Dragon, Karen E. (CDC/NIOSH/EID)

From: DanMcKeel
Sent: Friday, August 30, 2013 8:44 AM
To: pl.ziemer@comcast.net; Ziemer, Paul (CDC/NIOSH/OD); Katz, Ted (CDC/NIOSH/OD); NIOSH Docket Office (CDC); wimunn@aol.com; josiebeach@ j-poston@tamu.edu
Cc: danmckeel2@aol.com;
Subject: McKeel critique of Allen DCAS August 2013 white paper
Attachments: McKeel_AllenGSIdose_8.30.13.pdf

Paul Ziemer, Chair, and the TBD-6000 work group
Members of the full Board
Ted Katz, ABRWH DFO
NIOSH Docket 140 officer

August 30, 2013

Attachment <McKeel_AllenGSIdose_8.30.13.pdf> 3.4MB

Dear Dr. Ziemer, members of the full Board, Ted Katz and the NIOSH Docket 140 office,

I am hereby submitting a critical review of Dave Allen and DCAS' latest white paper dated August 2013, titled "Summary of Dose Estimates for GSI." I suggested this paper be created at the 6/20/13 TBD-6000 WG meeting.

Ted Katz, please distribute this paper to the entire ABRWH and TBD-6000 WG members as appropriate. Thank you.

NIOSH Docket 140 (GSI) office, please consider this as submission to GSI Docket 140 and listing as a Discussion paper under the next scheduled TBD-6000 work group meeting (probably September 2013). The title should be: Daniel W. McKeel, Jr., M.D., "Critique of Dave Allen DCAS August 2013 white paper 'Summary Dose Estimates for GSI.' " Thank you for your consideration.

I would like to reiterate my request when I submitted my white paper on NYO-4699 that SC&A be tasked to review it. I now add a request that SC&A also review the present paper which finds numerous factual errors and omissions in the Allen August 2013 white paper. I appreciate your consideration of this further request.

The Allen paper will serve as the basis for Appendix BB, revision 1. I find this paper is flawed as was the original Rev 0 of Appendix BB (June 2007) that omitted neutron dose, for example, yet nevertheless has been used for all GSI completed DR to date except 4 DRs that are the subject of PER-24. I urge the Board to allow SC&A to please review my input before Appendix BB Rev 1 is finalized.

Sincerely,

-- *Dan McKeel* 8/30/13 Friday

Daniel W. McKeel, Jr., MD
Cofounder SINEW
GSI SEC-00105 co-petitioner

Daniel W. McKeel, Jr., M.D. White Paper: "Critique of David Allen DCAS August 2013 GSI white paper "Summary Dose Estimates for GSI"

-- 8/30/13 --

Allen Page 1 of 6

Background

During the meeting of the TBD-6000 Work Group, held June 20, 2013, the Work Group requested that NIOSH revise its internal dose estimate for General Steel Industries (GSI), as well as provide a summary of the dose estimates to be used in revising Appendix BB as they now stand. This white paper is intended to address both requests.

Uranium Intake Estimate

Following discussions during the Work Group meeting on June 20, 2013, it was decided that the uranium intake estimate for GSI would assume that airborne activity at the 95th percentile concentration was inhaled for a time equal to the full uranium working time. Previously, the NIOSH estimate assumed exposure only for the 20% of the time the betatron operators were in the shooting area, since that is where the uranium was handled. Questions arose about the exposure incurred by other workers who transported the uranium metal to the betatron building. This question is explored here.

Based on worker input [McKeel 1], x-ray shots of uranium took 60 minutes [McKeel 2] each with 15 minutes between them. Furthermore, it was reported that 4 shots were taken on each piece of uranium. This implies the uranium was being moved only about 5% of the time the uranium was in the building (15 minutes out of 300 minutes). [McKeel 3] Since the uranium had to be positioned in the betatron building and not just moved, it may be reasonable to think that the manipulation of the uranium in the betatron building took more time than moving the same uranium to and from the building. That would imply the time involved in moving uranium around the site would be less than 5% of the time it was in the betatron building. [McKeel 4].

[1] Allen needs to cite specific transcript pages: what worker is being quoted?

[2] recently testified to Dan McKeel and that each uranium shot, after being set up, required only 40 minutes. His complete recent testimony is ATTACHMENT A. His testimony complements that of and

[3] That MCW uranium was in the Betatron building only 300 minutes is pure 100% speculation, made up. Not true, not verified by any worker testimony.

[4] The GSI uranium transport path by rail was very long and not thoroughly established as to actual length in yards or in transit time in minutes. Again 5% is pure conjecture, scientifically indefensible, certainly too short a time allocated.

• Summary: these 'facts" are either inaccurate or fabricated; all are scientifically indefensible.

However, there are several possibilities that could change that assumption. First, it is possible the handling inside the betatron building was more efficient than outside even if inside involved proper placement and not just movement. [McKeel 5] Second, it is possible the uranium was moved from conveyance to conveyance within the site (fork truck, rail car, crane, etc.) thus representing multiple

episodes of handling rather than one each direction. [McKeel 6] It should however be noted that it is unlikely this occurred in

Allen Page 2 of 6

one area. More likely, the uranium would be moved some distance with each conveyance before being transferred to another conveyance and airborne activity would thus not accumulate in a single area. [McKeel 7] Lastly, it possible that while the uranium is being moved on a conveyance, additional airborne activity could be produced by vibrations. Again however, this would not occur in a single area but rather all along the path. [McKeel 8]

[5] Pure speculation: why would uranium handling in Betatron facility be more efficient? Such speculation must be justified. This is not intuitively true. Speculation is not good science.

[6] It is 100% certain that multiple episodes of handling uranium occurred: unload from truck or RR car, carry with forklift to scale, weigh, reload on RR car with crane, etc.

[7] MCW uranium was transported over the same path multiple times fat GSI or 13 years, allowing for contamination to build up successively all along the transport path. Fallacious reasoning is used here by Allen.

[8] Same argument as [8], successive trips generate buildup all along the transport path.

With these uncertainties in mind, it was agreed during the June 20th 2013 working group meeting that assuming airborne activity was created during 100% of the uranium working time would be a bounding estimate. [McKeel 9] With this assumption in place, it becomes the bounding source of internal exposure for everyone on site. [McKeel 10] Resuspension from contamination was accounted for separately and assumed to be present year round regardless of whether uranium was being worked with or not. [McKeel 11]

[9] The 6/20/13 TBD-6000 WG transcript is 202 pages long. Mr. Allen needs to cite the specific pages where this agreement was reached at the stated meeting for, as he puts it, this overarching "assumption" about GSI intakes. And what period of time 1952 through 1993 (the correct end point of the GSI residual period as being 12/31/1992 is being challenged) did this bounding intake of uranium occur?

