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July 4-13, 2007

CRITIQUE TO NIOSH OF APPENDIX BB TO BATTELLE TBD-6000 FOR THE GENERAL STEEL INDUSTRIES SEC AWE SITE

(This report was released to me on 6/25/07)

via Fax _____ and E-mail

Submitted to OCAS and its Director, Larry Elliott, and as a Public Comment to the July 17-19, 2007, ABRWH Meeting, and as a Public Docket Comment to the Appendix BB for Posting on the OCAS Website

Office of Compensation Analysis and Support
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Site Profiles for Atomic Weapons Employers that Worked Uranium and Thorium Metals - Appendix BB
General Steel Industries

Page 1 of 12
Document Owner: David Allen
Subject Expert: Sam Glover

Appendix to Battelle-TBD-6000 describing the use of the TBD for claims at General Steel Industries

BB.1 Introduction

This document serves as an appendix to Battelle-TBD-6000, *Site Profiles for Atomic Weapons Employers that Worked Uranium and Thorium Metals*. This appendix describes the results of document research specific to this site. Where specific information is lacking, research into similar facilities described in the body of this Site Profile is used.

.: I find it interesting that Larry Elliott repeatedly refers to this document as TIB-6000 when it is actually a TBD as can be seen above. In a 9/25/05 letter to the Larry Elliott acknowledged in writing that no comparable site to GSI existed.

BB.2 Site Description

General Steel Industries performed quality control work for the Atomic Energy Commission (AEC) from 1953-1966. Utilizing a 25 MeV betatron machine, it performed x-rays on uranium ingots and betatron slices to detect metallurgical flaws for the Mallinckrodt Chemical Company1. The x-ray films were processed, but not interpreted, at General Steel Industries. The facility is located at 1417 State Street in southwest Granite City, Illinois, northeast of St. Louis, Missouri, east of the Mississippi River. The

use of the facility for these services was on an as-needed basis with no indication of the frequency or duration2.

(a) The phrase "using a 25 Mev Betatron" is inaccurate as two Betatrons were in use at GSI: (1) one from 1953-1973, (b) another moved from Eddystone, PA, where GSI had an operating division that closed, that operated in the New Betatron building from 1963-73. These two buildings and two Betatrons are clearly described in the DOE cleanup reports from the 1988-1994 era. How could Sam Glover and the technical peer reviewers, who Mr. Elliott has refused to identify, missed this key and essential point?
(b) The phrase "Mallinckrodt Chemical Company" is not completely accurate. The name of the company was Mallinckrodt Chemical Works, Uranium Division.
(c) a GSI supervisor, did read some of the Betatron x-ray films made of industrial castings. His testimony should be reviewed on this point, however, I believe Mr. said he did read some of the MCW uranium ingot films and made out a check list before he returned them to MCW-UR. I would also note that NIOSH apparently has made no attempt to retrieve any of the GSI Betatron records from DOE MCW files. Those records should include x-ray reports, shot lists, and memoranda relating to the uranium work. I would note also that the MCW-UR uranium Purchase Orders that were presumably issued to GSI 1953-57 have not been located, so the actual amounts of uranium ordered, and whether they consisted of ingots, dingots, slabs or slices and the sizes thereof cannot presently be determined. We also do not know what the exact composition was of the MCW-UR uranium. We are aware that MCW-UR "uranium" did contain some impurities, and that some R&D uranium alloy work was done at MCW as early as 1953.
(d) The sentence "The use of the facility for these services was on an as-needed basis with no indication of the frequency or duration2. " is again not entirely accurate or complete for the following reasons:

[1] There is worker testimony on this point from three meetings including a NIOSH Outreach meeting in Collinsville, IL, on 8/21-22/07. Mr. Glover should have reviewed this material and cited relevant portions of the testimony. In addition, SINEW will soon be sending OCAS the GSI affidavits that may add further information on this point.

[2] Mr. Glover's narrative completely ignores the voluminous worker testimony and information from the CATI interview and GSI workbook that the two GSI Betatrons were utilized around the clock in three shifts all year from 1963-73 by the New Betatron/Eddystone unit, and only slightly less frequently from 1953-1973 in the Old Betatron facility on large industrial/military castings such as tank hulls and turrets, nuclear power plant channel heads, nuclear submarine missile launch tubes, etc. Many of these castings required multiple (300-400 exposures of 10,000 R <u>each</u>) requiring many days to completely survey the entire casting using 14 x 17 inch film cassettes. The overall radiation exposure by the Betatron and from activation products in the industrial/military castings dwarfed the total exposure of the workforce from MCW-UR uranium. Since <u>all radiation source term exposures must be factored into dose reconstructions during the covered period</u>, the omission of these data is most serious.

[3] Several other unique radiation sources were used for nondestructive testing of industrial/military castings at GSI. These source terms included two cobalt-60 gamma sources, an iridium-192 gamma source term, and a 250 Kvp portable x-ray machine. Voluminous worker testimony and several affidavits have been submitted to OCAS concerning these other sources that were used throughout the plant. For example, one cobalt-60 source was used in a roofless concrete block room located within the interior of Building 6. The overhead crane operators and workers in the vicinity were directly exposed to this source. Mr. Glover makes no allusion that shows he is even familiar with this copious and thorough documentation of additional source terms to the one Betatron unit he does mention.

<u>Comment</u>: This lack of attention to existing readily available OCAS data is of utmost

concern to SINEW. It directly belies OCAS Director Elliott's assertions that the delays in issuing the GSI Appendix were to avoid a "rush to judgment" and were done in the name of carrying out "good science." This work is just the opposite, careless and superficial science that ignores absolutely essential information on multiple existing GSI source terms in addition to the one Betatron Mr. Glover does mention. Most importantly, it will lead to serious underestimation of total radiation doses for many in the GSI claimant workforce.

BB.2.1 Site Activities

During the late 1950s and early 1960s, General Steel Industries was the custodian of a government-owned betatron used to x-ray uranium ingots for the AEC under purchase orders issued by Mallinckrodt Chemical Works. Purchase orders were issued by the Uranium Division, Mallinckrodt Chemical Works, from February 1958 through June 1966, first to General Steel Castings Corporation and later (July 14, 1961 and after) to General Steel Industries, Inc., at the same address. The ingots were in the form of cylinders 18 to 20 inches in diameter, approximately 18 inches long, and weighing up to 3000 pounds. The betatron x-ray equipment was Government owned. The uranium to be x-rayed was owned by the AEC and provided by Mallinckrodt3.

