INTERNATIONAL
URANIUM (USA)
CORPORATION

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April 18, 2001

Via Overnight Mail

Mr. Phillip Ting, Branch Chief
Fuel Cycle and Safety and Safeguards Branch
Division of Fuel Cycle Licensing
Office of Nuclear Materials Safety and Safeguards
U.S. Nuclear Regulatory Commission
2 White Flint North, Mail Stop T-7J9
11545 Rockville Pike
Rockville, MD 20852

40-8681

Re: NRC Regulations Applicable to the Release of Vanadium Product from the White Mesa Mill Site, and Proposed Mill Procedures

Dear Mr. Ting:

1. INTRODUCTION AND SUMMARY

This letter reviews NRC regulations that are applicable to radionuclides associated with vanadium product produced at International Uranium (USA) Corporation's ("IUSA's") White Mesa uranium mill (the "Mill"), and the procedures that will be followed at the Mill to ensure that the vanadium product that leaves the Mill site is in compliance with all such regulations.

In summary, it is IUSA's position that NRC does not have jurisdiction over vanadium product produced at the Mill that contains less than 0.05% source material by weight. However, under 10 C.F.R. Part 20 the Mill must ensure that any product that leaves the licensed area of the Mill site is not inappropriately affected by licensed material. Accordingly, IUSA proposes additional procedures to be followed at the Mill to ensure that all vanadium products leaving the Mill site contain less than 0.05% source material by weight and comply with the applicable 10 C.F.R. Part 20 requirements.

2. BACKGROUND

During the most recent mill run, which was conducted in 1999, the Mill processed conventional ores from uranium/vanadium mines in the Colorado Plateau mining district for the recovery of uranium and vanadium. Most of the vanadium produced was in the form of "blackflake," although some vanadium was in the form of "vanadium pregnant liquor" ("VPL"), which is an intermediate liquid product that is extracted from the vanadium circuit prior to the oxidation and fusing process. VPL, if processed further in the vanadium circuit, becomes blackflake. Ammonium Metavanadate ("AMV") is another intermediate product in the form of a powder which is extracted from the process prior to the fusion stae, but after further processing of the VPL in the oxidation circuit. No AMV was produced in the last mill run as a final product. Blackflake is shipped in 55 gallon metal drums in lot sizes of 66 drums. There is approximately 550 lbs. of blackflake per drum. VPL is typically shipped as a liquid in bulk in tanker trucks.

All vanadium is produced from the uranium raffinate stream after it leaves the uranium solvent extraction circuit at the Mill.

During the 1999 mill run, after all of the conventional ore had been processed, the Mill re-processed certain vanadium clean-up materials (the "Cleanup Materials") from previous mill runs (performed by the previous operator of the Mill) that had been stored at the Mill site since 1988. The Cleanup Materials were re-processed through the fusion circuit only to produce blackflake. As the Cleanup Materials were only fused, no VPL or AMV were produced from the re-processing of the Cleanup Materials.

During routine alpha contamination surveys on the exterior surfaces of certain vanadium blackflake drums produced during the 1999 mill run, as the drums were being prepared for shipment to a vendor, it was discovered that there was elevated radioactivity coming from some of the drums. Mill staff held those drums back for further analysis, and it was determined that the blackflake in question had been produced from re-processing the Cleanup Materials. IUSA believes there is a likelihood that some of the Cleanup Materials somehow contained minor quantities of uranium prior to their being re-processed, and that some of this uranium found its way into this blackflake.

These facts were explained to an NRC Inspector at the July 2000 inspection of the Mill, and are referred to in the NRC's September 6, 2000 Inspection Report and Notice of Violation, as well as in other correspondence and discussions between IUSA and NRC. IUSA has agreed not to ship any blackflake or VPL off of the Mill site until the question of what constitutes acceptable levels of radioactivity in the vanadium products is determined.

3. APPLICABLE NRC REGULATIONS

3.1. 10 C.F.R. Part 40 and the Licensing Requirements of Section 62 of the Atomic Energy Act

As detailed in the August 10, 2000 letter from Shaw Pittman included as part of Attachment A to this letter, NRC's jurisdiction under the Atomic Energy Act (the "AEA") is material-based; that is, the AEA grants NRC jurisdiction to regulate only source, special nuclear and byproduct material. 42 U.S.C. § 2201. Since operations at the Mill do not involve special nuclear material or 11e.(1) byproduct material, NRC's jurisdiction over the Mill extends only to activities involving source material or 11e.(2) byproduct material. Further, as the vanadium products are not waste products they cannot be, and to date never have been considered or licensed as, 11e.(2) byproduct material.

With respect to source material at the Mill, NRC's authority is further circumscribed by Section 62 of the AEA, which expressly provides that "licenses *shall not* be required for quantities of source material which, in the opinion of the Commission, are unimportant." 42 U.S.C. § 2092 (emphasis added). NRC has taken the position that any chemical mixture, compound, solution, or alloy in which the uranium or thorium content is less than 0.05% by weight is considered to be an "unimportant quantity" and is exempt from regulation as source material. 10 C.F.R. § 40.13. Therefore, the requirement to have a license and the requirements of 10 C.F.R. Part 40 only apply to vanadium products if the products contain 0.05% or greater source material by weight. It is therefore necessary for the Mill to have procedures in place to ensure that vanadium products do not contain 0.05% source material by weight. Procedures to be established by the Mill to ensure that the vanadium products produced at the Mill do not exceed these source material levels are discussed in Section 4.1 below.

3.2. Labeling Requirements of Part 20.

The labeling requirements set out in 10 C.F.R. §20.1904 apply only to packages containing licensed material. Therefore, so long as the vanadium products contain less than 0.05% source material by weight, these requirements do not apply. The procedures discussed in Section 4.1 below will ensure that no vanadium products will leave the Mill site if they contain 0.05% source material by weight. The only potential circumstance in which vanadium products that contain 0.05% source material would leave the Mill site would be if the products were to be shipped to another site that is licensed to accept source material, in which case the labeling requirements of 10 C.F.R. §20.1904 would apply to those shipments of vanadium products. IUSA is currently unaware of any such circumstances having taken place in the past or that are likely to take place in the future.

3.3. Dose to the Public Requirements of 10 C.F.R. Part 20.

The only other provisions of 10 C.F.R. Part 20 that are potentially relevant to the shipment of vanadium products off site are the requirements set out in 10 C.F.R.

§20.1101, §20.1301 and §20.1302 which require that a licensee must have a radiation protection program in place that, among other things, ensures that the total effective dose equivalent to individual members of the public from the licensed operation does not exceed 0.1 rem (1 millisievert) in a year, and 0.002 rem (0.02 millisievert) in any one hour, in any unrestricted area.

It is IUSA's position that, as the requirements set out in 10 C.F.R. §20.1301 and §20.1302 apply only to the "licensed operation", and as vanadium products that contain less than 0.05% source material are not licensable under the AEA, these requirements do not apply to vanadium products that contain less than 0.05% source material by weight, if the source material originates from the natural ores or feed materials from which the vanadium is extracted.

However, it is possible that vanadium products and/or containers of vanadium product could, in unusual circumstances, become contaminated by licensed operations while at the Mill site. Therefore, IUSA will put procedures in place at the Mill to ensure that when containers of vanadium product leave the Mill site the requirements contained in 10 C.F.R. §20.1301 and §20.1302 are satisfied[1].

Since the ores from which the vanadium products are made contain uranium, some uranium may somehow end up in the final vanadium products. This, however, is not a situation where materials from licensed operations have been *added* to contaminate the vanadium products. Rather, the uranium is an element that co-exists naturally with the uranium in Colorado Plateau ores. So long as this natural uranium element does not result in the vanadium products containing 0.05% or more source material content, the requirements of 10 C.F.R. §20.1301 and §20.1302 do not apply. However, if source material from licensed operations is added to the vanadium products or if there is external source material contamination on the vanadium product drums, originating from licensed operations at the site, then the requirements of 10 C.F.R. §20.1301 and §20.1302 would be applicable.

To ensure that no such potential contamination of vanadium products from licensed activities at the Mill would result in a violation of 10 C.F.R. §20.1301 and §20.1302, the Mill proposes to adopt the procedures set out in section 4.2 below to ensure protection to human health and the environment.

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[1] This is similar to the requirement that a piece of equipment (originally made offsite by an unlicensed third party) that leaves the restricted area at the Mill must be decontaminated and surveyed. The uranium content of the piece of equipment is irrelevant (except to the extent it may contribute to a radiation dose to the public), but the piece of equipment must nevertheless be decontaminated and surveyed to ensure that it has not been contaminated by the licensed activities at the Mill. Once the piece of equipment meets the criteria for unrestricted release from the Mill, it can be released unconditionally, even though the metals originally used to make the piece of equipment may contain up to but less than 0.05% source material.

4. PROCEDURES TO BE FOLLOWED BY THE MILL

The Mill proposes to adopt the following procedures to ensure that the applicable laws and regulations discussed above are complied with:.

