F Basis for Proposing that Records and Information are Inadequate for Individual Dose — Complete Section F.

Complete at least one of the following entries in this section by checking the appropriate box and providing the required information related to the selection. You are not required to complete more than one entry.

F.1 ☐ **I/We have attached either documents or statements provided by affidavit that indicate that radiation exposures and radiation doses potentially incurred by members of the proposed class, that relate to this petition, were not monitored, either through personal monitoring or through area monitoring.**

(Attach documents and/or affidavits to the back of the petition form.)

Describe as completely as possible, to the extent it might be unclear, how the attached documentation and/or affidavit(s) indicate that potential radiation exposures were not monitored.

F.2 ☑ **I/ We have attached either documents or statements provided by affidavit that indicate that radiation monitoring records for members of the proposed class have been lost, falsified, or destroyed; or that there is no information regarding monitoring, source, source term, or process from the site where the employees worked.**

(Attach documents and/or affidavits to the back of the petition form.)

Describe as completely as possible, to the extent it might be unclear, how the attached documentation and/or affidavit(s) indicate that radiation monitoring records for members of the proposed class have been lost, altered illegally, or destroyed.

1) By virtue of the site profile, conducted by NIOSH/ORAU, there is limited to no individual data from 1942 until 1948. (See DOC A1 + A2).

2) Site Profile pg 39 of 125, 5.3.6 Information + Available Data Regarding Urinalyses (see DOC A3) Then (See DOC A4) It explains that .000 was used incorrectly, because it left the impression that tests were made w/zero results. (see Continuation page)

Part F is continued on the following page.

Special Exposure Cohort Petition
under the Energy Employees Occupational Illness Compensation Act

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

OMB Number: 0920-0639 Expires: 05/31/2007

Special Exposure Cohort Petition — Form B

Appendix — Continuation Page

Continuation Page — Photocopy and complete as necessary.

(2) Cont. Whereas, in many cases, there were no tests made nor recorded, so the magnitude of exposure is not known. Uranium Results in the Urine have been coded as Internal exposures, very misleading. In a letter, (see A5) dated 09/20/1951, a request is made to halt sending routine urine samples until after January 1. (also see A52 01/08/51

3) In reference to Breath Radon (see DOC A6 + A7 site profile pg 25 + 41) - Please see (DOC A4) Very Few BR Samples were taken + tested in 1946, none before. It didn't get going until 1948 + ended in 1957. Again the use of .000 is misleading.

*(4) Possible lost medical records (see DOC A8) pg 3 - Not one complete set of medical records/files from Weldon Spring. Possible Destruction of Key Records Vallel (see A8 Pg 2) Cover letter states these were the best records in the world in regard to uranium exposed workers.

(5) Altered illegally / conscious coverup. (See DOC A9) Referencing to a 1949 dust evaluation, Records + formal report was never prepared on this study - this was on the advice of MCW attorneys to avoid subpeona. There was a fake benchmark + correspondence on whether one might even consider making this study (by lying) more favorable or even not recording it at all.

(6) Exposures more than Realized at Weldon Spring (see DOC A10)

(7) Letter to Dr. Tom Mancuso, M.D.) - Stating that the quality of records is much more spotty than those in Hanford + Oak Ridge. Also states that records were incomplete + in many cases, not found at all. (see DOC A11)

(8) per FOIA Request to DOE / from CD / (see DOC A12) Speaks of - in spite of the gaps in their present knowledge, specific figures must of necessity be provided as a guide toward definition of safety.

Attach to Form B if necessary.

Name or Social Security Number of First Petitioner: ______________________

Special Exposure Cohort Petition
under the Energy Employees Occupational Illness Compensation Act

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention
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Special Exposure Cohort Petition — Form B

Appendix — Continuation Page

Continuation Page — Photocopy and complete as necessary.

(9) (See doc. A13) Titled: "Mallinckrodt's Uranium Operations for The U.S. Government: MED & AEC" Several hundred workers during 1942-1952 are among the most highly exposed AEC employees to internal deposition, gamma, (external) & beta radiation in the entire history of the U.S. atomic energy program. More than 50 individuals at MCW alone are known to have worked long enough in appalling concentrations to accumulate more than a permissible lifetime exposure.

(10) (See doc. A.14) Titled "Office Memorandum. United States Government" This is a cover letter from Merril Eisenbud, Health & Safety Dir. Director to W.E. Kelley, Subject: Report on Mallinckrodt Employees. Attachment will be (Doc. A15) "An Estimate of Cumulative Multiple Exposures to Radioactive Materials" Wherein workers were used as "Human Radiation Experiments"

(11) (See DOC 16 pgs 7+8) Titled: "Some Observation On Uranium Exposures within the Nuclear Industry" It is felt that the multiple exposure potential (internal & external) will be among the highest within the industry (also refer to pg 1) (a) personnel monitoring, detection devices & measuring were crude + unreliable.