(1) The first sentence is in error. SINEW has documentation that the US Government purchased both the Old Betatron Allis-Chalmers particle accelerator and the building that housed it in 1953. GSI refused to purchase this equipment. The US Government also purchased other major buildings and equipment at GSI at the same time. We are uncertain about ownership of the facility for the New Betatron government-owned unit that came to GSI in Granite City, IL, from the closed Eddystone, PA, GSI division in 1963. We believe that GSI constructed the New Betatron building that adjoined building 10.

(2) The narrative fails to note that Purchase Orders from 1953-58 from MCW and the AEC for uranium x-ray work were not recovered and are missing. Thus, the exact quantities and types of uranium ordered cannot be known. It is almost certain that the missing P.O.'s, or many of them, came from the MCW-Destrehan Street plant in contrast to P.O.'s for uranium during 1958-66 that must have come from Weldon Spring, since MCW downtown plant operations shut down completely in mid-1958.

(3) We have other evidence that MCW supplied dingots after 1960 and that uranium "ingots" were of various types and sizes (cylindrical, rectangular, relatively pure with trace impurities, or were alloyed with zirconium and molybdenum (NYO-1358) up to 7% on an experimental basis). The MCW-Destrehan Street site profile describes the production of Betatron slices and there are additional descriptions of Betatron slabs. The Appendix BB here or elsewhere fails to note these various forms of MCW uranium metal. We challenge the accuracy of a single description of MCW ingots as "cylinders 18 to 20 inches in diameter, approximately 18 inches long, and weighing up to 3000 pounds." What is the primary source literature for this characterization of unimorphic uranium ingots at MCW?

(4) Besides natural U-238 and uranium-238 alloys with zirconium and molybdenum, various types of enriched uranium (EU), highly enriched uranium (HEU), and recycled uranium (RU) were also processed at MCW-Destrehan and at the Weldon Spring Feed Materials Plant in St. Charles County. Appendix BB should be explicit in what type/s of uranium are being described within this complex framework of uranium products the downtown and St. Charles County plants produced from 1953 to 1966. A document we have (REF: E. A. Weakley, Product engineering, OPRA. Status of alloyed dingots program January 1963. Doc. # HW-73149 (Jan. 11, 1963) From General Electric Hanford Atomic Product Operation) indicates that some MCW uranium went to Hanford (WAPD) to charge or be charged in its nuclear reactors. WAPD are also mentigned by DOE as part of the cleanup reports.

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BB.2.2 Frequency of uranium X-rays

GENERAL COMMENT ON THIS SUBSECTION:

I have numbered the paragraphs in this section of Appendix BB for ease in referring to them.

[1] There is a major error in the first sentence. Obviously, MCW-AEC uranium work at GSI done between 1953 and 1958 using the Old Betatron unit were covered by Purchase Orders that are missing: lost, destroyed, not searched for and found in the MCW or other archives and national repositories, or have not yet been released by DOE.

[2] This section mentions that P.O. descriptions are "limits and not estimates." However, it was common practice for MCW-AEC to change the limits of P.O.'s to include additional work as needs fluctuated at the production facilities. There is no assurance the records reviewed are complete. The fact that P.O.'s for uranium are missing for 1953-58 argues strongly that MCW P.O. recovery was incomplete.

[3-6] The assumption, not further justified, that the estimates are maximum ones, can be challenged on several grounds. As the author admits, no actual records of work performed were recovered. There is no accounting given for the OCAS effort that went into locating any of the following highly pertinent records: shipping manifests between GSI and MCW, Betatron shot lists, x-ray reports of the ingots, pertinent MCW or GSI memoranda, GSI check lists of work performed, invoices from GSI to MCW, packing lists, etc. There being no description of this effort, we infer that no effort was made to recover these records. A further inference is that the amounts and times assigned are minimally accurate. We believe they may be serious underestimates that did not reflect the work actually done (see testimony that each ingot required 4 two hour exposures rather than the one hour exposure per ingot) that Appendix BB indicates.

[1] General Steel Industries work with uranium was performed under purchase orders with Mallinckrodt Chemical Works starting in March of 1958.

This statement is substantially incorrect. MCW-AEC uranium x-ray work started at GSI in 1953 and ran through 1966 in the Old Betatron Government owned facility using a 24/5 Mev Allis-Chalmers Betatron. The 1953-58 Purchase Orders have been lost. A second similar Allis-Chalmers Betatron (New Betatron) came online at GSI from the Eddystone, PA, division in 1963 and was used simultaneously with the New Betatron to do MCW-AEC contract uranium work until 1966. Both Betatrons were used up until 1973 as proven by donut tube replacements by Jack Schueltz (Personal communication at VK Development to and). Purchase Order change orders are in the cleanup reports.

These purchases orders cover the time period March 1, 1958 through June 30, 19664. These purchase orders indicate that the work was to "X-ray material as requested by Mallinckrodt...". They also contained "Betatron labor charges, including operation and maintenance and all overhead shall be billed at $16.00 per hour." The last purchase order covering the period of July 1, 1965 to June 30, 1966 indicated a billing rate of $35.00 per hour. The purchase orders also indicated that the work was not to exceed a set cost. The first purchase order, covering the period March 1, 1958 to June 30, 1958 stipulated a monthly limit of $500.

: "19664" is obviously a typo that should be corrected. We have no confirmation

in the way of MCW accounting records to show that the Purchase Order "limits" were actually adhered to. Nor do we have any indication in Appendix BB what additional efforts, if any, were expended by the creator of this Appendix to search for and capture additional GSI records to those furnished by DOE and posted on their websites at the inception of the implementation of EEOICPA.

[2] That purchase order was extended to October 31, 1958 and added $1800 to the total limit (an additional $450 per month). A new purchase order covered the period November 1, 1958 to June 30, 1959 and stipulated a monthly limit of $450 and a total limit of $3600 (equal to $450 per month). The next purchase order covered July 1, 1959 to June 30, 1960 and stipulated a monthly limit of $450 with a total limit of $7200. It should be noted that the total limit does not add up to 12 months at the monthly limit. This is the only purchase order with this conflict. Since these are limits and not estimates, the most limiting of the two values will be used in this appendix which is consistent with purchase orders written both before and after this one.

The 1953-58 Purchase Orders for MCW uranium work at GSI using their Betatron facilities have been lost, destroyed or are not being made available to the EEOICPA program by DOE. Thus any extrapolation as to their contents and the scope of uranium work based on 1958-66 MCW uranium Purchase Orders is invalid, a guess only. None of the other related records have been recovered from MCW either: Betatron shot records, x-ray reports, shipping manifests, receipts, etc. We know that MCW issued frequent Purchase Order change orders that often increased the amount of uranium shipped to GSI. There is no way to independently judge the completeness of these GSI Purchase Orders and change orders based on extant records that and are aware of as of 7/13/07.