4.1. Compliance with the Requirements of 10 C.F.R §40.13

In addition to the procedures detailed below in Section 4.2 relating to compliance with the relevant 10 C.F.R. Part 20 requirements, the Mill will follow the following procedures.

4.1.1. Vanadium Blackflake Product

As discussed above, vanadium blackflake is packaged in 55 gallon sealed metal drums and is sold in lots of 66 drums totaling approximately 36,300 lbs. The primary use of the blackflake is in the production of ferrovanadium. Over 90% of the world's production of vanadium is used in the manufacture of steel and other metal alloys. Vanadium is typically added in percentages ranging from 0.05 to 0.15 percent of the steel or alloy. Each lot of vanadium is added to the ferrovanadium conversion process as a complete lot.

The Mill will take a composite sample for each lot of vanadium blackflake, comprised of one grab sample from each 55 gallon drum in the lot. The composite sample will be assayed for total uranium and total thorium. No lot that has a composite sample with a source material content of 0.05% uranium and/or thorium or greater will leave the Mill site. If for any reason vanadium blackflake is not sold in a 66 drum lot, then the composite sample will be made up from such number of 55 gallon drums as make up such end-use quantity. Only quantities of vanadium blackflake that have a composite sample with less than 0.05% source material will be permitted to leave the Mill site.

4.1.2. VPL Product

As discussed above, VPL is a liquid that is sold and delivered in tanker trucks. The quantity of VPL to be deposited into each tanker truck will be segregated and a sample taken and assayed for total uranium and total thorium prior to loading the VPL into the tanker truck. Only quantities of VPL that have a source material content of less than 0.05% will be permitted to leave the Mill site.

4.1.3. AMV Product

AMV was only sold as a final product during the 1988 – 89 milling campaign. Since that time all of the AMV produced as an intermediary product was further processed to produce blackflake. In the event that AMV product is sold it will typically be packaged in one ton super sacs. A composite sample will be prepared for each super sac and assayed for total uranium and total thorium prior to sale. Only quantities of AMV that have a composite sample with less than 0.05% source material will be permitted to leave the Mill site.

4.1.4. Other Products

In addition to uranium and vanadium, the Mill is capable of extracting other metals, such as tantalum, scandium, zirconium and titanium from natural ores and alternate feed materials. These metals are generally extracted using the vanadium circuit at the Mill. The same analysis of the applicable laws and regulations discussed above for vanadium product apply in exactly the same manner to these other metals. When other such metals will be extracted, the Mill will follow procedures, similar to those discussed above for vanadium product, to ensure that no sale lots of such metals will leave the Mill site if the source material content in such sale lot of metals is 0.05% or greater.

4.2. Compliance with the Requirements of 10 C.F.R. §20.1301 and §20.1302

In addition to the procedures detailed above relating to compliance with the relevant 10 C.F.R. Part 40 requirements, the Mill will implement the following procedures.

4.2.1. General

10 C.F.R. §20.1302(a) provides that the licensee shall make or cause to be made, as appropriate, surveys of radiation levels in unrestricted and controlled areas and radioactive materials in effluents released to unrestricted and controlled areas to demonstrate compliance with the dose limits for individual members of the public in §20.1301 (1 mrem per year, and 0.002 rem in any one hour in unrestricted areas). 10 C.F.R. §20.1302(b) provides that the licensee shall show compliance with the annual dose limit in §20.1301 by *either*:

a) Demonstrating by measurement or calculation that the total effective dose equivalent to *the individual likely to receive the highest dose* from the licensed operation does not exceed the annual dose limit; *or*

b) Demonstrating that
   - (i) The annual average concentrations of radioactive material released in gaseous and liquid effluents at the boundary of the unrestricted area do not exceed the values specified in Table 2 of Appendix B to Part 20; and
   - (ii) If an individual were continuously present in an unrestricted area, the dose from external sources would not exceed 0.002 rem (0.02 mSv) in an hour and 0.05 rem (0.5 mSv) in a year.

Of these requirements, the proposed Mill procedures are intended to satisfy the requirements set out in paragraph a) above by ensuring that the total effective dose equivalent to the individual likely to receive the highest dose from the vanadium products does not exceed the annual and hourly dose limits. In developing the proposed procedures outlined below, the Mill has made a determination as to the individual likely to receive the highest dose from the vanadium products, and, in so doing has taken into account the use and manner of use of the vanadium product by purchasers of vanadium from the Mill. In developing these procedures, IUSA has retained SENES Consultants

Limited ("SENES") as independent radiation and health physics experts. Included as Attachment B to this letter is a copy of the memorandum prepared by SENES.

4.2.2. Summary of SENES' Findings

As described in the attached memorandum from SENES, it is possible to estimate the doses to transport workers and the public arising from the shipping of vanadium products from the Mill. In brief, using data from alpha spectroscopy the likely range of gamma dose rates from blackflake product were estimated by SENES for two cases which bracket actual experience.

For uranium and thorium set at 0.043% and 0.005% respectively, corresponding to a total source material content of 0.048%, two sets of calculations were performed. In the first case ("Case 1"), U-238 and all of its decay products were assumed to be in equilibrium as were Th-232 and all of its decay products. In the second case ("Case 2"), the Th-230 activity concentration (and all of the decay products following Th-230 were assumed to be in equilibrium) were assumed to be (the extreme of measured data) 55.6 times the U-238 activity along with Th-232 in equilibrium with all of its decay products.

Four exposure scenarios were considered by SENES: a Mill worker loading vanadium product for transport, a truck driver, a member of the public living near a rest stop used by the truck driver and a worker in the ferrovanadium plant where the Mill's vanadium blackflake product is further processed.

SENES concludes that the dose limits of 0.1 rem/y (1 mSv/y, 1000 μSv/y) and 0.02 mSv/hr (20 μSv/hr) are not exceeded in any of the Case 1 scenarios described above. In other words, vanadium product that contains source material below the 0.05% by weight threshold, when in equilibrium, would not be expected to result in the potential for overexposure to members of the public. However, in some situations vanadium product that contains less than 0.05% by weight source material that is not in equilibrium, can result in the potential for overexposure to members of the public. SENES concludes that it is therefore necessary for the Mill to scan each drum or other package of vanadium product before it is shipped from the Mill, to ensure that the dose from the drum or other package, whether alone or as part of a lot, will not cause a potential overexposure to members of the public. Procedures that address these issues are discussed in Section 4.2 below.

By backcalculating from the dose to the truck driver, estimated to receive the highest dose, for Case 2, SENES calculated the maximum contact dose rate on vanadium product that would still result in the dose to the public requirements not being exceeded. The average contact dose rate per lot, over all sixty-six 55 gallon drums in the lot, that would result in an annual effective dose equivalent of 1,000 μSv/y to the truck driver was calculated by SENES to be 9.07 μSv/h (907 μR/h). Using the same method, corresponding average contact dose rates on the drums were calculated for doses to the public and ferrovanadium workers.

The most restrictive contact dose rate was concluded by SENES to be an average of 907 μR/h per lot, and this value is proposed by SENES as the limit on the *average* contact radiation exposure rate for drums of blackflake, and for supersacs of AMV.

The limit on contact dose rate measured on *individual* 55 gallon drums and supersacs of 0.002 rem/h was converted by SENES to an exposure rate of 2,000 μR/h. By limiting the dose rate to 2,000 μR/h (20 μSv/h) at contact with the side of a 55 gallon drum or supersac, the effective dose equivalent rate is expected to be less than 20 μSv/h (0.002 rem/h) in all accessible areas to which workers and members of the public may be continuously exposed.

In summary, SENES concludes that:

- The limit on the *average* contact radiation exposure rate for a lot of sixty-six 55 gallon drums of blackflake, and for a comparable size shipment of supersacs of AMV, should be set at 907 μR/h. This limit is expected to ensure that the limit on annual dose (1,000 μSv/y) to members of the public and ferrovanadium workers will not be exceeded;

- The limit on the *individual* contact radiation exposure rate for drums of blackflake, and for supersacs of AMV, should be set at 2,000 μR/h. This limit is expected to ensure that the limit on hourly dose rate (0.002 rem/h) to members of the public and ferrovanadium workers will not be exceeded; and

- For shipments of VPL, the proposed limit on the individual contact radiation exposure rate should be set at 2000 μR/h. As each shipment of VPL is shipped in a single tanker truck, it is not necessary to calculate an average contact radiation exposure rate for shipments of VPL.

4.2.3. Vanadium Blackflake Product

Based on the foregoing analysis, the Mill will institute the following procedures:

- Each drum of blackflake will be scanned prior to release from the Mill's restricted area to ensure that the contact radiation exposure rate from the drum does not exceed 2,000 μR/h; and

- No lot of sixty-six 55 gallon blackflake drums will be permitted to be released from the Mill's restricted area unless the average contact dose rate for the lot, calculated over all drums in the lot, does not exceed 907 μR/h. If a lot size is not sixty-six 55 gallon drums of blackflake, then an equivalent calculation will be made to determine the appropriate average contact dose rate for such lot.

