40-7102

SHIELDALLOY METALLURGICAL CORPORATION

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RICHARD D. WAY
SENIOR VICE PRESIDENT, MANUFACTURING

March 19, 1991

Mr. Yawar H. Faraz
Mail Stop 6H-3
Advanced Fuel and Special Facilities Section
Fuel Cycle Safety Branch
Division of Industrial and Medical Nuclear Safety
Office of Nuclear Material Safety and Safeguards
United States
Nuclear Regulatory Commission
Washington, D.C. 20555

RE: Exemption, Modification or Amendment of License SMB-743 to Allow Handling and Sales of Imported Material Found to be a Source Material

Dear Mr. Faraz:

Shieldalloy Metallurgical Corporation (SMC) hereby submits its application for an exemption from the provisions of 10 CFR Part 40 to allow SMC to receive, possess, use, transfer, and deliver a specific quantity of a source material, ferrosilicon zirconium, containing greater than 0.05% uranium and thorium. The material, which was imported without prior knowledge that the combined U and Th levels exceeded 0.05%, is stored at the SMC facility in Newfield, New Jersey. The total amount of ferrosilicon zirconium is 55,920 pounds, containing a maximum of 0.020 curies of U and Th. SMC would sell the material to customers that have an NRC license that would authorize them to receive the material, or, in quantities of less than regulatory concern, to various customer throughout the United States.

SMC imports ferrosilicon zirconium (FeSiZr) from several suppliers around the world. FeSiZr is sold to purchasers who use it in steel foundaries to fix nitrogen. Shieldalloy never had any indication or reason to believe that any of the imported FeSiZr contained enough U and Th that it might be considered a source material. Indeed, one or more of our customers were known to monitor the material for its radioactive content.

In May 1990, a customer notified us that for the first time a routine exposure rate spot check of one of our shipments of FeSiZr indicated elevated levels of radiation. Upon receipt of samples of the returned lot, SMC forwarded two samples to TMA

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Eberline for evaluation. The combined U and Th content of those samples was 0.416%. SMC subsequently scanned inventories of the additional FeSiZr lots and found some to be elevated. The average concentrations of the lots with elevated levels were 0.35% combined U238 and Th232, as found by a second laboratory, Clean Harbors Analytical Services.

The ratio at which the material is added to the steelmaking process is approximately one-half pound of FeSiZr per ton of steel (0.1%). Our metallurgists believe that the U and Th contained in the FeSiZr become a slag constituent. The percentage of slag generated is 10 to 15% of the total heat weight. Consequently, even with the elevated levels of radiation contained in the FeSiZr, the slag would have a total U and Th content of approximately 0.0032%, well below levels of regulatory concern.

SMC began a program to cease sales of the material and to retrieve all of the FeSiZr that remained under SMC's control. That task has been completed and the material has been consolidated at SMC's licensed facility in Newfield, New Jersey.

We have had our consulting health physicist review the available data to determine whether any significant health threat was presented by the material. The conclusion reached was that "the estimated effective dose equivalents in all scenarios are below the NRC limit of 500 mrem/yr for unrestricted areas (general public). If, as considered in 10 CFR 20.105, an individual were continuously present near the storage of the FeSiZr pallet boxes, the radiation levels of two millirems in any hour or 100 millirems in any seven consecutive days would not be approached or exceeded."

In support of this application for an exemption, SMC has prepared addenda that describe the material, the actions taken by SMC upon discovering the problem, the quantity and content of the FeSiZr and the potential health effects of the material. The addenda are:

A. Identification of lots that exceeded 0.05% U and Th
B. Identification of steps taken by SMC to ensure that exposures were as low as reasonably possible
C. Discussion of health effects of FeSiZr with the levels of radiation contained in the SMC material

SMC believes that, under the circumstances, all reasonable and necessary steps have been taken to comply with the intent of the NRC's regulatory program in regard to this material. We

believe it is in the interest of all concerned, including our customers, that the regulatory status of the material be properly addressed in a prompt manner. In the event that an exemption for this material cannot be issued or that the exemption process may take so long that the material would have to be stored for a significant period of time, we request that this submission be considered as an application for a modification or amendment to our license and be acted upon as soon as possible.