[3] From that point on, the purchases orders were written annually covering a period of July 1 to June 30 of the next year. All but the last order stipulated a billing rate of $16 per hour. The purchase order starting in 1960 stipulated no total limit. Only a monthly limit of $450 per month was specified. After that, only a total limit was specified. These limits were $7000 for the purchase order starting in 1961, $2000 for the purchase order starting in 1962, and $450 for each of the remaining purchase orders.

: We have no confirmation in the way of MCW accounting records to show that the Purchase Order "limits" were actually adhered to.

[4] From this information, it is possible to determine the maximum hours per year that General Steel Industries spent on operations, maintenance and overhead associated with x-raying uranium for Mallinckrodt Chemical Works. Through June 30, 1961 the limit was generally $450 per month at $16 per hour or 337.5 hrs per year. The remaining years are shown below.

We have no confirmation in the way of MCW accounting records to show that the Purchase Order "limits" were actually adhered to.

[5] July 1, 1961 to June 30, 1962 437.5 hrs/yr (based on a total limit of $7000)
July 1, 1962 to June 30, 1963 125 hrs/yr (based on a total limit of $2000)
July 1, 1963 to June 30, 1965 28 hrs/yr (based on a total limit of $450)
July 1, 1965 to June 30, 1966 13 hrs/yr (based on a total limit of $450 at $35/hr)

: We have no confirmation in the way of MCW accounting records to show that the Purchase Order "limits" and work hour schedules were actually adhered to.

[6] These estimated hours are considered the maximum hours that could have been spent x-raying uranium. These are considered maximum because the purchase orders set these costs as a limit. There is no indication how much of the available funds were actually used. Also the cost was to include maintenance down time and overhead as well as the cost of film.

: We have no confirmation in the way of MCW accounting records to show that the Purchase Order "limits" and work hour schedules were actually adhered to.

[7] For the remainder of the year, it is assumed that various alloys of steel were x-rayed. The operators reported that overtime was very frequent. They indicated the aim of the operators was to get a check over $500 for a two week pay period. This was remembered because the company policy was to not issue a check over $500. When more than that was earned, the company issued two checks, one for $500 and another for the difference. One operator remembered receiving a check for 3 cents. One recollection of the pay-rate during this time period was $3.80 per hour. At that rate, and assuming time and a half after 40 hours worked in a week, it would take approximately 57 hours per week to earn $500. The operators indicated this was a goal but did not indicate how often the goal was achieved. However, they did indicate that an 8 hour work day was "not the norm". They indicated overtime was frequent5. Based on this, it will be assumed that the operators worked 2400 hours per year, which is between working straight 40 hours per week and working 57 hours every week.

[7] "For the remainder of the year, it is assumed that various alloys of steel were x-rayed" is a gross misleading estimate of the actual extent of GSI operations. First, both Betatrons were in operation for three 8 hour shifts year around especially after 1963 when Betatron #2 (New Betatron) arrived from Eddystone. The GSI facility produced tank hulls and turrets, railroad trucks, NY rail cars, nuclear submarine missile launch tubes, nuclear power plant channel heads and other huge industrial castings made of multiple types of steel alloys. Most of these castings required nondestructive testing using the two Betatrons, the two cobalt-60 and one iridium-192 gamma sources, and the portable 250 Kvp x-ray unit. Table 1, which SINEW got from the workers, illustrates the variety of these industrial/military production and NDT operations.

Table 1. Types of metal castings used at GSI

CASTING	METAL	WEIGHT	NO. OF SHOTS	COMMENT ON DOSE
Tank hull M48, M60 (Note 1)	Armor	approx. 30,000 lbs	Multiple	Shots were up to 10,000R each
Tank turret M48, M60	Armor	Approx. 15,000 lbs	Approx. 24	Shots were up to 10,000R each
Channel head (note 2)	Carbon Steel grade A	60,000 lbs	Hundreds	Shots were up to 10,000R each
Missile tube: Upper Lower	HY-80 HY-130	?	Multiple Multiple	Shots were up to 10,000R each
Steam Chest power plant	Carbon Steel grade A	60,000+	Multiple hundreds	Shots were up to 10,000R each
30+ alloys New York RR trucks	Nickel alloy	7500	Multiple	

Note 1 – P. ... : Chrome Moly 4100 series steel
Note 2 – Per . ASTM A 276 535 "Everchanging;" also must factor in it being a nuclear plant part
Note 3 – Maximum shot size is 14 x 17 inches dictated by available film

For additional data in this Table please see critique of Appendix BB. this data from 7/13/07 (personal communication). Obviously, many castings at GSI required large numbers of exposures.

BB.3 Occupational Medical Dose

No information regarding occupational medical dose was found in any of the site research or CATI materials. Information to be used in dose reconstructions, for which no specific information is available, is provided in ORAUT-OTIB-0006, the dose reconstruction project technical information bulletin covering diagnostic x-ray procedures.

Is it actually true that the author reviewed all of the CATI interviews on over 800 GSI claimants in order to make a true statement that "no information was found regarding occupational medical dose..."? Does not the CATI interview have a specific question about this practice? How many CATI interviews were conducted and how many and what percent were blank as implied by "no information?"

BB.4 Occupation External Dose

For clarity, sections of this paragraph have been assigned numbers.

[1] No data was found in the Site Research database related to measurements of occupational external dose during AEC work.

The statement "No data was found in the Site Research database related to measurements of occupational external dose during AEC work" is misleading. Months ago informed Larry Elliott that personal film badge monitoring data might exist at Landauer. We subsequently found this was so and recovered the data from 30 workers. Some lifetime exposures were elevated. This data should have been recovered and analyzed by NIOSH in order to achieve the goal of sufficiently accurate, claimant favorable dose reconstructions.

[2] The AEC work performed at General Steel Industries involved the handling of uranium ingots and other forms of uranium metal during the x-ray process. Since this estimate relies on estimates of exposure times and dose rates, the dose rates for specific types of work in table 6.4 do not apply. For this estimate, the dose rates in table 6.1 for a rectangular ingot will be used for unirradiated uranium metal. This produces the highest dose rate of the potential shapes of uranium metal handled at General Steel Industries.

The assertions made in this paragraph are completely unjustified and need to be documented by citing primary source references. The phrase "and other forms of uranium metal..." needs to be clarified. What other forms of uranium were x-rayed and how could the author be certain of that? Otherwise the statement is merely gratuitous and is without any scientific validity. What literature or calculations validate the statement that a

rectangular ingot "produces the highest dose rate of the potential shapes of uranium metal handled at General Steel Industries."? What are those "potential shapes" and how are they known (from what source documents)? Good science practice dictates that this type of assertion be fully justified. The present language would not pass muster in any peer review group I have been associated with during my faculty tenure at where I held research grants.

