Fernald DWE Missed Intake (Plants 2/3)

Discussion Paper

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ESTIMATION OF INTAKES TO URANIUM AND RADIUM-POOR RAFFINATES AT FERNALD

Summary

ORAUT-TKBS-0017-5, *Feed Materials Production Center – Occupational Internal Dose* (ORAUT 2017), Section 5.3.5.2.3 describes how ^{230}Th and other decay chain radionuclides are assigned to workers exposed to ore concentrates prior to the uranium being extracted from them in the refinery. The primary source of exposure for workers in Plants 2 and 3 occurred at the beginning of the processing operation – the ore and concentrate charging operations (i.e., the feed to the refinery digestors). Silo 3 materials are associated with the liquid stream contained in a closed piping system and then to a closed calcination system, which provides little exposure potential to the workers. For the period 1959 through 1961, these materials are assigned as described in ORAUT (2017).

The average daily weighted exposure (DWE) air concentration values for the combined raffinate area of the refinery are the same from 1959-1961 (Wing 1961, p. 9; ORAUT 2018), as they are from 1965-1968 (Ross 1969, p. 10; ORAUT 2018). This is significant since the combined raffinate area of the refinery would be the location most likely to have raffinate exposure. Between 1959 and 1961, the refinery was running ore concentrates as feed, while from 1965 to 1968, when the refinery restarted after being shut down for years; it was running scrap recovery as feed (Mead 1985; ORAUT 2018). The significance of running scrap recovery at refinery restart in fiscal year 1966 (Mead 1985; ORAUT 2018) is that the scrap is uranium that has previously been purified, so there are no decay chain radionuclides present. Since the airborne concentration of combined raffinate is the same for ore concentrates as it is for scrap recycle, there is no particular airborne exposure to ^{230}Th or other decay chain nuclides in the ore concentrate raffinate.

Background

The Refinery (Plants 2 and 3) consisted of three major process areas: digestion, extraction and denitration. Support areas included nitric acid recovery, raffinate treatment and refinery sump (Mead 1985, p. 34). The Refinery ran ore, Q-11 and Australian pitchblende, from 1954-1958 (ORAUT 2017). The potential exposure to uranium and radium-poor raffinates occurred from 1959-1961, when the refinery was running ore concentrates. The Q-11 ore contained all of the uranium daughter products, including ^{226}Ra. When the ore was refined, ^{226}Ra and other daughter products were concentrated in the waste stream, which was identified with the code "K-65." Pitchblende ore processing resulted in "hot" raffinates, indicating that relatively high concentrations of ^{226}Ra plus daughter products were in the waste stream. Silos 1 and 2 contained the K-65 "hot" raffinates and included concentrations of ^{226}Ra.

After 1958, when processing of the Q-11 and other pitchblende ores was completed, the source of the uranium for processing was yellowcake. The yellowcake had most of the radium and other impurities removed. This raffinate was called "cold raffinate" because the waste stream had much lower concentrations of ^{226}Ra plus daughters, compared to the K-65 raffinate. The cold raffinate was a calcined dry, dispersible powder that was transferred to Silo 3 using an enclosed airlift and was considered "radium-poor." The raffinates were either a slurry or liquid, and were kept as a slurry until they were pumped to disposal pits. The front end of Plant 2 is where the materials were dumped into the digestor in the refinery and uranium was present, since it had not been refined out.

Missed Intakes

It was assumed that workers were exposed to the ore concentrates as they were fed to the refinery, since the materials important in this process stream existed here. Because uranium was present, the potential exposure to uranium and radium-poor raffinates can be determined using the derived uranium intake based on bioassay, and including the non-uranium constituents from Silo 3, assuming that the ^{230}Th is in equilibrium with the uranium, as described in ORAUT (2017). Missed intake calculations for uranium based on urine bioassay from 1954-1958 were determined for absorption Type F, M and S (ORAUT 2018; IMBA files). The missed uranium intake calculations assumed a natural uranium enrichment and a minimum detectable activity (MDA) of 14 µg/L for urine. The urine sample was normalized assuming 1.4 L/day as the excretion rate. Missed intake calculations were estimated based on one-half of the MDA assuming that a urine sample was submitted on the last day of the intake period (i.e., December 31, 1958).

The ratios of the Silo 3 alpha constituents from Table 5-17 of ORAUT (2017) were summed with the uranium missed intake rates for the three absorption types. Actinium-227 was assumed to be in equilibrium with ^{227}Th. Absorption Type F uranium and the Silo 3 constituents were the most restrictive of the three absorption types, as shown in the "Missed 1954-1958 Nat-U bioassay" tab of the "Fernald DWE & Missed Intake Plants 2-3, Rev. 01" Excel spreadsheet (ORAUT 2018). Therefore, absorption Type F uranium and Silo 3 constituents (i.e., Minimum Total Alpha Inhalation Intake Rate) were used for comparison to the total alpha intake with the DWE air sample concentration (ORAUT 2018). The derived Type F uranium intake was subtracted from the "Minimum Total Alpha Inhalation Intake Rate" to obtain the "Minimum Total Alpha Non-U Inhalation Intake Rate" or Silo 3 constituents. The ^{230}Th amount was then subtracted to show the "Minimum Total Alpha Non-U Non-Th-230 Inhalation Intake Rate" amount.

Discussion

The "combined raffinate" total alpha DWE air sample concentrations from 1959-1961 were 0.1 MAC (25.9 pCi/day) or 0.1 NCG (37 pCi/day), as shown in the "Plant 2-3 DWE" and "SRDB Review" tabs of ORAUT (2018). The "SRDB Review" tab of ORAUT (2018) shows other supporting references, which were reviewed. There is no reason to believe that the 0.1 MAC during ore concentrate was from ^{230}Th. During the pitchblende ore-processing period, the ore radioactive components were based on uranium bioassay, and are higher than the ^{230}Th based on air sampling of the combined raffinates beginning in 1959.

This approach is bounding since the total alpha intake based on uranium bioassay including the Silo 3 constituents, is well above what would be calculated based on the DWE values for 1959-1961 from the "combined raffinate" in Plants 2 and 3.

References

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