R Nelson

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June 24, 1996

Mr. Gary Comfort
US Nuclear Regulatory Commission
Mail Stop TWFN 8-A-33
Washington, D.C. 20555

Dear Mr. Comfort:

As you are aware. Shieldalloy Metallurgical Corporation processes material with elevated levels of radioactivity (pyrochlore) during the production of ferrocolumbium (ferroniobium). One of the materials produced coincident with the ferrocolumbium is baghouse dust, with the other major coproduct being slag, and both of these materials demonstrate radioactivity levels above background. SMC has found and developed a beneficial use for the baghouse dust as a raw material in the cement industry, and has located a customer who is willing to accept and use this baghouse dust in their production process. The baghouse dust would replace commercially purchased lime in the production of cement and concrete on a like and kind basis. If the NRC approves the sale of the baghouse dust to a facility not holding an NRC license without requiring the facility to apply for a license, our customer has agreed to accept all the baghouse dust in our inventory. Their estimate for consuming our entire quantity of baghouse dust is less than one year, so the material would not be stockpiled at the customer's plant, but would stay at SMC until needed by the customer.

Accompanying this letter is a report titled "Technical Basis for the Sale of Baghouse Dust as an Additive in Concrete Production" which discusses at length both the technical and regulatory issues surrounding the sale of this baghouse dust to a facility not licensed by the NRC. As you will note from reading the report, there are sound technical and legal reasons that support and allow such a sale. This of course leaves aside the beneficial societal aspects of this sale such as eliminating the necessity of considering in situ versus off site disposal for the baghouse dust.

We have provided the attached report in an effort to provide the NRC with sufficient information so as to allow the staff to approve this sale. While we believe that there is no regulatory constraints on the sale of materials with less than 0.05% of uranium and/of thorium, we have been advised that the NRC is reviewing this situation with the potential of recommending that the regulations be revised. Because of the NRC's interest in this issue, we are requesting that the NRC approve this sale in advance, and have attempted to provide any and all applicable information that would be required to proceed with such a review and approval.

The cement industry processes material mainly on a seasonal basis, throughout the spring and summer months. Because this seasonal production has already started and because our customer could use our entire inventory this production season, we are requesting that the NRC provide us with a rapid review and response to our request.

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If there are any questions or if any additional information is necessary, please do not hesitate to contact the undersigned.

Very truly yours,

C. Scott Eves
Vice President
Environmental Services

CSE:emb
cc: w/enclosure
MAF, ELS
cc: w/o enclosure
HNS, JPV, DRS, MW
Carol Berger
Jay Silberg

TECHNICAL BASIS FOR THE USE OF BAGHOUSE DUST AS AN ADDITIVE IN CONCRETE PRODUCTION

TECHNICAL BASIS FOR THE USE OF BAGHOUSE DUST AS AN ADDITIVE IN CONCRETE PRODUCTION

Submitted to:

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by:

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Report No. 94005/G-7120
June 17, 1996

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INTRODUCTION

Shieldalloy Metallurgical Corporation (SMC) operates a facility located in Newfield, New Jersey. This facility manufactures or has manufactured specialty steel and super alloy additives, primary aluminum master alloys, metal carbides, powdered metals, and optical surfacing products. Raw materials currently used at the facility include beneficiated ores which contain oxides of columbium (niobium), vanadium, aluminum metal, titanium metal, strontium metal, zirconium metal, and fluoride (titanium and boron) salts.

During the manufacturing process, the facility generates a variety of by-products that have commercial application. For example, one by-product that has had a successful commercial market over the last several years is a ferrovanadium slag, known by the trade name of V-40©. Because of its alumina and calcium oxide content, this material serves as a valuable additive to the steel making process for reducing impurities in the final product.

Another by-product is the baghouse dust, also known as BHD. This product, which results from the production of ferrocolumbium and ferrovanadium, has desirable qualities as an additive to cement and concrete production. These qualities include its physical particle size, its color, and the fact that BHD also contains aluminum, calcium and silicon values, all of which are used in production of cement and concrete. However, because BHD also contains low-levels of radioactive materials, it is important to demonstrate that its sale to cement manufacturers will result in negligible radiological risk to their employees and members of the general population, and that it is compatible with federal regulations on possession of radioactive materials.

This report addresses the regulatory and radiological impacts associated with the use of BHD as a raw material in the cement production process, and an analysis of potential radiation doses to cement plant workers and members of the general public as a result of its use. It contains a description of BHD and how it is produced at Newfield, the basis for regulation of BHD by federal and/or state agencies, an assessment of the radiological constituents in BHD at various stages in the cement production process, a description of likely exposure scenarios and hypothetical radiation doses from the use of BHD from initial receipt by the cement producer to end product usage, and a comparison of those hypothetical doses to those that are typical of normal background radiation exposure. The conclusions of the report are that BHD contains only "unimportant quantities" of source material, thus obviating the need for licensing by any recipients, and that the use of BHD in manufacturing poses negligible radiological health risks for workers and the public.

