COMMENT AND REPLY RE:
APPENDIX BB TO BATTELLE TBD-6000
FOR THE GENERAL STEEL INDUSTRIES SITE
Submitted to OCAS and its Director, Larry Elliott
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

Document Number: Battelle-TBD-6000
Appendix BB
Effective Date: 6/25/2007
Revision No. 0

Office of Compensation Analysis and Support
Document Number: Battelle-TBD-6000
Appendix BB
Effective Date: 6/25/2007
Revision No. 0

Site Profiles for Atomic Weapons Employers that Worked Uranium and Thorium Metals - Appendix BB
General Steel Industries

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

: We have waited 18 months for this Document and this opportunity to review it. Our intentions have always been, and will continue to be, to help set the record straight about what took place at General Steel Industries as it applies to EEOICPA. We appreciate the opportunity to do so. We intend for it to help everyone. This is part of an ongoing investigation, and we would certainly appreciate any input on this topic. We certainly thank and appreciate others who are reviewing and taking into consideration our comments and remarks.

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.

REPLY/COMMENT:
We have been advised on numerous occasions, and in various communications by NIOSH that there were no sites similar in activities to GSI. This was mentioned and referred to in emails from NIOSH, and mentioned in 's public comments to the Radiation Board recently. Also at this meeting, we discussed a report that we would like to see, LAMS-2064 with DOE/Libby White. She said she would look into this specific document for us. She did so and advised us that it still was "highly classified". We were advised that review would require a "Q" clearance.

It appears that no one else (Govt. agencies/contractors), attempted to retrieve this very important document prior to SINEW (Southern Illinois Nuclear Workers). This fact was confirmed by NIOSH and SC&A. Nondestructive testing seems to have been overlooked. We would ask why, when some forms of NDT involve massive amounts of radiation and very widely, and long known hazards. Who decided to overlook this common activity at many of the AWE/DOE sites?

This fact also seems very suspect since the LAMS-2064 Title is:
"*NONDESTRUCTIVE TESTING OF URANIUM, A compilation of Papers for the Symposium in Los Alamos, October 5 and 6, 1956". Compiled by Gerald H. Tenney.*
(Please keep his name in mind. He was the Symposium General Chairman at Los Alamos, Group Leader, Non Destructive Testing Group LASL, and his expertise will be referred to later). This LAMS-2064 1956 information was not the only Nondestructive Testing Symposium. The experts referenced in LAMS-2064 were quite widely published. (ASTM Special Technical Publications as an example.)

LAMS-2064 was actually referenced on the Internet and found as a result of a simple Google Search by . One can only speculate why NIOSH and others did not seek out this information as part of the NIOSH extensive document research, not only for this specific General Steel Industries Appendix, but also for the other facilities in the nation's weapons complex. It appears that this should have been a basic, standard, scientific procedure considering their task and responsibilities under EEOICPA and specifically for GSI.

Once made aware of this document, NIOSH sent a "Q" clearance representative to look at the original LAMS-2064 document, that person being the "Subject Expert" of this GSI Appendix. SINEW has now received redacted copies and after studying the documents, asks why major, scientific facts regarding exposures and procedures are not included in the GSI Appendix.

As an additional note, SINEW has recently shared with NIOSH and other government agencies, the names and locations of other sites that also had Allis-Chalmers Betatrons. Some of these sites were EEOICPA involved sites, which should be investigated.

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.

REPLY/COMMENT:

Please keep in mind that this is the same site that was previously referred to incorrectly as Granite City Steel. (Granite City Steel bought the ground after GSI closed in 1974). We thank DOL, NIOSH, DOE, and the Board, who had to listen to our numerous repetitive pleas for almost two years for help in getting this corrected.

Here is the real reason for all of our concern. SINEW has a copy of a completed NIOSH dose reconstruction that was done on a man, who according to his family, "never worked at GSI". They confirmed that he worked at Granite City Steel for 36 years. SINEW advised the Board, NIOSH, DOL, and others of this man's situation by both email and by public comment. Needless to say, his family was not very happy to hear this story but they wanted to help by sharing his records with SINEW. They made and gave us copies of his information and permission to use them. This "Granite City Steel" worker, not a GSI worker, was given a probability of cause of 36.23 POC.