Sincerely,

Richard D. Way

Richard D. Way
Senior Vice-President, Manufacturing

RDW:lms
Enclosure
CC: Michael A. Standen
Michael A. Finn
William P. Cyr
David R. Smith
Michael R. Morgenstern
John Austin, Austin & Movahedi

List of Elevated Levels of FesiZr Identified Following Discovery of Elevated Levels of U and Th

WAREHOUSE STOCKS

Ware house	Lot #	FeSiZr in pounds	Percent U and Th	Pounds U and Th
AA	58114	3,000	0.42%	13
BB	58299	8,820	0.32%	28
CC	58299	44,100	0.32%	141

ACTIONS TAKEN BY SMC FOLLOWING DISCOVERY OF ELEVATED LEVELS OF U and Th IN CERTAIN LOTS OF FeSiZr

- Samples obtained and sent for analysis
- Inventories scanned to identify lots with elevated levels
- All lots submitted for radioisotopic analysis
- Contract specifications changed to ensure FeSiZr purchases were limited to less than 0.05% contained U and Th
- All purchases of FeSiZr discontinued
- Material Safety Data Sheets for FeSiZr were revised to indicated U and Th may exceed 0.05%
- Health physicist contracted to prepare report on health effects
- All FeSiZr with elevated levels of U and Th, in lots greater than 1500 pounds of contained U and Th, ordered returned from warehouse to storage in Newfield
- All sales of FeSiZr with elevated levels of U and Th were ceased, regardless of quantity
- All lots, regardless of size, with elevated levels of U and Th were recalled from warehouses to storage in Newfield
- Efforts were made to determine if returning any FeSiZr to foreign suppliers was feasible; non was obtained from domestic suppliers
- All other zirconium alloys and raw materials that exhibited radiation rates of greater than 20 uR/hour were analyzed and found to be well below 0.05% U and Th

Exposure Rate Assessment

SMC receives ferrosilicon zirconium (FeSiZr) at the Newfield Plant. The FeSiZr is not processed at Newfield but only packaged and shipped to customers in pallet boxes. Recently, isotopic analysis of the materials by Clean Harbors Analytical Services in Braintree, MA has indicated the presence of uranium and thorium at levels in excess of those which are regulated by U.S. NRC as source material. The FeSiZr has been handled at the Newfield plant, and handled and used at customer's facilities. The FeSiZr is not explicitly covered under SMC's current NRC license and many of SMC's customers are not licensed by U.S. NRC. An evaluation of the potential radiological exposure from this material is presented.

Objective and Approach

The objective of this assessment is to develop an upper bound estimate of the potential radiological exposure from FeSiZr during storage, transport, handling, and utilization. This assessment includes the determination of the dose rate from the FeSiZr, compilation of the most likely dose detriment to SMC and customer's staff, and conclusions of whether these dose detriments exceed limits as defined by federal regulation.

The overall approach to this assessment is focused to develop an upper-bound estimate of potential dose detriment. Available data on the isotopic composition, physical properties, and use and occupancy patterns associated with this material are considered. Dose conversion factors and associated computations (see References 1 and 2) are used to estimate dose detriments for these worst-case exposure scenarios.

Exposure Scenarios

The assessment addresses the total integrated dose per annum which is the significant factor to be considered. Scenarios that could lead to whole body dose from external exposure to gamma radiation from the raw material are expected to provide upper bound exposure cases. Because the FeSiZr is packaged and used as lump material (i.e., 2 in x 2 in lumps, and smaller), the potential content of respirable particulate (i.e., 10 micron diameter and smaller) in the material is expected to be small (i.e., $<<$ 1 percent, by weight). This exposure route is expected to result in a small contribution to the overall dose detriment.

The individuals who could have been exposed are:

1. SMC Newfield workers handling the material,
2. SMC storage staff,
3. SMC casual workers passing through or working close to the storage area,
4. workers of the transport company that transported the material to customers,
5. customer storage staff,

customer operations staff who handled the material, and

7. customer casual workers passing through or working close by the storage area.

Because the material is used as an additive in steelmaking operations, the likely exposure to the customer would be by handling the material as part of furnace loading operations.

Of the previous listed exposed individuals, the three that represent upper bound exposure scenarios are:

1. staff working near stored material,

2. casual staff passing through storage areas, and

3. furnace worker loading the material into furnace.

In addition, Scenario #2 also would give an upper bound estimation of exposure to the general public at a distance.

Exposure Rate Estimates

Dose Rate Estimation

The specific activity of the material is defined as the total radioactivity of an isotope (i.e., uranium or thorium) per gram of FeSiZr. The specific activities for separate lots have been measured and are tabulated in Appendix A. These six measurements are assumed to be representative. For the purpose of this upper limit assessment, the highest isotopic composition of 0.42 wt. percent U-238 + Th-232 has been used.