BB.4.1 Exposure Time

The exposure scenario used to estimate dose at General Steel Industries due to operating the Betatron machine assumes three basic periods of time: setup, x-ray exposure, and take down. Setup is intended to include the time it takes to position the x-ray film and the machine, and to maneuver the material to be x-rayed into position. The take down period includes the time required to remove the x-ray film, process the film, and remove the x-rayed object from the area. The exposure time is the time period in which the betatron is actually operating.

The cool down period after Betatron exposure, when activation of the Betatron components and the target (uranium, industrial targets at GSI) occurred, is another crucial time interval that should be analyzed based on the Los Alamos Betatron safety manual (see 's GSI workbook). The published work of Professor Vincent Kuttemperoor further attests to the potential harm to workers if this cool down period is not adhered to. Ample GSI testimony (see 7/7/06, 8/11/06, and 8/21-22/06 transcripts and GSI affidavits) indicates there was zero (no) planned cooling off period between exposures (shots) in normal operations of the 24/25 Mev GSI Betatrons from 1953-1966. This lack of a mandatory cool down period seriously exposed the GSI workers to activation exposure.

Operator interviews indicate takedown times varied but 30 minutes appeared to be a reasonable average5. It was indicated that it could sometimes be done in 15 minutes but not faster because it took time to process the film. This estimate will assume that takedown took 30 minutes and half of that time was spent at 1 foot from the material being x-rayed. For the remainder of the time, the operator is assumed to be performing other duties in the area at a distance of 1 meter.

What I believe the GSI workers testified was that they immediately swarmed over the large industrial castings immediately after the Betatron beam was turned off at the end of a shot. Many times they were is close physical contact with the larger castings to place the film cassette during setup. This was often necessary for domed castings (channel heads, tank turrets) to place film cassettes and magnetic shot markers inside the castings.

Due to the care necessary to position the film and machine, it is assumed that it would take longer to setup the x-ray exposure than to remove the film cassettes. Since little information was available on setup time, and radiation exposures would be higher during takedown time, it is assumed that these times are equal which represents a favorable assumption.

It should be realized there was usually no time gap between the takedown phase of one Betatron shot and the setup period for the next shot. In addition, the large castings and the MCW uranium ingots required many shots. Thus, during the setup phase the workers were often in direct contact with a highly activated casting or uranium ingot.

Exposure times recalled by the workers varied somewhat due to the time that has passed and the many different types of items x-rayed through the years. Operators remember exposures of 1 hour, a few hours, a couple hours, etc. 5 however, it is not clear if they were all discussing the same size and shape of uranium products. It appears these times may have been for the large uranium ingots. Exposure times for smaller slices and other shapes would be shorter. It is important to realize at this point that while the Betatron is operating, the operators are outside of the shielded area where dose rates are considerably less than exposure to a freshly x-rayed piece of uranium metal. Therefore, while longer x-ray exposures will result in higher dose rates coming from the uranium, it will also increase the time the operators are assumed to be in a low dose rate area. These competing affects tend to balance out somewhat. This appendix assumes that large pieces of uranium were x-rayed for two hours and smaller slices were x-rayed for less than one hour and thus a reasonable estimate of the average x-ray time is taken to be one hour.

The assumptions in the last sentence are not substantiated by any facts cited in source documents facts and are, in fact, contradicted by some GSI worker testimony. Betatron operator , for example, testified that uranium ingots required four 2-hour exposure by quadrants. There is no testimony about how long it took to x-ray the slices. LAMS-2064, a classified 1956 symposium on NDT of uranium and nuclear weapons at Los Alamos, Rocky Flats, and Oak Ridge, provides guidance about this. Mr. Glover viewed this document while it was still classified and should have referenced it in Appendix BB. These statements are vague and inaccurate in other aspects. The workers testified that on the larger castings, Betatron exposures to deliver 10,000R were common and repeated multiple times so that the largest castings required weeks to complete (see Table 1 page 6). Many times the same castings were re-xrayed once the identified defects had been corrected. To be able to calculate the actual Betatron doses from 1953 to 1966 with reasonable accuracy requires more than these very vague statements such as "these competing affects (sic) tend to balance out somewhat." One would have to have exact specifications of the geometries and shapes or the uranium and of the industrial castings to plug into simulation programs such as MCNP-5. A 3-D CAD program front end to MCNP5 as employed in the literature would have to be used accurately model the external doses, including activation, from both types of targets. There is no indication such a front end program was actually used.

BB.4.2 Skyshine

The betatron building was constructed with 10 foot thick wall to shield operators from radiation while the unit was operating3. Given that the walls were only one story high, it is possible for radiation to scatter up and out of the building then scatter again off the air and back down to ground level. This effect is known as skyshine.

This is a grossly oversimplified and inaccurate depiction of the true situation. First, only some of the outer walls were ten feet thick and the constructed inner wall consisted of sand. Second, floor diagrams of the Betatron facilities (Old and New) at GSI show that the control room walls are not as thick. Third, the walls of the portion that border the railroad tracks are not as thick as 10 feet either. When the Betatron head was "flipped" after 1963, worker testimony shows the Betatron beam scattered radiation down this hallway, exposing film around the corner from the main shooting area. Besides skyshine through the tin roof, signs on the front and back of the Old Betatron building warned people not to come within 100 feet of this building. There was a known radiation field outside through the walls. The New Betatron building facility offered even greater danger to the workers outside the Betatron room. Building 10 adjoined the New Betatron facility, being separated from it by railroad

tracks, a "ribbon type" steel door, and was only partly protected from exposure by thick Betatron building concrete and sand filled walls. We verified these physical aspects of both Betatron buildings during a site visit to the GSI plant in September of 2006 and took photos and video footage of the tin and tar roofs. There is absolutely no extant data from the GSI facility to indicate gamma, beta, alpha or neutron doses via Betatron activation of the air, target castings or uranium, or due to beam losses, floor and wall scatter that are in addition to skyshine. Landauer does possess some film badge data on about 30 GSI workers as we notified Mr. Elliott about months ago. We do not know whether NIOSH has attempted to retrieve that Landauer data.

External dose rate from skyshine was modeled using Attila software. This is a multi-group deterministic radiation transport environment that can directly use Computer Aided Design (CAD) data and model complex geometry efficiently and accurately to solve large 3-D problems7. A drawing and description of the Betatron building was used to determine the dose rate at various points outside the building. The drawing did not include vertical detail but photographs and operator comments indicated that the 10 foot thick walls were only one story high. The building description indicated the roof was a built-up type. Since no detail of the roof was discovered, the model did not contain a second story or a roof. This produces only a slight overestimate since any shielding provided by the built-up roof would be small. The location with the highest modeled dose rate is used in this exposure estimate, which is a dose rate of 0.72 mrem/hr while the Betatron is operating.