[10] Extrapolating a bounding dose for uranium intake based on Betatron radiographers and transport workers for "everyone in the plant" dose not meet the "sufficient accuracy" test for dose reconstructions that are addressed by Appendix BB. Also, the SEC Issues work group is currently assisting NIOSH in providing a sound definition of sufficient accuracy *for the first time*. The author believes this fact is deplorable for NIOSH and the Board to wait 12 years into the EEOICPA program to address this central issue. And as an outside observer, the SEC Issues WG and NIOSH have barely constructed an outline of a definition after meeting twice about the subject of sufficient accuracy.

[11] What does the phrase *"resuspension from contamination was accounted for separately and assumed to be present year round..."* mean? Mr. Allen, again, needs to

provide a page citation. Of course uranium contamination was present year round. Uranium "dust" doesn't all evaporate and U-238 has a radioactive half life of 4.85 million years!

A NIOSH white paper dated April 2013 included an estimate of intakes at GSI. [McKeel 12] The same estimate is reproduced here but the inhalation intakes from handling uranium metal were increased by a factor of 5. [McKeel 13] The increase is due to assuming intakes occurred for 100% of the uranium working time rather than 20%. The revised estimate is provided in Table 1 below. The inhalation intake from resuspended material and from ingestion remains the same. [McKeel 14].

[12] What specific pages of the 6/20/13 TBD-6000 WG transcript discussed GSI intakes? Mr. Allen needs to provide more specific citations to buttress his statements.

[13] Ingestion dose (last column at far right of Table 1): what method was used and where is this cited? Also, ingestion is a fraction of intake inhalation, which varies, so how is it that ingestion (dpm/day) remains constant to 2 decimal places over 14 years? Such a supposition lacks face validity and is not scientifically plausible or defensible.

[14] The first row of data in Table 1 starts 10/1/1952. The TBD-6000 WG did not on 6/20/13, and has not ever, discussed, proposed or agreed upon either external or internal intake or ingestion doses for the 1952 4th quarter extended covered period at GSI. Zero *monitoring data or source amount data* on this 1952 GSI operational period is available except for two brief operational monthly reports plus FUSRAP report IL.28-5 that Dan McKeel provided to the Board and WG including NIOSH for November-1952, and an AEC October 1952 report NIOSH provided to DOL, but has never released to the TBD-6000 WG or to McKeel or in a white paper. 1952 uranium 1952 R&D operations took place at the Old Betatron facility at GSI and involved MCW-AEC research and development on uranium billets to improve radiographic image quality. A lead shield manufactured at MCW and used at GSI was employed for the R&D NDT work on AEC/MCW billet sections.

The effect of a lead shield on 1952 external Betatron doses has not been determined by NIOSH. *This is brand new data never before presented to the Board/WG.*

[15] Column 4 of Table 1 ignores the Adley 1952 data on rail road car unloading of uranium at the Hanford Melt plant that McKeel believes is highly pertinent at GSI. McKeel stated his findings in an Adley review white paper submitted to the TBD-6000 WG and full Board on 6/7/13. The WG, Board and NIOSH have thus far ignored this McKeel paper except to briefly acknowledge the MCW uranium might have arrived by rail at GSI. The former GSI worker testimony in ATTACHMENT A clearly shows that some MCW uranium ingots arrived at the Old Betatron building in trucks on palettes in groups of 12 or so ingots. Other uranium ingots were apparently shipped to GSI from MCW (Destrehan Street and Weldon Spring Uranium Division) plants by rail. The Adley paper indicates that far higher Ur-238 inhalation intake doses should have been assigned to GSI workers who unloaded the MCW uranium from rail road cars. Dave Allen has ignored this discussion by the TBD-6000 work group and has used far less claimant favorable dose estimates in the current paper. Mr. Allen and NIOSH need to explicitly justify why the intake data they use is more applicable to GSI compared to the more claimant favorable Adley 1952 intake data. Or, they need to state clearly why Adley 1952 is not more compelling surrogate data to use at GSI.

Table 1 – Intake Estimate

Start Date	End Date	Uranium work (hr/yr)	Inhalation from handling (dpm/day)	Inhalation from resuspension (dpm/day)	Total inhalation (dpm/day)	Ingestion (dpm/day)
10/1/1952	6/30/1961	337.5	76.99	14.41	91.40	15.45
7/1/1961	6/30/1962	437.5	99.80	14.41	114.22	15.45
7/1/1962	6/30/1963	125	28.52	14.41	42.93	15.45
7/1/1963	6/30/1965	28	6.39	14.41	20.80	15.45
7/1/1965	6/30/1966	13	2.97	14.41	17.38	15.45

Page 3 of 6

After 6/30/1966				1.44	1.44	15.45

Note: the values after 6/30/1966 are reduced using depletion factor from ORUAT-OTIB-0070.

[16] Regarding the footnote to Table 1, page 3: [McKeel 16] The use of TIB-70 as being appropriate for GSI was strongly challenged by McKeel as GSI SEC-00105 co-petitioner in a white paper delivered to the TBD-6000 WG and full Board on 6/19/13.

Summary of External Dose Estimates

Below is the summary of the external dose estimates currently proposed to be used in revising Appendix BB. Most but not all have been discussed previously in work group meetings. Disagreement still exists for some and others have not been discussed. [McKeel 17]

[17] This statement in two sentences needs to be documented by specific citations of dose data Mr. Allen considers (a) established and agreed to by all (including the petitioners), (b) issues where known disagreement exists (including the petitioners), and (c) data that had never been discussed. That Mr. Allen avoids this necessary and obvious task severely weakens the impact of this paper. He especially needs to identify and scientifically justify new dose calculations NIOSH has made subsequent to the 6/20/13 TBD-6000 WG meeting. Avoiding that task is scientifically unacceptable.

First, a dose estimate for administrative personnel was derived in a NIOSH white paper issued in May 2013. [McKeel 18] The estimate was based on radium radiography in the areas of the plant outside the radiography room. [McKeel 19] No discussion was held about a dose estimate following the end of radium radiography in 1963. [McKeel 20] This white paper proposes to continue using that estimate to the end of the covered period. It is intended that this be favorable since dose estimates for radiographers persistently indicated higher exposures during radium radiography than during cobalt radiography and the trend should also apply to administrative personnel. [McKeel 21]

[18] "A dose estimate" is too brief and vague. Were doses for photons, neutrons and beta and intakes (inhalation and ingestion) for all GSI radiation sources in

compliance with OCAS-IG-003? For what period of time were doses estimated? What pages, figures and/or tables contain these data in the May 2013 white paper?

