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# DRAFT

**(Board got 10.31.08, McKeel 11/6/08)**
**Author? Agency? Date of report?**
**Note: all scientific reports should include such information**

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## WHITE PAPER FOR GSI APPENDIX BB REVIEW

For Discussion Purposes Only

**Background**

The NIOSH dose estimate for General Steel Industries (GSI) employees is described in Appendix BB to Battelle 6000, approved on June 25, 2007. This dose estimate was reviewed by SC&A and documented in a report dated March 17, 2008. The report was subsequently reviewed and made available on the OCAS website in April 2008. Neither report had the advantage of using film badge data later retrieved from Landauer Inc. This white paper describes the film badge data as well as analyzes the film badge results. It also identifies several inconsistencies in the SC&A report and the effect of correcting them. Lastly, the white paper will examine the effect of the film badge results on these corrected values.

(DAN MCKEEL comments in red) Why was collecting and reporting the Landauer film badge data delayed so long? I obtained part of these data, said to represent 30 GSI workers in 2006 and so informed both SC&A and NIOSH (possibly the Board as well) in 2006. Both agencies declined to obtain the Landauer data then.

NIOSH needs to document when it requested and when (date)) NIOSH obtained these film badge data and made it available to the Board and to SC&A. Why did NIOSH not inform the petitioners these data had been obtained so they could at least have obtained what NIOSH had through the FOIA process. Neither Dan McKeel nor Pat Coggins, the GSI petitioners, or advocate John Ramspott were so informed. Why not? NIOSH and SC&A should now make available to everyone concerned ALL the correspondence and contact notes it had with Landauer. My main contact was Chris Passmore.

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**Analysis of Film Badge Data**

Data

This section should begin with basic information physically characterizing the Landauer data as follows: From whom to whom, date requested and received, number of pages, format (hard copy, CD, electronic file with file name and size in MB), what were the request data, names of the two film badge project managers at GSI that were provided to Landauer and SINEW by Dan McKeel (fee charged for research and copying).

One of the Betatron operators cited in this white paper informed me that David Sundin of OCAS supplied the worker with his film badge data that consisted of 20 pages with other names redacted. The worker said that all 19 data pages were “completely unreadable.” The researcher at Landauer who I worked with apologized that many of the pages I

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would receive would also be unreadable despite valiant efforts on their part to provide the best available data. Her warning turned out to be accurate, the tabular text on some pages being a grey blur. NIOSH needs to disclose what percentage of the total data in terms of a readable/total number of GSI film badge data pages they received from Landauer were entirely decipherable.

NIOSH also needs to disclose how much Landauer charged them for the GSI badge data. Our bill was between $200-300.

What percentage *number/total" of the persons with badge data were (1) currently deceased, (b) had filed or had filed by their survivors an EEOICPA claim on the worker's behalf. How many claims and cases are we speaking about?

This white paper should note than NO (zero) neutron film badge measurements are recorded in any of the Landauer data as was the case in the data on 30 GSI workers that McKeel obtained in 2006.

The oldest data received from Landauer covers the week beginning January 1, 1964 (a Tuesday). The next oldest data covers the week beginning January 6, 1964 (a Sunday) followed by the week beginning January 13, 1964. The data continues to cover every week with the last week covered being the week beginning December 10, 1973.

The data provides the last name of the person to which the badge was assigned. It also provides the results of the badge processing. An "M" was recorded for readings that were less than the recording level of 10 mr. The current reading as well as the cumulative dose for the calendar quarter and year was included. The report also included a cumulative dose for the individuals' entire employment at the site.

How does NIOSH or would Landauer know or did determine that the badge data was for the entire employment period for these individuals? Did NIOSH verify this with their and DOL's employment data from the individual claims?

However, it is important to realize the beginning of this tabulation is the day that person started wearing a film badge, not the day the individual actually began employment. Lastly, the report indicates the number of times the person was monitored by film badge and the first week he was monitored. The early reports indicate 17 people were monitored beginning on November 6, 1963. However, the weekly reports prior to January 1, 1964 were not recovered.

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The question is, what specific attempts did NIOSH or SC&A make to obtain earlier film badge data from DOE/HASL or other badge vendors of that time period such as Picker C-ray that was active at the Dow Madison sister site?

A spot check of these values indicates several people were often missing from the report in late December and would show up again in January. The cumulative number of

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badges was not increased while the names were missing. This likely indicates vacation time was accounted for in this total.