DESCRIPTION OF BHD

Physical Description of BHD

SMC holds U. S. Nuclear Regulatory Commission (USNRC) License No. SMB-743 which allows possession, use, and storage of "source material".[1] SMC maintains this license because certain metal alloys that are produced at the Newfield plant are derived from ores which contain source material.

The alloys that are produced from source material are the result of conventional aluminothermic smelting techniques. In their production, a "charge", consisting of feed material, lime, aluminum, and other raw materials, is transferred to a furnace and packed around electrodes. The reaction begins when power is applied to the electrodes.

During the reaction, dust is generated, which rises and is collected under a large hood connected to baghouses by ducts. Of the total quantity (by weight) of feed material that goes into the production process, approximately 34 percent is returned as product, approximately 58 percent is returned as end slag, and the remaining eight (8) percent enters the dust collection system. Over 99 percent of the radioactive species in the feed material remains in the end slag and the baghouse dust.[2]

Periodically, the baghouses are emptied and their contents are transferred to the SMC Storage Yard.[3] For an average production year, approximately 3.64×10^5 kilograms of BHD are produced. As of 1992, approximately 20,000 cubic meters of BHD is in the Storage Yard.[4]

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[1] Source material is defined by the USNRC as uranium and/or thorium in any form and ores containing in excess of 0.05%, by weight of uranium and/or thorium.

[2] Rieman, C. R., Shieldalloy Metallurgical Corporation, letter to D. Hoffmeyer, U. S. Environmental Protection Agency, "Radionuclide Air Emissions Survey Form", December 17, 1991.

[3] The Storage Yard is located on the eastern portion of the property, and is used to store a variety of materials generated during manufacturing operations in addition to baghouse dust.

[4] From the volumetric information obtained from an October, 1991 fly-over of the Newfield site, the slag yard contained 15,100 m^3 of baghouse dust (Shieldalloy Metallurgical Corporation, "Applicant's Environmental Report for the Newfield, New Jersey Facility", October 1, 1992).

Radiological Constituents in BHD

On July 31, 1995, a sampling effort was instituted in order to quantify the radiological constituents in the stockpile of BHD in the Storage Yard. For this effort, samples were collected, using a soil probe, from the top one foot (approximate) of the stockpile at 15 separate locations.[5] Each sample was then placed into a large zip-lock baggie and homogenized. Approximately 20 grams of each sample were shipped to a commercial facility where they were analyzed for total uranium and total thorium by neutron activation analysis. The remainder of each sample was packaged, labeled and forwarded for subsequent metallurgical testing. The analytical results from this sampling effort are summarized in Table 1, which demonstrates that BHD contains only low concentrations of naturally-occurring radioactive materials (e.g., 0.03 percent by weight), and that the variation in uranium and thorium content throughout the 15 samples is minimal.

[5] Although the soil probe had a depth capability of 15 feet, it was unable to penetrate the BHD stockpile past the first 12 inches. However, from the minimal variation in uranium/thorium concentration noted in this sampling effort, and from knowledge of the manner by which BHD is produced, significant variations in the radionuclide concentrations "at depth" are not likely.

DESCRIPTION OF PROPOSED USE

Cement Production

Cement is generally defined as any substance that acts as a bonding agent for materials. However, in construction and engineering it almost always means hydraulic cement. Hydraulic cement is produced by burning an intimate mixture of finely divided calcareous and argillaceous materials and grinding the resulting material to a fine powder. The powder is typically mixed with gypsum to retard the setting process. The calcining process produces calcium silicates and calcium aluminates that react chemically with water to form a hard, stone-like mass. When mixed with sand, coarse aggregate and water, these cements produce mortars and concretes.[6]

There are three fundamental stages in the manufacture of Portland cement.[7] These are preparation of the raw mixture, production of the product, and preparation of the cement. In the process, the raw materials are selected, analyzed, and mixed so that, after treatment, the product has a desired, narrowly-specified composition. A typical factory slurry is calcium oxide (44%), aluminum oxide (3.5%), silicon oxide (14.5%), ferric oxide (3%), and magnesium oxide (1.6%). The remainder, in the form of carbon dioxide, is lost on ignition.[8]

The raw mixture is heated in a continuously operated furnace or kiln at a high temperature. The temperature is regulated so that the product consists of sintered but not fused lumps, referred to as "clinker".