(12) (See DOC A17) Merril Eisenbud, Oral History workers excreting in excess of a milligram of uranium a day in their urine. With loss of records, miscalculations, falsification, gaps, etc., how can anyone estimate dose accurately?

Attach to Form B if necessary.

Name or Social Security Number of First Petitioner: ______

Special Exposure Cohort Petition

Submitted on behalf of the Mallinckrodt employees

United Nuclear Weapons Workers
St. Louis Region

Table of Contents

07-17-2004

SEC Petition
Office Of Compensation Analysis and Support
NIOSH
4676 Columbia Parkway, MS-C-47
Cincinnati, Oh 45226

Att: Honorable Tommy G. Thompson
Secretary of Health and Human Services

Dear Sir:

I understand that the procedures for the petition by HHS pursuant to 42 USC 7384 (q) are now finalized and I would like to respectfully submit a petition for Special Exposure Cohort status for the employees of Mallinckrodt Chemical Works at the Destrehan, St. Louis, Mo. facility from 1942 until 1957 and for the employees of the Weldon Spring, Mo. facility from 1957 until 1967.

I am sending a hard copy binder as well as a faxed transcription of the petition.

There are three petitioners; myself, (UAW
and (survivor).

I would like to add the following comments to this petition.:

By virtue of the site profile and documents to date, on the MCW, St. Louis site, there is limited to no individual monitoring data for the time period of 1942 until 1948. Whatever other data is available is questionable at best. And this also includes the data or lack of, for the Weldon Spring site, in which, there has to date, not been a TBD completed.

I have attached numerous documents and statements that are indicitive of lost and destroyed records, incorrect exposure documentation, as well as possible falsification of records. I have also enclosed documents regarding concious "cover-up" by the vendor due to liability concerns, discussion of false bench marks, even documents discussing using these workers as "human radiation experiments".

Enclosed is documentation discussing there not being even one complete set of records for the Weldon Spring Mallinckrodt employees, as well as a report stating the exposures were more than realized.

I have enclosed several documents to and from Dr. Thomas Mancuso regarding "spotty" records, missing files,.even documentation that Mallinckrodt St. Louis records were more "spotty" than those of Oakridge. Which, as I understand it, is one of the four already designated SECs.

In a document, titled: "Mallinckrodts Uranium Operations For The U.S. Government: MED and AEC" It states that several hundred workers during 1942-1952, are among the most highly exposed workers in the entire history of the U.S. AEC program.

In an oral history of Merril Eisenbud, Director of Health and Safety Lab in N.Y.. conducted on January 26, 1995 by Thomas J. Fisher, Mr. Eisenbud states that many Mallinckrodt workers were exposed to in excess of over 200 times the preferred levels of exposure. He also commented that workers were excreting in excess of a miligram of uranium per day in their urine.

Mallinckrodt workers also handled K-65 residue, Sperry Press Cake better known as Airport Cake, their sludges and raffinates. At the St. Louis plant the workers were exposed to Actinium, Protactinium, Polonium, etc.. The Belgian Congo Pitchblend was 65 - 75% pure. The Weldon Spring workers were exposed to transuranics such as Plutonium, Neptunium, etc., with like circumstances to the Paducah Gaseous Diffusion Plant, which I understand, is also an original SEC. Workers from both MCW plants were never monitored for any of these.

It is my understanding that in order to become part of the SEC, one must fit the following two criteria:

(1) You must show that the workers were endangered
(2) You must show that NIOSH cannot dose reconstruct with sufficient accuracy.

I believe that in the case of both Mallinckrodt facilities, I have proven both beyond a shadow of a doubt.

I greatly appreciate all of the hard work that NIOSH has put forth in dose reconstructing the claims that they have completed and that have been positively adjudicated. But the fact remains in that, due to the loss and destruction of records, the altering or incompleteness of data, the inaccuracy or blatent mishandling of monitoring data.,as well as zero monitoring for all exposures, misidentification of employees and job description, there is the distinct possibility that a worker may be dosed on inaccurate and insuffient data.

To summarize, Mallinckrodt workers were obviously endangered, they were never monitored for all radionuclides and istopes. They were never told of hazards or given proper protective gear. And on occasion, were left in an area to conduct clinical experiment on, without their knowledge or consent. They are known and documented to be the most highly exposed population of workers in the history of the United States Atomic Energy Commision.

