If during a period of 1 calendar year a worker is subjected to a radon daughter exposure, caused by radon emanation from uranium ore, of more than 4 working-level months, a reportable overexposure has occurred.

4. Combination Exposures, Weekly Determination. For a worker exposed to yellowcake, it is necessary at the end of each week to determine whether a reportable overexposure has occurred. Since the 9600-microgram limit is intended to protect the kidney against chemical damage and since such damage from radon daughters is negligible, radon daughter exposure need not be considered in the weekly overexposure determination. However, *in vitro* solubility studies of uranium ore dust have indicated that uranium inhaled in this form will reach the kidney after buildup in the body and therefore should not be neglected in the weekly overexposure determination (Ref. 2). Therefore, the following procedure should be followed. In order to obtain the weekly average, use the ore dust uranium intake in micrograms for the most recent calendar quarter and divide by 13. This average is added to the yellowcake uranium intake in micrograms for the week in question. If the sum exceeds 9600 micrograms, a reportable overexposure has occurred.

5. Combined Exposures, Quarterly Determination. For a worker exposed to any mixture of these materials, at the end of each calendar quarter it is necessary to determine whether a reportable overexposure has occurred. The following

*I.e., 75 micrograms/m^3 x 630 m^3 = 47,250 micrograms. Similarly, 0.5 x 10^{-10} microcuries/ml x 10^6 ml/m^3 x 630 m^3 = 0.0315 microcurie.

procedure should be used for this purpose. Any ore dust uranium intake for the quarter, in micrograms, is divided by 47,250 micrograms (0.03 microcurie) to obtain the fraction of the limit that has been experienced. The yellowcake intake for the quarter, in micrograms, is divided by 126,000 micrograms (0.063 microcurie)* to obtain the fraction of that limit that has been experienced. The number of working-level months (radon daughter exposure) for the past 4 quarters is divided by 4. If the sum of these three fractions exceeds unity, a reportable overexposure has occurred.

4. ACTION LEVELS

4.1 The 40-Hour Control Measure

The 40-hour control measure specified in § 20.103(b)(2) is an action level of concern to the uranium mill operator only in the case of exposure to uranium ore dust and radon daughters. If during a period of 1 calendar week a worker is subjected to an intake of uranium in ore dust greater than 3,600 micrograms, radon daughters exceeding 1/13 working-level month, or fractional combinations exceeding one, § 20.103(b)(2) requires that the cause must be determined, corrective action to prevent another such occurrence must be taken, and a record of the corrective action must be maintained.

4.2 Administrative Action Levels

In addition, the licensee should establish administrative action levels for exposure to airborne radioactivity in accordance with the ALARA philosophy. These action levels should be some fraction of the allowable intakes or concentrations in 10 CFR 20 and should be established for at least the following:

1. Time-weighted exposures averaged over a week
2. Concentration of airborne radioactivity for any air sample.

*I.e., 200 micrograms/m^3 x 630 m^3 = 126,000 micrograms. Similarly, 10^{-10} microcuries/ml x 6.3 x 10^8 ml = 0.063 microcurie.

If any of these action levels are reached, an investigation should be performed by the RSO and any necessary action should be taken to ensure that both exposures and airborne concentrations are maintained as low as is reasonably achievable.

5. ESTABLISHMENT OF "AIRBORNE RADIOACTIVITY AREAS"

In general, yellowcake drying and packaging rooms and enclosures should always be considered to be airborne radioactivity areas because of the high concentrations that can result if any equipment malfunctions. On the other hand, ore crushing and grinding areas and areas outside yellowcake drying and packaging areas will not normally need to be classified as airborne radioactive areas when normal engineering controls are used. Any area, room, or enclosure is an "airborne radioactivity area" as defined in paragraph 20.203(d) if (1) at any time the uranium ore dust concentration or yellowcake concentration averaged over the different sampling locations exceeds 75 micrograms per cubic meter or 200 micrograms per cubic meter of air, respectively (i.e., the values in Appendix B to 10 CFR Part 20), or (2) the concentration exceeds 25 percent of the values in Appendix B to 10 CFR Part 20 averaged over the number of hours in any one week in which individuals are present in such area, room, or enclosure. For example, an area that is occupied 20 hours per week (out of the 40 hours assumed as a basis for the limits), is an airborne radioactivity area if the concentration of uranium in yellowcake exceeds 100 micrograms per cubic meter of air. The licensee must, of course, maintain adequate records to show that occupancy was in fact thus limited. If radon-222 daughters or ore dust are also present (see Section C.1.3 of this guide), their concentrations divided by the Table I Appendix B value should be added. If the sum exceeds unity or exceeds 0.25 after adjustment of the Appendix B value for the occupancy factor, the area is an airborne radioactivity area.