A total of one hundred eight different names were recorded between 1964 and 1973. Landauer told McKeel they only had any GSI data for **30** GSI workers, a huge discrepancy with this statement. NIOSH needs to verify with GSI workers that all 108 names were actually GSI employees. A GSI Betatron operator cited in this report furnished McKeel a GSI seniority list from 1963-64 with 91 names, 61 of which were badged. Magnaflux operators who operated in buildings 8/9/10 were not badged. Again, the Board and work group need to check the NIOSH/OCAS and Landauer correspondence to investigate this huge discrepancy.

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Also, if 17 of the 108 were isotope people, then what were the job descriptions of the other 91 names of badged workers?

There were never that many names assigned a badge at any one time.

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What was the maximum number of names at any one time?

Through June 1966, a total of 6999 badge readings were recorded for how many individuals. Of these, 22 were recorded at or greater than the 10 mr recording level. For the full amount of data, from 1964 through 1973, a total of 16292 individual badge readings were recorded with a total of 49 recorded greater than 10 mr. Also, there were 114 badges recorded as "Betatron CTL" for the Betatron Control room. The last was the week of February 6, 1966. All 114 readings were less than 10 mr.

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In the annual summary film badge data McKeel/SINEW got from Landauer in 2006, there were 3 individuals with far higher cumulative doses than any others. The highest level was an isotope person among the top two people listed on the 1963-64 GSI seniority list. Why does NIOSH not cite these values and attempt to explain them as NOT BEING BOUNDING, WHICH WOULD BE THE MOST CLAIMANT FAVORABLE ASSUMPTION FROM THE LANDAUER INDIVIDUAL BADGE DOSIMETRY DATA?

Representativeness of Data

Individuals that clearly identified themselves as being associated with radiography (Radiographer, Radiographer Helper, Film Processor, etc) during worker outreach meetings (a total of five people) were checked against the film badge data. The names of all five appear in the records.

However, as alluded to earlier, there were far more than 5 Betatron operators between 1953 and 1966 (around 100, at least). DOL and NIOSH should have extensive job descriptions of the named Landauer individuals from their CATI interviews and other EEOICPA claims information databases.

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This reports fails to mention major classes of job classifications in the GSI industrial radiography department. Such workers included "Chem Lab" workers and the isotope certified subset who worked with three gamma sources not mentioned in this white paper that contributed to dose, Betatron operators, Magnaflux operators, layout people who planned shots, and film readers/processors who inspected the x-rays for MCW uranium to ensure the x-rays produced were technically satisfactory. Betatron operators also handled the larger Co-60 source that was used in the Betatron buildings with the Betatrons "locked out."

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Also, an article from a company publication named 11 people that had passed a 32-hour course in Health Physics. The article indicated the course was to "qualify them as radiographers in handling radioactive isotopes". All 11 names were checked against the dosimetry reports and all 11 appear in the records.

Does the author of this report recognize that "isotopes" refers to two GSI Cobalt-60 sources, and an iridium-192 gamma source? These should have been included in the dose and film badge data analysis since they were used during the AEC MCW uranium contract period at GSI. Why was this not done? In addition, St. Louis Testing conducted additional Co-60 gamma source studies of GSI castings, some on the outside near the Old Betatron Building. He attended and testified at the Oct. 9, 2007 SC&A-Anigstein meeting in Collinsville, IL.

Note: The 250 Kvp portable industrial x-ray device at GSI, contrary to the mandate of OCAs-IG-002 and the Act that all source term doses must be considered during dose reconstruction in the production period (1953-1966), omission of dose due to this source term in Appendix BB, the white paper, and NIOSH's SEC-00105 evaluation report is a serious misapplication of its own technical guidance that needs to be explained in detail.

McKeel and SINEW have maintained since 2005 that the three gamma sources and the 250 Kvp x-ray sources at GSI (1) have not and cannot be accurately characterized by either NIOSH or SC&A, and (2) on this basis alone an 83.14 SEC was the proper course for GSI. We still maintain the same position.

With all 17 people known to be associated with radiography included in the records,

This is a totally untrue and inaccurate statement. Only a subset of 11 of 17 "Chem Lab" radiographers was isotope trained. The number of 17 thus may include all Chem Lab/isotope" workers. It certainly does NOT include all GSI betatron operators from 1953 to 1973 by any means. NIOSH should be well of this fact three years into intensive study of this AWE site.

it appears that the all the employees directly associated with radiographers were assigned a film badge at GSI between 1964 and 1973.

Completely untrue and inaccurate statement as explained above.

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It also appears these radiographers were indeed the ones who performed the source radiography.