Equity and parody demand that this class of workers be added to this special status. These workers fit the very criteria as the other four sites that were in the original legislation. Please do not let these Atomic Cold War Warriors contributions to our country's ongoing prosperity continue to go unrecognized. I implore you to add the

Mallinckrodt workers 1942-1967, to the Special Exposure Cohort.

Respectfully submitted,

7.4.2 Estimating Dose, Unmonitored Period 1942-1945: Workers Without Subsequent Dose Monitoring Records

It is assumed that workers without subsequent dose monitoring records either terminated prior to the beginning of dose monitoring or performed work that did not meet later Mallinckrodt criteria for monitoring. For the former, a surrogate dose history is to be formulated based on workers with similar job titles during the period of external radiation dose monitoring. The latter may have had low- or no-dose jobs during the 1942-1945 unmonitored period, in which case assignment of a lower dose based on the median dose from the early monitored period is a claimant-favorable measure.

1. Workers assumed to have terminated prior to the start of external radiation monitoring.

   Doses to these individuals should be assigned based on surrogate dose history estimated from recorded doses of co-workers from 1946, or the closest subsequent period. Dose reconstructors must compare information available from the DOE record and the computer-aided telephone interview (CATI) to the reference documents in order to identify workers with a similar work history, whose recorded doses should then be applied to the worker for whom no doses were found. Care must be exercised to identify the appropriate work history to use as a surrogate for the subject employee, but adequate information is likely in the documents to formulate a reasonably accurate surrogate dose history when the case file contains adequate work history information for the employee.

2. Workers who were outside the uranium division operation during the monitored period.

   For these individuals with no identified records, and work assignments subsequent to the unmonitored period that would probably not result in significant exposure, application of the average doses from the early monitored period provides a claimant-favorable estimate that likely addresses any incidental dose that may have been received from 1942-1945. These are presented in Table 36.

The values in Table 36 were generated from the average doses received by Mallinckrodt "pilot plant" workers during the earliest known period of film badge monitoring, the 15-week program described above (Rochester 1950). It incorporates significant uncertainty due to the following features of the data. Firstly, only total doses were listed for each worker for the number of weeks monitored (n = 1-15). Second, no detail is supplied in the reference as to what activities the workers were engaged in, other than the fact that the location was listed as "pilot plant." The memo, however, states that the doses are from "prior to the operation of the current plant", and is dated around the time that Plant 6 became operational; also, it is known that Plant 4 was called "the pilot plant" after Plant 6 was built and before a pilot plant was established at Plant 6. Thus, though it is unknown whether the listed doses were received at Plant 1, Plant 2, Plant 4, or a combination of plants, the results likely reflect doses received in the early operations prior to the improved control measures presumably implemented in the construction of Plant 6. Further, to what extent early "benchtop" operations may have resulted in doses that differ from the estimates below is not known. Finally, as clear production levels have not come to light for the early period, no attempt has been made to scale the exposures to reflect the quantity of material processed. These factors result in dose estimates that are highly uncertain, but represent the best information at hand.

The methodology used to create Table 36 was compared with the techniques discussed in Watson et al. (1994). Whether it would be a better fit to use the department median or mean, due to the fact that Mallinckrodt was a uranium facility like Y-12, or to use the NEARBY procedure is unfortunately academic in the case of workers without monitoring records subsequent to the unmonitored period, as

7.3.2.3 Photons in the 75% AP/75% ROT Category

Exposure geometries for this category of workers reflects a 75% AP/25% ROT geometry. This geometry is appropriate for many process workers.

7.3.2.4 Photons in the 90% AP/10% ROT Category (Process Workers)

Time-and-motion studies document that certain workers received most of their external exposure in a short period of time performing dose-intensive activities. This geometry should be applied to process workers in the higher-dose categories.

7.3.2.5 Photons: Non-Process Workers

These workers are expected to have entered process areas only incidentally and rarely approached process equipment as part of their assigned duties. Examples of these types of workers are clerks, other office workers, and dispensary personnel.

7.3.3 Photon Energy Ranges

Metal plant workers are exposed to natural uranium separated from radium and its progeny, the source of high-energy photons in uranium ore. Workers in the refinery were exposed to uranium in many states, from minimally processed ore through the various stages of uranium separation. Other workers, such as laboratory workers and guards, were exposed to uranium in varying states also.

Photon doses for all workers should be assumed to be evenly divided between the 30 – 250 keV and > 250 keV energy ranges.

