RADON SUPPRESSION IN STORAGE SILOS AT THE UNITED STATES DEPARTMENT OF ENERGY FEED MATERIAL PRODUCTION CENTER, FERNALD, OHIO

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ABSTRACT

Two silos at the Department of Energy Feed Material Production Facility in Fernald, Ohio, contain an estimated 8,800 metric tons of high-grade pitchblende ore residue solids, which contain approximately 3,300 Ci of radium and 1,810 Ci of thorium. DOE has determined that these wastes represent a potential threat to human health and the environment. Fugitive radon emissions from the silos exceed EPA limits. In addition, structural analyses have revealed that the silos have little credible remaining design life and may fail in a tornado and particulates may be released.

The emplacement of a covering layer of bentonite slurry inside the silos will reduce the fugitive radon emissions and mitigate the effects of dome structural failure, while presenting minimum impact on potential final remedial action alternatives for the silos.

BACKGROUND

The Atomic Energy Commission (AEC), predecessor to the Department of Energy (DOE), established the Feed Materials Production Center (FMPC) for manufacturing uranium metal from natural ore concentrates for U. S. government military needs. The production facility, located in a rural area northwest of Cincinnati, Ohio (see Fig. 1), began operations in the early 1950s. The current priority at the site is environmental management.

During the early 1950s, the FMPC refined processed high-grade pitchblende (uranium-rich ore) from Zaire, formerly the Belgian Congo. The residues from this process, referred to as K-65 material, contained significant amounts of radium.

Four silos were constructed in 1951 and 1952 for dewatering and storing radioactive waste effluent from the plant processing lines. However, only silos 1 and 2 were used to store K-65 residues. The concrete silos are 80 feet in diameter with overall heights of 36 feet (27-ft-high walls and 9-ft-high domes). The walls are constructed of 8-in.-thick, post-tensioned, reinforced concrete (Fig. 2). The domes are constructed of concrete reinforced by wire mesh, and taper from a thickness of 8 in. at the silo walls to 4 in. at their apexes.

The silos received waste residues primarily between 1952 and 1958 from three sources: FMPC process lines; a plant in St. Louis, Missouri; and from a DOE facility in western New York. The silos are estimated to contain approximately 8,800 metric tons of solids that include approximately 3,300 Ci of radium and 1,810 Ci of thorium.

Some weathering effects on the exterior surfaces of the silos were apparent in 1963, and a repair program was begun as a precautionary measure. Repairs were made to the shot-crete coat, and an earthen embankment (berm) was constructed around silos 1 and 2 to counterbalance the load from the silo contents. The berm also protected the walls from further weathering and provided radiation shielding. Vents in the silos were sealed in 1979, and the berms were enlarged in 1983 to reduce erosion. A protective foam covering was applied to the domes in 1987. Structural analyses indicated that little credible design life remained and that the silo domes could breach under tornado loads.

RADIOLOGICAL CONDITIONS

The radium-bearing residues in the silos emit radiation in the form of high-energy alpha particles as they decay to radon gas. Radon daughter products (see Fig. 3) are solids that emit high-energy alpha particles and beta and gamma radiation (1).

Ninety-six percent of the radon generated decays in the matrix material and is contained in the silos. Some radon gas accumulates in the head space in the silos; there is approximately 38,000 ft^3 of head space in silo 1 and 48,000 ft^3 in silo 2. Small amounts of radon in excess of EPA limits are emitted to the atmosphere.

The radiological constituents of the K-65 residues have been estimated to include 7 Ci of uranium (0.71 percent uranium-235), 3,300 Ci of radium (radium-226), and 1,810 Ci of thorium (thorium-230). Currently, silos 1 and 2 produce approximately 11 Ci/day of radon in the head spaces. Together both silos produce approximately 4,100 Ci/yr of radon in the head spaces, representing approximately 4 percent of the total radon production within the bulk of the wastes. The concentrations of radon in the head spaces have been measured to be as high as 3×10^7 pCi/L. Using this concentration and the volume of the head space of each