The dose conversion factors employed (Reference 2) are based on radionuclides present in a uniformly contaminated zone of infinite depth and lateral extent. The computations used (Reference 1) to develop the dose conversion factors assume a cylindrical geometry and source dimensions of 5 meter diameter and 15 centimeter depth. Conservative correction factors for geometry and density were applied. The dose conversion factors developed in "A Manual for Implementing Residual Radioactive Material Guidelines" (Reference 2) agree quite closely with those developed in the NUREG/CR 5512 document. Both references base their guidelines on the recommendations and the system of standards and models provided in Publications 26 and 30 of the International Commission on Radiological Protection (ICRP).

The basic assumptions used in Reference 2 include:

1. an idealized region of cylindrical shape;

2. a shape factor which is less than one, if the source is irregularly shaped; and

3. if radionuclide distributions are approximately uniform throughout the source, the source geometry is a single cylinder that specifies a homogeneous contaminated zone with limiting radionuclide concentrations, referred to as single-radionuclide guidelines, derived for each cylindrical volume.

This geometry/volume assumption should overestimate the dose expected from the actual pallet boxes, as no correction factors for geometry are applied and the volume of the assumed area is several times that of an actual pallet box.

The dose due to external gamma radiation is first calculated for an individual exposed continuously to radiation from an infinite contaminated zone at a distance of one meter from the plane surface. Correction factors are then applied for the finite area and thickness of the contaminated zone, irregular shape, and less than continuous exposure.

The distribution of dose within the body depends upon the type of radiation involved and the location of the radionuclides emitting the radiation (i.e., within or external to the body). The ICRP has provided a useful quantity that, on a risk scale, can be applied to any radiation pattern. This quantity - the effective dose equivalent - is the weighted sum of the dose equivalent in various organs. In the case of external radiation, the dose rate in the organs depends on the concentrations of the radionuclide in the environment. These relationships are expressed as dose/exposure ratios called "dose conversion factors". A dose conversion factor is the ratio of the effective dose equivalent rate (for external exposure) to the concentration of a radionuclide in the air, water, or ground.

External exposure rates for unit quantities of individual radionuclides are calculated considering contributions from electromagnetic radiation from gamma- and x-rays; bremsstrahlung from the slowing down of beta particles, auger electrons, and conversion electrons; and annihilation radiation from positrons. The external dose rate conversion factors are based on the deep dose equivalent (i.e., photon energies that penetrate to a depth of 1 cm of tissue).

Dose conversion factors for radionuclides distributed in the ground depend on the bulk density (d) of the soil. Factors for $d = 1.0\ g/cm^3$ and $d = 1.8\ g/cm^3$ are listed in the dose conversion factor table (see Appendix B). The values for the density of FeSiZr are obtained by linear extrapolation. Assuming a bulk density of FeSiZr of $2.37\ g/cm^3$ (see Appendix C). Extrapolating the uranium + daughters volume factors for the bulk density of FeSiZr ($d = 2.37\ g/cm^3$) would derive a volume factor of 4.5×10^{-6} (mrem/hr)/(pCi/gm). For thorium 232 + daughters, the new volume factor is 1.4×10^{-4} (mrem/hr)/(pCi/gm).

The computed dose rates are tabulated in Appendix D for two lots of FeSiZr with the highest measured concentrations of U and Th. The calculated dose rates of 20 to 55 urem/hr at one meter from the idealized pallet box are computed from the dose/energy conversion factors for U-238 and Th-232, corrected for a bulk density of $2.37\ g/cm^3$. The calculated dose equivalent ranges from 112 to 306 uRem/hr at 1 cm. This estimate is the same magnitude as a single dose rate of approximately 600 uR/hr taken by a direct-reading gamma radiation detection instrument at contact for a 1,000 lb. pile of FeSiZr (lot P58114). The computed dose rates at 10 m range from 0.6 to 1.7 urem/hr and represent the dose at distance.

Dose Detriment Calculations

Scenario #1

SMC records indicate that one customer received several shipments of 4,000 lb/month of FeSiZr. This SMC Lot #58114 has a total U and Th concentration of 0.42 percent (Appendix D). The material is shipped and stored in "Super" bags contained in 1 cubic yard pallet boxes. The pallet boxes weigh approximately 4,000 lb. and must be moved with a forklift.

It is unrealistic to expect a worker to work in the storage area continuously (24 hours/day). This scenario bases effective dose equivalent calculations on exposure scenarios of 8 hours/day for one year and 8 hours/day, 5 days/week for one year. The calculations are based on a 54.9 urem/hr dose rate at 1 meter (Appendix D). A field measurement of 180 uR/hr was taken with a gamma radiation detection instrument. The measurement was taken at 1 meter from a bag placed in the storage area. Other factors that contribute to the field measurement are the background and the large volume of material at the SMC facility.