(1) The source and program version of the Attila modeling software, and added justification for its appropriateness to this complex task, should have been included. Can Attila accurately model neutron dose from the Betatron and was this done? We have a neutron dose curve from an A-C Betatron at a St. Louis hospital that proves Betatrons of the GSI type generated neutron flux fields that must be incorporated into GSI dose reconstructions. I do not see neutron doses mentioned anywhere in Appendix BB.
(2) The second paragraph says "can directly use CAD data and model complex geometry" without stating explicitly whether and what CAD front end was used. This is a serious omission.
(3) It is our understanding that the SC&A team is using MCNP-5 Los Alamos software to model Betatron external doses at Fernald, and this data analysis should be sought and added into this Appendix as the two efforts appear to complement one another. The SC&A Betatron modeling work project was a direct outgrowth of input from and

(4) It is not clear what Betatron building, Old or New, floor plan and description (source document/s) was being assessed. This document should be cited in the References section of the Appendix. Both building facilities should have been modeled since workers indicate that both were used for the MCW uranium work and for x-raying large industrial castings between 1963 and 1966. The New Betatron building directly abutted and was joined to Building 10, whereas the Old Betatron building sat in a field a short distance away from the New Betatron facility that housed the second Betatron x-ray unit.
(5) What does the statement the roof "was a built-up" type mean? The roofs of the two Betatron buildings at GSI were tin, wood and tar that offer no protection from very high energy gamma and x-rays. People worked on repairing the Betatron area roofs routinely.
(6) Worker testimony indicates the Betatron facilities contained a second story that housed the capacitor banks, for example. Electricians had to use those second floor facilities.
(7) What are the source documents or calculations that justify the statement: "*The location with the highest modeled dose rate is used in this exposure estimate, which is a dose rate of 0.72 mrem/hr while the Betatron is operating.*"

BB.4.3 Steel Dose Rates

Operators of the betatron reported that the control panel had a meter that displayed the amount of radiation emitted by the device during an x-ray. This meter was reported to be capable of being set for a desired exposure in Roentgens (R). Operators reported values of 4.5 hours to accumulate a 10,000 R exposure, 2.5 hours to accumulate a 5,000 R exposure, and 1 hour to accumulate a 1,000 R exposure. These equate to approximately 37, 33, and 17 R/min respectively. Operators also reported machine values of 100 R/min and 250 R/min.

What does "machine values" mean? Does this refer to the compensated or the uncompensated beam or to the Old or New Betatron units that undoubtedly had different outputs that varied with each individual donut tube? The donut tube specs and manufacturing design changed over time as well.

In an interview with Jack Schueltz, who worked with Betatrons for Allis Chalmers, it was learned that the output of the machine was variable and that the 100 R/min was the design maximum value, but that was only achievable in his laboratory when the compensator (or filter) removed.6 The cone shaped aluminum compensator was used to flatten the beam intensity so that a uniform x-ray could be taken. That is, it shielded the high intensity center of the beam more than the outer edges, thereby creating a relatively uniform exposure over area of the film. This also reduced the x-ray intensity by about a third. In addition, the 100 R/min was measured at a distance of three feet from the beam's focal point. The radiation meter, which was an integral part of the betatron, was calibrated to indicate the uncompensated radiation at three feet from the focal point.

and also interviewed Mr. Schueltz for over an hour, and have corresponded with him since, when they visited Professor Kuttemperoor in Wisconsin earlier this year. Jack Schueltz currently services the only three known U.S. operating 22-25 Mev A-C Betatrons that are located at NDT Specialties, Inc., in West Allis, WI (old Allis-Chalmers plant), at China Lake in California, and at Letterkenney Army Depot in Pennsylvania. He is a repair person, not a degreed scientist as is Professor Kuttemperoor whose input was ignored in Appendix BB. This is an overarching concern and weakness of the current version of this Appendix. Mr. Schueltz told us that he changed donut tubes at GSI as late as mid-1973. He also informed us about marked variances in donut tube output characteristics and the danger of the activation period that he believed was most dangerous for only 15 minutes. He informed us that a building wide radiation survey was made of all A-C Betatrons when they were first installed. Jack Schueltz says that all such survey records he knows of have been lost. The literature refers to a report of the Picatinny Army Arsenal Betatron facility with very high gamma fluxes that we have not yet been able to obtain. Picatinny Arsenal has been recently removed but once was a covered EEOICPA AWE site. The NDT Specialties facility in West Allis that was our host had a 22/25 upgraded Betatron we observed operating and a spare donut tube that was being degassed while being energized electrically to keep moisture out of the glass envelope.

The narrow beam of the betatron required that the distance of the material being x-rayed be greater than three feet to expose an area of reasonable size. For example, a distance of 6 feet was required for an 11" x 14" film. It was reported that common film sizes in use were as large as 17 inches. This is consistent with information provided by the operators at General Steel Industries. They indicated they normally made exposures at either 6 feet

or 9 feet and had a string on the machine to measure that distance5. This evaluation assumes that all x-ray exposures were made at 6 feet and that the uncompensated exposure rate at 3 feet is 100 R/min.

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Jack Schueltz reported to us, confirmed by other sources such as the A-C Betatron operating manual, that various 22-25 Mev A-C supplied Betatron donut tubes produced 100 to 250 R/min uncompensated outputs, so the <u>100/R figure is on the low side and is not claimant favorable</u>.

The high energy x-rays emitted by the Betatron machine can cause non-radioactive components in the material being irradiated to become radioactive through photo-neutron (**: "activation" should have been used here**) reactions (.: and through phototission of uranium). The build up of radioactive isotopes from this reaction in a large piece of steel from a Betatron x-ray spectrum was determined using a computer program MCNPX 2.5.08. (. **: I thought the Los Alamos software was up to version 6.0 at least)** MCNPX is a general-purpose Monte Carlo radiation transport code that utilizes the latest nuclear cross section libraries. This modeling resulted in the determination that one isotope was the major contributor to the initial dose-rate. The isotope, iron-53 (53Fe) is produced from the photon-neutron reaction of iron-54. The half-life of 53Fe is 8.51 minutes and it decays by electron capture. This results in the emission of two 511 keV annihilation photons. A 379 keV photon is also emitted from 53Fe.