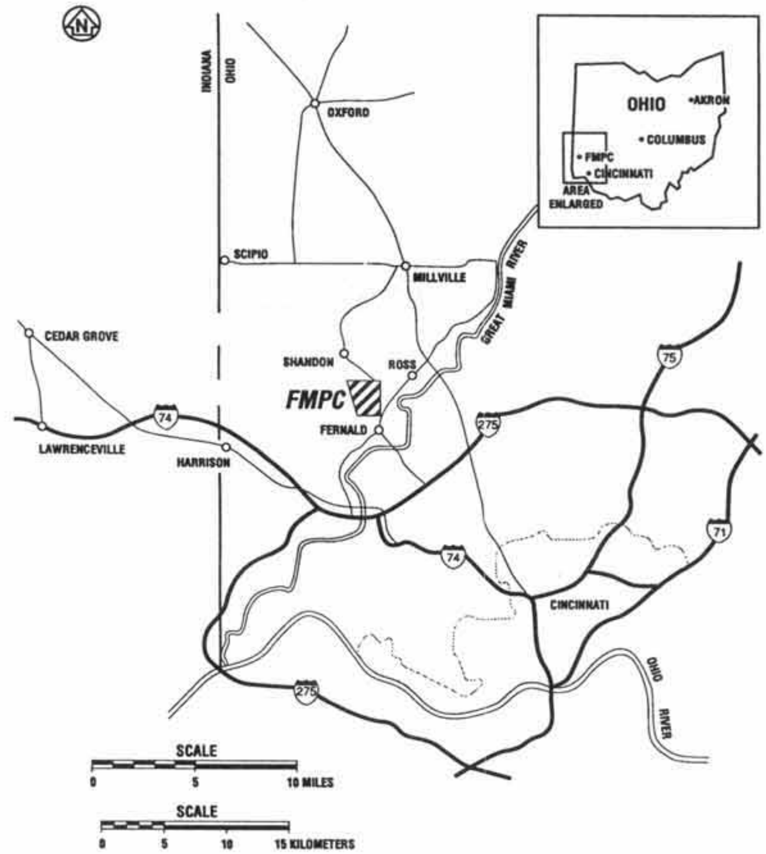

Fig. 1. Location of the FMPC site.

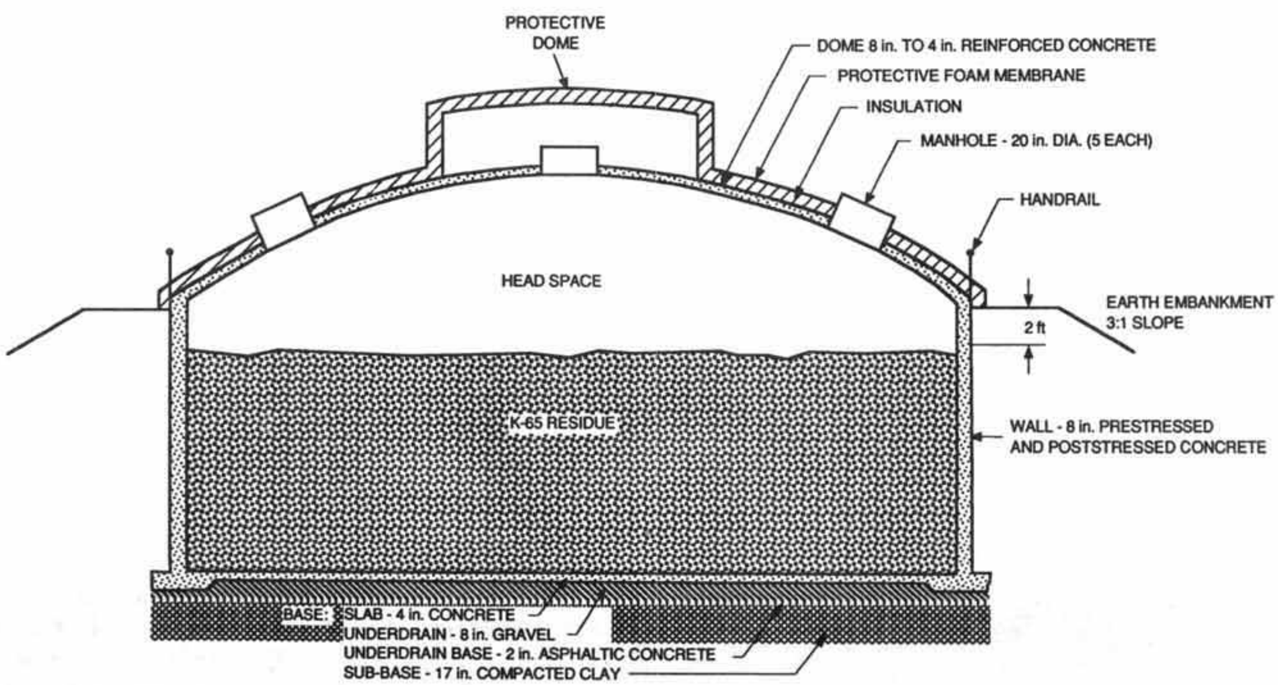

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Fig. 2. Typical cross section, silos 1 and 2.