	Total Annual Dose (mrem) (2920 hours/yr)	Total Annual dose (mrem) (2080 hours/yr)
Equivalent Dose @ 1m	160	114

Based on the storage and handling requirements for the pallets, it is unlikely that an individual was exposed to the radiation continuously for an entire working year. Therefore, a realistic exposure for a full-time worker in the storage area would be considerably less than the estimated 114 to 160 mrem of total annual dose.

Scenario #2

A casual worker who must either pass through or spend some amount of time working near the storage area would receive an annual dose based on time in area and proximity to storage pallets. Considering the same hours worked per year from Scenario #1, but utilizing an occupancy factor of 0.5 (50 percent of the time in the storage area) and the proximity to the pallets at 1 meter and 10 meters. The calculations are based on a 54.9 urem/hr dose rate at 1 meter and 1.67 urem/hr at 10 meter (Appendix D).

	Total Annual Dose (mrem) (2920 x 0.5 hr/yr)	Total Annual Dose (mrem) (2080 x 0.5 hr/yr.)
Equivalent Dose		
@1 meter	80	57
@ 10 meters	2.4	1.7

Scenario #3

The pallet is loaded to a furnace during the heat. Assuming the pallet box is lifted by crane and conveyed to the furnace where the FeSiZr is dumped into the furnace, the potential exposures would be received by individuals rigging the pallet box and the forklift operator who delivers the pallet box from storage. Basic assumptions utilized in this scenario are:

1. Forklift operator
   - sits 1 meter from pallet box
   - moves box four times per shift
   - each move lasts 0.5 hours

2. Rigging crew
   - works 10 cm from pallet box
   - rigs box four times per shift
   - each rigging operations lasts 0.25 hour (hook and unhook)

The calculations are based on a 54.9 urem/hr dose rate at 1 meter and 178 urem/hr at 10 cm (Appendix D).

Forklift Operator

	Total Annual Dose (mrem) (365 days x 2 hr/day = 730 hr/yr)	Total Annual Dose (mrem) (260 days x 2 hr/day = 520 hr/yr)
Equivalent Dose		
Forklift Operator @1m	40	29

Rigging Crew

	Total Annual Dose (mrem) (1 hr/day x 365 days/yr = 365 hrs/yr)	Total Annual Dose (mrem) (1 hr/day x 260 days/yr = 260 hrs/yr)
Equivalent Dose		
Rigger @ 10cm	65	46

In the three scenarios, conservative approaches to worker occupancy and proximity to the pallet boxes were utilized to estimate conservative annual equivalent doses to individuals. Given that the FeSiZr at any site is shipped and ultimately is consumed with an associated decrease in dose rate from the pallet box as a result of this consumption. In addition, the pallet box is continuously moved by forklift from storage to the furnace area to supply FeSiZr for the furnace heat.

The exposure risk from inhalation of particles is expected to be small compared to direct radiation exposure. It is expected that a small fraction of the FeSiZr would be reduced to inhalable size particles. The exposure would most likely occur during packaging at the SMC plant or during loading into the furnace at a customer's facility. In all phases in between, the material is contained in a "Super" bag packed inside the pallet box.

Conclusions

Based on the data available, the expected material handling, transport and storage parameters, and the calculated effective dose equivalents, the scenarios presented provide a conservative upper bound estimation of the potential dose equivalents received by individuals working near the FeSiZr. These calculations are not corrected for the different shape and area factors as recommended in the NUREG model. The inclusion of the correction factors would reduce the dose conversion factor and, therefore, equate to smaller dose rates than those calculated. These factors were not utilized in the calculations because the introduction of uncertainties, as these factors would be estimated only, was considered unnecessary.

The estimated effective dose equivalents in all scenarios are at levels below the NRC limit of 500 mrem/yr for unrestricted areas (general public). If, as considered in 10 CFR 20.105, an individual were continuously present near the storage of the FeSiZr pallet boxes, the radiation levels of two millirems in any hour or 100 millirems in any seven consecutive days would not be approached or exceeded.

REFERENCES:

1) "Residual Radioactive Contamination from Decommissioning - Technical Basis for Translating Contamination Levels to Annual Dose." Draft Report for Comment. NUREG/CR-5512, PHL-7212, Pacific Northwest Laboratory.

2) "A Manual for Implementing Residual Radioactive Material Guidelines. A Supplement to U.S. Department of Energy Guidelines for Residual Radioactive Material At Formerly Utilized Sites Remedial Action Program and Surplus Facilities Management Program Sites." ANL/ES - 160, DOE/CH/8901. Argonne National Laboratory (1989).

