Department of Energy

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MEMORANDUM FOR DISTRIBUTION

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OFFICE OF HEALTH, SAFETY AND SECURITY

SUBJECT: Radiological Control Technical Position Providing an Alternative Means of Measuring Alpha Emitters in Uranium Contamination to Demonstrate Compliance with Title 10, Code of Federal Regulations, Part 835

The Office of Worker Safety and Health Policy issues Radiological Control Technical Positions in response to questions or issues associated with Department of Energy (DOE) occupational radiation protection programs.

The attached Radiological Control Technical Position provides an alternative means of measuring alpha emitters in uranium surface contamination to demonstrate compliance with title 10, Code of Federal Regulations, part 835 (10 C.F.R. 835), "Occupational Radiation Protection."

In June 2007, 10 C.F.R. 835 was amended. Footnote 7 of Appendix D, "Surface Contamination Values," was added to clarify measurement of alpha particles from the isotopes of uranium in surface contamination. DOE contractor sites have noted problems in meeting this requirement due to the difficulties in alpha monitoring. It has also been noted that the beta radiation is typically more abundant and easier to detect. Therefore, analysis of the conditions described shows that it is acceptable to monitor the beta radiation in assessing alpha contamination for uranium provided the numerical relationship between the two is assessed.

The attached technical position does not represent new policy or direction to the field. Rather, it provides an alternative means of measuring uranium contamination.

Please assure further distribution of the attached document to the applicable radiation protection organizations at your facilities.

Attachment

cc w/attachment: Frank B. Russo, NA-3.6
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Department of Energy
Office of Worker Safety and Health Policy
Radiological Control Technical Position
RCTP 2010-01

An Alternative Means of Measuring Alpha Emitters in Uranium Surface Contamination to Demonstrate Compliance with Title 10, Code of Federal Regulations, Part 835

Issue:

Several Department of Energy (DOE) facilities have observed that when monitoring for uranium surface contamination, they frequently encounter low levels of alpha contamination, but more than twice as much beta/gamma radiation due to uranium contamination. Because of the difficulties in measuring alpha particles on surfaces (due to several factors, including significant self absorption) it may be more reliable to measure the beta/gamma radiation. However, title 10, Code of Federal Regulations, part 835 (10 C.F.R. 835), "Occupational Radiation Protection," per footnote 7 of Appendix D, "Surface Contamination Values," specifies that the limits for natural uranium, uranium-235, uranium-238, and associated decay products *apply only to the alpha emitters within the respective decay series*. Accordingly, this Radiological Control Technical Position (RCTP 2010-01) is provided to describe a means of assessing the level of alpha emitters, within surface contamination from these isotopes, based on measurement of beta/gamma radiation. This method can be used to demonstrate compliance with the related provisions in 10 C.F.R. 835 that reference appendix D.

Discussion:

Applicable Provisions

10 C.F.R. 835

§835.2 Definitions

(a) As used in this part:

Contamination area means any area, accessible to individuals, where removable surface contamination levels exceed or are likely to exceed the removable surface contamination values specified in appendix D of this part, but do not exceed 100 times those values.

High contamination area means any area, accessible to individuals, where removable surface contamination levels exceed or are likely to exceed 100 times the removable surface contamination values specified in appendix D of this part.

§835.401 General Requirements

(a) Monitoring of individuals and areas shall be performed to:

(1) Demonstrate compliance with the regulations in this part;
(2) Document radiological conditions;
(3) Detect changes in radiological conditions;
(4) Detect the gradual buildup of radioactive material;
(5) Verify the effectiveness of engineered and administrative controls in containing radioactive material and reducing radiation exposure; and
(6) Identify and control potential sources of individual exposure to radiation and/or radioactive material.

§835.1101 Control of Material and Equipment

(a)(1) Removable surface contamination levels on accessible surfaces exceed the removable surface contamination values specified in appendix D of this part; or

(a)(2) Prior use suggests that the removable surface contamination levels on inaccessible surfaces are likely to exceed the removable surface contamination values specified in appendix D of this part.

(b) Material and equipment exceeding the removable surface contamination values specified in appendix D of this part may be conditionally released for movement onsite from one radiological area for immediate placement in another radiological area only if appropriate monitoring is performed and appropriate controls for the movement are established and exercised.

(c) Material and equipment with fixed contamination levels that exceed the total surface contamination values specified in appendix D of this part may be released for use in controlled areas outside of radiological areas only under the following conditions:

§835.1102 Control of Areas

(b) Any area in which contamination levels exceed the values specified in appendix D of this part shall be controlled in a manner commensurate with the physical and chemical characteristics of the contaminant, the radionuclides present, and the fixed and removable surface contamination levels.