[19] The former "radium era" and this dose estimate neglect he fact that other radiation sources were in use 1952-1962, besides Ra-226, which administrative personnel could have been exposed to incur both neutron and beta doses. Namely, OCAS-IG-003 stipulates that all sources must be used in DR: at GSI this included the Old Betatron (24 MEV), two 250 Kvp x-ray units, an Ir-192 source, all of which could have delivered dose to administrative personnel. NIOSH and SC&A have neglected these doses of neutrons, x-ray scatter and beta dose from administrative personnel in the Betatron facility. NYO-4699(Suppl. 1) 1957 demonstrates that ancillary personnel, nurses across a courtyard to be specific, were exposed to betatron neutrons at U. IL medical school in the 1950s from their 22.5 Mev Betatron.

[20] NIOSH admits but doesn't address why this omission occurred or why they cannot and have not calculated an intake dose for 1963-66 to the end of the covered period. This should have been easily accomplished given that radiographer film badge data was available for these 3 years.

[21] This analysis omits the fact that Betatron neutrons and beta dose were also delivered to administrative personnel in addition to Ra-226 1952-1962 and cobalt-60 1963-66 gamma dose. Again, no dose has been discussed for the last quarter of 1952 when both Ra-226 and the Old Betatron plus two 250 Kvp x-ray and an Ir-192 source were in use for GSI NDT radiography.

It should also be noted that with the source of gamma exposure being sealed radium sources, no neutron or non-penetrating dose is produced and those dose estimates are zero [McKeel 22] The dose estimates are listed in Table 2 below.

[22] "...*the* source of gamma exposure being sealed radium sources..." is an incorrect statement. There were Ir-192 gamma photons, Betatron neutrons and beta skin dose and x-ray photons, uranium photons and alpha, and x-ray photons from two portable 250 Kvp x-ray sources delivered to administrative personnel as well as radium gamma photons.

Table 2 – External Dose Estimate for Administrative Personnel

	Gamma	Neutron	Non-Penetrating Hands and Forearms	Non-penetrating whole body
10/1952 – 1963	571.5 mr/yr [a]	0	0	0
1964 – 6/1966	571.5 mr/yr [b]	0	0	0

Notes:

a. From NIOSH White Paper "GSI – Dose Estimate from Radium Radiography to Employees not Routinely Working in Production Areas", May 2013.

b. Post radium era estimate continues radium era estimate as favorable based on radium era estimates for radiographers being bounding.

[McKeel 23] The "radium era" was not uniform with respect to exposures during 1952-1962. No calculations have been made for 1952. The 6 building radiography room was not built until 1955, and Ra-226 was testified to have been stored in 5 building in a storage room when not being used for NDT work. There was also a well documented

one week-long stolen Ra-226 overexposure incident (§83.9) in October 1953, reported in three newspapers, that needs to be factored into the equation and for which NIOSH and SC&A have not calculated a gamma dose. SC&A has admitted and apologized to workers for dismissing this incident as occurring at another location or not having occurred at all.

For reasons stated above, the zeros in columns 3, 4 and 5 of Table 2 need to be changed to reflect the other GSI source terms noted above. It is incorrect and not scientifically defensible to project gamma photon doses from Ra-226 only during 1952-1962 to the last years of the covered period (1963-66) when Co-60 was used in addition to uranium, Old and New Betatrons, 2 x-ray sources from GSI, Ir-192 sources and, St. Louis Testing and American Steel, and two Co-60 small sources and possibly an 80 Ci Co-60 source 1964-66 as testified to by at least 6 GSI radiographers. of StLT Labs testified recently the SLTL Ir-192 source was used at GSI 25 to 50 times from 1963-66, while the StLT Labs 80 Ci Co-60 source was used only once, outside bldg. 10, for 1 week and 1 day for a huge steel casting. Mr. has documented those SLTL sources.

Mr. Allen needs to document (prove) that Ra-226 gamma doses were higher than (that is, were more bounding) compared to Co-60 gamma doses + Ir-192 gamma doses in column 2 of Table 2.

Allen Page 4 of 6

Next, the doses for the remainder of the plant personnel are summarized. The dose estimates are divided into three time frames. The first being the start of the GSI operational period until a change to the dose limits found in NBS handbook 59 (October 1952 – 1958). The second period is from then to the end of the radium radiography (1959-1963). [McKeel 24] The third is from the end of the radium radiography until the end of the operational period at GSI (1964-1966).

[24] Mr. Allen neglects to state he is referring to TABLE 3, PAGE 4 in the ensuing narrative. A dose cannot/should not be assigned for the 1952 extended covered period until the different operational conditions prevailing at that time are acknowledged and discussed by NIOSH as part of TBD-6000 WG deliberations. That has not yet happened.

First, the uranium source term for this 1952 period has not been defined by any means; AEC/MCW purchase orders have not been discovered for 1952-1958. NIOSH has never discussed on the record the reports it submitted to DOL for October 1952, or that were addressed in Dan McKeel's white paper on the subject from November-December 1952 FOIA he submitted, that led DOL to alter and extend the GSI covered period start date from 1/1/53 to 10/1/52. DOE FOIA records submitted by Dan McKeel show that, in the last quarter of 1952, GSI performed R&D Betatron work for the AEC using Mallinckrodt uranium sectioned billets in conjunction with a new uranium shield to improve NDT radiographic image quality. This was a different NDT radiography mission than GSI subsequently pursued in its AEC MCW purchase order contract 1958-1966.

Second, Mr. Allen needs to cite the relevant pages in NBS 59 he alludes to.

Third, Allen neglects mentioning that neither film badge nor AEC MCW purchase orders nor any other source monitoring records for uranium exist from 1953 up through part of 1958.