6. POSTING OF CAUTION SIGNS, LABELS, AND NOTICES TO EMPLOYEES; ACCESS CONTROLS

The radiation protection staff should periodically survey to ensure that signs, labels, required notices to employees, copies of licenses, and other items are properly posted as required by 10 CFR Part 20.

The mill and tailings area should be fenced to restrict access, and the fence should be posted with "Caution, Radioactive Material" signs as required in paragraph 20.203(e)(2). If the fence and all entrances are thus posted and in addition contain the words "Any area within this mill may contain radioactive material," the entire area is posted adequately to meet the requirement in paragraph 20.203(e)(2). Additional posting of each room with "Radioactive Material" signs is not necessary. "Radiation Area" and "Airborne Radioactivity Area" must still be posted in accordance with paragraphs 20.203(b) and (d). Parking for employees and visitors should be outside the restricted area.

7. CALIBRATION OF SURVEY INSTRUMENTS

Portable survey instruments should be placed on a routine maintenance and calibration program to ensure that properly calibrated and operable survey instruments are available at all times for use by the health physics staff.

An adequate calibration of survey instruments cannot be performed solely with built-in check sources. Electronic calibrations that do not involve a source of radiation will not determine the proper functioning and response of all components of an instrument. However, an initial calibration with a radiation source and periodic tests using electronic input signals may be considered adequate for high ranges of survey instruments that are not used routinely.

Survey instruments should be checked prior to each usage. This check should be supplemented at 6-month intervals or at the manufacturer's suggested interval, whichever is shorter, with a calibration of each instrument at two points separated by at least 50 percent of each linear scale routinely used or with a calibration at one point near the midpoint of each decade on logarithmic scales that are routinely used. Digital readout instruments with either manual or automatic scale switching should be calibrated in the same manner as are linear readout instruments. Digital readout instruments without scale switching should be calibrated in the same manner as are logarithmic readout instruments. Survey instruments should be calibrated following repair. A survey instrument may be considered properly calibrated when the instrument readings are within ±10 percent of the calculated or known values for each point checked. Readings within

±20 percent are considered acceptable if a calibration chart or graph is prepared and attached to the instrument.

Errors in estimates of the volume of air that has passed through filters should be avoided by accurate calibration of the flow rate and by preventing or correcting for the loss of flow caused by accumulation of material on the filter. Air flow rates through filters should be determined by calibrating pumps with the filter paper in place once every 6 months to ±20% accuracy. These calibrations should be done in accordance with manufacturer's recommendations. Further information on these calibrations is contained in Draft Regulatory Guide OH 905-4, "Calibration and Error Limits of Air Sampling Instruments for Total Volume of Air Sampled."

The fluorometric analysis system should be calibrated by running a known standard uranium and a blank with each batch.

Alpha counting systems used for radon daughter measurements should be calibrated at least monthly by using a known standard alpha source.

8. PROTECTIVE CLOTHING

Workers working in airborne radioactivity areas should be provided with protective clothing such as coveralls and shoes or shoe covers. Gloves should be used when yellowcake will be handled because of its high beta dose rate. Rubber gloves should provide almost total shielding against the beta rays.

Protective clothing should be changed and discarded or laundered weekly or whenever yellowcake is visible on the clothing. Potentially contaminated clothing should not be sent to a laundry that is not specifically authorized by the NRC or an agreement state to process clothing contaminated with uranium unless the clothing has been surveyed and found to have less uranium contamination than the values in Table 1 of this guide.

9. QUALITY ASSURANCE PROGRAM

The licensee should ensure the accuracy of survey measurements by having a quality assurance program. Regulatory Guide 4.15, "Quality Assurance for Radiological Monitoring Program (Normal Operations)--Effluent Streams and the Environment," should be consulted for guidance on quality assurance.

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9. "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct Source, or Special Nuclear Material," Division of Fuel Cycle and Material Safety USNRC, Washington, DC 20555, November 1976.