In order to obtain the desired setting qualities in the finished cement, about two (2) percent gypsum (calcium sulfate) is added to the "clinker" and the mixture is pulverized. For every ton of Portland cement, over two and one-half tons of raw materials and cement clinker is ground finely.[9]

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[6] McGraw-Hill, Inc., McGraw-Hill Encyclopedia of Science & Technology, 7th Edition, Volume 3, New York, 1992.

[7] Portland cement is the most widely used material for cementing purposes, accounting for roughly 98% of the cement production in the United States. (McGraw-Hill, Inc., McGraw-Hill Encyclopedia of Science & Technology, 7th Edition, Volume 3, New York, 1992.)

[8] Considine, D. M. and G. D. Considine, Editors, Van Nostrand's Scientific Encyclopedia, Seventh Edition, Van Nostrand Reinhold, New York, 1989.

[9] Considine, D. M. and G. D. Considine, Editors, Van Nostrand's Scientific Encyclopedia, Seventh Edition, Van Nostrand Reinhold, New York, 1989.

BHD Production

To prepare BHD for same, material will be removed from the stockpile in the Storage Yard with an excavator and carried to a staging area a short distance away. There metallic units, foreign objects and other items that may be physically-detrimental or unnecessary for cement production process will be removed.[10] During the removal process, each load of BHD will be excavated from different strata of the stockpile in order to reduce whatever segregation in baghouse dust types (e.g., batches from various production runs) might be inherent in the pile, and ensure that the final product contains a blend of all of the material present in the pile.[11] The BHD will then be shipped by truck to a local cement manufacturing firm.

Radiological Screening

To ensure that BHD used in cement production meets the requirements of the manufacturer, a screening step will be incorporated into the production procedures. A minimum of four (4) samples will be collected from each quadrant of each batch staged for transfer to provide product certification. Composites of the samples will be analyzed for Al_2O_3, CaO, SiO_2, MgO, isotopic thorium and isotopic uranium, and other constituents that are of interest to the cement industry. Shipments of BHD will not take place until the results of the uranium/thorium analyses confirm that the mean source material content is less than 0.05%.

Radiation Safety During Production of BHD

BHD will be sorted, staged and shipped under the provisions of a project-specific health and safety plan. The plan will describe the potential safety impacts associated with the preparation of BHD, a description of likely exposure scenarios and hypothetical radiation doses associated with its production, and a description of the means by which workers will be protected from unnecessary radiation exposures during the operation.

Use of BHD by Cement Manufacturers

At the local cement plant, BHD will be fed into a production kiln as a replacement for gypsum and other additives. As a result, further dilution in the source material content of the BHD will be achieved. The cement will then be dried in the kiln, packaged, and sold for use in construction, stabilization, and other typical industrial/municipal activities. These might include construction of solid surfaces (e.g., sidewalks and road beds), and production of concrete blocks for use as decorative borders, foundations, walls and fences.

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[10] Crushing of excavated BHD will not be necessary.

[11] Historically, dusts generated from production runs with various feed materials were not segregated.

REGULATORY CONSIDERATIONS

Licensing Requirements

Title 10, Code of Federal Regulations, Part 40.4, "Domestic Licensing of Source Material", defines source material as:

> "(1) Uranium or thorium, or any combination thereof, in any physical or chemical form or (2) ores which contain by weight one-twentieth of one percent (0.05%) or more of (i) Uranium, (ii) thorium or (iii) any combination thereof. Source Material does not include special nuclear material."[12]

BHD meets the definition of source material since it contains uranium and thorium "in any physical or chemical form". As such, a license to receive, possess, use, transfer, or deliver materials like BHD would be required under the provisions of 10 CFR 40 unless the conditions of exemption as described in §§40.11 through 40.13 are met.

The exemptions contained in §§40.11 and 40.12 do not apply to BHD because neither SMC nor the receiving cement manufacturer performs work with BHD under a USNRC or U. S. Department of Energy (USDOE) contract, and neither are carriers of BHD. On the other hand, the "unimportant quantities" exemption of §40.13 applies to BHD. Section 40.13 states that:

> "Any person is exempt from the regulations in this part . . . to the extent that such person receives, possesses, uses, transfers or delivers source material in any chemical mixture, compound, solution, or alloy in which the source material is by weight less than one-twentieth of 1 percent (0.05 percent) of the mixture, compound, solution or alloy. The exemption contained in this paragraph does not include byproduct material as defined in this part."

In 10 CFR 40.4, byproduct material is defined as the "tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content, including discrete surface wastes resulting from uranium solution extraction processes". None of the materials that comprise BHD meet this definition since they are neither tailings nor wastes from a uranium extraction or concentration process. Therefore, based upon its classification as an "unimportant quantity" pursuant to 10 CFR 40.13, BHD is exempt from the licensing requirements in 10 CFR 40 because it contains less that 0.05% source material, by weight (see Table 1) and is not a "byproduct material as defined in this part".