4.2.4. VPL Product

Based on the foregoing analysis, the Mill will institute the following procedure:

- The exterior of each tanker truck containing VPL will be scanned prior to release from the Mill's restricted area to ensure that the contact radiation exposure rate from the tanker truck does not exceed 2,000 μR/h.

4.2.5. AMV Product

Based on the foregoing analysis, the Mill will institute the following procedures:

- Each super sac or other conveyance of AMV will be scanned prior to release from the Mill's restricted area to ensure that the contact radiation exposure rate from the conveyance does not exceed 2,000 μR/h; and

- No lot of AMV will be permitted to be released from the Mill's restricted area unless the average contact dose rate for a lot of comparable size to a 66-drum lot of blackflake, calculated over all conveyances in the lot, does not exceed 907 μR/h. If a lot is not comparable in size to sixty-six 55 gallon drums of blackflake, then an equivalent calculation will be made to determine the appropriate average contact dose rate for such lot.

4.2.6. Other Products

When other metals are to be extracted at the Mill, the Mill will follow procedures, similar to those discussed above for vanadium product, to ensure that no sale lots of such metals will leave the Mill site unless the requirements set out in 10 C.F.R. §20.1301 and §20.1302 are satisfied.

4.2.7. Standard Operating Procedures

The Mill will develop SERP-approved Standard Operating Procedures that incorporate the procedures discussed in Sections 4.2.3 to 4.2.6 above prior to any further vanadium shipments from the Mill.

5. CONCLUSION

While the 10 C.F.R. Part 40 and licensing requirements do not apply to vanadium products that have a source material content of less than 0.05%, the requirements set out in 10 C.F.R. §20.1301 and §20.1302 could apply to the extent that vanadium products having a source material content of less than 0.05%, and/or containers containing such products, may be contaminated with licensed material. The additional procedures outlined above are intended to be applied to *all* vanadium products to be shipped from the Mill site, regardless of source material content, to ensure that the applicable NRC laws and regulations are complied with in *all* circumstances and to ensure protection of public health and safety.

If you have any questions or would require any further information, please contact the undersigned at 303-389-4130.

Yours truly,

David C. Frydenlund
Vice President and General Counsel

cc: Ron F. Hochstein
Michelle R. Rehmann
William N. Deal
Ron E. Berg
Bill von Till/NRC
Dwight D. Chamberlain/NRC
Pat Mackin/NRC
Maria Schwartz/NRC
William J. Sinclair/UDEQ
Anthony J. Thompson, Shaw Pittman

ATTACHMENT A

cf

INTERNATIONAL URANIUM (USA) CORPORATION

Independence Plaza, Suite 950 • 1050 Seventeenth Street • Denver, CO 80265 • 303 628 7798 (main) • 303 389 4125 (fax)

August 25, 2000

VIA FACSIMILE AND FIRST CLASS MAIL

Mr. Louis Carson
U.S. Nuclear Regulatory Commission
Region IV
611 Ryan Plaza Drive, Suite 400
Arlington, TX 66011-8064

Re: Source Material License No. SUA-1358
Conference Call Exit Meeting Regarding NRC Inspection No. 40-8681/2000/1 for the White Mesa Mill

Dear Mr. Carson:

Further to our telephone meeting held on August 22, 2000 and our letter to you of August 24, 2000, I enclose a copy of a letter addressed to International Uranium (USA) Corporation ("IUSA") from our counsel, Shaw Pittman, relating to the issue as to the NRC's jurisdiction over vanadium processing at the White Mesa Mill.

Although a copy of the attached letter has been sent to you by Shaw Pittman, we are enclosing a copy of the letter herewith as a formal submission by IUSA for your consideration in evaluating this issue.

If you have any questions or concerns, please do not hesitate to give me a call.

Yours truly:

David C. Frydenlund
Vice President and General Counsel

Enclosure

cc: William von Till, NRC
Anthony J. Thompson, Shaw Pittman

REC'D

AUG 24 2000

ShawPittman

A Law Partnership Including Professional Corporations

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August 10, 2000

By Facsimile

David C. Frydenlund, Esq.
Vice President and General Counsel
International Uranium (USA) Corporation
1050 17th Street, Suite 950
Denver, Colorado 80265

Re: NRC Jurisdiction Over Vanadium Processing Activities At The White Mesa Mill

Dear Mr. Frydenlund:

This letter is intended to address several questions regarding the Nuclear Regulatory Commission's (NRC's) jurisdiction over vanadium processing activities at International Uranium (USA) Corporation's (IUSA's) White Mesa Mill, located near Blanding, Utah (the Mill). Specifically, you have asked us to opine as to whether, and to what extent, NRC can lawfully exercise regulatory jurisdiction over the feedstock, end products and wastes associated with vanadium processing that occurs in the Mill's vanadium circuit. These issues arose recently in the context of an NRC inspection of the Mill; however, this letter merely confirms the oral advice that we provided to you on this issue prior to the recent inspection.

Before addressing the scope of NRC's jurisdiction, it would be useful to set out the relevant facts.

Factual Background

The Mill has been a dual uranium/vanadium circuit mill from the time it was designed and constructed. This design was intended to allow recovery of both the uranium and vanadium values that are characteristic of the Colorado Plateau ores, which were to be the primary feedstock for the Mill. Broadly speaking, when the Mill is operated to recover uranium and vanadium, ore passes through the uranium and vanadium circuits in sequence. First, ore containing uranium and vanadium is crushed and ground and fed into the uranium leach/solvent extraction (SX) circuit. After the uranium is recovered from the ore, the raffinate from the uranium recovery process is fed through the vanadium circuit. Thus, the raffinate from the uranium recovery process becomes the feed material for the vanadium circuit, which uses different chemicals and operating conditions to recover the vanadium.[1] Finally, after processing through the vanadium recovery circuit is complete, the remaining *waste* stream proceeds to the Mill's tailings impoundments.

The Mill is operated pursuant to a *source material* license issued by NRC under the Atomic Energy Act (SUA-1358). The terms and conditions in that license are intended to address the uranium recovery aspects of Mill operations. Under ordinary operating conditions, the license is not (and has not been) applicable to the vanadium circuit portion of the mill (other than the tailings and wastes from that process, which are managed as 11e.(2) byproduct material). This is because, under normal operating conditions, the vanadium feed material and the final vanadium product are not source material or 11e.(2) byproduct material and the processing activities that occur in the vanadium circuit do not involve 11e.(2) byproduct material or licensable quantities of source material.

Discussion

The starting point for our analysis is the AEA, from which NRC derives its authority over the Mill. NRC's jurisdiction under the AEA is material-based; that is, the AEA grants NRC jurisdiction to regulate only source, special nuclear and byproduct material. 42 U.S.C. § 2201. Since operations at the Mill do not involve special nuclear material or 11e.(1) byproduct material, NRC's jurisdiction over the Mill extends only to activities involving source material or 11e.(2) byproduct material.

With respect to source material at the Mill, NRC's authority is further circumscribed by Section 62 of the AEA, which expressly provides that "licenses *shall not* be required for quantities of source material which, in the opinion of the Commission,

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[1] Two points about the vanadium circuit are worth noting. First, although the raffinate from the uranium circuit becomes feed material for the vanadium circuit, in their final recovery stages, the uranium and vanadium circuits are separate and distinct. Also, since it is intended to remove only vanadium, the vanadium recovery circuit has little or no impact on (either enhancing or diminishing) any naturally occurring radionuclides contained in the vanadium circuit's feed material and, similarly, no such impact on the final vanadium product.

are unimportant." 42 U.S.C. § 2092 (emphasis added). NRC has taken the position that materials containing less than 0.05% source material are "unimportant quantities" of source material. Specifically, the regulations provide that "any chemical mixture, compound, solution, or alloy" in which the uranium or thorium content is less than 0.05% by weight is considered to be an "unimportant quantity" and is exempt from regulation as source material. 10 C.F.R. § 40.13. Thus, under Section 62 of the AEA, NRC is prohibited from exercising its "source material" regulatory authority with respect to materials that contain less than 0.05% uranium or thorium.

Under normal operating conditions at the Mill, licensable quantities of source material (i.e., materials containing greater than 0.05% uranium) are not present in the vanadium circuit, because the bulk of the uranium content of the feedstock is removed in the uranium circuit.[2] Consequently, since there normally are no licensable quantities of uranium in the vanadium circuit (including the feed material, the final vanadium product and the resulting tailings and wastes), NRC cannot ordinarily exercise jurisdiction over the vanadium circuit (or the materials involved in the vanadium circuit) on the basis of its AEA authority over source material.

Similarly, the materials involved in the vanadium circuit, other than the tailings from that circuit (i.e., the vanadium feed material and the final vanadium product) are not 11e.(2) byproduct material. The statute defines 11e.(2) byproduct material 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.