Appendix A
Shieldalloy Metallurgical Corporation
Newfield Plant

FeSIZr Isotopic Composition					
SMC Lot Number	U-238[a] pCi/g	Wt. % U	Th-232[a] pCi/g	Wt.% Th	Total U + Th%
P57514-02	480	0.144	123	0.113	0.257
P58238	45	0.013	0.84	0.00076	0.014
P58299[b]	700	0.21	119	0.11	0.31
P58114A	86	0.026	300	0.28	0.31
P58114B[b]	220	0.068	380	0.35	0.42
57834	790	0.24	169	0.155	0.395

(a) Clean Harbors Analytical Services data reports. Reports of analysis of FeSIZr submitted for isotopic analysis.

(b) Isotopic compositions from these samples are used in subsequent exposure calculations (See Appendix D).

Appendix B

Dose Conversion Factors as a Function of Density

Radionuclide	Volume Factor[a] d = 1.0 g/cm^3	d - 1.8 g/cm^3	d = 1.93 g/cm^3
U-238+D	1.45×10^{-5}	7.96×10^{-6}	7.5×10^{-6}
Th-232+D	4.60×10^{-4}	2.55×10^{-4}	2.4×10^{-4}

Extrapolating the volume factors for the bulk density of FeSiZr (d= 2.37 g/cm^3) would derive a volume factor of 4.5×10^{-6}(mrem/h/pCi/g).

For Thorium, the new volume factor is 1.4×10^{-4} (mrem/hr)/(pCi/g).

These volume factors are used in Appendix E to compute the dose rates.

(a) See references 1, Table 2.1; reference 2, Table B.1.

Appendix C

Bulk Density of FeSiZr

Weight of FeSiZr Pallet Box[a]	=	1818 kg (4,000 lb)
Volume of FeSiZr Pallet Box[a]	=	7.645×10^5 cm^3 ($1yd^3$)
Bulk density of FeSiZr	=	1818 kg/7.645×10^5 cm^3
	=	2.37 g/cm^3

(a) Per telephone conversation with M. Morgenstern (SMC).

APPENDIX D

CALCULATED SPECIFIC ACTIVITY
(SMC Lot #58114B)

	Th232	U238	TOTAL
Atomic Weight (gm)	2.32E+02	2.38E+02	
Half Life (yr)	1.40E+10	4.50E+09	
Activity for Pure TH232,U238(pCi/gm)	1.10E+05	3.34E+05	
Percent by Weight (Th232 or U238)	3.50E-01	6.60E-02	
Specific Activity (pCi/gm)	3.85E+02	2.20E+02	6.06E+02

EXTERNAL DOSE CALCULATION[b]

	Th232	U238	TOTAL @ 1m	TOTAL @ 1cm	TOTAL @10 cm	TOTAL @10 meter
(urem/Hour)(pCi/gm)[a]	1.4E-01	4.5E-03				
Dose Rate (urem/Hr)[a]	5.39E+01	0.99E+00	54.9E+01	3.06E+02	1.78E+02	1.67E+00

(a) Pages 2.12 and 2.13 of NUREG/CR-5512 - "Residual Radioactive Contamination from Decommissioning: Technical Basis for Translating Contamination Levels to Annual Dose. Draft Report for Comment." Derived by linear extrapolation, based on FeSiZr bulk density.

APPENDIX D
(Continued)
CALCULATED SPECIFIC ACTIVITY
(SMC Lot #58299)

	Th232	U238	TOTAL
Atomic Weight (gm)	2.32E+02	2.38E+02	
Half Life (yr)	1.40E+10	4.50E+09	
Activity for Pure TH232,U238(pCi/gm)	1.10E+05	3.34E+05	
Percent by Weight (Th232 or U238)	1.10E-01	2.10E-01	
Specific Activity (pCi/gm)	1.21E+02	7.01E+02	8.23E+02

EXTERNAL DOSE CALCULATION[b]

	Th232	U238	TOTAL @ 1m	TOTAL @ 1cm	TOTAL @10 cm	TOTAL @10 meter
(urem/Hour)(pCi/G)[a]	1.4E-01	4.5E-03				
Dose Rate (urem/Hr)[a]	1.69E+01	3.15E+00	2.01E+01	1.12E+02	6.54E+01	0.62E+00

(b) External dose estimates were calculated using the following formula:

$$\frac{d}{d_r} = \frac{\ln\left(1+\frac{r^2}{x^2}\right)}{\ln\left(1+\frac{r^2}{x_r^2}\right)}$$

where d = dose at distance
d_r = dose at 1 meter
r = 2.5 meter
x_r = distance, meter