Why is this so important? One of the now confirmed facts is that "all radiation sources were not used" to do his dose reconstruction. The 2 Betatrons were not even mentioned! The same issue repeats itself for the Cobalt 60, Iridium 192, 250kvp x-ray device and all of the activation factors that are now coming to light. This includes the activation and photo fission of uranium and various other alloys. This "missing" Betatron in this Appendix is very difficult to understand since the "TWO" Government Owned Betatrons are clearly mentioned in every report we have seen from the Government. The New Betatron and building seems to have disappeared along with all of the radiation, and the accompanying complexities, that it generated. We can provide independent proof that both Betatrons were being used at the same time from 1963-1973, which is also included in the Official Site Cleanup documents. (The New Betatron and the New Betatron Building went into service in 1963.).

The proper authorities have been given numerous and copious amounts of information regarding GSI by the on many occasions. We are baffled why very little of this well-documented information is included in this Appendix.

Please keep in mind that everyone (NIOSH, DOL, SC&A, the complete Board with the exception of new members), had been given a 400+ page Workbook about GSI, including the two Betatrons and their respective Buildings (maps, photos, history etc.). This was done some time ago in an effort to avoid errors and omissions. (More workbooks can be provided if requested.)

The Basis and outline for the GSI Workbook, was the very extensive CATI interview that was conducted, checked, double checked, revised etc. by a very professional, competent, individual interviewer named Heather. That information was meant to give a lot of our then-known details to everyone very early in this process. (Sept. 7, 2005, 15 pages incl. cover) We heard two versions of what then happens to our CATI:

1. It will be passed along and shared with everyone involved with GSI.
2. It will go into the claimant's file.

It appears to us that it went into the claimant's file.

All of the information in the workbook was discussed and covered in detail at the NIOSH sponsored GSI Outreach Meeting, along with personal testimony from workers. SINEW provided NIOSH with professional, certified transcripts, and video, so the record would be accurate. This GSI Appendix Document Owner, and two other NIOSH employees attended the meeting. Where is the resultant information in the Appendix?

The facts actually get worse. The "Old" Betatron that is mentioned in this Appendix was 24 MeV in power and not 25 MeV, according to the GSI Betatron operators who are assisting us. We feel that "someone" knew about the second, "New" Betatron, the one 25 MeV in power, or why was there a reference to 25 MeV at all? Perhaps it was simply overlooked. This must be corrected.

Why must the New Betatron be included? One of the most important and crucial missing facts is that this second, New Betatron and it's Building were directly connected to the most worker-populated areas that included all of the other connected buildings. A visit to the site, confirmed that there were no thick 10 ft. walls or shielding in this area, connecting to Building #10. What went into #10 Building from the New Betatron area, went into Buildings 9, 8, etc. and the Main Foundry. There were no walls between these buildings, which means there was maximum exposure for all workers. There was a simple ribbon door, not heavily shielded, from the New Betatron building into #10 Building. X-rayed castings were rushed into this #10 building right after NDT. That was the primary reason for the close proximity of the New Betatron building to the main "finishing" work area, without regard to the safety of many workers. (Distance is a factor that is always mentioned in radiation safety material.) Again, these facts were provided to NIOSH in many forms at various times.

This "open" buildings arrangement saved valuable GSI internal R.R. track movement time and also got the castings into the New Betatron very quickly. (The

Polaris submarine work, and the nuclear channel heads were specifically mentioned because of the need for much more stringent quality control, the most in GSI's history). It also meant no GSI locomotive was needed inside the Building, which was again a big money saver! Materials were brought into the New Betatron Building via an electric powered flatbed transfer car as well as by truck. They stayed inside the facility, originating in 8, 9, or 10 Building. This practice allowed workers maximum exposures to possible radiation sources.

In part to speed up production, workers said that there was no radiation cooling-off period, which added to their exposures. Management actually wanted to keep the castings hot, temperature-wise too, so they were easier to work on if flaws were located by inspectors and needed to be repaired by workers such as grinders, burners, chippers and welders. Castings were covered with asbestos blankets to keep them warm. Production and speed were the "order of the day". Management and efficiency experts did time studies. The requirement of speed and efficiency by management, as well as proximity to dangerous sources, contributed to radiation exposures of many classifications of workers.
Many workers were involved; workers who often changed jobs for advancement, who changed job titles and responsibilities, and thus had a variety of radiation exposures in the GSI Plant.