7.4 RECONSTRUCTED EXTERNAL DOSE

Some considerations for the reconstruction of external dose in this technical basis document are based on the methodology discussed in Watson et al. (1994). That study utilized external doses for workers at the Oak Ridge National Laboratory (ORNL) and the Y-12 Facility in Oak Ridge, Tennessee to evaluate the accuracy of estimates resulting from the use of the NEARBY procedure, developed by D.J. Strom, as cited in the reference. The procedure is not treated in detail here, due to the ready availability of the reference. The results are significant for this document, however. A statistical test for goodness of fit between estimated doses and actual doses showed the first step (of the 10 ordered steps) of the NEARBY procedure to result in the smallest difference between estimated and actual doses for ORNL. The correlation between estimated and actual dose went down, in general, with increasing step, with exceptions. For the uranium facility, Y-12, the use of department median or mean doses produced as good a fit as use of the NEARBY procedure. Though exact application of the NEARBY procedure is not possible in this case, the methodology is followed to the extent possible with existing dose monitoring data.

7.4.1 Estimating Dose, Unmonitored Period 1942-1945: Workers With Subsequent Dose Monitoring Records

The lack of early external monitoring data for Mallinckrodt likely reflects the novelty of the uranium processing industry, the provisional nature of early uranium activities at Mallinckrodt and the assumption that airborne exposure was the primary hazard. The implementation of a more comprehensive health and safety program in the early post-war period led to questions about external doses that previously had gone unmeasured. This resulted in the publication of the AEC report "An

DOC A3

At the Oak Ridge Gaseous Diffusion Plant (ORGDP), test measurements in 1957 on clothing showed that the highest spot reading was typically about 3.5 times the average reading (Becher 1958); this is probably roughly applicable to Mallinckrodt as well, although the uranium compounds at ORGDP were mostly soluble whereas the Mallinckrodt compounds were mostly insoluble. The ORGDP tests also showed 1620 alpha dpm/cm^2 to be equivalent 9700 cpm/100 cm^2 as measured on a Samson alpha meter, giving an "efficiency-geometry" factor of 6%. (Note that for the "surface transferable activity" on filter paper used for air sampling also reported in Becher 1958, an efficiency-geometry factor of 20% was assumed for the Samson alpha meter.) Finally, the ORGDP measurements showed that about half the uranium applied to the clothing at the beginning of the test had dropped off within the first two hours of wearing. This suggests that uranium that gets on clothing can come back off it readily and that surface contamination on clothing can contribute to airborne levels via resuspension.

Railcar interiors were invariably found to be contaminated above 2500 dpm/100 cm^2 after unloading uranium oxide, UF_4, or uranium metal at uranium processing plants, even though the sites made an effort to decontaminate them (AEC 1949). AEC advised that strippable coatings would eventually need to be used (AEC 1949), but there was no evidence that this was ever done. This suggests that even where closed containers of uranium-bearing materials were being unloaded, it must be assumed that surface contamination was typically present.

5.3.6 Information and Available Data Regarding Urinalyses

Mallinckrodt uranium processing workers were given a pre-employment physical that included an initial urinalysis and a blood count and they were given an annual physical that included a routine urinalysis and a blood count (MCW 1955; Mason 1958a). From about the summer of 1948 on, this included a measurement of uranium in the urine. In addition, up to March 1954 some worker classifications had more frequent urinalyses, either every 4 months or every 6 months depending on the worker classification (MCW 1955; Mason 1958a); after this, time the frequency was no more than semiannual (MCW 1955). As urinalysis records indicate, some office workers appear to have been given urinalyses, but it is not clear whether this was done on a regular basis.

The radiological analysis was apparently only for uranium content (referred to as "X in urine" or "uranium-in-urine"). It is not clear how the urinalyses were done, but Ross et al. (1975) states that for all AEC contractors before 1961, estimates of lung dose were made on the basis of urinalysis and that this was usually done on the basis of electrodeposition and subsequent counting.

The urinalyses were performed by AEC-NYOO from about 1948, when Barnes Hospital at Washington University (St. Louis) began to do them. However, an AEC health official stated (AEC 1948) that it was his understanding that the analyses were being done at Barnes Hospital (at Washington University), but it turned out that they were being done in laboratories at the Mallinckrodt St. Louis site. This came to light when it was discovered, apparently in late 1947, that some urinalysis samples were contaminated due to contamination in the laboratory. An undated, untitled urinalysis listing found in dose reconstruction project files indicates that closed, blank samples were found to have significant levels of uranium in them, indicating contamination in the laboratory; it was suggested that this might explain the high levels of some of the non-blank (worker) samples. Thus at least the early urinalysis samples must be considered to be potentially contaminated (i.e., some of the uranium content may have come from the laboratory analyzing them).