Not true or accurate, either. Many GSI Betatron operators were not isotope certified and never worked in the Chemistry Lab (a $1,000,000 facility pictured in John Ramspott's elegant GSI workbook and as described above. This can be easily verified with current Betatron operators. Many more than 5 Betatron operators and helpers testified at the three GSI worker meetings held in 2006 in addition to the 10/9/07 SC&A outreach meeting. Verbatim (names, job redacted) transcripts are available under GSI on the OCA website and (hopefully) on the O drive in unredacted form.

The betatron buildings were described as a very busy place. With only 108 names appearing over the entire time span, it appears equally clear that ancillary workers (those working to move or repair castings, maintenance personnel, etc.) that were not directly involved with the radiography were not issued film badges.

That is not entirely clear, either. NIOSH has not adequately categorized the jobs of those 108 individuals and, I suspect, cannot do so,

The question of how representative these readings are for years prior to 1964 must be asked. Only one betatron existed at the site prior to 1963. During 1963, a new betatron building was built and a betatron was moved from the Eddystone, PA site to the Granite City site. The "new betatron" as it was called was reportedly upgraded when it was moved to Granite City. Operators indicated that the new betatron had a higher output than the old betatron.

More importantly, a supervisor for the Betatrons described work prior to 1963 as much slower paced. He indicated prior to 1963 the radiography was essentially a quality control function that checked a sampling of castings.

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This is a misleading statement that unfairly and with little compelling data indicates that 1953 to 1964 Old Betatron work was trivial. This is not true! The proof is that AEC and MCW selected GSI to perform Betatron 24 Mev particle accelerator-based x-ray work to characterize the quality of its extremely valuable uranium metal products. The fact is that ten years+ of GSI film badge dosimetry data (1953-1963) has been lost, destroyed, at another badge vendor ant not found, or withheld. The extent of film badge data on hand at NIOSH appears to be more extensive (108 workers) than Landauer told McKeel and SINEW it possessed two years earlier in written communications (30 GSI workers). This discrepancy casts doubt on the validity of NIOSH assertions of this entire white paper.

In 1963 the role of radiography at GSI changed from "two people who worked there part time to, as these guys have said, seven days a week, 24 hours a day and we were 500 percent overscheduled". Another worker indicated that 1963 to 1966 was the peak production period.

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Dan McKeel wonders why NIOSH so readily accepts one GSI worker's testimony that supports its thesis on why 10+ years of missing badge data is unimportant, while it steadfastly refuses to accept the sworn testimony of 11 Dow workers who say that Dow Madison shipped to Rocky Flats large amounts of thorium alloy, of the same type DOE now accepts was used in nuclear weapons during 1957-58 at MCW. This policy appears to be very capricious and self-serving to this petitioner.

It appears after 1963 the radiography at GSI occurred much more often and included a higher output machine. This indicates the film badge readings starting in 1964 would not necessarily be representative of the pre-1963 dose but it should be higher and thus bounding.

This is pure speculation using fuzzy logic based on subjective limited information. Terms such as "much more" and "should be" unless quantified and objectified are uninformative, misleading and have no place in scientific communications. The petitioners CHALLENGE NIOSH's assertion the 64-66 questionable badge data are in fact bounding, given the very much higher doses several individuals have recorded (up to 30,000 mrem lifetime that Landauer might have occurred over a short time period, I can supply the person's name)

I must note that workers used their badges only in the Betatron buildings, probably while handling the Co-60 sources, one of which was used in a concrete roofless structure in Building 6, and took them off when working in the Chem Lab, for example. Only two GSI workers could produce AEC badge dosimetry reports, and all agree the badge data was not reported back to them as either positive or negative feedback concerning safety of the 24-25 Mev Betatrons, the 250 Kvp source, or the multiple gamma NDT sources used at GSI.

The badges were red Landauer types and the workers relate they were loaded with standard dental film packs that are "useless" according to our experts from Milwaukee School of Engineering (VK and RK). The badges did not measure neutrons. This white paper fails to address the accuracy of film badges for monitoring 24-25 Mev x-ray sources. Doing this is a necessity.

Analysis

From 1964 through the end of the contract period (June 1966) only 22 of the 6999 film badges processed resulted in a reading greater than 10 mr.

List the three individuals with cumulative doses in the 6,000, 7.000 and 30,000 mrem ranges. These data stood out in the Landauer badge data I obtained in 2006.