An all-encompassing Plant rotation of shift hours that included 3 shifts was in place "forever" according to numerous former workers and GSI management.
We have been told that the shifts were 7AM to 3PM, 3PM-11 PM, and 11PM to 7 AM. These changes took place every week. Overtime was also put into this equation as well, 7 days a week, with no exceptions. Where in the Appendix is this factor accounted for, that all workers would have been exposed to whatever radiation sources or byproducts were in existence around the clock?

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.

REPLY/COMMENT:

1953 is not the late 1950's, and 1966 is not the early 1960's. The contract period was 1953-1966. GSI received the Old Betatron in 1952. AEC work per government information started in 1953. The second Betatron came to GSI in 1963 according to newspaper articles and former workers. The reference to ingots seems to match as

to weight, at 3300 lbs. The size of 18-20 inches in diameter, 18 inches long, appears correct and matches photos that SINEW has from the Weldon Spring DOE Visitor Center. Workers agree.

More importantly, a recently discovered description of the exact size of a patented dingot has become available. This description is unique to Mallinckrodt (the ingots referenced in OTIB-0004, 3.2.1, page 13 of 25 are actually smaller than the Mallinckrodt dingots, because that document is describing ingots, not dingots. Mallinckrodt had both!) Thus, one would assume GSI received both. GSI also received some from MCW Destrehan Plant, and then they started getting some from Weldon Spring after 1958. Trying to guess at the quantities, type, and material composition is certainly not accurate science.

This "size" difference is a perfect example of inaccuracy. The Appendix says: The size as described by the Appendix of 18-20 inches in diameter, 18 inches long, 3300-pounds, is correct.

Then look at this maximum size of the uranium ingots used in the atomic weapons program, which was used to estimate external exposure during processing. The dimensions of the two larger ingots are shown below:

Shape	Dimension
Rectangular	24L X 16W X 4H
Cylindrical	20L X 13 dia.

This information is from OTIB-0004 , Rev 03, P. 13 of 25, Bonfer 2003.
This report says: The maximum size of the uranium ingots used in the atomic weapons program was different than what Mallinckrodt had. The newly located Direct Dingot Patent agrees with the Appendix size, the "dingots" are larger than the ingots that the other AWE/DOE locations appear to have had. Photos from the Weldon Spring Site verify the larger size too (photo is in GSI Workbook).
So, using MCNP, and MicroSchield as referenced in this report (OTIB-0004, Rev 03, P. 13 of 25) would seem to require some adjustment, would it not?
The definition of Cylindrical indicates either being hollow or solid. So that there are no doubts, the Mallinckrodt Dingots were solid, 3300 pounds, 18-20 inches in diameter per the Direct Ingot Patent, and the GSI Appendix. A Google Search located the Patent: Direct Ingot Process. (Patent filed Aug 16, 1957)

However, we have also seen references to slices, slabs, dingots, and billets for which there does not appear accounting. (photos, newspaper articles, previous Mallinckrodt meetings and government documents from all of the Mallinckrodt research and actual meetings) actually discussed this information with some of the workers, at the MCW Meetings in Saint Louis (Adams Mark, The Chase Park, and Westin Hotels).

Here is an important question that nobody seems to be able to answer: "Government-owned Betatrons", who, or what agency actually paid for both of the Betatrons (2), and the Betatron Buildings at GSI? Keep in mind that the Old

Betatron and the building housing it, has always been in Granite City, Illinois. However, the New Betatron came from Eddystone, Pennsylvania when that plant closed, and those operations were moved to Granite City, Illinois in1963.
GSI was known as General Steel Castings Corporation when the two Betatrons and the first two Betatron buildings were installed. The date for Eddystone's installment was 1951 and the one in Granite City was built in 1952 per newspaper articles. Who wrote the check, whose funding? We know USACE "built" the buildings. We know the Army had GSI use them. (in support of Army contracts does not answer the question) Who owned them from their inception? Who exactly is "The Government"? The specific serial numbers have been provided to NIOSH. Since both Betatrons should be part of this Appendix, could NIOSH supply the workers this information since it could prove to be "claimant friendly"?