Apparently Barnes Hospital resumed doing the urinalyses (MCW 1950b). However, in 1949, AEC compared the Mallinckrodt analyses against those for other sites handling similar material and concluded that the results were consistently high (MCW 1950b). They then sent Mallinckrodt some spiked samples and also had an independent Mallinckrodt party prepare a stock solution of known concentration. The spiked samples and samples of the stock solution were sent to Barnes as regular samples, while Barnes standards and samples of the stock solution were sent to NYOO for analysis. AEC also compared Barnes methods and equipment. The conclusion was that the samples were indeed reading high at Barnes. Subsequent data analysis showed a gradual precipitation of uranium in the Barnes standards, which meant that the daily standard curves showed a gradual loss of slope over time, up to 30%. Also, Mallinckrodt had been called three times over the previous year to service the Barnes instrument because of sensitivity loss, when the problem was actually the standard. The maximum error in the urinalyses over the preceding 14 months was estimated to be +89%.

AEC technical personnel thought that the affected data was of doubtful value (AEC 1950j). Still, AEC (1950c) asked Mallinckrodt if the urinalysis data could be salvaged, i.e., if there was a consistent factor that could be applied to all of the subject urinalyses; MCW (1950c) thought that there was not. AEC also recommended that a note regarding the problem should be inserted into the medical files of the affected individuals (AEC 1950b), presumably to aid in the interpretation of the results. It is not clear whether this was done or not. AEC-NYOO stated that it was not possible for them to take over the urinalyses again since the number of samples to be analyzed was too high for their capacity (AEC 1950j).

It is not clear who did the urinalyses from 1950 to 1954, although MCW (1950d) suggests that this was no longer being done at Barnes Hospital but at AEC-NYOO. In 1954 AEC gave Mallinckrodt permission to perform their own urinalyses (MCW 1954), presumably in the laboratories at the Mallinckrodt St. Louis site. From the Mallinckrodt Health Office monthly reports, they were analyzing for "X in urine" (i.e., uranium) and it appears that at times there was a significant backlog of overdue analyses, at least in the early 1950's. Eventually AEC-NYOO must have resumed performing the analyses, because a 1955 Mallinckrodt description of its health program stated that NYOO was doing so (MCW 1955). This report states that NYOO was analyzing about 2500 Mallinckrodt urine samples a year and that urine sample that were taken were split, with half going to AEC-NYOO for the radiological analysis and half to Barnes Hospital for the medical analysis.

Because of these questions regarding the validity of the samples and the variations in sample analysis methods, the Mallinckrodt urinalysis data should be used with care. However, it appears that the errors, if any, are in the conservative direction and thus are claimant-favorable.

Urinalysis records appear to be available, but many appear to be handwritten notes on cards. These are found scattered in various dose reconstruction project files. Fortunately, in about the 1970's, the records were entered into a computer data base for research purposes and have been used in that form since then by Oak Ridge Associated Universities and other research groups. The resulting file has more than 40,000 records (i.e., lines, with each line representing one urinalysis). A "stripped" version (ORAU 2003) is also available, with the names and Social Security numbers removed for privacy reasons.

The large stripped urinalysis file (ORAU 2003) was reviewed for comparable or surrogate worker cases that could be used to produce a table of intakes applicable when bioassay data for an individual is missing or spotty. Cases were selected on the basis of their containing a reasonably uninterrupted series of urinalyses and having reasonably clear notations of job title and/or area worked in. The selected cases were then further evaluated and a subset was extracted for each of various categories of identified locations and operations or position titles. These categories are given in Table 31. Where there were more than two applicable cases for a category, the IMBA program was then used with the assumptions of chronic intake and Type M form with the data from these cases to produce a category-specific distribution and standard deviation for the typical daily intake, as shown in Table 31; otherwise, the actual data (i.e., for one or two cases) was given. Since there were changes in

DOC A4

MALLINCKRODT CHEMICAL WORKS

Subject: Concerning the Grouping of Death Certificate Cards into Exposed VS unexposed groups.

The exposure printout cards are incorrect in two major aspects:

* 1. Under the headings: Internal Exposures, External Exposures, Breath Radon Exposures: .000 is used where there is no record of exposure. This, of course, is incorrect because it leaves an impression that tests were made with zero results. Whereas, in many cases, there were no tests made (or recorded as yet in the CTC files) so the magnitude of exposure is not know. The appropriate printout would be "No Data" where that is appropriate. The record .000 should appear only where test results are recorded as zero. Note: When .000 is printed below the subhead Internal Exposure and there were no entries for the individual; a .000 when accompanied by a date denotes a negative finding, i.e., No Exposure; this is an erroneous conclusion.