With 99.7% of the readings being below the recording level, statistical analysis is limited. The rank-file 95$^{th}$ percentile is obviously less than 10 mr. If a lognormal distribution is assumed, the distribution results in a geometric mean of $2.06x10^{-5}$ mr/badge reading. The geometric standard deviation of this distribution would be 100. This results in a 95$^{th}$ percentile of 0.04 mr/badge reading. While there is no standard value considered too

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high for a geometric standard deviation, a value of 100 is very high. If a normal distribution is assumed, the mean is 0.46 mr/badge reading with a standard deviation of 29.8 mr. This results in a 95th percentile of 49.4 mr. Since a normal distribution is symmetrical about the mean, this distribution implies 49.3% of the values of this distribution are less than zero. Obviously it is impossible for the true radiation dose to be less than zero. While a small percent of negative values may still represent a distribution that is an acceptable approximation of the true distribution, nearly half the values being negative is clearly not a good approximation.

Next, the average badge reading for each individual was determined. The individuals were monitored for different periods and lengths of time. Therefore, to normalize the values an average weekly reading was determined for each individual. That is, each person's recorded dose was divided by the total number of badges he was assigned. A distribution of these averages was then determined. Sixty-seven of the eighty-nine individuals (approximately 75%) had no dose recorded at or above the recording level of 10 mr. The average of these values was 0.371 mr with a standard deviation of 2.76 mr. Again, this results in a normal distribution with a large fraction of the values (44.6%) being less than zero. If a lognormal distribution is assumed, the geometric mean is 0.0065 mr with a geometric standard deviation of 16.7. The 95th percentile of this distribution would be 0.673 mr. With the high percentage of censored data and a GSD that is still relatively high, additional distributions were explored.

From the above description, it is clear that no analysis of this data is going to provide a distribution that clearly well represents the data.

In plain English, the Landauer GSI film badge data is not representative because it is very incomplete and inaccurate and is based on a flawed radiation safety program. The workers say they mistrusted the badge data, for good reasons that are partly evident in this analysis. These data cannot be used to reconstruct GSI doses with sufficient accuracy, and actually support my and SINEW's position that an 83.14 SEC should be issued knowing now that the scanty real dosimetry data for this site is very incomplete and flawed.

This is due to the high percentage of censored data. As an alternate approach, the recording level (10 mr) was substituted for each reading recorded below the recording level. As with the last analysis, a weekly average reading for each individual was then determined using these substituted values. A distribution of these values has an average of 10.35 mr with a standard deviation of 2.75 mr. That produces a 95th percentile of 14.87 mr. If a lognormal distribution is assumed, the geometric mean is 10.2 mr with a geometric standard deviation of 1.15 for a 95th percentile of 12.78 mr.

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The parameters of both of these distributions are more reasonable than the previously-reported distributions. The normal distribution does not imply a large fraction of the readings have a negative value. The GSD of the lognormal is not exceedingly high and the median and 95th percentiles of both distributions are relatively similar. The substitution is obviously a bounding substitution (replacing those recorded as less than 10

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mr with 10 mr). It is equally obvious that with 99.7% of the values replaced with this substitution that the result is a bounding estimate of the recorded dose. However, in order to insure the doses actually recorded are accounted for, the 95th percentile is used. This is essentially the upper bound of a bounding distribution. Therefore, the 14.87 mr per reading (per week) is used for the rest of this white paper.

This whole analysis should be submitted to an expert in statistical analysis. Our position is these calculations, with all the negative values are invalid because the primary data is incomplete and inaccurate. The film used cannot accurately monitor very high energy x-rays, photons and electrons, so statistical analysis of the resulting data is futile and provides very misleading results that should not be used in GSI dose reconstructions.

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**Inconsistencies in SC&A review of Appendix BB**

**This entire section is misleading and superficial. What NIOSH needs to do is to respond point by point to SC&A's review of Appendix BB and each of the 13 findings that conclude NIOSH ignored several source terms and neutron doses, and seriously underestimated external doses. The work group and SC&A should review the unredacted versions of the McKeel and Ramspott critiques of Appendix BB and resolve those finds as well, since the McKeel critique now represents the view of a co-petitioner of SEC-00105.**

Betatron Operator Exposure to Apparatus
In the SC&A review of Appendix BB, photon dose from the betatron apparatus was based on two different scenarios. For the "short shot" scenario, the casting was assumed to be 9 feet from the betatron target and the betatron operators' distance from the apparatus was assumed to vary uniformly between 3 feet and 6 feet. The operator is therefore assumed to be at a distance of 3 feet to 6 feet from the casting. However, the photon dose from the casting was based on the assumption that the operator was 1 foot from the casting half of the time and 1 meter (approx. 3.3 feet) from the casting the other half. Combining these two scenarios effectively puts the operator in two places at one time.