BB.2.2 Frequency of uranium X-rays

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

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.

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.

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)

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 actuallyused. Also the cost was to include maintenance down time and overhead as well as the cost of film.

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.

REPLY/COMMENT:

Where are the purchase orders for 1953-1958? Can NIOSH 100 % guarantee that they have all of the AEC/Mallinckrodt Purchase orders to GSI from 1953-1966? (We know that 1953-1958 Purchase Orders are missing.) What were those quantities? Just a guess??? These five years calculates at 38% of the contract period. How can this Appendix be reflecting good and accurate science with this much missing data?

What happened to the accounting for the additional memos like the ones referenced in the Cleanup documents? They show that there were add-ons to the totals. See the quoted example below:
Example: (from section 5 of the clean up information, with the PO's NIOSH referenced)

Mallinckrodt Chemical Works *Feb. 20 1958*
Uranium Division
Weldon Spring

TO: Mr. J.P. O'Haire
FROM: C.M. Brownfield
Subject: General Steel Castings Corporation Invoice M-216 (then circled Req M-1196-D)

We are submitting the attached invoice and requisition for payment "without a purchase order" because the requirement was completed prior to our receipt of the requisition.
Based on the cost of a previous contract this price is fair and equitable and should be paid as received.

C.M. Brownfield
Manager of Purchasing

There is no dollar amount referenced. How often did this take place? Were there other similar documents?

Considering the fact that quality uranium products were critical and could have no flaws, SINEW believes all of the material from Mallinckrodt had to be tested. NDT of uranium was not a haphazard, maybe, sometime, as needed, proposition. It had to be perfect 100% of the time. NDT was the only way to guarantee this. It required the power of the Betatron.

Can NOISH be 100% sure how much uranium metal went to GSI? Does NIOSH have proof that everything from Mallinckrodt didn't go to GSI for testing? How many ingots, dingots, slices, slabs, or billets did Mallinckrodt make during 1953-1958? What about 1958-1966? NIOSH is simply referencing a few documents from the cleanup. There should be much better records considering all of the past experience from Mallinckrodt. Where is it?

There is a special concern regarding 1953-1958 ingots, etc. They would have been from AEC/Mallinckrodt Destrehan Plant during that period. The Weldon Spring site was still being built, opening in 1958. What were the quantities, and what "type" of uranium metal were they sending to GSI for x-raying? Was pitchblende material being used? What about the uranium alloys that Mallinckrodt was testing and producing? The Appendix totally overlooked the fact that Mallinckrodt was dealing with the manufacturing of alloyed uranium products (*AEC RESEARCH AND DEVELOPMENT REPORT Oct. 15, 1953* (GSI contract period 1953-1966 per DOE*) Report number NYO-1358, by W.M. Leaders and Pilot Plant Personnel.*
This topic must be factored in when a Betatron is involved.

The Appendix also missed the *"STATUS OF ALLOYED DINGOT PROGRAM January 1963, Hanford Atomic Products Operation-Richland, Washington Author: E.A. Weakley, Product Engineering Oper. Production Fuels Section, Irradiation Processing Department. Document number # HW-73149.* Mallinckrodt is clearly mentioned:
"Dingot metal refers to the metal made by Mallinckrodt Chemical Works...."
"the aprox. 18 diameter x 18 high dingots..... St. Louis Destrehan Street Pilot Plant "

The GSI Appendix says:
"The ingots were in the form of cylinders 18 to 20 inches in diameter, approximately 18 inches

long, and weighing up to 3000 pounds". (We have also seen 3300 pounds, the 300 pound difference is significant.) All of the references agree on the dimensions. So do we. Perhaps the ingots in the Appendix were more correctly "dingots'. The measurements, weight etc. that everyone agrees with matches the dingot. All told, the size and weight is the most important factor.