2. It is my opinion that the most severe and important exposures before 1948 were to radioactive dust. Dust exposure values have not yet been entered into the CTC files. Urinalysis for uranium was not begun until 1948. Urinary uranium results have been coded into the CTC files as Internal Exposures. I have consistently objected to this as a misleading terminology which should be changed to read just what it is: uranium in urine. A positive UU value of course specifically identifies with internal deposition of uranium by some mode of entry but does not identify with any known magnitude of internal deposition or dose. We hope eventually to attach some exposure significance to UU values.

* A zero UU (internal exposure) value would suggest minimal dust exposure during the period preceding the giving of a urine sample.

However, a zero value used to reflect No Data is grossly misleading, particularly if there was sufficient exposure to have caused a positive UU value if a sample had been tested (see above).

* 3. There was no film badging until 1946, and then only in the Plant 6 radium areas until 1948, when plant wide film badging was started. Again: A .000 value to reflect No Data is obviously misleading. (see 1 above).

* 4. A very few breath radon samples were taken and tested beginning in 1946, none before. The comprehensive BR program did not get underway until 1948 and ended for all practical purposes in 1957. Here again the use of .000 for No Data can be highly misleading (see 1 above).

Several names were tested by the simple process of checking the termination date. If termination was before 1946, there should be no exposure data in the CTC records. If termination was between 1946 and 1948, there could only be film badge data (External Exposure) or BR data in the MCW files, although the University of Rochester representatives did conduct some sampling of the population.

Some of the set marked "Non Exposed Employees of Record" were checked against original Health Department records; some of the more severely dust exposed employees were included in this group. The raw data needed to correctly reflect a Destrehan employee's exposure awaits key punching and entry to CTC files. It was sorted in 1973 but not punched. The recent movement of files has contributed to some disorganization of that raw data which has been reorganized. Programmer time has been made available to work out the interlocking programs for tying all of the raw data together. This is a difficult problem due to the facts that various data may be recorded in the MCW files by: 1) Name, or 2) film number, or 3) payroll number—but never by Social Security number, which is, of course, required by CTC to identify with a person.

First priority was assigned to complete the program planning so as to instruct the key punch representative from University of Pittsburgh, who is to be here on or about August 18th.

Now, concerning the 39 names identified as Non Exposed, the following judgments were submitted by M. Mason:

1. Many of these were Main Plant guards who were never assigned to guard duty at Plant 4 or Destrehan or Plant 51 or Weldon Springs. It was postulated that these names were picked up at MCW headquarters by University of Pittsburgh investigators in 1967 when they went there to search out additional names of possibly exposed uranium project employees from sources not in the Uranium Health files. The investigators had no way of knowing how to sort out candidates from non-candidates. The clerks who provided them with raw personnel or payroll files were eager to supply more than enough records and so gave the investigators files of people who _might_ have been associated with the project. Many Plant 1 guards who _were not_ project workers fell in that category. The same is true for many employees in various administrative service groups at the Main Plant who received some pay from project accounts but never went near the uranium areas. I suspect that there may be as many as 300 _non project_ employees or consultants in this category.

More dependable means are being sought to test for and identify those individuals as being _non project_ for purposes of the data bases.

The Health & Safety department personnel reportedly searched all corporate files in 1948 - 1949 for the name and work history of

EJCB 894 last pg

A4

every former and the then current uranium project employees. These were recorded and both a job history and a dust exposure index for each of those individuals was constructed, except that they did not construct the exposure index for guards, some former administrative employees, and some very short term employees. However, they did record, file, and preserve the names collected and confirmed as having been project employees.

It was recommended that the names and dust exposure histories referred to above be accepted as the only bona fide list of Mallinckrodt Project employees prior to 10/1/49 and that additions to or deletions from those name lists be permitted only when there is compelling evidence to do so. It was further recommended that the present CTC files remain intact along with the complete data sheet file; however, any name which does not appear in a Health Department file should be clearly identified as a non project person who cannot be included in the Health and Mortality evaluation unless there is a specific need and justification to do so for any one or all of the individuals.

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* .000 in the column at end of all entries merely reflects the fact that there were no entries in this column (no exposure data recorded).

Doc (Urine) (T)
only pg
A5 (1)

C. L. Karl, Area Manager, St. Louis September 20, 1951

W. B. Harris, Chief, Industrial Hygiene Branch, Health and Safety Division

URINE SAMPLES - MALLINCKRODT CHEMICAL WORKS

SYMBOL: HSH:WBH:hmh

In view of the unusual work load to be placed on our chemical laboratory during the last quarter of this calendar year, we will be unable to analyze routine urine samples of Mallinckrodt plant personnel.