Fourth, separate external/internal doses at GSI have not been calculated by NIOSH or SC&A for 1958-1963. SC&A relies entirely on a single summary 18 quarter film badge report from GSI part-time radiographer and a letter from GSI management to bound external doses during this period. Mr. Allen omits the important information, as has SC&A in the past, that (a) this same film badge summary report also includes a dose of 7.2 REM incurred for 2 quarters (6 months), while the GSI part time

radiographer worked for Pittsburgh Testing doing Ir-192 NDT work (personal phone call communication to and Daniel W. McKeel from during 2013; and (b) the film badge summary report is not from RS Landauer Company who supplied all of the GSI program #2084 film badges. The report format is completely different and one sheet contains Nuclear Consultants Corp. as the source. Two FOIA requests to DOE and NRC have failed (1) to establish NCC as a legitimate corporate entity or to reveal a source term license even though a discrete AEC license number was quoted in McKeel's NRC FOIA 2010-0012 documents. Therefore, McKeel and assert the summary badge report emanated from GSI rather than from Landauer and thus that film badge data pedigree cannot be relied upon. is unable to this day to explain the exact source of his film badge data. He acknowledges never seeing any RS Landauer film badge reports.

In the third time period, the dose is based on the estimate for the layout man, which includes a gamma, neutron and beta dose component. [McKeel 25] The beta dose estimate was based on activation of steel by the betatron. It was pointed out previously that activation rates derived from MCNPX would change in later versions of MCNPX. The values were recalculated using MCNPX 2.7 and the new values entered into the same calculations performed previously to obtain a new non-penetrating dose estimates. [McKeel 26]

[25] "Layout man" is not a formal job description that existed at GSI. No person we know of worked exclusiely as a layout person full time.

It is utter scientific neglect not to recognize that during 1952-1962, the entire "radium era" at GSI, the Old Betatron, a 24 Mev Allis-Chalmers model with its own standalone concrete and sand-filled thick walls and tin roof building, was in operation processing AEC MCW uranium for NDT purposes., During 1963 through mid-1966 GSI used both the Old Betatron and the New Betatron, which was moved from Eddystone PA GSI Division when it closed in 1963 to Granite City GSI, where a New Betatron facility was built attached by a short walkway to GSI building 10.

Dan McKeel's August 2013 white paper on the HASL, NYO-4699(Suppl. 1) 1957 report gave measured high MEV Betatron *photon and neutron data and film badge data* at three facilities (two at U. IL and a third at Memorial Cancer hospital in NY). In a similar way, the GSI Old Betatron accelerator operating in x-ray mode gave significant beta dose and, especially, neutron dose as well as photon doses that must be calculated by NIOSH to replace the scientifically inaccurate "zeros' in columns 3, 4 and 5 rows 2 and 3 of Table 3 on page 4. Note that in 2008 NIOSH, and especially SC&A calculations, Betatron operators received far higher doses compared to other GSI personnel, as is reflected in June 2007 Appendix BB Rev 0 data that has been used as primary guidance at GSI for all but 4 DRs that are covered by PER-24. Allen omits this key fact entirely.

[26] Mr. Allen and NIOSH, while admitting that MCNPX 2.7 had rendered old numbers invalid, should not be allowed to so cavalierly state "*the new values entered into the same calculations performed previously...*" since the exact, precise assumptions and input parameters used previously (when was that, exactly?) with MCNPX have never been described fully by either NIOSH or SC&A for the TBD-6000 WG or the full Board.

The gamma dose estimate for the first two time periods was agreed to during a working group meeting held on 2/21/2013. [McKeel 27] These estimates were based on radium radiography and differ only by the maximum dose prescribed by the triangular distribution. Since the radium sources would not produce any neutron or beta radiation, the neutron and non-penetrating dose estimates are zero. [McKeel 28] There is, however, a significant non-penetrating dose estimate for betatron operators. This opens the possibility that the radium radiography dose estimate could be favorable to most workers but the betatron

operator estimate could be favorable to some. [McKeel 29] Therefore the betatron operator estimate is included as Table 4 for comparison. [McKeel 30a,b]

[27] Mr. Allen should cite the page numbers in the 2/21/13 TBD-6000 WG transcript.

[28] I assume the foregoing paragraph refers to Table 4 (External Dose Estimate fro Betatron Operators) and its legend on pages 5 and 6. This sentence should read "...the gamma dose estimate for the two Ra-226 sources... The sentence as written falsely implies the radium source(s) were the sole (only) GSI radiation sources during 1952-1962. As amply documented herein, Mr. Allen and NIOSH glibly ignore the many radiation sources at GSI (uranium, Ir-192, Co-60, 250 KVP x-ray) as well as previous dose estimates in Appendix BB Rev 0, which is totally ignored in this white paper, and dose estimates for Betatrons modeled at first using Attila code by NIOSH and later by MCNPX versions 25 through 27 code by SC&A. Allen ignores the much higher dose estimates for Betatron operators for both NIOSH and SC&A in the 2008 time frame. Mr. Allen fails to explain that NIOSH manipulated ("adjusted") MCNPx photon dosimetry downwards using 'film badge normalization,' a process SC&A disapproved of using, in the absence of validating measured Betatron doses, to conform with film badge data on a subset of GSI radiographers 1963-66. The GSI petitioners have vigorously argued all along the RS Landauer 1963-66 film badge data on 89 people was not representative of the entire 13 year covered period, or even of radiographers in general, or certainly of the 97% of the GSI work force who were never badged but obviously should have been. The film badge data from Landauer applied to only 3 of 13 years during the GSI covered period.

[29] We object to the vague phrase "*radium radiography dose estimate could be favorable to most workers but the betatron operator estimate could be favorable to some...*".used by Mr. Allen on several grounds. He needs to spell out in detail and justify this rationale. Which specific workers fall into each "favorable" group? Certainly the high Betatron-related neutron doses should be favorable to all GSI workers including administrative personnel and anyone walking near the Betatron buildings. We have proven previously the outdoor space between the two Betatron buildings at GSI was heavily trafficked by a main road, numerous railroad tracks and related personnel including yard men and crane operators. Many vehicles were parked in that area.

Table 3 – External Dose Estimate for Operational Personnel (non-administrative personnel)

	Gamma (rem/yr)	Neutron (rem/yr)	Non-penetrating hand and forearm (rad/yr)	Non-penetrating whole body (rad/yr)
10/1952-1958 [a]	Tri 15/9.69/6.279 [b]	0	0	0
1959 – 1963	Tri 12/9.69/6.279 [b]	0	0	0
1964 -1966	4.483 [c]	0.148 [c]	2.658 [c],[c]	1.462 [c],[d]

Notes:

a) Dose limit changed from 0.3 rem/week (15 R/yr) to 3 rem/quarter (12 rem/yr) in Addendum to NBS 59 published 4/15/1958.

b) Triangular distribution agreed to in a Work Group meeting on 2/21/2013. The maximum of the distribution was to be the dose limit. The mode was the SC&A estimate contained in "Update on the Use of Sealed Radioactive Sources at General Steel Industries" issued October 2011. The minimum was the NIOSH estimate from "Battelle-TBD-6000 Appendix BB General Steel Industries Dose Estimates for Portable Radiography sources" issued August 2011 and adjusted to 1 radiographer instead of two.

c) Values for 1964 – 6/1966 are for Layout man from NIOSH "Addendum to Dose Estimates for Betatron Operators White Paper" issued March 2012.

d) Non-penetrating dose values adjusted based on new activation calculation using MCNPX 2.7.