The highly classified LAMS-2064 report helped us confirm beyond any doubt a procedural and scientific fact. That information is on page 13 of the redacted copies:

"The 22 MeV betatron represents the highest energy for radiography of uranium available among the installations contributing to this Symposium. With a radiographic half-value layer ranging from 0.3 to 0.4 inch, the 22Mev x-rays from the betatron make exposures practical on medium speed film for uranium sections up to 3 inches thick". NDT people from Los Alamos, Oak Ridge, and Rocky Flats among others were mentioned as contributors and participants. Mr. Dana Elliott of Los Alamos made the reference above. Jack Schuetz told us that Dana Elliott originally worked for Allis-Chalmers Company, the manufacturer of the A-C Betatrons at GSI and Los Alamos.

This thickness issue means an 18-inch diameter "dingot" would require not just one betatron shot or exposure, as the Appendix states, but 4 or 5!
A Betatron simply cannot go through 18 inches of Uranium metal.

What does a "large" piece of uranium mean as is stated in the Appendix? This too needs to be scientific and exact. Further, any mention of "pure" uranium metal is incorrect. Mallinckrodt's dingot was alloyed. A review if the Patent mentioned herein will confirm that fact. We also know this was constantly being improved, and changed.

Lastly, shooting uranium four or five times, creating activation of some already activated or fissioned material, needs to be accounted for and included in the science of this Appendix.

The formula used in this section is a "wild guess" by NIOSH. The only known factors are the cost of the film and the hourly cost of the labor and overhead. Each ingot took 4 or 5 pieces of film, measuring 14x17 inches (at 96 cents ea. per POs).

Special note: A statement in this section needs to be discussed. "For the remainder of the year, it is assumed that various alloys of steel were x-rayed". This is correct regarding the statement "various alloys of steel". However, it is a direct contradiction in this Appendix where alloys are ignored in the Activation Section by only identifying one isotope - 53Fe. There was no 100% 54Fe, pure iron at GSI per workers including a GSI Chemist / isotope specialist, and a GSI Metallurgist / Betatron manager. (met with them again this week to confirm this fact. He gave them both a copy of the GSI Appendix to review. They both laughed

at the one isotope reference. The comment was made: NIOSH needs to hire a good Metallurgist.)

GSI documents clearly mention 30+ alloys. (GSI Workbook). Examples: HY-80, HY-130, Army tank armor, nuclear power plant casting, and manganese steel, just to name a few. All of these are special alloys. The total components must be factored in. The formula for HY-80 is easily found on the Internet. (It is not just iron.) GSI workers discussed their work on Nuclear, Polaris submarine parts including missile launch tubes. The Polaris subs are mentioned re: HY-80, including the ill-fated Thresher. (The GSI workers clearly remember that sad day. Navy inspectors swarmed the GSI Plant.) This Appendix totally ignores this alloy information. It needs correction.

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.

REPLY/COMMENT

No comment.
Refer this to Dr.

ÍBB.4 Occupation External Dose

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

REPLY/COMMENT:

NIOSH is essentially admitting that they cannot do an accurate dose reconstruction regarding the exact uranium materials that went to GSI. These questions must be addressed:
From where does this proposed dose rate information come?
What are the dimensions, and weight of a rectangular uranium ingot?
Are rectangular uranium ingots all of the same size? What about the components?
What is the chemical make-up of these types of ingots vs. direct ingots?
Is there any proof that Mallinckrodt even manufactured rectangular ingots? This

Appendix should use the known and recognized cylindrical shape and size.

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.

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 thattakedown 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.

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.

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.

REPLY/COMMENT

Workers described having to x-ray an ingot "like the actual round ones" that were described in BB.2.1, not the rectangular ones NIOSH is proposing. Why the switch? "The ingots were in the form of cylinders 18 to 20 inches in diameter, approximately 18 inches long, and weighing up to 3000 pounds". This ingot, recognized as the approximate size and shape by the workers, required 4 or 5 Betatron shots, not just one. Each shot was a totally manual process since the Betatron had only one beam and could not penetrate deeply into the ingot. The ingots were x-rayed in quarters.