(c) Areas accessible to individuals where the measured total surface contamination levels exceed, but the removable surface contamination levels are less than corresponding surface contamination values specified in appendix D of this part, shall be controlled as follows when located outside of radiological areas:

(1) The area shall be routinely monitored to ensure the removable surface contamination level remains below the removable surface contamination values specified in appendix D of this part; and

(e) Protective clothing shall be required for entry to areas in which removable contamination exists at levels exceeding the removable surface contamination values specified in appendix D of this part.

Appendix D, "Surface Contamination Values"

Surface Contamination Values in dpm/100 cm^2

Radionuclide	Removable	Total (Fixed + Removable)
U-nat, U-235, U-238, and associated decay products	[7]1,000	[7]5,000
***	***	***

[7] These limits apply only to the alpha emitters within the respective decay series.

Discussion

The 10 C.F.R. 835 does not specify how to perform monitoring of individuals and areas. Per §835.401(a), 10 C.F.R. 835 specifies performance-based objectives for monitoring of individuals and areas. Accordingly, for the case of natural uranium, uranium-235, uranium-238, and associated decay products, it is acceptable to monitor the beta/gamma radiation as an alternate means of determining the level of the alpha radiation emitted by these isotopes if it can be demonstrated that doing so will result in compliance with the provisions of 10 C.F.R. 835. This determination should, as a minimum, address the following considerations:

- Does the measurement of beta/gamma radiation provide a more reliable and sensitive measurement of surface radioactivity than does the direct measurement of alpha radiation?
- Does measurement of beta/gamma radiation provide a reliable indicator of the alpha radiation (i.e., are the ratios of beta/gamma contamination level to alpha contamination level)?
- Type of measurement: How is the surface contamination being measured? A direct measurement of total (fixed plus removable radioactivity) or a measurement of the removable radioactivity on a swipe?

Reliability and sensitivity:

Monitoring for surface contamination presents numerous practical problems. When monitoring for alpha contamination, it is often difficult to position the probe close to the surface and avoid damage or contamination. In addition, uneven surfaces and self-absorption of alpha particles can significantly reduce the alpha count rate measured. Conversely, measurement of beta/gamma radiation is relatively straight forward because:

(1) self-absorption from radioactive contamination on a surface is not significant; (2) the radiation detector does not have to be as close to the surface as when monitoring for alpha radiation; and (3) beta/gamma detectors typically have a greater efficiency than alpha detectors. For these reasons, there may be situations when monitoring beta/gamma radiation emitted by certain uranium isotopes and their decay chains may give a better estimate of alpha-emitting contamination than monitoring alpha radiation directly.

The difficulty in measuring alpha radiation is reflected in Section 4.2.3.1, DOE-STD-1136-2009, "Guide of Good Practices for Occupational Radiological Protection in Uranium Facilities," which states:

> "Typically, detection of uranium contamination has been performed using the alpha activity. However, for some conditions and situations, detection of the beta/gamma radiations from uranium decay products may be a more sensitive and more appropriate monitoring technique. For natural uranium, depleted uranium, and the lower levels of enriched uranium that are in equilibrium with their decay products, the detection sensitivity for the beta/gamma radiations is about five times greater than by the detection of the alpha alone."

A study of uranium in mills, "Measurement of Uranium and its Decay Products on Contaminated Surfaces," by M.W. Carter also concluded it was better to monitor surface contamination by detecting beta particles, rather than alpha particles.

Based on the discussion above, it is clear that there are situations in which measurement of beta/gamma radiation provides a more sensitive measure of surface contamination for alpha emitters from uranium isotopes and their decay chains than do direct measurement of alpha radiation.

Beta/gamma radiation as an indicator of alpha radiation:

Because the surface contamination values for natural uranium, uranium-235, uranium-238, and associated decay products are given in terms of alpha radiation, it will be necessary to know the ratio of beta/gamma radiation being emitted from a surface to alpha radiation being emitted from a surface by these radionuclides.