42 U.S.C. § 2014e.(2) (emphasis added). Tailings are the waste materials that come out of the tail end of the mill once the extraction of valuable metals from ore has been completed. As NRC has explained in the context of its uranium milling regulations,

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[2] It is conceivable that, as a result of process upsets or other unintentional deviations from normal operating conditions at the Mill, the levels of uranium contained in the uranium circuit raffinate might exceed 0.05%. In such circumstances, the raffinate would presumably be subject to regulation by NRC as source material (or source material ore, if the raffinate were further processed to recover uranium). Under normal operating conditions, however, the levels of uranium in the uranium circuit raffinate should fall well below 0.05%.

tailings, consisting of sands, slimes and liquids, comprise the bulk of the wastes generated at a mill. USNRC, *Final Generic Environmental Impact Statement on Uranium Milling* NUREG-0706 (September 1980) (hereinafter *GEIS*) vol. 1 at 5-1 to 5-4. See also *GEIS* vol. 2 at B-11 ("The tailings represent the bulk of the wastes originating from the uranium mill and, with the exception of the recovered uranium and process losses, account for practically all of the ore solids and the process additives, including water.") Thus, tailings are one kind of waste (indeed, the biggest single waste) produced as a result of the milling process.[3] Other wastes that would constitute 11e.(2) byproduct

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[3] This understanding, that tailings are *wastes,* is consistent with the mining industry definition of "tailings" which is: "The parts, or a part, of any incoherent or fluid material separated as refuse, or separately treated as inferior in quality or value; leavings; remainders; dregs." Bureau of Mines, U.S. Department of the Interior, *A Dictionary of Mining, Mineral and Related Terms* (1968). Moreover, NRC's interpretation of the AEA, as amended by the Uranium Mill Tailings Radiation Control Act (UMTRCA), and the legislative history of the statute reveal that when Congress defined 11e.(2) byproduct material to consist of "tailings and wastes" produced from the extraction and concentration of uranium, its intent was to ensure that *all* wastes (*tailings and other wastes*) associated with milling uranium would be covered by the regulatory program put in place for 11e.(2) byproduct material. For example, NRC has noted that:

> The UMTRCA amended the AEA to include uranium and thorium mill tailings *and other wastes* from the milling process as material to be licensed by NRC. Specifically, the definition of byproduct material was revised in section 11e of the AEA by adding
>
> "and (2) the tailings or wastes produced by the extraction or concentration . . ."
>
> Such byproduct material includes *all the wastes* resulting from the milling process, not just the radioactive components.

57 Fed. Reg. 20,525, 20,531 (1992). In other words, 11e.(2) byproduct material is defined to encompass *all* wastes resulting from the milling process; tailings are one kind of such waste.

A similar conclusion was reached by the Court of Appeals for the D.C. Circuit upon that court's review of UMTRCA's legislative history in *Kerr-McGee v. U.S. Nuclear Regulatory Commission*, 903 F.2d 1 (D.C. Cir. 1990). The court in that case, quoting from the legislative history, noted that:

> Uranium mills are a part of the nuclear fuel cycle. They extract

Footnote continued on next page

material could include equipment used in the milling process when that equipment is ready for disposal, and other similar decommissioning wastes.[4]

The vanadium feed material (the raffinate from the uranium circuit) is not tailings or other waste; it is valuable feed material that is processed for the removal of vanadium.[5]

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> uranium from ore . . . leaving radioactive sand-like waste – commonly called uranium mill tailings – in generally unattended piles.

Id. at 2 (quoting from H.R. Rep. No. 1480, 95th Cong., 2d Sess., pt 2, 28 (1978). Later the court went on to conclude that:

> It is clear from this exchange [in the legislative history] that the definition of "byproduct material" proposed by [then NRC chairman] Dr. Hendrie and adopted by Congress was designed to extend NRC's regulatory authority over *all wastes* resulting from the extraction and concentration of source material

Id. at 7.

[4] *See* Memorandum from Paul H. Lohaus, Division of Low-Level Waste Management and Decommissioning, NMSS to All Uranium Recovery Licensees (March 15, 1989) ("Wastes from the decommissioning of buildings and equipment whose primary function was to conduct the extraction or concentration of uranium or thorium from ore processed primarily for its source material content, are considered to be byproduct material.").

[5] There can be no question that Congress did not intend to reach process intermediates like the vanadium feed material when it defined 11e.(2) byproduct material to consist of "tailings and wastes." The statute and the legislative history clearly indicate that Congress intended 11e.(2) byproduct material to encompass the *wastes* produced from milling operations – both tailings and other kinds of wastes as outlined above -- and the regulatory program created under UMTRCA was intended to provide for the management and disposal of those *wastes*. Thus, for example, the "Findings and Purposes" section of UMTRCA provides that:

> The Congress finds that uranium mill tailings located at active and inactive mill operations may pose a potential and significant radiation health hazard to the public, and that the protection of the public health, safety and the regulation of interstate

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Similarly, the final vanadium product obviously is not tailings or other waste. Consequently, these materials are not subject to regulation as 11e.(2) byproduct material. Thus, the only material from the vanadium circuit that constitutes 11e.(2) byproduct material are the mill tailings – i.e., the tailings that exit the vanadium circuit and that are then deposited into the Mill's tailings impoundments. Under normal operating conditions then, these tailings would be the only material associated with the Mill's vanadium circuit that would be subject to regulation as 11e.(2) byproduct material.

This analysis is the only one that comports with the plain meaning of the AEA, as amended by UMTRCA, and with Congressional intent. In addition, this analysis is also consistent with NRC's general approach to the regulation of secondary process streams. Specifically, there is a long history of NRC and Agreement state regulation of *portions* of mineral recovery facilities that are not nuclear fuel cycle facilities but that recover uranium in a *secondary* processing circuit. In those circumstances, NRC has required a source material license *just for the uranium circuit*; however, because the uranium circuit is not the *primary* purpose of the facility, the portions of the facility that are unrelated to the uranium circuit have not been licensed by NRC and the waste stream from the facility is *not* considered 11e.(2) byproduct material.[6] As NRC has explained:

> Sometimes [uranium] is captured in a side-stream recovery operation, in which uranium is precipitated out of the pregnant solution before or after the rare earth or other

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> commerce require that every reasonable effort be made to provide for the *stabilization, disposal and control*, in a safe and environmentally sound manner, of such tailings.

42 U.S.C. § 7901.

[6] The Climax molybdenum mill is a case in point. The primary purpose (and the primary circuit) of the mill was for molybdenum recovery; however the mill at one time also recovered uranium in a side-stream process. Although the mill was required to have a source material license for the side-stream uranium recovery circuit, such a license was not required for other parts of the mill (i.e., the mill was not a licensed nuclear fuel cycle facility) and the mill tailings were not regulated as 11e.(2) byproduct material.

> metal. Although this side-stream operation is licensed by NRC, the tailings . . . are not 11e.(2) byproduct material. This is because the ore was not processed primarily for its source material content, but for the rare earth or other metal.

57 Fed. Reg. 20,527 (1992). Conversely, at a licensed fuel cycle facility (for example, the White Mesa Mill) where the *primary* purpose of processing ore is for its source material content, any *secondary* mineral recovery processes that do not involve licensable quantities of source material are not subject to NRC jurisdiction. Because the *primary* purpose of the Mill is to recover uranium, however, the mill tailings – the final waste stream from the milling activities at the facility – are regulated as 11e.(2) byproduct material.

Thus, given the fact that NRC and Agreement States have routinely differentiated between AEA and non-AEA portions of mineral recovery facilities (*see, e.g.*, footnote 6 above), and since the vanadium recovery circuit at the Mill does not involve 11e.(2) byproduct material or, under normal operating conditions, licensable quantities of source material, it is evident that neither the vanadium recovery circuit nor the vanadium feed material nor vanadium product itself is subject to NRC's regulatory jurisdiction.[7]

Sincerely,

Anthony J. Thompson

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[7] Similarly, any non-AEA radionuclides in the vanadium product would not be subject to NRC jurisdiction either. For example, to the extent that *some* radium may accompany the vanadium product, it is not subject to NRC jurisdiction because it is not associated with either source or byproduct material.

ATTACHMENT B

SENES Consultants Limited

MEMORANDUM

TO:	International Uranium (USA) Corporation ("IUC")	33010
FROM:	Doug Chambers, Morley Davis	18 April 2001
SUBJ:	Estimated Annual Dose from Vanadium Products	

Further to our telephone discussion of 9 April 2001 with Mr. Hochstein and Mr. Frydenlund, we have reviewed the information available to us concerning the potential levels of uranium in vanadium products produced at the White Mesa Mill, and made (conservative) estimates of potential annual dose to transport workers and the public arising from exposure to these products.

In brief, our understanding of the issues are as follows:

- strictly, NRC licensing jurisdiction applies only to source material containing 0.05% or more uranium and thorium;
- if the vanadium product is found to contain less than 0.05% uranium and thorium, there should be no licensing issues with NRC; however
- an issue could arise with respect to potential doses from vanadium products containing levels of uranium and thorium less than 0.05%.

Our approach to evaluating this issue was to review data provided by IUC and to evaluate likely potential doses to transport workers (loader, driver) transporting vanadium products (containing less than 0.05% uranium and thorium by weight) in lots, to members of the public living adjacent to roadways, and to ferrovanadium plant workers.