Using the same technique described in the review, the dose from the apparatus can be recalculated to be consistent with the other scenarios. That is, the operator is assumed to be 1 foot from the casting half of the time (5 feet from the apparatus for long shots, 8 feet for short shots). The other half of the time, the operator is assumed to be 1 meter from the casting (approximately 2.7 feet from the apparatus for long shots, 5.7 feet for short shots)

The formula on page 19 of the SC&A report were used to calculate dose based on a uniform varying distance. However, since the exposure scenario elsewhere in the report indicates a dose rate from two set distances was used, this formula is not necessary. The inverse square law was used to determine the initial exposure rate at the various distances. These were based on the exposure rate of 15 mr/hr at 6 feet. The initial exposure rates are then 73 mr/hr at 2.7 feet, 16.5 mr/hr at 5.7 feet, 21.6 mr/hr at 5 feet, 15 mr/hr at 6 feet and 8.44 mr/hr at 8 feet.

The formula on page 20 was used to determine the dose over the exposure period taking into account the decay rate. This formula assumes an operator is exposed from the moment the Betatron is turned off to the end of the assumed period of time (11 minutes for the short shot scenario, 15 minutes for the long shot scenario). However, when the dose from the uranium metal and steel after the shot was calculated in the report, it was assumed that the operators were not exposed for the first 5 seconds after the shot. This was described as the minimum amount of time it would take to exit the control room and reach the vicinity of the metal object. In order to allow this same assumption for the apparatus dose calculation, the formula on page 20 is adjusted to:

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$$X(t) = \frac{R_0}{60}\int_{t1}^{t2} e^{-\lambda t}\,dt = \frac{R_0(e^{-\lambda t_1} - e^{-\lambda t_2})}{60\lambda}$$

In this equation, t1 is the time from the end of the x-ray exposure until the operators reach the betatron (5 seconds). Also, t2 is the time from the end of the x-ray exposure until the operators leave the betatron area (11 minutes for the short shot scenario and 15 minutes for the long shot scenario).

In order to minimize rounding errors, the dose rates in the SC&A document were first recreated. Next, the exposure was calculated as described above and the exposure for the two appropriate distances were averaged. This average was multiplied by the number of "shots" described in Table 16 to arrive at the exposure per shift.

Railroad Shot Exposure Scenario

Dose rates outside the new and old betatron building were modeled based on two scenarios. One was a "center shot" in which the betatron was in the approximate center of the shooting area while an x-ray exposure was occurring. The other was a "railroad shot" in which a casting is assumed to be exposed while sitting on a railroad car straight in from the equipment door. The betatron has limit switches that prevent a shot from occurring in this position but operators indicated they were ordered to defeat these limit switches by "flipping the head" of the betatron and perform shots in this position.

The author does not understand what was done. Allis-Chalmers that manufactured both GSI Betatrons recommended railroad track (RR) shots. This was done routinely in the 1953-1963 (see below).

Flipping the head was a disapproved, known to be dangerous and unsafe maneuver that took the Betatron beam out of the approved exposure zone and subjected the control room to extra exposure. Noteworthy is that SC&A's MCNP modeling showed highest exposures in the Betatron control rooms that were designed to protect operators. Footnote: Our GSI Old Betatron building site visit photos from September 2006 clearly show a port through the control room wall for the chain that opened the large Co-60 "pig" to expose the inner Co-60 "pill."

The operators went on to indicate that this was not done until the supervisor present in the early 1960s left the company and was replaced by another. This supervisor left the company on 6/30/1966 which is the last day of the uranium work. This information indicates the railroad shots occurred after the covered period.

No, this is an incorrect interpretation. RR Betatron shots were done THROUGHOUT the production period, confirmed 11/8/08 with one of the knowledgeable GSI Betatron operators cited in this white paper report.

The analysis performed by SC&A summarized photon dose rates based on the railroad shot scenario. However, some dose rate information for the center shot was included in the report.

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Table 2 shows that the exposure rate in the control room of the new betatron building is calculated to be 1.9 mr/hr for the railroad shot and 0.3 mr/hr for the center shot. Likewise the neutron dose is calculated to be 0.6 mrem/hr for the railroad shot and 0.3 mrem/hr for the center shot. Table 3 provides two exposure rates for the control room of the old betatron building. These two values were averaged when calculating values for Table 16. The average of the railroad shot photon exposure rate was 1.05 mr/hr. The SC&A report provided no values for a center shot, however, values for the center shot can be calculated similar to those calculated for the new betatron building. This was done using MCNP to find control room values for both neutron and photon doses. The same two points in the control room were used. Only the location and orientation of the betatron and the steel were changed.