[30a] The legend to Table 3 requires further commentary.

TABLE 3 legends:

• Footnote (a) There are several "official" radiation dose limits, including a letter from at Landauer to Dan McKeel dated 2/5/2007 [ATTACHMENT B]. Mr. Allen needs to justify why these NBS 59 data 4/15/1958 are determinative. NYO-4699 (Suppl. 1) 1957 REF1 also has information about prevailing maximum permissible dose limits HASL NYO was using in its Accelerator Survey Program during the 1950s. Mr. Allen should identify the exact pages on which the relevant dose limits he proposes are presented within NBS 59 *to avoid citation ambiguity.*

• Footnote (b) The page(s) from the 2/21/13 TBD-6000 WG transcript and the two August and October 2011 white papers that Allen refers to need to be stated here.

• Footnote (c) "Layout man" as a concept about a discrete job category at GSI was discredited by additional worker testimony and examination of a GSI union jobs list of 163 discrete jobs that was presented to NIOSH. No one was an exclusive Layout worker.

• Footnote (d) Mr. Allen needs to provide the full methodology NIOSH used to make "adjustments" and "new activation calculations using MCNPX 2.7." He needs to give details of the new assumptions and parameters used for these calculations. What person actually performed the new activation calculations? We have previously strongly objected to NIOSH using a single Fe59 isotope as the sole Betatron activation product, citing papers by Guo and Ziemer and Kuttemperoor and others proving that high Mev Linacs and Betatrons induced activation in a far larger range of isotopes emanating from the Betatron internal components and the external metallic targets. This simplistic approach of modeling activation at GSI is claimant unfavorable and scientifically indefensible. Betatron activation of metal castings produced many radionuclides with half lives longer than iron. We have documented these facts repeatedly and had them ignored by NIOSH, the TBD-6000 WG and SC&A, and the full Board in its 12/11/12 final 9 to 8 vote to deny a GSI for 1953-1992. The covered period segments of 10/1/52-12/31/52 and extension of the residual contamination period into 1993 have not been considered.

Table 4 – External Dose Estimate for Betatron Operators

Year	Photon [a] (rem/yr)	Neutron [b] (rem/yr)	Non-penetrating Hands and forearms (rad/yr) [a]	Non-penetrating whole body (rad/yr) [a]
10/1952-1960	0.590	0.050	26.904	2.755
1961	0.620	0.056	30.496	2.946
1962	0.557	0.043	22.863	2.539
1963	0.435	0.019	8.154	1.755
1964	0.406	0.013	4.669	1.569
1965	0.401	0.012	4.130	1.541
1/1966 – 6/1966	0.199	0.006	1.796	0.756

Note:

a) Photon and non-penetrating values in this table come from the NIOSH white paper "Dose Estimates for Betatron Operations" January 2012.

b) Neutron values in this table come from the NIOSH white paper "Addendum to Dose Estimates for Betatron Operations" March 2012.

[30b] continued:

TABLE 4 legends:

• Footnote (a) Mr. Allen should cite the exact pages from the January 2012 white paper. As stated many times in this paper and elsewhere, petitioners believe the assigned photon doses based on MCNPX adjusted and normalized to the limited and not representative GSI film badge data set should not have been used and are inaccurate. These photon doses need to be assessed relative to measured Betatron photon doses in REF 1 (NYO-4699[Suppl.1] 1957.

• Footnote (b) Mr. Allen should cite the exact pages from the March 2012 white paper. As stated many times in this paper and elsewhere, petitioners believe the assigned neutron doses based on MCNPX should not have been used and are inaccurate (far too low). These MCNPX calculated (modeled) doses need to be assessed relative to measured (real) Betatron neutron doses in REF 1 (NYO-4699[Suppl.1]) 1957.

Allen Page 6 of 6

With the exception of the hand and forearm dose, the total dose in Table 3 is always higher than the doses in the betatron operator table (Table 4). For hands and forearms, the betatron operator total dose is higher many of the years. Therefore, the recommendation in this white paper is to use Table 3 values for claims (including betatron operators) but to use the more favorable values of Table 4 for skin dose of the hands or forearms. [McKeel 31]

[31] Use of Table 3 as it now stands would be distinctly unfavorable for anyone in the 10/1952-1963 period because neutrons, non-penetrating hand and forearm doses, and Non-penetrating whole body doses are listed as "0" (zero) values. As explained previously, measured neutron data in NYO-4699 (Suppl.1) 1957 from similar Betatrons to those used at GSI shows that neutron dose is a significant fraction of Maximum Permissible Dose and in some instances (i.e. some locations) equals or exceeds the maximum permissible dose.

Use of Table 4 is highly unfavorable to all Betatron operator radiographers for multiple reasons:

(a) Assigned photon doses in column 2 are way below 2008 SC&A and NIOSH levels. *Do both agencies feel their 2008 computer models were grossly inaccurate?* SC&A used MCNPX from the beginning based on documented research that began in 2006 at the Fernald site (personal e-mail communication from John Mauro to cc: to Dan McKeel). NIOSH used Attila at first and switched to and adopted the SC&A model. These important data have been suppressed by NIOSH-SC&A from the time the NIOSH Path Forward for GSI Dave Allen initiative was first introduced and embraced. This deliberate suppression and avoidance of historical data is scientifically dishonest.
(b) Table 4 data must, in the GSI co-petitioner's opinion, be reconciled with the highly relevant measured Betatron photon and neutron data and film badge data contained in NYO-4699(suppl.1) 1957 [REF 1]. The neutron doses will definitely be higher [REF 1].

NIOSH and SC&A both need to review REF 1 (NYO-4699[Suppl.1] 1957) and report back to the TBD-6000 WG and full Board. Dan McKeel requested the Board to do so when he submitted the NYO-4699 white paper on 8/9/13; thus far there has been no response by the WG or by NIOSH/DCAS to this very reasonable and appropriate McKeel request.