Kindly discontinue the sending of such routine samples until after January 1st. This does not preclude sending any sample required for emergency exposure.

CC: Harley

DOC Breath Radon (1) - importance of radon breath samples

A5 (2)

ESTABLISHED 1867

MALLINCKRODT CHEMICAL WORKS

MANUFACTURERS OF
FINE CHEMICALS FOR MEDICINAL, PHOTOGRAPHIC
ANALYTICAL AND INDUSTRIAL PURPOSES

FACTORIES, ST. LOUIS, JERSEY CITY, MONTREAL
SALES OFFICES: ST. LOUIS, NEW YORK, CHICAGO, CINCINNATI, CLEVELAND
LOS ANGELES, PHILADELPHIA, SAN FRANCISCO, MONTREAL, TORONTO

CABLE ADDRESSES
MALLINCKRODT, ST. LOUIS
DESABRIDO, NEW YORK
CODES

Mallinckrodt FINE CHEMICALS Standard Since 1867

SECOND AND MALLINCKRODT STS. ST. LOUIS. 7, MO.

January 8, 1952
Dict. 1/6/51

Mr. W. B. Harris
U. S. Atomic Energy Commission
New York Operations Office
P. O. Box 36, Ansonia Station
New York 23, New York

MEDICINE, HEALTH & SAFETY - 1 (MCW)

Subject: TECHNIQUES OF RADON BREATH SAMPLING

Dear Bill:

You may remember our conversations of a few weeks ago concerning the reliability of a set of breath radon results which were returned from your laboratory with readings of 1.3 to 1.4 x 10^{-12} curies per liter. This matter was also discussed with John Harley.

We have just received a set of results which were the re-checks on these same individuals. Both sets of samples were taken by our old technique without the respirators recently furnished us by Mr. Harley. You will note that the difference between the reported breath samples is of the same order as the difference in the room air concentration on the day of the sample. This is clearly indicated in Table I.

TABLE I

COMPARISON OF BREATH SAMPLES AND "ROOM AIR" SAMPLES
(All units 10^{-12} c/1)

Name	Room air 0.8	Room Air 0.2
	1.3	0.8
	1.4	Lost
	1.4	0.6
	1.4	0.7

b5 Deletions [illegible]

Breath Radon (2) - importance of room sampling

* We were informed some years ago by the Bureau of Standards that the room air concentration, as long as it was in the same order of magnitude as the breath sample, was of little importance in taking breath radon samples. Evidently this information was incorrect. I believe this set of data, although the number of samples is not large, is a dramatic demonstration of the point which Mr. Harley has been trying to make; that close control of the inhaled air is necessary in order to obtain valid and reproducible breath radon results.

Very truly yours,

MALLINCKRODT CHEMICAL WORKS

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5.0 RADIOLOGICAL CHARACTERISTICS, CONDITIONS, CONSIDERATIONS, AND AVAILABLE DATA

As AEC (1950a) observed, no radiation measurements or evaluations of dust exposure were made in the Mallinckrodt plants in the first few years of operations because it was expected that the processing of uranium ores and compounds would involve little risk of radiation injury; this was because of the low specific activity of uranium and because of what was thought at the time to be the temporary nature of the work. However, when AEC's New York Operations Office (NYOO), which oversaw the Mallinckrodt work, evaluated the potential hazards (which at this time included those of radium-bearing pitchblende ores), they determined them to be "considerable" (AEC 1950a). NYOO and Mallinckrodt began a program of workplace and personnel monitoring.

AEC and Mallinckrodt had already begun to issue film badges in 1946 (AEC 1950a), with apparently a small-scale effort begun in late 1945. To this was added breath radon determinations in 1946 and a formal dust measurement program in 1948 (AEC 1950a). Urinalysis measurements appear to have begun in 1947 also.

Since little individual monitoring data is available prior to about 1946, some extrapolation of existing data to cover the unmonitored periods is necessary, as AEC itself tried to do (AEC 1950a). Also, data must be analyzed to allow missing dose to be calculated for individual workers where there are gaps in the monitored period. The sections below provide information as to the available data and other information that will allow this to be done.