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[12] Title 10, Code of Federal Regulations, Part 40.

While SMC is obliged to account for the source material in BHD (by virtue of the conditions of License No. SMB-743) while it is present at the Newfield site, the source material in BHD is considered to be an "unimportant quantity". Since § 40.51 allows the transfer of source material to a person exempt from licensing, and since §40.13 would allow a non-licensee to possess "unimportant quantities" of source material without a license, purchasers of BHD are exempt from licensing.

Dose Objective

A precondition to the use of BHD as a cement-making additive is to demonstrate the acceptability of radiological conditions (e.g., ambient exposure rate, airborne radioactivity) associated with its use. An acceptable dose, in this case, refers to the maximum dose above background that may be incurred by workers and members of the general public from the possession and use of BHD (and its end-use products) such that there is negligible risk of radiation-induced health effects.[13]

There are a number of dose criteria promulgated by standards groups and regulatory agencies that represent negligible risk. Any one of these would constitute an acceptable objective for unrestricted use of BHD. For example:

- The National Council on Radiation Protection and Measurements (NCRP) recommends a dose limit of 100 millirem per year from manmade sources for individual members of the public.[14] This limit is based on scientific recommendations developed through an impartial consensus process.
- The USNRC, in a 1991 Final Rule, adopted the recommendations of the NCRP as its basic dose limit applicable to any licensed facility.[15]
- The NCRP also recommends that any facility that might contribute an annual dose of 25 millirem to any individual take special precautions to assure that the dose to that individual from all manmade sources does not exceed 100 millirem.[16]

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[13] Human beings in the United States receive between 150 and 600 millirem per year from natural background radiation, exclusive of medical exposures (National Council on Radiation Protection and Measurements, Report No. 94, "Exposure of the Population in the United States and Canada from Natural Background Radiation", 1987).

[14] National Council on Radiation Protection and Measurements, "Ionizing Radiation Exposure of the Population of the United States", NCRP Report No. 93, September, 1987.

[15] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation", January 1, 1994.

[16] National Council on Radiation Protection and Measurements, "Ionizing Radiation Exposure of the Population of the United States", NCRP Report No. 93, September, 1987.

- Consistent with the recommendations of the NCRP, the U. S. Environmental Protection Agency (USEPA) imposes a limit of 25 millirem per year to any member of the public from nuclear fuel cycle facilities.[17]

For the purposes of this report, however, a dose objective of 10 millirem above background is deemed applicable and is used as the basis for demonstrating that BHD may be sold/used without regard for its radiological constituents. The reasons for selecting this objective are:

- It is less than 10 percent of the average dose from natural background radiation.
- It is lower than the values listed above and demonstrates a desire to implement conservative radiological protection practices; and
- The intent is consistent with federal requirements that licensed radioactive materials be handled and released in a manner that ensures that exposures are as low as is reasonably achievable (ALARA) taking into account economic and societal factors.[18]

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[17] Title 40, Code of Federal Regulations, Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations", 1991.

[18] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation".

RADIOLOGICAL CONSIDERATIONS

The potential radiation dose that workers or the general public may incur from exposure to radioactive materials is influenced by a number of factors. These include the amount of radioactivity involved, the types of radiation emitted by the material, the chemical and physical form of the material, the solubility of the material, the particle size distribution, the duration of the exposure, the inhalation pathways (including both airborne material and resuspended material), the ingestion pathways involving contaminated water, food stuffs and animal feeds, and the demographic and physiological characteristics of the population exposed.

With respect to BHD, workers at the cement plant may be exposed to low-levels of ambient gamma radiation during handling of the material upon delivery and with usage. In addition, a worker may be exposed to airborne radioactivity from re-suspended BHD.

Once the final cement is produced, users may incur a radiation dose from direct radiation and from inhalation. In its end form as concrete, members of the general population may be exposed by direct radiation (road beds, walls, floor slabs) and radon gas (building foundations). In addition, children may ingest cement used as a soil amendment (e.g., as a source of lime).

The hypothetical radiation doses to both workers and members of the general public from these exposure scenarios were determined. The intent of this effort was to establish a conservative exposure scenario (i.e., worst case) that is still within the range of possibility. Whenever possible, the assumptions needed to complete the dose assessment were selected conservatively such that the maximum reasonable dose would be result. The following is a description of the approach and the assumptions used for each of the exposure scenarios.