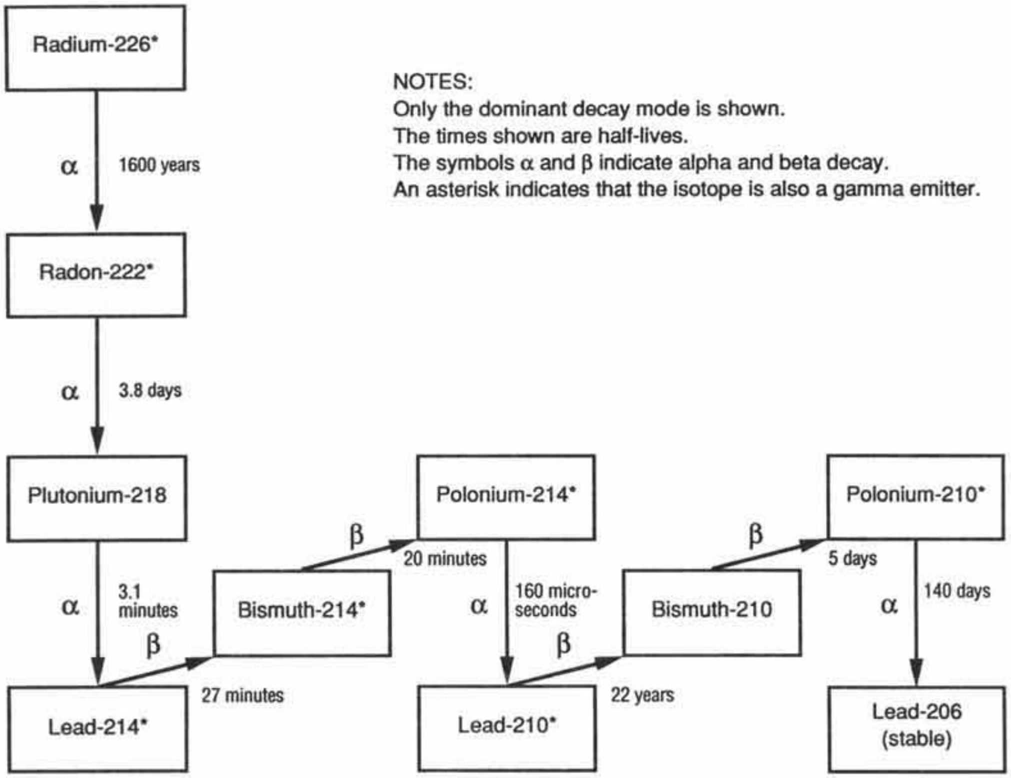

Fig. 3. Radium decay chart.

silo, it has been calculated that a relatively constant inventory of approximately 33 Ci of radon exists in the head space of each silo. Radiation levels on the surfaces of the silo domes currently range from 145 to 185 mrem/h without operating the radon treatment system (a temporary system installed to reduce radiation levels while performing work on the domes). The chronic radon emissions from the two silos are estimated to be 650 Ci/yr.

SCOPE AND OBJECTIVES

The FMPC is involved in a long-term cleanup effort under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). A remedial investigation/feasibility study (RI/FS) was initiated in 1986 and is continuing.

In this RI/FS, the FMPC is divided into five operable units. An operable unit is any logical grouping of parts of the site that are similar, based on physical features, contaminant sources or types, schedules, or possible responses. One of the operable units for the FMPC includes those facilities used for storage of radiological wastes from FMPC operations. These facilities include silos 1 and 2, which contain K-65 residues, and are part of operable unit 4.

To address the current situation, a non-time-critical removal action was begun while the selection of a method of final remediation continued. The authority to respond to any hazardous substance released into the environment or the substantial threat of any such release is contained in CERCLA, Sections 104 and 106. Section 104(a)(1) authorized EPA to undertake a removal or remedial action, unless it is determined that such action will be conducted properly by the owner or operator of the facility or another responsible party. Executive Order 12580 (52 FR 2923) delegates the response authority of Section 104 to the U.S. Secretary of Energy for action taken at DOE facilities.