No actual (real) neutron doses were available at GSI to validate the neutron exposures so we challenge the use of purely virtual MCNP modeled neutron and gamma doses at GSI.

250 R/min Exposure Rate from Old Betatron Machine
SC&A used a betatron output of 250 R/min from both the new and old betatron machines. This was based on a letter from a former Allis Chalmers employee. It was also noted that this was consistent with a GSI employee recollection of 160 R/min once a 35% reduction for the beam compensated was factored in. However, the seven tube outputs listed by the Allis Chalmers employee represent shipping dates between 12/29/1969 and 5/31/1973. In the paragraph immediately preceding this table, the employee wrote:

> *Tubes manufactured in the early 1950s produced outputs between 125-150 R/M, the 1960s between 200-275 R/M and by the late 1970s, between 300-375 R/M @ 25 Mv.*

Both Betatrons were built in the early 1950s but the new betatron was originally in Eddystone, PA. That betatron was moved to GSI in 1963 and reportedly underwent an upgrade at that time. The statement above from the Allis Chalmers employee indicates the early 1950s model would have an output between 125 and 150 R/min. This is also consistent with GSI employee recollections. During an August 21, 2006 meeting, an operator indicated the output of the new betatron was between 200 and 250 R/min but the old betatron "couldn't do that good". He indicated the old betatron had an output of "probably 100, 110 at maximum". The SC&A report relied on the recollection of a GSI employee that he recalled 160 R/min on the new betatron. The same employee in a meeting held on October 9, 2007 indicated that a 10,000 R shot would have taken 1 hour and 15 minutes (133 R/min) but that the old betatron would have taken longer because it did not have a capacitor bank.

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The compensator used to flatten the photon flux causes a reduction of about 1/3 of the beam intensity (35% per the SC&A report). The Allis Chalmers employee was referring to the uncompensated output of the betatron. If the maximum 1950s output is assumed (150 R/min) the compensated beam would have an output of approximately 100 R/min.

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This is consistent with the GSI employee recollection. Either way, both GSI employees clearly remember the output of the old betatron being lower than the output of the new betatron. Therefore, the rest of this white paper will consider the uncompensated output of the new betatron to be 250 R/min and the uncompensated output of the old betatron to be 150 R/min.

The Betatron output varied short-term due to heating and degradation of the capacitors. Fluctuations in beam output intensity were not routinely recorded at any time. There was apparently a meter that gauged and recorded power input variations to the machines.

Inconsistent Assumption between Photon and Beta dose

A summary of the annual doses is presented in the SC&A report. Section 2.6.1 describes the photon and neutron doses while Table 21 in section 2.6.2 describes the beta doses. In order to estimate the beta dose, an estimate of the amount of uranium work was performed and a mixture of uranium and steel work was used. However, in order to estimate the photon and neutron doses, no uranium work was assumed. This leads to the inconsistent assumption that employees were working both with and without uranium at the same time. The remainder of this white paper will use the estimated uranium versus steel work time used in the beta dose calculation.

The effect of adjusting for these inconsistencies is shown in the next two tables. The first table is a recreation of Table 16 from the SC&A report. The second table is the same table with the values adjusted as described above. The values in the first table were recreated as best as possible from the SC&A report as well as MCNP output files provided by SC&A. The recreation produced some differences between this table and Table 16 in the SC&A report due primarily to different rounding errors. One value, the photon exposure from uranium metal in the new betatron building, was incorrectly reported in the original SC&A report as 0.66 mr/shift and later corrected to 6.8 mr/shift. However, the recreation below resulted in a value of 6.56 mr/shift. This represents the largest difference in attempting to recreate this table. The 6.56 mr/shift was recreated starting with values from tables 8 and 9 from the SC&A report. While round-off error may explain some of the difference, it cannot explain it all.

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Unexplained errors mean more uncertainty in the bounding dose calculations. How was this handled?