LAMS-2064, page 13 of the redacted/sanitized version confirms Betatron NDT testing on uranium ingots: "the 22 MeV x-rays from the betatron make exposures practical on medium speed film for uranium sections up to 3 inches thick", by Dana E. Elliott, Los Alamos Scientific Laboratory. Mr. Elliott was a former ALLIS-CHALMERS Co. employee per Mr. Jack Schuetz. Mr. Schuetz appears in the GSI Appendix reference page.

Please keep in mind no one can confirm the types of uranium materials that went to GSI. Per this Appendix: "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". What other forms? What were the exact chemistry, shape, size, and thickness?

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.

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.

REPLY/COMMENT:

For the record: One Betatron building, 100x100 is missing from this Appendix. This was the New Betatron that went into operation in 1963. (GSI Workbook). It was directly connected to the Main Plant. (See maps, photos in GSI Workbook). The only thing separating it from this most populated, highest activity area was a common industrial roll up door without heavy shielding. The way in and out of the Betatron building was through the main plant and the 10, 9, 8, buildings. Workers testified and photos clearly show a massive, wide-open area. All of this connected to the Main Foundry.

The two Betatrons and buildings double the problem regarding skyshine radiation. Close proximity of the New Betatron to a majority of workers also complicates any formulas for amounts of radiation exposure.

The walls of the Betatron buildings were not all 10 ft. thick. (We have recent photos). The exterior walls were filled with foundry sand. They consisted of approximately 1 foot of concrete, 8 feet of sand, and 1 foot of concrete. (like an Oreo cookie) Some walls inside the buildings, for instance, by the tracks and the entrance, were only 12-18 inches thick.

SINEW questions the accuracy of the 3-D process completely. "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 problems." Were drawings and descriptions of the Betatron buildings used to determine the dose rate at various points outside the building?

What were the exact measurements and factors used for this elaborate description of the Building described? The Cleanup Report information is also inaccurate and should not have been used in its present configuration in this Appendix. NIOSH's example of only mentioning 10ft. thick walls as the norm does not give reliable, scientific results.

Other factors to consider: the roofs were wood and tar on the Old Betatron Building, tin on the New Betatron. Roof ventilators helped remove heat, and we would assume these ventilators also removed radioactive materials (dust particles, etc.) as well. Other radioactive sources were also used in these 2 same buildings. These sources do not appear in this Appendix.

This needs review: "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". Question: Where was the highest modeled dose rate? What exact material was being examined by the operating Betatron? Was the material steel, uranium, or something else? How long was the exposure? Operators remember exposures of 1 hour, a few hours, and much longer. It is not clear if they were all discussing the same size and shape of uranium products.

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 becapable 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.

One very important point is often overlooked regarding a Betatron used at a Steel

Foundry. Fortunately I ( ) have been meeting with 15 retired Betatron Building employees. They explained that the material type and thickness determined the total amount of R required. If metal is thick, or dense, or both, they simply set the dial for the amount of R required.
The concluding point is that the GSI Betatrons stayed on "max MeV" per the workers. They simply ran as much R as required. They took whatever time was necessary, which was how they had to do it. The resultant problem then becomes more exposure time for employees.
The Betatrons at GSI, according to the workers, were capable of putting out the following:
Old Betatron 24MeV 100-120 R (That matched what Jack Schuetz told me.)
New Betatron 25Mev up to 250 MeV (Jack said he had one in his lab capable of this output.)
According to the workers at GSI, the New Betatron had additional capacitor banks.

In an interview with Jack Schuetz, 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.

Jack told that he was a service technician for Allis-Chalmers "forever". He was a very helpful man. He is not a physicist, author etc. The variable R is what he explained to me ( ) too.
The Betatron MeV was variable but everyone left them on max MeV. It was faster, and the donut tube guarantee was by the hour, so max power got you more for your money.
This statement: "the 100 R/min was the design maximum value, but that was only achievable in his laboratory when the compensator (or filter) removed", is not correct according to my ( ) discussion with Jack. Perhaps he got something mixed up. I have an Allis-Chalmers Operator Manual that states the normal R output is 100. I have an Allis-Chalmers Product Brochure that states the guaranteed R output is 100.
Jack did say that the Betatron with 250 MeV could only be done in his lab.
I also have a recent photo of the control panel of a 25MeV Betatron at 23 MeV producing over 100 R. with a compensator on.
I believe the lab part, was re: the 250 MeV reference.