McKeel Comments in Conclusion

(a) NIOSH and SC&A need to incorporate AEC HASL report NYO-4699(Suppl.1) 1957 [REF 1] measured Betatron photon and neutron and film badge data in order to validate their GSI Betatron models that are not now so validated.

(b) McKeel REFS 3 nd 4 offer added proof of his contention that MCNPX models of various radiation dosimetry situations agree to within 2 to 5% with "empirical measured" data. The Board should hold NIOSH and SC&A to similar standards. They shared input files and the best case agreement was 2-fold (200%), which does not meet modern professional standards.

(c) This paper omits a review of Appendix BB Rev 0 and NIOSH and SC&A external/internal dosimetry values. This is a major omission since the purpose of this paper is to highlight proposed changes since June 2007 that have been made for Rev 1 of the same guidance.

(d) The paper states that some new values have been introduced but doesn't say exactly what those changes are. This is another major omission. The new data needs to be flagged as such explicitly and thoroughly discussed. **DCAS was NOT tasked to create new GSI data.**

(e) Specific pages in specific white papers and meeting transcripts are alluded to but not listed. This makes verifying the citations for accuracy very difficult. In general, scientific references by primary authors should be as exact and complete as possible.

(f) Doses assigned to administrative and all other personnel must include neutron and beta skin doses. NYO-4699(Suppl.1) 1957. Betatron and film badge measured data should be the basis for these numbers.

(g) This paper does not comply with OCAS-IG-003 in ignoring the uranium, Old Betatron, 250 KVP x-ray units and Ir-192 sources in use during the radium era at GSI (1953-1962).

(h) NIOSH needs to bound Betatron photon, neutron and beta skin dose during the 10/1952 through 12/52 extended covered period, when GSI was conducting R&D NDT image improvement research with AEC uranium billet sections from MCW. SC&A needs to review this work. The new bounding data needs to be assessed for sufficient accuracy by the WG/SC&A..

(i) Photon and neutron external doses need to be calculated for persons working and traversing the area between to Old and New Betatrons and who were exposed to the two GSI Ra-226 sources 1952-1955 before the 6 Bldg. radiography room was built,

(j) **ATTACHMENT A** contains highly pertinent GSI Betatron multi-operator detailed descriptions of the AEC supported MCW NDT radiography work performed at GSI 10/1952 through June 1966. One operator describes working with Betatron slices, whereas the other workers describe Betatron work on uranium ingots. Other details of the NDT scenarios vary among the workers as well. The resulting data as to time it took to shoot uranium with the Old and New Betatrons should thus use the most claimant favorable. The testimony supports the idea that grazing corner shots primarily sharply delineated the pure uranium, Mg-Fluoride slag/Ur ingot interface.

(k) **ATTACHMENT B** is historical February 2007 correspondence between GSI SEC-00105 co-petitioner Dan McKeel and , and of the RS Landauer company that supplied GSI program #2084 photon film badges to 89 GSI Betatron and isotope radiographers during a minor part of the covered period November 1963 through June 30, 1966. Landauer's badge monitoring program extended to the end of the active castings activities at GSI in 1973. Ms. with Mr. assistance, outlines Landauer's information on "the reporting level and radiation exposure limits" in force during the #2084 GSI film badge program.

McKeel References

1. McLaughlin Jr. JE, O'Brien K, Solon LR, Zua AV, Lowder WM, Blatz H. "Stray radiation at particle accelerator sites," NYO-4699(Supplement 1), Health and Safety Laboratory AEC and Division of Research AEC, 86 pages, April 1, 1957. URL link: www.osti.gov/bridge/servlets/purl/4306039-Gel6fn/

2. Solon LR, McLaughlin JE, Blatz H. "Stray radiation measurements at particle accelerator sites," Report NYO-4699, June 1, 1956, 62 pages. URL link: (furnished to DWM Jr by James Neton of NIOSH): www.osti.gov/bridge/servlets/purl/4361972-MVSO9P/

3. Leone J, Furler M, Oakley M, Caracappa P, Wang B, Xu XG. **Dose mapping using MCNP5 mesh tallies.** Health Phys. 2005 Feb;88(2 Suppl):S31-3

Source

Rensselaer Polytechnic Institute, Troy, NY 12180, USA.

Abstract

Rensselaer Polytechnic Institute has a 69.6 GBq (1.88 Ci) (137)Cs source that is used for

research, calibration of various instruments, and teaching. Recently it was calibrated using ion chambers. The source and room were also modeled in Monte Carlo N-Particle transport code (MCNP5) to determine if the use of a new feature called mesh tallies produces a dose map in the entire room that agrees with the measured results. The dose rate in the hallway, while the source is exposed, was also calculated. **It was found that the dose rates calculated from the MCNP5 are in reasonable agreement with the measured results and theoretical predictions**. It was also confirmed that the dose rates where the user often stays during the measurement are well below the annual limits. This project shows that the MCNP5 mesh tallies are useful tool for dose mapping in many operational radiation protection situations.

PMID: 15654243 [PubMed - indexed for MEDLINE]

Table 1 from this article, column 5, shows that at multiple locations **experimental (measured) data agrees with MCNP5 data within 2.19 to 5.32%**.

Table 1. Comparison of MCNP calculations and measured data. The statistical errors from the MCNP5 code are less than 2% for the locations on the calibration bench. The measured results here were interpolated from the ion chamber readings using Microsoft Excel (Microsoft Corporation, One Microsoft Way, Redmond, WA 98052).

Distance (cm)	MCNP results (Gy h^{-1})	Statistical Uncertainty in MCNP (%)	Measured results (Gy h^{-1})	Difference between MCNP and measured results (%)
0	203.1404	0.001		
20	0.1323	0.193		
40	0.0332	0.387		
60	0.0147	0.581	0.0152	2.70
80	0.0083	0.773	0.0085	2.19
100	0.0053	0.968	0.0055	2.49
120	0.0037	1.168	0.0038	3.48
140	0.0027	1.359	0.0028	2.87
160	0.0020	1.563	0.0021	4.23
180	0.0016	1.766	0.0017	5.20
200	0.0013	1.959	0.0014	5.32

4. Juste B, Miro R, Morera D, Diez S, Campayo JM, Verdu G.
The Institute for (Industrial, Radiophysical and Environmental Safety (ISIRYM), Polytechnic University of Valencia. Valencia, Spain. bejusvi@iqn.upv.es **MCNP5 Monte Carlo simulation of amorphous silicon EPID dosimetry from MLC radiation therapy treatment beams.** Conf Proc IEEE Eng Med Biol Soc, 2012;2012:5786-9. doi: 10.11091EMBC.2012.6347309