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Recreation of Table 16 from SC&A review of Appendix BB

| Metal | Type of shot | Number per shift | Fraction | Source of radiation | Duration (h/shift) | Exposure (mR/shift) | Neutron dose (mrem/shift) |
|---|---|---|---|---|---|---|---|
| 25 MeV | | | | | | | |
| HY-80 | Short | 32 | 64% | Control room | 1.6 | 3.11 | 0.92 |
| | | | | Metal | 5.87 | 0.35 | |
| | | | | Doughnut | 5.87 | 34.56 | |
| | | | | Total | | 38.02 | 0.92 |
| | Long | 6 | 36% | Control room | 6.0 | 11.66 | 3.44 |
| | | | | Metal | 1.5 | 0.66 | |
| | | | | Doughnut | 1.5 | 13.03 | |
| | | | | Total | | 25.35 | 3.44 |
| | Composite | | 100% | | | 33.46 | 1.82 |
| Uranium | Long | 6 | | Control room | 6.0 | 11.66 | 3.44 |
| | | | | Metal | 1.5 | 6.56 | 0.67 |
| | | | | Doughnut | 1.5 | 13.03 | |
| | | | | Total | | 31.25 | 4.11 |
| 24 MeV | | | | | | | |
| HY-80 | Short | 32 | 64% | Control room | 1.6 | 1.68 | 0.59 |
| | | | | Metal | 5.87 | 0.35 | |
| | | | | Doughnut | 5.87 | 34.56 | |
| | | | | Total | | 36.58 | 0.59 |
| | Long | 6 | 36% | Control room | 6.0 | 6.29 | 2.20 |
| | | | | Metal | 1.5 | 0.66 | |
| | | | | Doughnut | 1.5 | 13.03 | |
| | | | | Total | | 19.97 | 2.20 |
| | Composite | | 100% | | | 30.60 | 1.17 |
| Uranium | Long | 6 | | Control room | 6.0 | 6.29 | 2.20 |
| | | | | Metal | 1.5 | 6.56 | 0.67 |
| | | | | Doughnut | 1.5 | 13.03 | |
| | | | | Total | | 25.88 | 2.87 |

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Adjusted Table 16 from SC&A review of Appendix BB

| Metal | Type of shot | Number per shift | Fraction | Source of radiation | Duration (h/shift) | Exposure (mR/shift) | Neutron dose (mrem/shift) |
|---|---|---|---|---|---|---|---|
| 25 MeV | | | | | | | |
| HY-80 | Short | 32 | 64% | Control room | 1.6 | 0.50 | 0.52 |
| | | | | Metal | 5.87 | 0.35 | |
| | | | | Doughnut | 5.87 | 14.37 | |
| | | | | Total | | 15.21 | 0.52 |
| | Long | 6 | 36% | Control room | 6.0 | 1.86 | 1.96 |
| | | | | Metal | 1.5 | 0.66 | |
| | | | | Doughnut | 1.5 | 10.28 | |
| | | | | Total | | 12.79 | 1.96 |
| | Composite | | 100% | | | 14.34 | 1.04 |
| Uranium | Long | 6 | | Control room | 6.0 | 1.86 | 1.96 |
| | | | | Metal | 1.5 | 6.56 | 0.67 |
| | | | | Doughnut | 1.5 | 10.28 | |
| | | | | Total | | 18.70 | 2.63 |
| 24 MeV | | | | | | | |
| HY-80 | Short | 32 | 64% | Control room | 1.6 | 0.07 | 0.22 |
| | | | | Metal | 5.87 | 0.21 | |
| | | | | Doughnut | 5.87 | 8.62 | |
| | | | | Total | | 8.90 | 0.22 |
| | Long | 6 | 36% | Control room | 6.0 | 0.27 | 0.84 |
| | | | | Metal | 1.5 | 0.39 | |
| | | | | Doughnut | 1.5 | 6.17 | |
| | | | | Total | | 6.83 | 0.84 |
| | Composite | | 100% | | | 8.16 | 0.45 |
| Uranium | Long | 6 | | Control room | 6.0 | 0.27 | 0.84 |
| | | | | Metal | 1.5 | 4.08 | 0.40 |
| | | | | Doughnut | 1.5 | 6.17 | |
| | | | | Total | | 10.52 | 1.24 |

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**Application of Film Badge Data**
With an analysis of the film badge data and the adjustments to the SC&A model in place, it is possible to put the information together. A briefing of the model was previously given to a working group of the Advisory Board by SC&A. An overview of the dose was provided in a table format during that briefing.

Dan McKeel has never seen this table nor was he informed of its existence. What meeting (work group, which one? Or full Board meeting number and date and transcript Reference) on what date was this Table reviewed, please?

The table is a recreated below.