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(1) This modeling of Betatron photon activation is too simple and is poorly described and the results are not well justified and validated by any real input parameter specifications. (2) A 3-D CAD front end was required to accurately model the external Betatron dose. MCNP-5 was developed for human dosimetry and the default shapes for a human body are a cylinder, a gross simplification for humans and an unacceptable and invalidating over simplification for large industrial castings with complex shapes such as nuclear channel heads and tank turrets and hulls examined by the Betatron at GSI. (3) Fe-53 is but one of many photon activation products in uranium and the many different types of steel in GSI castings. The film cassettes, Betatron column, air and concrete walls, Magnaflux powder that covered the castings, oxides that coated the uranium ingots all were also activated. Were these also modeled and the results factored into dose calculations? The description of this exceedingly complex modeling problem is far too brief. The results modeling methods and data should be checked by SC&A who should be tasked by the Board to do so. This omission of the wide spectrum of activation and photofission products in Appendix BB invalidates the report as sufficient to accurately calculate GSI doses. In addition, this document completely fails to factor in gamma doses from two cobalt-60 sources and an iridium-192 NDT source at GSI as well as the 250 Kvp portable x-ray unit.

MCNPX was next used to model the dose-rate from a large piece of steel that was x-rayed for 60 minutes. The initial dose-rate at the end of the exposure period was calculated to be 0.5 mR/hr at one foot and 0.0668 mR/hr at one meter. After 30 minutes of decay, these dose-rates drop to 0.0433 mR/hr and 0.00578 mR/hr, respectively.

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What were the sizes used for the "large piece of steel" and what other parameters such as the components of steel (there are many kinds) were used in the modeling? HY-80, HY-130, stainless were all steel types used at GSI, for example. Were these modeled? (see Table 1, page 6)

Integrating the dose rates for the 30 minutes following exposure produces a dose of

0.0934 mR at one foot and 0.0125 mR at one meter. Assuming half the time the individual is one foot away and the other half, one meter away, the integrated dose is 0.0529 mR for the 30 minutes following a one hour exposure. [. **Is something missing from this sentence?]**
capable of being set for a desired exposure in Roentgens (R). Operators reported values of 4.5 hours to accumulate a 10,000 R exposure, 2.5 hours to accumulate a 5,000 R exposure, and 1 hour to accumulate a 1,000 R exposure. These equate to approximately 37, 33, and 17 R/min respectively. Operators also reported machine values of 100 R/min and 250 R/min.

The overall estimate for Betatron x-ray of steel is: 30 minutes setup with no dose; one hour Betatron x-ray exposure due to skyshine at 0.72 mR/hr; and, 30 minutes takedown resulting in 0.864 mR of dose (primarily from activation of the aluminum compensator). This totals 1.58 mR of dose over two hours or a 0.792 mR/hr average dose rate while x-raying steel.

The assumptions based on "a large steel piece " are far too simplistic to be scientifically useful or valid. It is not apparent that 3-D CAD front end was used to model the large variety of GSI military and industrial castings. Many components of the Betatron radiation primary and activation spectra, the size, shape and mass of the castings themselves, the omission of the Betatron operating manual data and total reliance on technician Scheultz' opinion while ignoring other key data provided by the and Professor Kuttemperoor, and the ignoring of neutron doses, and the fact that at least three gamma sources (2 Co-60, Ir-192) and a 250 industrial portable x-ray source that are ignored, were used on the GSI castings, largely invalidate this section.

BB.4.4 Uranium Dose Rates

External exposure to radiation during betatron operations with uranium comes from three sources. The uranium metal itself exposes the operators to external radiation while they are in the process of setting up and taking down the shots and moving the piece into and out of the building. The source of exposure while the Betatron is operating would be primarily skyshine from x-rays scattered up and out of the building then down to the operators. Any x-rays penetrating the 10 foot thick shielded walls of the building is also accounted for. The last type of external radiation exposure is from the activation of the uranium itself. This is caused by the photon-neutron reaction of the high energy photons from the 25 MeV x-ray spectrum.

External radiation from activation products are
actually negligible compared to the dose-rate emitted by the uranium metal itself,

Mr. Glover must demonstrate the calculations and modeling results, and reference them if source documents are being referred to, in order to that justify this statement and omit activation products as part of the overall dose calculations.

however, the photo-fission reaction that also occurs produces short-lived fission products that for a short time increase the external dose rate.

The primary literature references, the photo fission products modeled (if they were), the composition of the uranium ingots (purity, alloys), and the definition of "short lived as

specific product half-lives, must all be quoted and analyzed for this section to be scientifically valid."

The external dose rate from the uranium itself is applied to both the setup and take down time but not the time the Betatron is operating since the operators are not in the area during this time. The dose rates used are from the rectangular ingot from Table 6.1. The one foot (30.48 cm) and 1 meter dose rates are used with the assumed exposure scenarios discussed earlier.

But MCW also supplied GSI with cylindrical ingots, dingots after 1960, plus slabs and slices. How were these various geometries modeled?

The dose rate from irradiated uranium was evaluated using MCNPX 2.6c. Several different sizes and shapes of uranium metal were x-rayed at General Steel Industries.
(**: What were they, specifically?)**
Because of this, a large block (**how is this defined, precisely?)** of uranium metal was evaluated as a bounding condition.
The results of the MCNPX evaluation indicated that fission occurs predominately within a few centimeters of the surface being exposed, which indicates a similar result should be obtained regardless of the shape of the uranium piece. It also indicates any shielding provided by the uranium is limited.

This section needs to be expanded to include the supporting data that justifies these very dogmatic statements.

The short half-life fission products decay quickly producing more radiation and thus higher dose rates than the longer-lived isotopes. Conversely, the short-lived products produce these higher dose rates for a shorter time.

For the following calculations to be credible, the exact activation and fission products need to be much more fully characterized as to specific isotopes and their daughters and the decay characteristics with half-lives. Some products have half-lives of days – is this considered to be "short." How are short and long defined by Mr. Glover with respect to specific MCW uranium Betatron induced activation and photofission products? Lots of this data resides in Dr. Vincent Kuttemperoor's two peer reviewed papers and book chapter that were available at OCAS to Mr. Glover as well as the two Sugarman and Duffield papers we supplied to OCAS on Betatron-induced uranium photofission.

To evaluate the net effect, the dose rate was determined at 1 foot and 1 meter at various times after the x-ray machine was turned off.

As stated above, the GSI betatron operators testified they were often in direct contact with uranium and castings immediately after the Betatron beam was turned off, so the quoted distances are not accurate and would underestimate the actual worker exposures.

The dose-rate as a function of time at the two distances was found to be best expressed by the equations provided below.