The presumption is that none of these individuals will receive more than 1 mSv/y (1000 μSv/y) and no more than 0.02 mSv/hr (20 μSv/hr) from exposure to these materials. 10 C.F.R. §20.1301(a)(1) and (2). It is further assumed that the dose calculations can be performed for gamma radiation only as it is assumed that the exterior of the vanadium drums will be cleaned (to surface contamination criteria values specified in NRC Regulatory Guide 1.86) prior to transport. In developing our assessment, we have also considered the relation between surface gamma and the uranium and thorium contents of the vanadium products.

After reviewing the possible doses to the individuals described above, we propose additional procedures that can be followed by the Mill to ensure that members of the public, as exemplified by such individuals, will not receive doses in excess of these limits.

Information Provided by IUC

The following information was provided by IUC via facsimile dated 5 April 2001 and used in this analysis:

1. Excerpts from the NRC Inspection Report dated September 6, 2000, from Inspection 40-8681/00-01 which state the concern of the NRC regarding uranium contamination in the vanadium product.
2. An internal IUC memorandum dated May 5, 2000, which detailed the first identification of the potential contamination of the final vanadium blackflake product at the White Mesa Mill.
3. Assays of uranium (U-234, U-235 and U-238) and thorium (Th-228, Th-230 and Th-232) from each of the remaining lots at the White Mesa Mill. We understand that Lots 51 and 52 are not intended to be sold, due to the level of contamination, and will therefore not be considered in this analysis.
4. Letter to NRC Region IV dated August 25, 2000, outlining IUCs initial position regarding regulation of the vanadium circuit.
5. A letter to NRC Region IV dated January 19, 2001, detailing a potential miscommunication between IUSA and the NRC regarding the sale of vanadium pregnant liquor (VPL).
6. An IUC memorandum dated January 22, 2001, regarding the addition of the uranium concentration stated in microcuries per millilitre of solution.
7. Selected text from 10 C.F.R. Part 20.

Subsequently, information on the vanadium purchasing cycle was provided by IUC in a memorandum dated 16 April 2001.

Discussion of Measurements on Drums of Vanadium Blackflake (VBF)

In this part, the results of measurements of radioactivity concentrations and exposure rates at contact with VBF drums are discussed.

Composite samples of product from individual lots 34 to 52 were analysed for U-238, U-234, Th-230 and Th-232 by alpha spectrometry by IUC. A Th-232 concentration of 3.6 pCi/g is the detection limit for this radioisotope. External gamma exposure rates at contact with drums from 5 of the lots were measured by NRC. The results are summarized in Table 1 (left side). We understand that lots 51 and 52 have been removed from the scope of work and they are not discussed further.

During preparation of this memorandum, the calculations on the right side of the table were made. Specifically, the ratios of U-238/Th-230, U-234/Th-230, ppm U (using 0.33 pCi U-238/μg U), and ppm Th (using 0.11 pCi Th-232/μg Th). The mass of Th-230 is insignificant with respect to the mass of Th-232 present.

Based on alpha spectroscopy results, the lots appear to fall into two groups. The results indicate depletion of U-238 and U-234 compared to Th-230 in one group (lots 34 to 42, and lots 48 to 50, inclusive). Also, the results indicate equilibrium or slight excess of uranium between U-238 and U-234 compared to Th-230 in lots 43 to 47, inclusive. The alpha spectroscopy results provide no indication of the concentration of Ra-226 relative to its parent Th-230. For the analysis in this report, it is assumed that all decay products of Th-230 are in secular equilibrium with Th-230.

Most of the external gamma radiation from the uranium series isotopes is attributable to Ra-226 and its short-lived decay products. Therefore, it is considered reasonable, more likely than not, to calculate external gamma dose rate using the assumption that all decay products of Th-230 are in equilibrium with Th-230. The exposure rates at contact with drums in each lot were calculated using the results of MicroShield™ (V5.05-00170) code runs. The results of these calculations are shown in Table 1. Predicted exposure rates overestimate measured rates in three cases, lots 44, 45 and 52, and underestimate dose rates in the other two cases, lots 49 and 51. It is possible that Ra-226 concentrations are higher than corresponding Th-230 concentrations; however, there are no data to support this assumption other than the exposure rate measurements.

The lowest ratio of U-238 to Th-230 is calculated to be 0.018. In the calculations described in the following parts, the inverse of this ratio, 55.6, is used to calculate the highest concentrations of Th-230 and its decay products relative to the U-238 concentration.

The highest concentration of Th-232 in lots 34 to 50 was calculated to be 42.8 ppm Th-232 in lot 34. Therefore, the concentration of thorium is expected to be less than 50 ppm (0.005% thorium) in all blended lots. To estimate an upper limit on the external gamma exposure and dose rates from vanadium products described in the following parts, the maximum total concentration of uranium and thorium was set at 0.048%, and the corresponding nominal concentrations of uranium and thorium were set at 0.043% (i.e. 430 ppm U) and 0.005% (i.e. 50 pm Th-232).

In summary, exposure and dose rate calculations described in the following parts are made using concentrations of uranium and thorium set at 0.043% and 0.005%, respectively which are below the NRC definition of source material. For each vanadium product configuration two sets of calculations are made.

- In Case 1, U-238 and all of its decay products are set in radioactive equilibrium; and
- In Case 2, the Th-230 activity concentration (and all of its decay products in equilibrium) are set at (the extreme of) 55.6 times the U-238 activity.

Dose Rate Near Product Containers

In this part, dose rate calculations at selected distances from various forms of vanadium product containing "unimportant quantities" of uranium and thorium (i.e. less than 0.05%) are described.

Specifically, calculations were made for concentrations at 0.048% uranium and thorium in individual product containers, and from full loads.

Individual Drums of Blackflake

The exposure and dose rates at selected distances from a 55 gallon drum of blackflake were calculated using the MicroShield™ code and the following parameter values:

- Drum height 80 cm;
- Drum diameter 60 cm;
- Blackflake density 1.189 g/cm^3;
- Case 1 concentrations –0.043% uranium (all decay products in equilibrium), and 0.005% Th-232 (pCi/g Th-232, all decay products in equilibrium); and
- Case 2 concentrations –0.043% uranium (Th-230 and each decay product 55.6 times the U-238 activity concentration), and 0.005% Th-232 (all decay products in equilibrium).

The results of the dose calculations were used to calculate the number of hours of exposure required to accumulate 1000 µSv at various distances in the two cases, Figure 1. In the first case where all the U-238 decay products are in equilibrium, a person could not accumulate 1000 µSv in a working year of 2000 hours at distances of greater than ½ m from a drum of blackflake, nor would he/she be exposed to an hourly dose of 0.02 mSv/hr (20 µSv/hr).

In the second case where Th-230 and its decay products are 55.6 times the U-238 concentration, a person could not accumulate 1000 µSv (1 mSv) in a working year of 2000 hours at distances of greater than 4 m from a drum of blackflake. Similarly, at these distances a person would not be exposed to an hourly dose of 0.02 mSv/hr (20 µSv/hr). However, at closer distances to the drum the exposure limits for individual members of the public could be exceeded in this second case scenario. We propose procedures below that will ensure that these limits are not exceeded.

Trailer Truck Load of Blackflake Drums

The exposure and dose rates at selected distances from a trailer loaded with a lot consisting of sixty-six 55 gallon drums of blackflake were calculated using the MicroShield™ code, and the following parameter values:

- The drums are loaded in two layers onto a trailer of width, height and length of 2.4, 2.4 and 13.7 m (approximately 8 by 8 by 45 ft);
- Case 1 concentrations –0.043% uranium (all decay products in equilibrium), and 0.005% Th-232 (pCi/g Th-232, all decay products in equilibrium);

- Case 2 concentrations –0.043% uranium (Th-230 and each decay product 55.6 times the U-238 activity concentration), and 0.005% Th-232 (all decay products in equilibrium);
- Dose calculations at distances of 1 to 5 m from the end of the load were used for individual dose calculations (the driver); and
- Dose calculations at distances of 5 to 30 m from the side of the load were used for public dose calculations.

The results of the dose calculations were used to calculate the number of hours of exposure to drivers required to accumulate 1000 μSv at various distances in front of the load in the two cases, as illustrated in Figure 2. In the first case where all the U-238 decay products are in equilibrium, a driver could not accumulate 1000 μSv in a working year of 2000 hours, or an hourly dose of 0.02 mSv/hr (20 μSv/hr), at distances of greater than 1.5 m from a load of blackflake drums.

In the second case where Th-230 and its decay products are 55.6 times the U-238 concentration, a driver could potentially accumulate 1000 μSv or more in a working year of 2000 hours. We propose procedures below that will ensure that these limits are not exceeded.

The results of the dose calculations were also used to calculate the number of hours of exposure to members of the public required to accumulate 1000 μSv at various distances to the side of the load in the two cases (Figure 3). In the first case where all the U-238 decay products are in equilibrium, a member of the public could not accumulate 1000 μSv in a year (8766 hours), or an hourly dose of 0.02 mSv/hr (20 μSv/hr), at distances of greater than 10 m from a load of blackflake drums.