Radiological Constituents

For the purpose of this report, the following conservative assumptions were made in regard to radiological constituents:

- The mean radionuclide content listed in Table 2, which is equivalent to 28.7 pCi/g of ^{232}Th and 13.8 pCi/g of ^{238}U, is characteristic of all truckloads of BHD to be used in the cement production process.

- BHD has a density that is equivalent to that of gypsum, or 2.3 grams per cubic centimeter.[19]

- The BHD makes up 25% of the additive to the silicon oxide, calcium oxide and aluminum oxide clinker, for a radionuclide concentration of 7.2 pCi of ^{232}Th per gram and 3.5 pCi of ^{238}U per gram.[20]

- The BHD comprises six (6) percent of concrete, which also contains sand and other amendments such as stone or cinders, for a radionuclide concentration of 1.7 pCi/g of ^{232}Th and 0.8 pCi/g of ^{238}U.[21]

Exposure Assessment for Workers in the Vicinity of BHD

Evaluation of the ambient radiation exposure of workers in the vicinity of BHD sold to a cement manufacturing firm requires knowledge of the exposure rate in the location of interest, along with the likely duration of the exposure. The following is the calculation methodology used:

$$DE = E_R \times t$$

where DE = the dose equivalent (rem) incurred by workers, E_R = the exposure rate (rem per hour), and t = the exposure duration (hours). The following are the assumptions used for this analysis.

- The worker spends one hour per work week (a total of 50 hours per year) standing directly on top of a 100 m^2 pile of BHD that has a thickness of one (1) meter.

- The exposure rate on top of the BHD is 93 microR per hour, at a height of one meter above the surface of the pile, calculated using the Microshield 4.21 code.[22]

The maximum possible dose to the cement worker by this pathway is 4.7 millirem per year.

To estimate the radiation dose incurred when radioactivity becomes re-suspended, knowledge of the amount of material that may be re-suspended, the radionuclide concentration of the re-suspended material, the breathing rate of the worker while in the vicinity of the material, and the

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[19] Chemical Rubber Company, Handbook of Chemistry and Physics, 48th Edition, 1967.

[20] Leonard, P., Erase, written communication to M. Williams, Shieldalloy Metallurgical Corporation, December 19, 1995.

[21] Leonard, P., Erase, written communication to M. Williams, Shieldalloy Metallurgical Corporation, December 19, 1995.

[22] Grove Engineering, Inc. Microshield 4.21 (February, 1995)

duration of the worker's exposure is required. These doses are determined by first estimating the magnitude of intake of material by:

$$I_S = E \times V_m \times C_S$$

where I_S = the number of grams of re-suspended material inhaled, E = the Exposure Duration, V_m = the minute volume of air breathed, and C_S = the airborne concentration of BHD. For this analysis, the following parameters are assumed:

- A continuous airborne concentration (C_s) of 200 micrograms of BHD per cubic meter of air is representative of the conditions for any action being performed. This value is the maximum dust loading noted for dusty occupations.[23]

- The workers' respiratory rate (V_m) will equal that of an adult male performing light work for a minute volume of 20 liters, or $1.2\text{x}10^{3}$ m^3 per hour.[24]

- For the exposure duration (E), it is assumed that work will proceed at a rate of one (1) hour per work day, continuously, for a total of 250 hours per year.

From the estimated intake of re-suspended material, the reasonable maximum intake of radioactive materials is estimated by the following:

$$I_R = I_S \times C_R$$

where I_R = the intake of ^{238}U (and daughters) or ^{232}Th (and daughters), I_s = the number of grams of material inhaled, and C_R = the concentration of radioactivity in the re-suspended BHD. For this analysis, C_R is equal to the radionuclide concentrations for uranium and thorium in BHD (13.8 and 28.7 pCi/g, respectively). The daughter radionuclides are assumed to be present in equilibrium concentrations.

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[23] National Council on Radiation Protection and Measurements, "Exposures from the Uranium Series with Emphasis on Radon and its Daughters", NCRP Report No.77, Bethesda, Maryland, March, 1984.

[24] International Commission on Radiological Protection, Reference Man, ICRP Publication 23, Pergamon Press, New York, New York, 1973.

The USEPA, in Federal Guidance Report No. 11, provides a series of factors to convert annual intake of radioactive materials into committed effective radiation dose equivalent (CEDE).[25,26] These factors are based upon contemporary metabolic modeling and dosimetric methods. Using the USEPA methodology, the maximum committed radiation dose equivalent which may be incurred by workers while handling BHD as a result of inhalation of suspended material is estimated by:

$$CEDE = I_R \times DCF$$

where CEDE = the committed effective dose equivalent incurred by the workers, I_R = the amount of radioactivity inhaled, and DCF = the dose conversion factor for inhalation of the various radionuclides. The maximum possible dose by this pathways is 2.9 microrem per year.