10. Regulatory Guide 1.86, "Termination of Operating Licenses for Nuclear Reactors," June 1974.

DRAFT VALUE/IMPACT STATEMENT

1. PROPOSED ACTION

1.1 Description

Applicants for a uranium milling license must submit a license application containing the information specified in Regulatory Guide 3.5, "Standard Format and Content of License Applications for Uranium Mills." The purpose of this proposed action is to describe health physics surveys to protect workers that are acceptable to the NRC staff. Information about health physics surveys is covered under Section C.5, "Operations," in Regulatory Guide 3.5.

1.2 Need

Licensees are now uncertain what the NRC staff will accept in the way of a health physics survey program to protect workers. As a consequence, a wide variety of programs are submitted. In order to meet minimum acceptable standards, much correspondence between the applicant and NRC is required. A guide will reduce the amount of correspondence needed, save manpower for both NRC and the applicant, show clearly how NRC regulations apply to uranium mills, and establish a uniform standard for an acceptable survey program for worker protection.

1.3 Value/Impact

1.3.1 NRC

The impact of the proposed guidance will be primarily to reduce licensing staff effort expended in reviewing applications and corresponding with applicants in areas where the application does not meet acceptable NRC licensing standards. An estimated 0.5 man-year is required to develop the guide.

1.3.2 Other Government Agencies

The proposed guidance will impact on the Mine Safety and Health Administration (MSHA) because they also regulate occupational health protection at uranium mills and on Agreement State regulatory agencies that regulate mills, primarily agencies in New Mexico, Colorado, Texas, Washington, and Florida. A Memorandum of Understanding (MOU) signed by NRC and MSHA states that each agency will coordinate the development of standards with the other agency. The MOU was published in the Federal Register (45 FR 1315) on January 4, 1980.

1.3.3. Industry

Industry will benefit from having clear guidance on what constitutes NRC licensing policy. The total cost of the occupational health physics program (surveys plus other parts of the program) is estimated to be roughly 4 man-years per year or about $300,000 per year per mill when the costs of overhead, supplies, equipment, and contracted services are included. This does not include the cost of the environmental and effluent monitoring program nor does it include amortization costs on equipment in the mill installed to limit occupational exposure. Equipment design is not covered in this guide, therefore, costs are not estimated here. However, the annual amortization and operating costs of equipment installed to protect workers is not negligible.

1.3.4 Workers

Workers' protection should improve from having clearly stated and consistent standards for health physics survey programs. Workers and workers' representatives will now have access to a clearly defined standard health physics survey program. This will help them understand whether their employer has an adequate program and why some things are done as they are.

1.3.5 Public

The guidance pertains to worker protection programs. It will not directly affect the public.

1.4 Decision

The NRC should develop guidance on standard health physics survey programs for worker protection that are acceptable to the NRC licensing staff.

2. TECHNICAL APPROACH

The technical approach in the guidance will be based on (1) NRC licensing policy as expressed in Safety Evaluation Reports (SER) written by the NRC licensing staff, especially the recent SER for Minerals Exploration Company Sweetwater

Uranium Project; (2) the IAEA Manual on Radiological Safety in Uranium and Thorium Mines and Mills, IAEA Safety Series No. 43, 1976; and (3) other references to be cited in the guidance.

3. PROCEDURAL APPROACH

3.1 Procedural Alternatives

There are three reasonable procedural alternatives: (1) publish the guidance directly in the regulations, (2) publish the guidance in a regulatory guide, and (3) continue to provide guidance to applicants on a case-by-case basis.

3.2 Value/Impact of Procedural Alternatives

A regulation is not a really suitable vehicle for the type of guidance envisioned because much of a health physics survey program must be tailored to the design and needs of the individual mill. Regulations do not provide for the needed flexibility.

A Safety Evaluation Report is not the most desirable way to distribute the guidance because these reports are not widely circulated to the industry and public, and each Safety Evaluation Report differs from others because of the needs and desires of individual mill licensees.

The guidance envisioned seems best suited for a regulatory guide. A guide provides the best mix of flexibility and clear statement of a uniform and consistent licensing policy.

3.3 Decision on Procedural Approach

Developing a regulatory guide is the favored procedural approach.

4. CONCLUSION

In summary, it is proposed that a regulatory guide on health physics survey programs for worker protection in uranium mills be developed.

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