In the second case where Th-230 and its decay products are 55.6 times the U-238 concentration, a member of the public could potentially accumulate 1000 μSv during an exposure of 2000 hours at a distance of 30 m from a load of blackflake drums, although, as discussed below, at the more likely exposure of 500 hours in a year, such a member of the public would not accumulate 1000 μSv. In neither case would the individual be exposed to an hourly dose of 0.02 mSv/hr (20 μSv/hr).

In addition, exposure scenarios for workers in the ferrovanadium plant to which the vanadium product is delivered were evaluated. In certain circumstances, described below, vanadium in the second case where Th-230 and its decay products are 55.6 times the U-238 concentration, such workers could potentially accumulate 1000 μSv in a year. Additional procedures that can be followed by the Mill to ensure that such exposure limits are not in fact exceeded are described below.

Detailed calculations for each of these scenarios are set out below.

<u>Other Products</u>

We understand that most of the vanadium product is produced as blackflake; however, another product, vanadium pregnant liquor (VPL), is an intermediate liquid product that is also produced.

VPL is shipped as a bulk liquid in tanker trucks. We understand that the VPL liquid typically contains 0.016 g U_3O_8/L (or less). On occasion, another product, ammonia metavanadate (AMV), is produced as a powder. AMV is shipped in "super sacs" of about 1 ton capacity.

Our calculations using MicroShield™ indicate that the dose rate from VPL is very much lower (orders of magnitude) than for blackflake. However, these predictions are based on the assumption that each radionuclide in the U-238 series is in equilibrium with U-238. Direct measurements of external gamma dose rate in contact with containers or loaded tankers, as discussed in more detail below, is recommended to verify this assumption. For present purposes, AMV is assumed to present the same radiation dose characteristics as blackflake.

Vanadium Shipping Cycle

From information provided by IUC, during the last mill run, approximately 2.0 million lbs. of vanadium were produced, of which 1.8 million lbs was in blackflake and the remaining 200,000 lbs in VPL.

VPL

The VPL was contracted for sale with only one chemical supplier (a broker). The commercial arrangement is such that the VPL is stored at the Mill until the chemical supplier's customers can receive additional material. The supplier informs the Mill that additional material is required and dispatches a tanker truck to the Mill. The Mill prepares a solution for transport at which time the solution is assayed. The truck is loaded at the White Mesa Mill and then scanned for release. Since the Mill began shipping VPL, in February 2000, twelve loads of VPL have been shipped. The average solution shipped per truckload is approximately 35,400 lbs., containing approximately 6,400 lbs. of V_2O_5. The shipping schedule varies between one and two shipments per month.

It is our understanding based on information from IUC that the tanker transfers the material from the truck to tanks located in the customer's facility. From this tank the solution is directly metered into the process. There are no intermediary facilities.

Blackflake

The vanadium blackflake is packaged in 55-gallon drums and grouped into lots consisting of 66 drums per lot. Each lot is sold on the basis of the vanadium content of the lot, which is determined from an assay of a composite sample from the entire lot.

During the last campaign, a total of 38 lots were sold to four different buyers. The purchases were typically on either a lot-by-lot basis or on a batch basis varying from 3 to 12 lots. There were no long-term supply contracts during the last mill run. Once a contract is signed, the lots are kept at the Mill until the purchaser picks up the lot at the Mill.

The buyer is responsible for arranging transportation. Only one lot is shipped per truckload. Based on a preliminary review of the documentation for the 38 lots shipped from the last mill run, one driver shipped four lots, three drivers shipped three lots and different drivers shipped the remainder.

IUC has indicated that vanadium from the Colorado Plateau ores is a swing source of vanadium for the ferrovanadium producers. They typically source their vanadium from spent catalyst converters or from primary vanadium producers in South Africa and Australia. Typically the purchaser will spread the shipments out to match production schedules. The ferrovanadium producer usually processes the material, again on a lot-by-lot basis, within one to three days of receipt of the material.

Estimate of Annual Doses to Workers and Members of the Public

The following analysis considers the potential doses to workers loading the product, the transport drivers and members of the public living along the roads used to transport the vanadium product. In addition, we have also considered the dose to workers at the ferrovanadium plant(s) receiving the vanadium product. For this assessment, we have assumed that no worker at the White Mesa Mill is permitted to receive more than the occupational limit of 5 rem/y (50 mSv/y), and that the truck driver, workers at the receiving ferrovanadium plant and members of the public are not permitted to receive doses in excess of 0.1 rem/y (1 mSv/y, 1000 μSv/y) and 0.02 mSv/hr (20 μSv/hr).

Assuming a vanadium production of 28 lb/ton feed, 2 x 10^3 tons feed/d and 330 operating days per year, the annual production of vanadium is about 500 lots, when the Mill is operating at full capacity. Assuming 4 buyers, each buyer is assumed to receive some 125 lots. It is further assumed, based on information provided by IUC, that each lot is processed within 3 days of receipt.

<u>White Mesa Mill Worker Loading Vanadium Product</u>

A White Mesa Mill worker loading blackflake would be exposed to gamma radiation from blackflake (or AMV) while transferring loaded shipping containers (drums or super sacs) to trucks. Using the following dose rates (assumed for the operator at 1 m from the source), calculated using MicroShield™:

		From 1 Drum	From a Pallet of 4 Drums
Dose Rate at 1 m:	Case 1	0.12 μSv/h	0.24 μSv/h
	Case 2	6.2 μSv/h	12.4 μSv/h

and assuming 500 shipments per year requiring 2 h per shipment to load, we estimate the following doses:

$$\text{Case 1: } 0.24\frac{\mu Sv}{h} \times 500\ shipments \times \frac{2\ h}{shipment} = 240\frac{\mu Sv}{y}\ (0.24\frac{mSv}{y})$$

$$\text{Case 2: } 12.4\frac{\mu Sv}{h} \times 500\ shipments \times \frac{2\ h}{shipment} = 12{,}400\frac{\mu Sv}{y}\ (12.4\frac{mSv}{y})$$

These exposure levels are within the occupational exposure limits of 5 rem/y (50 mSv/y) for Mill workers. However, this memorandum will not address any further the occupational exposure limits for White Mesa Mill workers, as such workers are subject to the Mill's radiation protection program for workers, which is designed to ensure that the occupational dose rates for Mill workers are not exceeded.

Truck Driver

The annual effective dose to a truck driver was estimated using the following assumptions and calculations.

- The barrels are loaded in two layers onto a flatbed truck trailer of width, height and length of 2.4, 2.4 and 13.7 m (approximately 8 by 8 by 45 ft);
- The driver's seat in the tractor is assumed to be located at a distance of 3 m from the front of the drums, and no credit is taken for shielding by the metal sides on the trailer and the metal in the tractor cab;
- The effective dose equivalent rate at the driver's position is calculated using MicroShield™ to be Case 1: 0.22 μSv/h, Case 2: 11.7 μSv/h;
- The duration of the delivery with full load is assumed to be 34 hours (exposure during the return trip is assumed to be zero);
- The annual frequency of deliveries is assumed to be 30.

The annual effective dose equivalent to the truck driver who makes 30 deliveries is calculated to be:

$$\text{Case 1: } 0.22\frac{\mu Sv}{h} \times 30\frac{trips}{y} \times 34\frac{h\ (loaded)}{trip} = 227\frac{\mu Sv}{y}\left(0.227\frac{mSv}{y}\right)$$

$$\text{Case 2: } 11.7\frac{\mu Sv}{h} \times 30\frac{trips}{y} \times 34\frac{h}{trip} = 11{,}900\frac{\mu Sv}{y}\left(11.9\frac{mSv}{y}\right)$$

It can be seen that the dose limits of 0.1 rem/y (1 mSv/y, 1000 μSv/y) and 0.02 mSv/hr (20 μSv/hr) are not exceeded in the Case 1 scenario, while the annual dose limits are exceeded in the Case 2 scenario. Procedures to be followed by the Mill to ensure that such exposure limits are not in fact exceeded are proposed below.

Resident Along the Transport Route

The annual effective dose to a resident along the transport route was estimated using the assumptions described above and the additional assumptions and calculations described below.

- The resident is assumed to live at a distance of 30 m from a truck stop on the transport route at which all loaded transport trucks stop for an average of 1 hour on each trip;
- The effective dose equivalent rate at 30 m from the side of the loaded trailer is calculated to be:

$$\text{Case 1:} \quad 0.0136\,\frac{\mu Sv}{h}$$

$$\text{Case 2:} \quad 0.72\,\frac{\mu Sv}{h}$$

- The annual effective dose equivalent to the resident at 30 m from the parked truck is calculated to be:

$$\text{Case 1:}\ 0.0136\frac{\mu Sv}{h}\times 500\,\frac{shipments}{y}\times 1\,\frac{h}{shipment}=6.8\,\frac{\mu Sv}{y}\left(0.0068\,\frac{mSv}{y}\right)$$

$$\text{Case 2:}\ 0.72\frac{\mu Sv}{h}\times 500\,\frac{shipments}{y}\times 1\,\frac{h}{shipment}=360\,\frac{\mu Sv}{y}\left(0.36\,\frac{mSv}{y}\right)$$

assuming 500 shipments a year along a give truck route and use of some rest areas.