() *hrshrs tt eetD* ____ += 0864.07181.030 01.00793.0

() *hrshrs tt eetD* ____ += 0883.0741.0100 0014.00107.0

These equations describe the dose (in rem/hr) at any time post irradiation. By integrating these equations, the total dose for a period of time post irradiation can be determined. The estimate here assumes the take down time is 30 minutes and that half of the exposure is at 1 foot from the uranium while the remainder is at 1 meter. This results in a dose of 21.7 mrem over the first 30 minutes following irradiation.

Using the methodology in section 6.3 of this Technical Basis Document, the non-penetrating dose to the skin of the forearms and hands can be calculated to be 5.75 R/yr. The non-penetrating dose to the skin of the rest of the body can be calculated to be 0.52 R/yr.

The overall estimate for the Betatron x-ray of uranium thus includes 30 minutes setup at 1.227 mR/hr for 0.613 mR of dose. An additional 0.613 mR is received from the uranium metal during takedown. Also during takedown, 21.7 mR of dose is received from 30 minutes of exposure to the fission product radiation and 0.811 mR from exposure to the activated compensator. Lastly, skyshine from the one hour Betatron x-ray exposure produces an additional 0.72 mR of dose. This totals 24.4 mR of dose over two hours or 12.2 mR/hr average dose-rate while x-raying uranium.

This calculation underestimates the external uranium dose because uranium ingots were exposed four times each for a total of 8 hours according to `s testimony.

BB.4.5 External Dose Summary

The external photon dose for Betatron operators is summarized in the table below.

R/yr
Year Photon Skin Hand and
forearms Skin
1953-1960 5.751 1.755 19.406
1961 6.321 2.015 22.281
1962 5.109 1.463 16.172
1963 2.774 0.398 4.399
1964 2.220 0.146 1.610
1965 2.135 0.107 1.179
1966 1.025 0.034 0.374

Half of the photon dose should be entered into IREP as greater than 250 keV photons and the other half as 30 keV and 250 keV photons. Further, since a number of bounding estimates were used (i.e., no maintenance or other down time, operators instantaneously in the area after exposure, etc.) to determine these doses, the values should be considered a constant distribution. Skin doses should be entered into IREP as a constant distribution of electrons greater than 15 keV.
This dose should be used to estimate the dose to radiographers and anyone else that was routinely handling the steel or uranium within 2 hours following the x-ray exposure. While other radiography sources existed at General Steel Industries, the dose estimates in this appendix are considerably higher than those typically received by radiographers. Because of this it is more favorable to assume these employees were always operating the Betatron.

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.: A summary of weaknesses and omissions for Betatron operator doses:

1. Oversimplification of the activation products as Fe-53 only and as "short lived"
2. No specification of specific uranium photofission products and their exact half-lives
3. Lack of use of a 3-D CAD front end software program to model complex large casting shapes
4. Neutron doses were left out
5. Cobalt-60 source gamma doses were left out; one such source was used in Building 6
6. Iridium-192 gamma doses were left out
7. Portable 250 x-ray doses were left out
8. No cool down period was observed
9. Betatron operators touched castings with no cool down or waiting period after beam-off
10. Betatron air, floor scatter and wall backscatter were not considered
11. New Betatron exposures to building 10 workers and to those walking within 100 ft. of the building exterior outside of the Old Betatron building were not considered

Some employees did not normally work in the Betatron building or with x-rayed steel within 2 hours of exposure. For these employees, the maximum exposure at General Steel Industries would be from the skyshine due to the Betatron. Therefore, the dose rate of 0.72 mR/hr will be assigned to these employees with the assumed work year of 2400 hours per year. This results in an annual photon dose of 1.73 R/yr.

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This section neglects doses to many GSI workers from the two Co-60 sources, the Ir-192 source and the 250 Kvp x-ray sources that were used throughout the GSI plant complex including building 6 and 8-10. Many of them frequently cycled in and out of the Betatron buildings. [grinders, welders, burners, laborers, railroad crane operators, inspectors etc.]

This dose rate is highest very near the Betatron building and lower as the distance from the building is increased. Since this is the maximum exposure outside the building, this dose should be entered into IREP as a constant distribution. The energy should again be considered 50% greater than 250 keV photons and 50% 30 keV to 250 keV photons.

:

What doses outside the building should be entered into IREP?

BB.5 Occupation Internal Dose

No data was found related to occupational internal dose during AEC work. In addition, no records of air monitoring were found in the site research database. Since no cutting, machining, or abrading of the uranium was involved, there was a low potential for producing elevated air concentrations of uranium.

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This statement is not true according to the workers. The Betatron facilities floors were covered with dust, some of which was uranium. Uranium dust contamination of the rail cars and railroad tracks so severely that it had to be scraped off the area between the tracks (Sept. 2006 personal observation,). The railroad cars were used continuously throughout the plant for all products and thus carried contamination throughout the building complex. This was the only mode of transporting the activated metals and all products that could have become secondarily contaminated.

Of the work processes presented in this

Technical Basis Document (TBD), this work process most closely resembles the "Slug Production" process, as described in Section 2.1.5 of this TBD. Occupational Internal Dose from inhalation and ingestion should be calculated and assigned in accordance with Section 7.0 of this Technical Basis Document using the data in Tables 7.8 and 7.9 for the Slug Production process. The data represents worst-case exposures and is favorable to the claimants. However, the intakes assumed in these tables are based on 2000 hours of work per year. Since operators at General Steel Industries did not work with uranium full time, the intakes must be pro-rated. Also, even though these values are the median value, it is important to remember it is the median value for slug production work. This work included some machining of uranium metal while the work at General Steel Industries did not. Therefore, these values should be considered a bounding estimate and assigned a constant distribution.

BB.5.1 Intakes from Fission Products

Intakes of fission products must also be considered. Because there are many different isotopes produced as fission products, it makes it difficult to estimate internal dose from this process. Internal dose from uranium is caused by a low dose-rate delivered over years. Many fission products on the other hand have a relatively short half-life so they do not deliver a dose-rate for a long period of time. Immediately following the one hour x-ray exposure, the concentration of uranium atoms is actually 3.36 trillion times higher than fission product atoms. However, the activity concentration of fission products is approximately 11 times that of the uranium activity concentration. This percentage decreases quickly to less than 10% after 8 hours. The internal dose is determined by the total number of decays times the energy emitted by those decays. Fission products decay is primarily beta and photon decay and the energy is almost always less than 2 MeV. Meanwhile, uranium decays by alpha decay with energy always greater than 4 MeV. Also, alpha particles are more effective at causing damage. To account for this, the International Commission on Radiological Protection (ICRP) uses a multiplier of 20 named the radiation weighting factor. The weighting factor is used to increase the energy deposited by this factor of 20 to determine dose. Even assuming the worst case 2 to 1 energy ratio, the dose delivered by fission products over the first year after inhalation is approximately 0.005% that of the dose delivered by uranium. Therefore, it is sufficient to estimate the internal dose from fission products by assuming the uranium intake is 1% higher than that listed in Tables 7.8 and 7.9. It should be noted that this is favorable since a) the 2 to 1 energy ratio is actually a favorable assumption, b) uranium will continue to deliver a dose long after the first year after intake while fission products will continue to decrease and c) the radiation weighting factor for alpha radiation is 20 times higher than that of beta and gamma emitting fission products. The increase to 1% is intended to account for the differences in biokinetic models between uranium and the various fission products.