Estimated Annual External Exposures of Betatron Operators

| Years | External exposure (R/y) | | Neutron dose (mrem/y) | Skin dose (rads/y) | | | |
|---|---|---|---|---|---|---|---|
| | | | | Hand & forearms | | Other skin | |
| | SC&A | NIOSH | SC&A[a] | SC&A | NIOSH | SC&A | NIOSH |
| 1952-1957[b] | 12.4 | 5.8 | 470 | 27.2 | 19.4 | 2.5 | 1.8 |
| 1958 | 12.4 | 5.8 | 470 | 25.9 | 19.4 | 2.4 | 1.8 |
| 1959-1960 | 12.4 | 5.8 | 470 | 24.7 | 19.4 | 2.4 | 1.8 |
| 1961 | 12.4 | 6.3 | 470 | 28.1 | 22.3 | 2.6 | 2.0 |
| 1962 | 12.4 | 5.1 | 470 | 20.9 | 16.2 | 2.2 | 1.65 |
| 1963 | 12.4 | 2.8 | 470 | 7.0 | 4.4 | 1.4 | 0.4 |
| 1964 | 13.6 | 2.2 | 735 | 3.8 | 1.6 | 1.2 | 0.15 |
| 1965 | 13.6 | 2.1 | 735 | 3.3 | 1.2 | 1.2 | 0.11 |
| 1966[c] | 6.8 | 1.0 | 368 | 1.4 | 0.37 | 0.6 | 0.034 |

[a] Neutron doses not assessed by NIOSH
[b] NIOSH assumed covered period began 1953
[c] Total during covered period: January 1 – June 30

There is a huge difference between SC&A and NIOSH external exposure that again casts serious doubt on NIOSH's ability to perform DR at DSI with sufficient accuracy. Supports my and SINEW's repeated 83.14 SEC requests for the GSI site.

The photon dose of 14.87 mr/week from the film badge data can be multiplied by a 50 week work year resulting in an annual exposure of 743.6 mr/yr. The values in the table above were recreated and then adjusted for the inconsistencies described earlier. After that, a value of 743.6 mr/yr was substituted for the photon exposure and the neutron and skin dose was adjusted proportionately. The resulting dose is shown in the table below.

Adjusted Annual External Exposures of Betatron Operators

| Years | External exposure (R/y) | Neutron dose (mrem/y) | Skin dose (rads/y) | |
|---|---|---|---|---|
| | | | Hand & forearms | Other skin |

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| | | | | |
|---|---|---|---|---|
| 1952-1957 | 0.7436 | 41 | 6.733 | 0.536 |
| 1958 | 0.7436 | 41 | 6.369 | 0.514 |
| 1959-1960 | 0.7436 | 41 | 6.009 | 0.493 |
| 1961 | 0.7436 | 41 | 0.550 | 6.978 |
| 1962 | 0.7436 | 41 | 0.431 | 4.959 |
| 1963 | 0.7436 | 41 | 0.224 | 1.450 |
| 1964 | 0.7436 | 41 | 0.160 | 0.485 |
| 1965 | 0.7436 | 54 | 0.156 | 0.418 |
| 1966 | 0.3718 | 54 | 0.076 | 0.175 |

A summary comment on the overall effect of the film badge data would be helpful. It appears these calculations result in a severe attenuation of assigned doses. This usage of the spotty non-representative Landauer film badge data should not be allowed and the co-petitioners strongly object if we understand the above Table correctly. To be more explicit, for the reasons cited and others that we can put forward as the SEC and Appendix BB progresses, the use of the fragmentary and still to be validated and authenticated GSI film badge data should be prohibited.

**NIOSH's external dose underestimation is highlighted in SC&A's review of Appendix BB. This paper and this last table suggests, rather, for example in 1958, that NIOSH now believes it's own data in Appendix BB overestimates doses by 8-fold and that SC&A overestimated doses by up to 17-fold. Since all the dosimetry calculations up until the badge dosimetry data suddenly appeared were much higher, the implication of these new Betatron exposure numbers in the last table on page 7 is quite significant. The new numbers also mean that Attila and MCNP-based external dose models are off by a factor of 8 to 17-fold from real data and this conclusion is inconsistent with many studies that compare data from these programs with real measured exposure data.**

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SC&A NIOSH 12.4 R/yr, SC&A 5.8 R/yr, NIOSH factoring badge data .74 R/yr. a 16.7:7.8:1 ratio.

NIOSH appears to be bolstering its recommendation to deny the GSI SEC-00105 and to markedly lower the assigned external dose to Betatron operators, further controvert SC&A's findings. We strongly recommend the Board reject this new finding.

Respectfully submitted 11/9/2008,

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