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.

We would like to discuss this point further.

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 reactions. 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. 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.

What exactly does "in a large piece of steel" mean, what "exact type" and size of steel? There were 30+ alloys at GSI in 1956. That grew substantially as the company grew. Example: HY-80, manganese etc.
This is too general and very misleading

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.

This is too general and very misleading.

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.
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.

This is too general and very misleading.

In an interview with Jack Schuetz, 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.

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.

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 reactions. 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. 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.

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.

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.
Mr. Schuetz also reported that the Betatron itself is activated by the beam and produced a dose rate of 15 mR/hr that quickly decays to near zero within 15 minutes.6 Although Mr. Schuetz indicated this was caused by the platinum target becoming radioactive, no isotopes of platinum could be identified to explain this rapid decay. The more likely source of this radiation is the aluminum compensator. This compensator receives the full force of the x-ray beam at very close proximity. This beam can cause the creation of Aluminum-28 (28Al) which has a half-life of 2.25 minutes. This half-life would result in the dose rate decreasing from 15 mR/hr to 0.15 mR/hr in 15 minutes. It would also result in an integrated exposure over 30 minutes of 0.811 mR.

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.

REPLY/COMMENT:

This section of the Appendix requires experts.
Considering the fact that the 2 Betatrons at GSI were never even mentioned as radiation generating devices prior to SINEW pressing the issue, we will reserve judgment until we see your reply to our comments.

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

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.

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. Because of this, a large block 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.

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

REPLY/COMMENT:
This section needs to be discussed in much greater detail.
A review by SC&A and other experts would appear fitting.

BB.4.5 External Dose Summary

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

Year	R/yr 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.

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.

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.

REPLY/COMMENT:
It needs to be made totally clear that the Betatron Buildings were like "Grand Central Station". Numerous other workers had to come in and out of these buildings to perform their normal duties. As an example, but not limited to, these included: electricians, inspectors, maintenance workers, railroad workers, etc.

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. 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 thetotal 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.

REPLY/COMMENT:
This section will be re-addressed on it's own in a separate comment at a future date. It needs special attention, for example: Vincent Kuttemperoor, SC&A, etc.

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.

REPLY/COMMENT:
This section will be re-addressed on it's own in a separate comment at a future date. It has been very oversimplified.

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 wasoperating 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

REPLY/COMMENT:

The radioactive dust in the vents was found 30 years after the contract period ended. This raises major concerns about the possibility of:

Some residual uranium contamination may have been present that could become airborne and cause additional intakes.

They removed the ductwork and vents. What would be the consequence?

The primary radioactive uranium residue was shown to be in the "only" pathway in and out of the betatron main work areas.

BB.6 Residual Contamination

A survey was performed in the old Betatron building in March 19892. 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. Ingestionrate must also be included and will be based on this average air intake and OCAS-TIB-009.

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.

REPLY/COMMENT:

The quality of the DOE cleanup will always be in question. Coming into an industrial site about 30 years after the contract period ended and trying to recreate the past is impossible. What was really there when the workers were walking around? That is the real fact finding.

We visited the site and most likely saw what was seen during the cleanup. The grounds had been bulldozed. Some areas have been filled in. The grounds, according to aerial maps, do not resemble the working plant, as it existed. Example: almost all of the R.R. tracks are gone. The ground has been scraped; the pond is gone, filled in. This type of covering up of the actual terrain doesn't leave much contamination where it may have been previously.

This comment about the vacuum made all of the workers laugh.
Is it believed that the vacuum was only emptied "one time" during its existence? During the cleanup radioactive residue was found in it. The vacuum was used every shift to pick up the metal shavings, rotoblast steel bb's, and magnaflux dust etc. that was on the floor so they could walk without breaking a leg. We would imagine some of the uranium that fell on the floor went into it too.
There were no hepa filters at GSI. Fine dust went airborne as the vacuum canister captured the more bulky metal.
Not mentioned was the fact that the vent over the vacuum had uranium dust in it, and was removed during the cleanup and taken to an approved disposal center for radioactive materials. This measurement needs to be reevaluated. The bad dust was already gone! When the cleanup began the vacuum was probably empty.