BB.5.2 Intakes from Activation Products in Steel

The purpose of x-raying steel castings was to detect internal flaws. Once found, they could be ground out and repaired. This implied the steel could be ground out soon after the x-ray while it is still radioactive, which would cause radioactive dust to be inhaled by the person grinding the casing. To estimate this intake pathway, the modeled x-ray exposure was again used. This model indicated the 53Fe activity near the surface immediately after the x-ray exposure is 3.13 nCi/gm.

Table 7.5 of this Technical Basis Document lists air concentrations for uranium

machining operations. Of the three grinding operations, centerless grinding had the highest results of 4000 to 5000 dpm/m3. This equates to 3.571 mg/ m3 to 4.286 mg/ m3. This estimate will assume the airborne concentration from grinding steel is 4 mg/m3. Since the grinding could not occur until after the film was processed, it is further assumed that it did not start until 30 minutes after the x-ray exposure ended. If the grinding continued until the activity was completely decayed away, the total activity inhaled would be approximately 0.267 pCi. The maximizing scenario is that the casting is moved out of the betatron building so that the grinding can take place while another piece is being x-rayed. With the exposure scenario described in this appendix, this allows the grinding to start on a freshly x-rayed piece every 2 hours. If 0.267 pCi is inhaled every two hours for 2400 hours per year, the total intake would be 320 pCi. This intake of 53Fe would result in an annual dose of less than one mrem for all organs. Therefore, no internal dose will be assigned from the inhalation of steel.

BB.5.3 Summary of Intakes of Radioactive Material

Inhalation of uranium is based on 198 dpm/m3 from Table 7.8 of this Technical Basis Document. This value is applied for the number of hours operators were in the Betatron building working with the uranium. It is not applied to the time the Betatron was operating to x-ray the uranium since operators were excluded from the building during that time.

During the rest of the time the operators were x-raying steel and other materials. Some residual uranium contamination may have been present that could become airborne and cause additional intakes. In order to estimate this, a terminal settling velocity of 0.00075 m/s was used. This is an estimate of the velocity of deposition on surfaces in the building. It was assumed that uranium settled on plant surfaces at a steady rate for the entire time that operators where working with the uranium with no cleaning, tracking, or other removal mechanism. This results in a surface contamination value of 117,000 dpm/m2 or 1170 dpm/100 cm2 for the July 1, 1961 to June 30, 1962 time frame. This is the time frame with the most possible hours of uranium work. This is reasonably close to the maximum value of 540 dpm/100 cm2 measured in a 1989 survey2. Therefore, it is assumed that this value existed in the building between uranium operations starting on July 1, 1961 until remediation occurred. Prior to that, a similar calculation results in a contamination level of 90,200 dpm/m2 which will be used for that time frame. Using a resuspension factor of 1E-6 m-1, these levels of contamination results in a constant airborne concentration of 0.0902 dpm/m3 and 0.117 dpm/m3 for the early and later time frames respectively. These level will be applied to operators intakes for all hours they are in the Betatron building for operations not involving uranium.

Also, as discussed in section 5.1, these values are increased by 1% to account for the inhalation of fission products. Ingestion rate must also be included and will be based on this average air intake and OCAS-TIB-009.

The uranium inhalation intakes during the operational period are summarized in the following table. The 1% increase for fission products has been included.

Year	Uranium Operations dpm/cal. day	Residual between Operations dpm/cal. day	Total dpm/cal. day
1953-1960	110.95	0.62	111.57
1961	127.38	0.69	128.07
1962	92.46	0.82	93.28
1963	25.15	0.90	26.05

1964 9.20 0.92 10.13
1965 6.74 0.92 7.66
1966 4.27 0.93 5.20
NOTE: 1966 values only apply through 6/30/1966

COMMENT ON SECTION BB.5 INTERNAL INTAKES:

Weaknesses identified throughout are:

1. Underestimation of dose from aerosolized uranium floor dust and rafter dust as the cranes moved across the ceiling to shift the target and the Betatron position
2. Aerosolization of the rail car and railroad track uranium dust are underestimated
3. Fission products and activation products are not characterized so the assumptions made about doses from them are challengeable
4. Questionable default assumptions such as arbitrary resuspension factors are used

BB.6 Residual Contamination

A survey was performed in the old Betatron building in March 19892. ("19892" is a typo that needs to be corrected) The maximum direct (fixed plus removable) alpha contamination measurement was 540 dpm/100 cm2. However, calculations in section BB.5.3 of this appendix resulted in a contamination level of 1170 dpm/100 cm2. This value will be applied to all time frames in the residual contamination period starting on 7/1/1966 and ending 12/31/1993 (when remediation was completed). This results in a uranium inhalation of 0.932 dpm/calendar day. Ingestion rate must also be included and will be based on this average air intake and OCAS-TIB-009.

Mr. and I do not understand how and why no residual uranium contamination was found in the New Betatron building at the same time it was found in the Old Betatron building. Based on what we know of GSI operations and from additional worker testimony and the cleanup reports, uranium work was performed in both the New and Old Betatron buildings and the uranium dust should have been there during 1963-73. Perhaps the New Betatron Building was cleaned up because it was later repurposed as office space after GSI ceased operations in mid-1973.

This level of contamination would result in an annual external dose of less than 1 mrem per year to most organs. However, the 1989 survey also included a dose rate survey of the building. While most measurements were consistent with background levels of radiation, a vacuum cleaner in one corner measured 90 uR/hr on contact. This results in a radiation dose higher than that from the surface contamination levels calculated above. Assuming someone is in contact with this vacuum cleaner for 2400 hours per year, the resulting dose would be 216 mrem/yr. This value will be assigned to each year of exposure during the residual contamination period as a constant distribution. The energy should be assumed to be 50% greater than 250 keV and 50% 30 to 250 keV.

Mr. and I have many concerns about the adequacy and completeness of the 1989 DOE radiological survey at GSI that are beyond the scope of this current Appendix BB critique.

Respectfully submitted,

7/13/07

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