Abstract
The present work is focused on a MCNP Monte Carlo (MC) simulation of a multi-leaf collimator (MLC) radiation therapy treatment unit including its corresponding Electronic Portal Imaging Device (EPID). We have developed a methodology to perform a spatial calibration of the EPID signal to obtain dose distribution using MC simulations. This calibration is based on several images acquisition and simulation considering different

thicknesses of solid water slabs, using a 6 MeV photon beam and a square field size of 20 cm x 20 cm. The resulting relationship between the EPID response and the MC simulated dose is markedly linear. This signal to dose EPID calibration was used as a dosimetric tool to perform the validation of the MLC linear accelerator MCNP model. **Simulation results and measurements agreed within 2% of dose difference**. The methodology described in this paper potentially offers an optimal verification of dose received by patients under complex multi-field conformal or intensity-modulated radiation therapy (IMRT).
• PMIO: 23367244 [PubMed • indexed for MEDLINE] (**REF [3] and [4] emphases added**)

Dan McKeel white papers mentioned in this report (from NIOSH Docket 140 GSI):

[1] Docket 140 citation: Submission from Daniel W. McKeel, Jr., M.D., Analysis of the Adley et. al. 1952 Hanford Melt Plant Technical Report_(June 7, 2013)_ PDF 782 KB (23 pages)

[2] This paper addresses McKeel suggested goals and the discussion of the 4/26/13TBD-6000 WG meeting on OTIB-70 and other dosimetry matters as they apply to the GSI AWE site.
• Docket 140 citation: Submission from Daniel W. McKeel, Jr., M.D., "Goals for the TBD-6000 Work Group"_(June 21, 2013)_ PDF 1 MB (17 pages). The discussion of TIB-70 and GSI follows the discussion of proposed work group goals, page 2 ff of 17.

McKeel TBD-6000 WG 4.26.13 transcript: OTIB-070 & Other Dosimetry

TBD-6000 GSI WORK GROUP MEETING ANALYSIS:
Selected Parts of the 4/26/13 Meeting Transcript

by
Daniel W. McKeel, Jr., M.D.,
GSI SEC-00105 co-petitioner
(June 19, 2013)

[3] Docket 140 citation: Submission from Daniel W. McKeel, Jr., M.D., "A Review of AEC Report NYO-4699: Accelerator (Including Betatron) Stray Radiation Measurements and Film Badge Data at 23 Sites"_(August 19, 2013)_ PDF 431 KB (19 pages)

ATTACHMENT A pages 15-19 and **ATTACHMENT B** -- See page 20

Respectfully submitted,

Daniel W. McKeel, Jr., M.D. **8.30.13**
GSI SEC-00105 co-petitioner

ATTACHMENT A-1

GSI_affidavits_2013.fp5

NUM	02
TITLE	MCW UR Ingots were x-rayed in the GSI Betatrons
LASTNAME	
FIRSTNAME	
START_YR	
END_YR	
JOB	Betatron operator
MTG_DATE	7/7/2006
KEY_WORDS	pp 15-17; 31

Probably about 1965, they sent some slices with a waxy coating on it for us to x-ray on the midnight shift. They came into the old Betatron building on flatcars. A couple of nights later they sent some small ingots. We had to use three different films to shoot them because of the exposure and the variation of thickness. We divided the slices up into four shots and backed it up with lead, and pointed the Betatron straight down. It took a lot longer than a normal piece of metal that you were shooting. There were four exposures and each exposure took a couple of hours (7/7/06 Meeting Transcript, pp. 15-17). There was some type of identification on them that we wrote from that ingot onto the shot sheet. They were x-rayed in both the new and old Betatron buildings. I operated back and forth, but most of mine was in the old Betatron building.

DMLIBRARY1-#259452-v1-GSI_Affid

ATTACHMENT A-2a

Hello Ed,

Your answers are indeed all very helpful and much appreciated. The GSI record is now much clearer on this particular subject. It seems that ; the only person alive, who we have interviewed, that actually performed the GSI Betatron shots on MCW uranium. Perhaps we can persuade him to clarify whether or not he shot both Uranium slabs (in his existing affidavits) and ingots, or just "Betatron slices," as they are referred to in a 1957 MCW official document. I have obtained an index of the MCW records that DOE now holds at Oak Ridge, and hope more information from the Mallinckrodt side will emerge about the GSI Betatron NDT uranium inspection program 1952-1966.

Most sincerely with deep gratitude for all your assistance,

-- Dan McKeel 7/17/13 Wed.

In a message dated 7/16/13 4:57:42 PM, writes:

Gentlemen: I doubt that there is much that I can add to what we already know about the above subject but I will try to answer each question as best as I can.

3. I personally saw three (3) trucks leaving the Old betatron . We were on a 4 week swing schedule where we would work 4 weeks of day shift (7-3) then 4 weeks of afternoons (3-11) and then 4 weeks of midnights (11 p.m.-7 a.m.) Each time that I saw them I was coming to work on the day shift and I witnessed the trucks leaving the old betatron. Probably about 6:50 a.m.

4. There were probably 12 ingot on each truck. Seems to me that there were three separate groups of 4 ingot each. All were loaded forward against the bulkhead of the flat bed, open staked truck which would indicate three pallets of 4 each ingot.

5. The trucks were not Mallinckrodt. They were old, rather beat up trucks, painted a dark green. I don't know why but the name "Metro hauling" seems to stick in my mind.

6. I never saw them come in but I know that they were now in house at 3 p.m. on Friday. This would indicate to me that they came in on early Saturday mornings and always returned on Mondays. I never saw them being held longer that that.

7. It is possible but don't know for sure.

8. Never saw them in the New Betatron.

9. No.

10. None, I was not a radiographer. I was a Foreman and film interpreter.

11. All were done in the Old Betatron.

ATTACHMENT A-2 b

12.. If the trucks were moved into the betatron, then each one would be handled indivually with the overhead crane and chain and a choker. If they were unloaded into the betatron, a fork truck would move each pallet and place them in the shooting area. Don't know. Never saw it happen.

13.Don't nave any idea.

14. I think on wooden palettes.

15. Don't know

16. Don't know.

17. Don't know. We had two methods of marking the metal castings. One was with a metal stamp which looked like a 6" cold chisel with a number on one end. It was placed on the metal and hit with about a five lb sledge to leave a nember indent on the metal.. The second method was with a paint tube. This looked like a tube of toothpaste with a boll on the end which when depressed would allow yellow paint to come out of the tube andyou could write on the metal surface.