The dose rate for individuals that use cement (dry form) is similar to the exposure rate for employees handling BHD, reduced by the relative concentration of radioactive materials in the final cement product (e.g., reduced by a factor of about four). The result of this assessment is a maximum annual dose of 0.7 microrem.

Exposure Assessment for General Population from Utilization of Cement

The dose rate for members of the public that might use concrete containing BHD as a foundation for their homes is conservatively estimated using the following assumptions:

- Portland cement containing BHD is mixed with sand, water and gravel in order to produce concrete for the foundation of the home. The radionuclide concentration in the concrete is 0.8 pCi/g of ^{238}U and 1.7 pCi/g of ^{232}Th.
- The floor slab is assumed to be 100 square meters and 0.3 meters thick, with a density of 3 g/cm^3.[27]
- The flooring in the home is assumed to be slab-on-grade, rather than wood flooring mounted some distance above the foundation.

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[25] U. S. Environmental Protection Agency, "Federal Guidance Report Number 11", 1988.

[26] The CEDE is the dose equivalent weighted over all body organs for an irradiation period of 50 years.

[27] Because the computer code used for this calculation assumes that the shape of a "contaminated area" is circular, two annular areas were used as input to the code to account for the square shape of a floor slab. The first area, with a radius of 0.005 meters, is composed of only contaminated area (e.g., 100% of the area represented is concrete made with BHD). The second area, with a radius of 0.007 meters, is composed of only 27.3% contaminated area (e.g., 27.3% of the area represented is concrete made with BHD).

- The exposure pathway for a hypothetical resident is direct (ambient) exposure.
- The hypothetical resident spends 50% of their lifetime in the home standing on the slab.

The maximum possible dose rate for this hypothetical individual, using the RESRAD computer code, is 1.3 millirem per year.[28]

Exposure Assessment for Ingestion by Children

The dose rate from ingestion of Portland cement is determined by multiplying the estimated rate of intake of soil by an appropriate Dose Conversion Factor (DCF). For this assessment, the following assumptions were used:

- Cement makes up 25% of the soil's mass, since it is assumed to be used as a soil conditioner (e.g., source of lime). Under this scenario, the radionuclide concentration in soil is 0.86 pCi/g of ^{238}U and 1.8 pCi/g of ^{232}Th.
- The soil ingestion rate is assumed to be 200 milligrams per day for a child under six and 100 milligrams per day for older children and adults.[29]
- The DCFs were taken from Federal Guidance Report No. 11.

The results of this assessment indicate a maximum possible dose of 1.3 millirem per year for a child under the age of six (6), and 0.6 millirem per year for older children and adults.

Exposure Assessment in the Event of a Road Accident

Vehicles designed for transport on U.S. highways and must meet certain performance standards in terms of retention of integrity of containment. These standards apply to conditions likely to be encountered in routine transport (e.g., accident-free conditions), during normal conditions of transport (e.g., minor mishaps), and during accident conditions of transport. However, for the purposes of this assessment, it is assumed that a truck carrying BHD is involved in a serious accident wherein the container is breached and a cloud of dust is released. For this scenario, there are three exposure groups: the truck driver, members of the general public, and emergency

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[28] Yu, C., A. J. Zielen, J. J. Cheng, Y. C. Yuan, L. G. Jones, D. J. LePoire, Y. Y. Wang, C. O. Loureiro, E. Gnanapragasam, E. Faillace, A. Wallo, W. A. Williams, and H. Peterson, "Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD", ANL/EAD/LD-2, Argonne National Laboratory, 1995.

[29] U. S. Environmental Protection Agency, "Exposure Factors Handbook", Report No. EPA/600/8-89/043, Office of Health and Environmental Assessment, Washington, D.C., July, 1989.

response personnel. The following are the assumptions used to develop this inhalation exposure scenario:

- A truck, carrying BHD overturns and creates a cloud of dust.

- The cloud of dust contains BHD at a concentration of 5 milligrams per cubic meter of air.[30]

- The driver and a member of the general public (passerby) are exposed to this plume for a period of one minute.

- Once the plume passes, the driver waits by the truck until a recovery team arrives. The duration of this period is assumed to be two (2) hours, and the driver is exposed to airborne BHD at a concentration of 0.2 milligrams per cubic meter of air.[31]

- When the recovery team arrives, the spilled material is repackaged and the truck is righted. During this period, which lasts for two (2) hours, members of the recovery team and the driver are exposed to airborne dust at a concentration of 3 mg per cubic meter of air.[32]

- While in the vicinity of the plume, the passerby and the driver are assumed to have a respiratory rate equal to that for high physical exertion (e.g., 100 liters of air per minute). After the plume passes, the driver is assumed to have a respiratory rate equal to that for light work (e.g., 20 liters per minute).[33] During recovery, the driver and response team are assumed to have a respiratory rate equal to that for high physical exertion (e.g., 100 liters of air per minute). No credit for the respiratory protection or protective clothing likely to be worn by the response team is taken.