The National Oil and Hazardous Substances Contingency Plan (NCP) requires that the lead agency (DOE in this case) conduct an engineering evaluation/cost analysis (EE/CA) to assist in the selection of a non-time-critical removal action. This EE/CA evaluated the feasibility of performing a removal action to mitigate the threat to public health and the environment from the wastes stored in silos 1 and 2 (2). This removal action is an element of a larger remedial action being planned by DOE, and is currently in the developmental stages.

The function of the EE/CA is to investigate removal alternatives in response to short-term threats to public health and the environment from the K-65 residues in silos 1 and 2, to select the most appropriate response, and to document the decision-making process.

TABLE II

Comparison of Removal Alternatives

ASSESSMENT FACTORS	ALTERNATIVE 2 TORNADO-RESISTANT ENCLOSURES FOR SILOS	ALTERNATIVE 3 RELOCATION OF RESIDUES FROM SILOS	ALTERNATIVE 5.1 COVER RESIDUE WITH SAND	ALTERNATIVE 5.5 COVER RESIDUE WITH BENTONITE SLURRY
SHORT TERM PROTECTION OF PUBLIC HEALTH AND ENVIRONMENT	Fair	Poor	Good	Good
LONG-TERM PROTECTION OF PUBLIC HEALTH AND ENVIRONMENT	Good	Good	Good	Good[1]
REDUCTION OF TOXICITY, MOBILITY OR VOLUME	Good	Fair	Good	Good
CONSISTENCY WITH FINAL ACTION	Fair	Poor	Good	Good
TECHNICAL FEASIBILITY, DIFFICULTY	Fair	Poor	Fair	Good
TIMELINESS	10 months	32 months	10 months	10 months
COMPLIANCE WITH ARARs	Good	Good	Good	Good
NORMALIZED COST	$5,000,000	$60,000,000	$2,100,000	$2,900,000

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Source: EE/CA, Bechtel National, Inc. (Ref. 2)

[1] Dependent on ability to retain plastic condition.

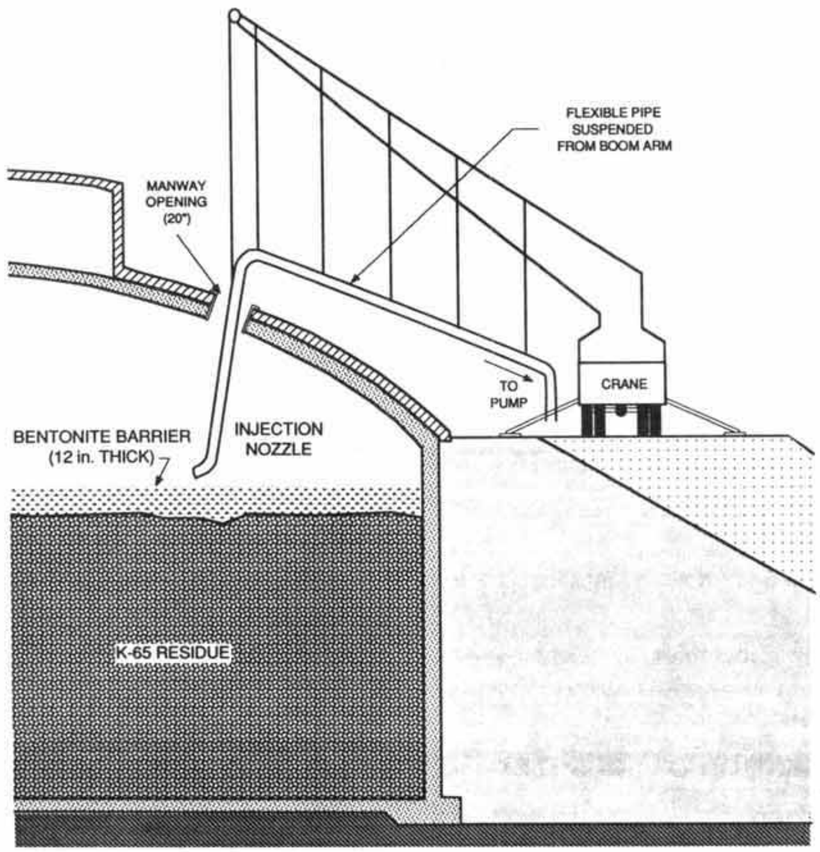

Fig. 4. Placement of bentonite layer.

tively affecting the full range of potential final remedial action alternatives.

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