From a theoretical standpoint, the ratio of beta particles to alpha particles varies with enrichment. This ratio ranges from 2.5 for depleted uranium to less than 1.0 for enriched uranium. According to section 2.1.2, DOE-STD-1136-2009:

> "Uranium-processing steps (milling or refining) separate the decay products and other impurities in the ore from the uranium. It takes months after processing before the first few decay products build up and come to equilibrium with the parents. In depleted uranium, the beta radiation from the decay of ^{234}Th and ^{234m}Pa amounts to nearly twice the alpha radiation from ^{238}U and ^{234}U. In commercially

enriched uranium, the beta radiation from ^{231}Th, ^{234}Th, and ^{234m}Pa nearly equals the alpha radiation from ^{238}U, ^{234}U, and ^{235}U. In natural ore, the later decay products (especially ^{230}Th and ^{226}Ra) are present and add significant gamma radiation to the emitted radiation. In processed uranium (natural, enriched, or depleted), all decay products below ^{234}U and ^{235}U are removed. Because of the long half-lives of ^{234}U and ^{231}Pa, the radionuclides that follow these two nuclides are generally ignored."

Accordingly, in order to use beta/gamma radiation as an indicator of alpha radiation, it is necessary to consider the degree of enrichment and the time the decay products have had to come into equilibrium with the parent isotope.

As an alternative to a theoretical calculation, the ratio of beta/gamma radiation to alpha radiation for a given situation can be determined by measurements of both types of radiation. However, two possible sources of error could affect the determination of this ratio.

Because of the previously noted difficulties inherent in alpha radiation measurements, it is possible that the magnitude of the alpha radiation will be underestimated. In that case, the ratio of beta/gamma radiation to alpha radiation will be underestimated. Then, subsequent use of the ratio of beta/gamma radiation to alpha radiation will result in an underestimate of the alpha radiation.

The background levels of beta/gamma radiation will typically be higher than the background levels of alpha radiation. Thus, if measurements are taken where the background level of beta/gamma radiation is significant relative to the beta/gamma radiation resulting from the surface contamination, the level of beta/gamma radiation may be overestimated unless it is corrected for the presence of background radiation. Unless this correction is made, the ratio of beta/gamma radiation to alpha radiation will be underestimated; and, consequently, the alpha radiation will be underestimated.

Type of measurement:

The types of measurements required for compliance with the provisions of 10 C.F.R. 835 that cite appendix D are measurement of total (fixed plus removable) surface contamination and measurements of removable surface contamination. Determination of the total contamination on surfaces is performed by direct measurement of the surface using survey meters. For natural uranium, uranium-235, uranium-238, and associated decay products, measurements of alpha radiation are subject to the problems mentioned above. Depending on considerations of sensitivity and the reliability of beta/gamma radiation as an indicator of alpha radiation, measurement of beta/gamma radiation may be an acceptable alternative method for determining surface contamination of alpha emitters from these radionuclides

Determination of removable contamination is typically performed by wiping a specified area of a surface with a small piece of paper called a swipe. Because the swipe can be taken to a laboratory for measurement, it may be preferable to directly measure the alpha radiation emitted by natural uranium, uranium-235, uranium-238, and associated decay products for removable contamination. This is because the problems associated with measurement of alpha radiation in the workplace can be either eliminated or reduced in a laboratory. If the swipe is to be measured in the field, then it may be preferable to measure the beta/gamma radiation emitted by the natural uranium, uranium-235, uranium-238, and associated decay products on the swipe and from that measurement, determine the level of alpha emitters present in the contamination.

Technical Position:

- For natural uranium, uranium-235, uranium-238, and associated decay products, it is acceptable to monitor the beta/gamma radiation and from those measurements determine the alpha contamination present to comply with the pertinent provisions of 10 C.F.R. 835. This approach is an alternative to making a direct measurement of the alpha radiation emitted by these isotopes. Of course, if this method is adopted, it is necessary to analyze, verify, and update the ratio at predetermined intervals.

  When considering the measurement of beta/gamma to assess surface contamination, the following items should be addressed:

  - The degree of enrichment;
  - The time the decay products have had to come into equilibrium with the parent isotope;
  - Problems with the measurement of alpha radiation; and
  - Possible interferences from beta/gamma background radiation.

- Measurement of beta/gamma radiation from swipes measured in a laboratory, as an alternative to direct measurement of alpha emitters in natural uranium, uranium-235, uranium-238 and associated decay products, may not be appropriate to demonstrate compliance with related provisions of 10 C.F.R. 835. The reason is such measurement may not be as reliable as direct measurement of alpha emitters under those circumstances.

References:

10 C.F.R. 835, "Occupational Radiation Protection," U.S. Department of Energy, June 8, 2007.

Carter, M.W., "Measurement of Uranium and its Decay Products on Contaminated Surfaces," Radiation Protection Dosimetry," Vol.5, No. 4, 1983.

DOE-STD-1136-2009, "Guide of Good Practices for Occupational Radiological Protection in Uranium Facilities," 2009.