18. They would have to be unloaded, chained and set up on sew horses, a cassette with film loaded would then be placed or positioned behind the Ingot. I understand the cassette was propped up on wooden blocks to get the right position. Lead number and/or letters were placed on the cassette which would allow the allow the position and the number of the shot to be superimposed on the film. Then a corresponding number would be stamped or printed on the ingot.. Then the film and the camera was lined up at the correct angle and distance. When all was ready, the shot would take place.

19. The first positioning would probably take about one hour. Each subsequent set-up would take about 15 minutes. Chaining and flipping the ingot would probably add another 15 minutes to the operation. Therefore one hour 15 mins. to get the 1st two shots, 45 minutes to flip and get the next two shots and about 15 minutes to chain and return the ingot to the pallet or the truck.

20.I am almost positive that each shot took 40 minutes.

21. Remember several names. all of whom are deceased and

22. Again, I never personally shot or was even present when and ingot was processed.

Sorry, this is the best that I can do. 50 years is a long time for me to remember anything.

Daniel W. McKeel, Jr., MD

ATTACHMENT A-3 a

April 17, 2009

On Wednesday, April 15, 2009,
Had a discussion about Uranium Ingots , Dingots, and Billots at General Steel Industries. was a railyard worker, and at one time, Assistant Yardmaster at GSI. had many years and Extensive experience at GSI, and was actually the last person to leave the property at shutdown. stated, " I definitely saw billots and ingots brought in mostly by rail, and some brought in by truck. They were brought in , usually on midnight shift or on the weekends." The ingots and billots were of "ROUGH" finish, or surface."

Of the ingots that and saw in the Betatrons, were all of a "rough"- "crusty", Surface and not at all anything resembling a "finished " surface.

The ingots were brought in to the Betatrons to have glancing corner shots taken of a shallow depth. AS recalled by The film was a 14 x 17 Metal Cassette extending outward on the side and top of the cylinder to catch the flattened curvature as it was blown on the film. The glancing corner shots were remembered to be of short duration for shallow penetration of the ingot corner surface. When the top two corner shots were completed, the ingot was flipped. End to end and rotated 180 degrees, and then the last two, just inverted and rotated quadrant was shot. The ingot was inverted by using the betatron house crane.

was considered management and a FILM READER at GSI and John Dutko was a Betatron OPERATOR and Magnaflux operator. stated that the INGOT FILM was only routinely developed and checked at GSI and NOT READ---The film was then boxed and sent out.

ATTACHMENT A-3 b

From:
To: Dan McKeel <
Subject: Fwd: Emailing: ingots-uranium follow up
Date: Tue, Jun 4, 2013 9:58 am

Begin forwarded message:

From:
Date: April 22, 2009 11:15:03 AM CDT
To:
Cc:
Subject: Re: Emailing: ingots-uranium follow up

Dr. Dan--4/22/09 I talked with this morning to clarify what he thought was a billot. stated" it was about 10 feet long, circular, and flat on one side, and the shipping tag said General Steel and underneath it said Granite City Army Depo. It was unclear to me if this was a billot. I do confirm 's sightings of ingots, for I saw them myself.

The ingots I saw were a solid cylinder, about 20 inches high and 18 inches or so in diameter.The ingot, when shot, was stood on end and the upper left and upper right corners were shot. The ingot was then inverted end for end, and rotated 180 degrees, and the other two corners shot. The 14 x 17 metal film cassette was set vertically. With extension of the film on the side and top to create a black edge. This allowed enough room to flatten a curved surface on a flat film and show the "black" edge. The film would be set to expose the first one inch to inch and one half of metal. In reading the film, left to right, you would see a black edge, lighter metal, and then increasing lighting on the film as depth and density increased towards the center of the core. In short, desirability would be to read the first inch to inch and one half of metal depth. If the ingots were numbered it was usually painted on the ingot and the lead number taped on a readable portion of the film cassette. The shots were of no unusually long duration and were treated as shooting 3 to 3 and one half inches of steel.

24 & 25 MEV Betatron & Magnaflux Operator
General Steel Industries

------Original Message------

From: DanMcKeel
Date: 4/22/2009 5:06:36 AM
To: .et
Cc: DanMcKeel
Subject: Re: Emailing: ingots-uranium follow up

and

Thanks to for the write up and for forwarding it and having the meeting. Attached is a

ATTACHMENT B

Subj: **Re: Historical data details reply**
Date: Monday, February 5, 2007 5:13:36 PM
From: DanMcKeel2
To:
cc:

and

My sincere thanks for these excellent data. Rarely these days do I get such clear and straightforward answers. The workers are indebted to you. We will probably request some detailed weekly reports on perhaps up to 4 or 5 of the individuals with film badge data. We need to find out more details about what the men with the highest readings did. It looks like they worked with isotopes, probably the cobalt-60 and iridium-192 sources and did overtime work as Betatron operators.

I will make sure you get paid promptly for your research and copying expenses. Thank you again for the really great way you handled this request to resurrect the past in order to help some people living today.

-- Dan McKeel 2/5/07

In a message dated 2/5/07 4:37:29 PM,

Hello Dan,
When we spoke last, you asked me to find the minimum reporting level and radiation exposure limits for the badges that were reported in 1963-1973 for account 2084. I have found this information, with help from Here is what we found.
For the years 1963-1970, the minimum reporting levels are as follows:
Xray or gamma: 10mrem
Hard beta: 40mrem
Fast neutron: 15mrem
Thermal neutron: 10mrem
In 1970, the Fast neutron minimum changed to 20mrem and all other levels remained the same, despite changes in badge types. This information was procured from archived Landauer reports.
As far as permissable doses, this is what we found:
Starting in 1958, the dose limit regulations began using the concept of a dose limit beyond one year. In other words, the average dose over a period of years should not exceed an average of 5 rem per year.
The dose limit specified is 3.0rem/13 weeks. The annual limit is 5(N-18)rem when N=participants age. This information is from the Addendum to the NBS handbook #59.
The regulation stated above was in place from 1958 until 1988 when the DOE changed the limit to 5rem/year.
This information was confirmed on a few different websites:
http://www.nmcco.com/education/facts/history/standards.htm
http://www.hps.org
www.ieer.org

Please let me know if you have any other questions.
Thanks,

ATTACHMENT B

Daniel W. McKeel, Jr. MD