- The mean radionuclide content listed in Table 2, which is equivalent to 28.7 pCi/g of ^{232}Th and 13.8 pCi/g of ^{238}U, is characteristic of all truckloads of BHD to be used in the cement production process.

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[30] Mishma, J., "Data useful in Evaluation of Airborne Plutonium from Postulated Accident Situations", Appendix F of Considerations in the Assessment of Consequences of Effluents from Mixed-Oxide Fuel Fabrication Plants, BNWL-1697, Rev. 1, 1975.

[31] National Council on Radiation Protection and Measurements, Report No.91, "Recommendations on Limits for Exposure to Ionizing Radiation", June 1, 1994.

[32] American Conference of Governmental Industrial Hygienists, "Threshold Limit Values for Chemical Substances and Physical Agents", limit for respirable nuisance dusts, 1992.

[33] International Commission on Radiological Protection, Report No. 23, "Reference Man", 1974.

- Factors to convert intake of dust to committed effective dose equivalent were obtained from Federal Guidance Report No. 11.[34]

From this exposure scenario, the maximum possible dose to the driver, a member of the general public, and a member of the response team is 1.9 x 10^{-3} millirem, 3.03 x 10^{-5} millirem, and 1.82 x 10^{-3} millirem, respectively.[35] If the response team dons respiratory protection and protective clothing, the doses to this population group would be negligible.

Exposure Assessment for General Population in Vicinity of Road Beds and Foundations

The dose rate from cement used as road bed or sidewalks is not likely to exceed the dose rate to members of the public whose homes are built of the material since the amount of time spent standing directly on road or sidewalk surfaces is likely to be less than the amount of time spent standing on the floor of a home. Therefore, the dose by this pathway was considered to be negligible and was not calculated.

Comparison with Background

Table 3 contains a summary of the exposure potential from the various scenarios described in the previous sub-sections. This table shows that the maximally-exposed hypothetical individual has the potential to incur up to 4.7 millirem per year (e.g., cement plant worker scenario). All other exposure scenarios resulted in lower estimated doses.

To put this value into perspective, it is important to note that everyone in the world is exposed to radiation at all times from natural radiation sources. This is called "natural background radiation". The sources of background radiation include "cosmic" radiation, which is radiation from the solar system and outer space; "terrestrial" radiation, which is radiation from the radioactive elements found in soil; "airborne" radiation primarily from household radon; "internal" radiation from natural sources of radiation found in foodstuffs and the human body itself; and radiation from consumer products, such as emissions from coal-fired plants, smoke detectors, television sets, tobacco products, and a wide variety of other items. In addition to natural background, humans are also exposed to radiation from medical and dental x-rays and nuclear medicine studies.

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[34] U. S. Environmental Protection Agency, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion", Federal Guidance Report No. 11, September, 1988.

[35] The same considerations and findings are assumed to be applicable to a rail accident.

The National Council on Radiation Protection and Measurements gives some examples of common radiation exposures.[36,37,38] Members of the general population receive, on average, the following radiation exposures:

- 1300 millirem per year for the average cigarette smoker
- 650 millirem per nuclear medicine examination of the brain
- 110 millirem per computerized tomography of the head and body
- 7.5 millirem per year to spouses of recipients of certain cardiac pacemakers
- 18 millirem per year from the potassium in our bodies
- 6 millirem per dental x-ray
- 6 millirem per year from the use of phosphogypsum in houses
- 5 millirem per year from foods grown on lands in which phosphate fertilizers are used.
- 4 millirem per year from highway and road construction materials
- 1.5 millirem from each 3,000 miles flown in an airplane
- 1 to 6 millirem per year from domestic water supplies
- 1 millirem per year from television receivers
- 0.8 millirem per year from the use of coal for home heating
- 0.5 millirem from eating one-half pound of Brazil nuts

Background radiation is unavoidable and its magnitude varies from one location on earth to another, depending on elevation, soil conditions, and other factors. For instance, the average

[36] National Council on Radiation Protection and Measurements, Report No. 93, "Ionizing Radiation Exposure of the Population of the Untied States", 1987.

[37] National Council on Radiation Protection and Measurements, Report No. 95, "Radiation Exposure of the U. S. Population from Consumer Products and Miscellaneous Sources", 1987.