It can be seen that the dose limits of 0.1 rem/y (1 mSv/y, 1000μSv/y) and 0.02 mSv/hr (20 μSv/hr) are not exceeded in either of the Case 1 or Case 2 scenarios.

Worker at Ferrovanadium Plant Receiving Product

As for the loader operator at the Mill, it is assumed that the loader operator at the ferrovanadium plant is exposed at 1 m from four drums on a pallet, and that each lot requires 2 h to unload for a total of 250 h (125 lots x 2 h/lot) of exposure. Exposure rates for the unloading activities are assumed to be the same as those used above for the loading activities at the White Mesa Mill. In addition, there is some potential for incidental exposure in proximity to the lot until the lot is processed. To estimate this dose, using MicroShield™, we assumed 1h per day for 3 days at a distance of 5 m from the lot, thus:

$$\text{Case 1}: \left(0.24\frac{\mu Sv}{h}\times 125\ shipments \times 2\frac{h}{shipment}\right)+\left(0.31\frac{\mu Sv}{h}\times 125\ shipment \times 3\frac{h}{shipment}\right)$$
$$= 60 + 116$$
$$= 176\frac{\mu \text{Sv}}{\text{y}}$$

$$\text{Case 2}: \left(12.4\frac{\mu Sv}{h}\times 125\ shipments \times 2\frac{h}{shipment}\right)+\left(16.3\frac{\mu Sv}{h}\times 125\ shipment \times 3\frac{h}{shipment}\right)$$
$$= 3{,}100 + 6{,}100$$
$$= 9{,}200\frac{\mu Sv}{y}$$

It can be seen that the dose limits of 0.1 rem/y (1 mSv/y, 1000 μSv/y) and 0.02 mSv/hr (20 μSv/hr) are not exceeded in the Case 1 scenario, while the annual dose limits are exceeded in the Case 2 scenario. Procedures to be followed by the Mill to ensure that such exposure limits are not in fact exceeded are proposed below.

Limit on Average Contact Exposure Rate

Based on the foregoing analysis, it is evident that the dose limits of 0.1 rem/y (1 mSv/y, 1000 μSv/y) and 0.02 mSv/hr (20 μSv/hr) are not exceeded in any of the Case 1 scenarios described above. In other words, vanadium product that contains source material below the 0.05% by weight threshold, when in equilibrium, would not be expected to result in the potential for overexposure to members of the public. However, in some situations vanadium product that contains less than 0.05% by weight source material that is not in equilibrium can result in the potential for overexposure to members of the public. It is therefore necessary for the Mill to scan each drum or other package of vanadium product before it is shipped from the Mill, to ensure that the dose from the drum or other package, whether alone or as part of a lot, will not cause a potential overexposure to members of the public. In the following discussion we propose additional procedures that can be performed by the Mill to ensure that vanadium product that is shipped from the Mill will not give rise to any such overexposures.

Specifically, limits on the average contact exposure rate on all drums in a lot, and on individual drums and supersacs are calculated. These limits ensure that the annual limit on dose of 0.1 rem/y (1 mSv/y, 1000 μSv/y) from external gamma radiation to members of the public and ferrovanadium workers is not expected to be exceeded.

The limit on the average contact dose on all drums in a lot was determined by the following method. Based on the calculations described above, the estimated effective dose equivalent rate to each group of workers and the public from drums containing 0.048% uranium and thorium by weight (all radioactive series in equilibrium) are summarized in the following table, and range from 6.8 to 240 μSv/y. MicroShield™ calculations also predicted an effective dose equivalent rate of 2.06 μSv/h in contact with the side of the 55 gallon drum of blackflake.

The average contact dose rate per lot, over all sixty-six 55 gallon drums in the lot, that would result in an annual effective dose equivalent of 1000 μSv/y to the truck driver was calculated to be 9.07 μSv/h (2.06 μSv/h x 1000 μSv/y ÷ 227 μSv/y). To be conservative, the equivalent exposure rate is calculated to be 907 μR/h, assuming 100 μR/h is equivalent to 1 μSv/h. Using the same method, corresponding average contact dose rates on the drums were calculated for doses to the public and ferrovanadium workers (as shown in the following table). As the IUC Mill Worker is an Atomic Radiation Worker subject to the higher annual occupational dose limits, so these calculations are not relevant to such workers.

	Annual Dose μSv/y	Contact Dose Rate, μR/h (=1000 μSv/y)
IUC Mill Worker	240	n/a
Truck Driver	227	907
Public	6.8	30,300
Ferrovanadium Worker	176	1,170

The most restrictive contact dose rate is an average of 907 μR/h per lot, and this value is proposed as the limit on the <u>average</u> contact radiation exposure rate for drums of blackflake, and for supersacs of AMV.

The limit on contact dose rate measured on <u>individual</u> 55 gallon drums and supersacs is derived from the regulatory requirement in 10 C.F.R. 20.1301(a)(2). This section states that the dose in any unrestricted area from external sources must not exceed 0.002 rem/h. This criterion has been demonstrated in the preceding calculations. The limit on effective dose equivalent rate of 0.002 rem/h can be conservatively converted to an exposure rate of 2000 μR/h using the conversion factor 1 μR/h = 1 μrem/h.

MicroShield™ was used to calculate the effective dose equivalent rate at selected distances from several configurations of 55 gallon drums which have a contact exposure rate of 2000 μR/h on the side. At all distances from an individual drum, the predicted dose rate is obviously less than 2000 μR/h. At 1 m from a stack of drums (4 wide and 2 high), the dose rate is predicted to be 1000 μSv/h (10 μSv/h), and less at greater distances. Similarly, the dose rate at 1 m and greater from a supersac is expected to be 1000 μR/h and less when the contact dose rate on the supersac is 2000 μR/h (20 μSv/h).

In summary, by limiting the dose rate to 2000 μR/h (20 μSv/h) at contact with the side of a 55 gallon drum or supersac, the effective dose equivalent rate is expected to be less than 20 μSv/h (0.002 rem/h) in all accessible areas to which workers and members of the public may be continuously exposed.

Conclusions

None of the illustrative calculations shown above indicate the potential to exceed relevant dose limits, when the total uranium and thorium concentration is 0.048% and all members of the U-238, U-235 and Th-232 decay series are in equilibrium with the respective parent of the series.

The proposed limit on the average contact radiation exposure rate for a lot of sixty-six 55 gallon drums of blackflake, and for a comparable size shipment of supersacs of AMV is 907 μR/h. This limit is expected to ensure that the limit on annual dose (1000 μSv/y) to members of the public and ferrovanadium workers will not be exceeded.

The proposed limit on the individual contact radiation exposure rate for drums of blackflake, and for supersacs of AMV is 2,000 μR/h. This limit is expected to ensure that the limit on hourly dose rate (0.002 rem/h) to members of the public and Ferrovanadium workers will not be exceeded.

For shipments of VPL, the proposed limit on the individual contact radiation exposure rate is 2000 μR/h. As each shipment of VPL is shipped in a single tanker truck, it is not necessary to calculate an average contact radiation exposure rate for shipments of VPL.

DBC/MWD/ls

Table 1

Drum	U-238 pCi/g	U-234 pCi/g	Th-230 pCi/g	Th-232 pCi/g	uR/h	U-238/ Th-230	U-234/ Th-230	ppm U by U-238	ppm Th by Th-232	ppm U+Th	Predicted uR/h by Th-230	Predicted uR/h by Th-232	Predicted uR/h total
34	28.8	31.1	697	4.7		0.041	0.045	86.7	42.8	129.5	1037	10	1047
35	26.6	25.4	1450	3.77		0.018	0.018	80.1	34.3	114.4	2157	8	2165
36	14.3	14.9	305	1.37		0.047	0.049	43.1	12.5	55.5	454	3	457
37	18.2	21.8	300	3.6		0.061	0.073	54.8	32.8	87.6	446	8	454
38	14.2	14.8	409	3.98		0.035	0.036	42.8	36.2	79.0	608	8	617
39	24.2	23.6	434	3.6		0.056	0.054	72.9	32.8	105.6	646	8	653
40	17.2	25.9	338	3.6		0.051	0.077	51.8	32.8	84.6	503	8	510
41	43.7	45.4	494	4.44		0.088	0.092	131.6	40.4	172.0	735	9	744
42	50.4	43.1	593	3.6		0.085	0.073	151.8	32.8	184.5	882	8	890
43	237	223	228	3.6		1.039	0.978	713.6	32.8	746.4	339	8	347
44	304	302	276	3.74	100	1.101	1.094	915.4	34.0	949.4	411	8	418
45	325	309	326	3.6	200	0.997	0.948	978.6	32.8	1011.4	485	8	492
46	412	374	362	3.6		1.138	1.033	1240.6	32.8	1273.4	538	8	546
47	238	213	242	3.6		0.983	0.880	716.7	32.8	749.4	360	8	368
48	139	121	470	3.6		0.296	0.257	418.5	32.8	451.3	699	8	707
49	91.7	95.7	808	3.6	1600	0.113	0.118	276.1	32.8	308.9	1202	8	1209
50	57.9	63.2	405	3.6		0.143	0.156	174.3	32.8	207.1	602	8	610
51	416	415	297	3.6	700	1.401	1.397	1252.6	32.8	1285.4	442	8	449
52	325	308	750	5.89	1000	0.433	0.411	978.6	53.6	1032.2	1116	12	1128
						0.428	0.410	441.085	34.048	475.133	= average		

Radioactivity levels from laboratory analysis results provided by IUC 5 April 2001.