[38] National Council on Radiation Protection and Measurements, Report No. 100, "Exposure of the U. S. Population from Occupational Radiation", 1989.

person living in Dallas, Texas receives a dose of 80 millirem per year due to "cosmic" and "terrestrial" radiation only. The average person living in Denver, Colorado receives 180 millirem per year from the same two sources.[39] In certain areas of India and Brazil, the residents receive over 1,000 millirem per year from "terrestrial" radiation alone. However, these residents show no abnormal increase in cancer rates, birth defects, or genetic problems.

When all of the general sources of background radiation are considered, the average human being typically receives between 150 and 600 millirem per year, exclusive of medical exposures.[40] The highest maximum reasonable dose calculated for any of the hypothetical individuals addressed herein (4.7 millirem per year due to direct exposure of a cement plant worker) is over 75 times less than the dose associated with typical background radiation exposures received by average members of the general population.

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[39] The difference of 100 millirem between the two locations is primarily due to Denver's higher elevation.

[40] United Nations Scientific Committee on the Effects of Atomic Radiation, "Sources, Effects and Risks of Ionizing Radiation", 1988 Report to the General Assembly, 1988.

SUMMARY AND CONCLUSIONS

Shieldalloy Metallurgical Corporation (SMC) intends to sell baghouse dust arising from ferrocolumbium production operations to cement manufacturing firms as a source of calcium, aluminum and silicon. Although the baghouse dust (BHD) contains low concentrations of uranium and thorium, those concentrations are considered to be "unimportant quantities" pursuant to 10 CFR 40. Thus the recipients of BHD are exempt from federal licensing requirements.

A pathways analysis and dose/risk assessment was performed to assure that the radiological impact of BHD use will be negligible (e.g., less than a dose objective of 10 millirem per year). The results of this analysis shows that, indeed, the use of BHD in cement and concrete meets the dose objective and demonstrate that the maximum possible radiation dose to cement workers or end users is inconsequential when compared to the range of radiation doses incurred by these individuals by virtue of being alive.

However, it is important to note that the estimates shown in Table 3 reflect the maximum dose *potential* for the groups of interest. There is no evidence that any radiation dose in excess of background will occur as a result of proximity to BHD or its end use products. Furthermore, even after application of generous assumptions, the radiological conditions that may result from the use of BHD in cement manufacturing will not result in demonstrable adverse health effects.

TABLES

Table 1 - Uranium and Thorium Content in Baghouse Dust Samples

Sample No	U - ppm	Th - ppm	Percent (by Weight)
BHD-001	17.10	144.00	0.01
BHD-002	3.10	10.00	0.00
BHD-003	63.50	397.00	0.04
BHD-004	58.30	368.00	0.04
BHD-005	15.10	38.00	0.00
BHD-006	63.80	450.00	0.05
BHD-007	59.60	427.00	0.04
BHD-008	43.80	326.00	0.03
BHD-009	46.30	341.00	0.03
BHD-010	54.00	373.00	0.04
BHD-011	58.60	202.00	0.02
BHD-012	59.40	197.00	0.02
BHD-013	26.80	200.00	0.02
BHD-014	28.00	261.00	0.03
BHD-015	29.60	182.00	0.02
Average $\pm$ σ	41.80 $\pm$ 19.48	261.07 $\pm$ 131.74	0.03 $\pm$ 0.01

Table 2 - Radionuclide Concentrations at Various Stages of Concrete Production

Stage	**Radionuclide Concentration (pCi/g)**	
	^{232}Th (plus daughters)	**^{238}U (plus daughters)**
Baghouse Dust (BHD)	28.7	13.8
Cement made with BHD	7.2	3.5
Concrete made with BHD-bearing cement	0.8	1.7

Table 3 - Summary of Dose Assessment Results

Exposure Scenario	Maximum Individual Dose (millirem per year)
Direct Exposure of a Cement Worker Handling BHD.	4.700
Inhalation Exposure of Cement Worker from BHD	0.003
Inhalation Exposure of Cement Worker from Cement Containing BHD	0.001
Total Exposure of Member of the Public from a Concrete Foundation	1.278
Ingestion Exposure of Children from Soils Containing Cement	1.260
Ingestion Exposure of Older Children and Adults from Soils Containing Cement	0.630
Inhalation Exposure of Driver in the Event of a Truck Accident	0.002
Inhalation Exposure of Member of the Public in the Event of a Truck Accident	0.000
Inhalation Exposure of Response Team Member in the Event of a Truck Accident	0.002
Dose Limit (above background) to Individual Members of the General Public set by the U. S. Nuclear Regulatory Commission	100.000
Mean Dose Incurred by a Member of the General Public from Normal Background Radiation (including medical exposures)	360.000

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