Figure 1
Hours of Exposure to Reach 1000 uSv
(55 gallon drum black flake 0.043%U and 0.005% Th)

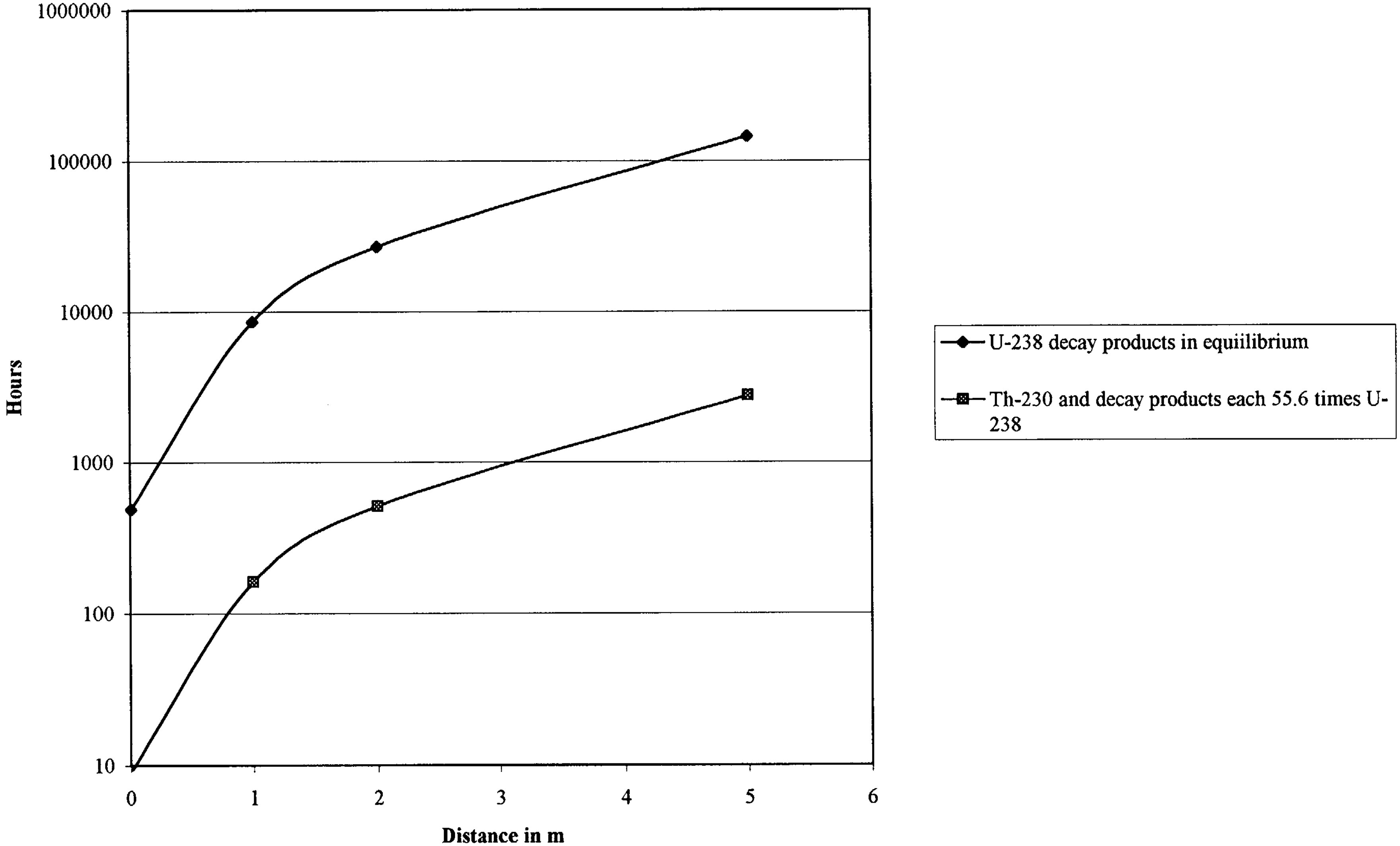

Figure 2
Hours of Exposure to Driver to Reach 1000 uSv
(Load of drums black flake 0.043%U and 0.005% Th)

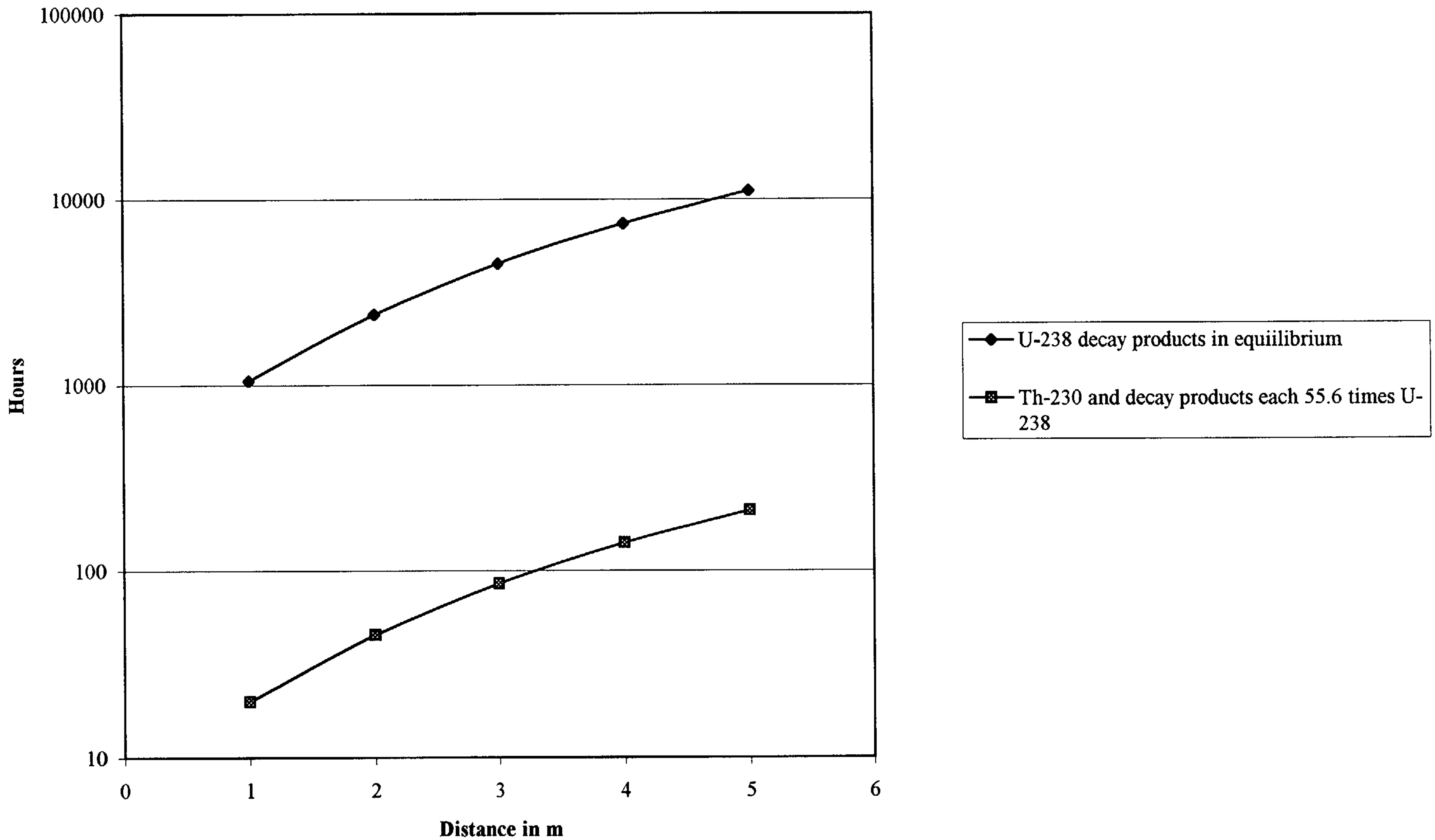

Figure 3
Hours of Exposure to Members of the Public to Reach 1000 uSv
(Load of drums black flake 0.043%U and 0.005% Th)