AEC thought that as a result of improvements planned for 1949 and early 1950, there would be no whole-body radiation exposures greater than 300 mrep/week in Plant 6 and the dust concentrations would be reduced to the AEC's "preferred level" of 50 $\mu g/m^3$, or 70 dpm/m^3 (AEC 1949). AEC was also expected that construction of a new metal plant (Plant 6E), in which UF_4 would be reduced to metal as was currently done at Plant 4, would produce satisfactory (occupational) environmental conditions (AEC 1949). It was also expected that in 1951, the new UO_2-to-UF_4 plant (Plant 7) would further reduce exposures (AEC 1949). However, with the increase in production, these goals were not met in all cases, although there were some successes and although doses and air concentrations did decrease overall. The effects of the various plant changes and improvements were reflected in the airborne and external exposure levels, as shown in the text and tables below.

5.1 UNITS, LIMITS, AND RECOMMENDATIONS

The exposure (dose) units used by MED/AEC during most of the relevant period were milliroentgen (mR) for gamma doses and millirep for beta doses; the abbreviations in the film badge and other records were mr and mrep respectively. The rep is equal to 0.93 rad.

During the war, AEC's recommended ("tolerance") levels of external exposure for the uranium processing plants were 700 mR per week to the whole body and 3500 mrep per week to the hands (AEC 1949; AEC 1950b); AEC (1950b) stated that this was 700 mrep per week "each of beta and gamma", as accepted by the University of Rochester in processing film badges (i.e., Rochester did not flag reported doses as above tolerance if the weekly beta and gamma doses were each below 700 mrep). At some point, when NYOO had assumed the job of reading the film badges, the tolerance level was lowered to 500 mrep per week, which Mallinckrodt continued to interpret as applying to either beta or gamma but not to the total (AEC 1950b). However, Mallinckrodt used a control level of 150 mrep per week, called the "preferred level" in its 1946-1952 film badge records. The number that was compared to this level was the sum of the gamma dose in mR (i.e., mr in the records) and the beta dose in mrep, as registered by the film badge, apparently with no adjustment of the mrep by the exposure potential at various times due to process improvements, engineering modifications, or the building of new plants, three periods were established for the determination from the cases of the typical daily intake, as given in Table 31.

Table 31 does not include intakes for workers who processed wastes containing thorium (ionium); estimated annual intakes for these workers are given in Table 32. It appears that there were few such workers: (1) AEC (1955c) reports studying only six workers in their Plant 7E dust exposure study whereas, e.g.,119 were studied in Plant 6E, (2) few worker cases were found in the large stripped urinalysis file where it was clear that the worker did this type of work, and (3) the thorium worker in every case that was found had worked in other areas where an intake of uranium material was possible. It is not clear that thorium itself in urine was measured at all, rather than, say, gross radioactivity. Thus there likely was not any differentiation in the urine analyses between uranium (and its daughters) and thorium. Hence in dose reconstruction the urinalysis data from mid-1955 on for workers who processed thorium wastes should be generally be assumed to consist of whichever source set (U-234, U-235, and daughters or Th-230) gives the more conservative result.

5.3.7 Information and Available Data Regarding Other Types of Bioassay

Breath radon measurements began to be made in 1947, but only for workers who worked in areas where there was a potential for radium intake (AEC 1950a). Breath radon samples were sent to AEC-NYOO for analysis; in 1955, AEC-NYOO was analyzing about 500 Mallinckrodt samples a year, taken semiannually at a minimum but about quarterly when permitted by AEC-NYOO sample capacity (MCW 1955). Breath radon records are available in scattered form in reconstruction project files.

Breath radon samples were collected by obtaining one-liter samples of exhaled breath after two days of non-exposure, usually on a Monday morning (AEC 1950a); MCW 1950f). The samples were measured at NYOO by an "automatically recording pulse-counting device" (AEC 1950a). In early 1950 AEC apparently became concerned about the high background that seemed to be present where the samples were being taken (MCW 1950f). Mallinckrodt agreed to take test samples elsewhere than in their usual testing area and also to take a room air sample in their normal testing room; these samples were then sent to AEC-NYOO. The normal testing room sample showed a radon content of 0.8 x 10-12 Ci/L, which AEC judged was a high background for a breath radon testing area (AEC 1950l). It is known that in 1950 the Mallinckrodt medical department was located adjacent to the change rooms, which enabled workers to take their physicals after a shower without getting dressed (AEC 1950k); if the breath radon samples were also taken there, that could explain the relatively high background radon. Mallinckrodt apparently corrected this by moving the breath radon sampling location to a lower-background area.

AEC considered that many of the early breath radon samples likely represented transient as well as fixed burden and that the background level at the point of sampling (which was generally ignored) was likely to have been relatively high; thus the resulting estimates they made of alpha radiation to the bone based on breath radon measurements would typically be higher than was actually the case (AEC 1950a). Up to about 1950, AEC assumed that 1 μCi/L of sample after at least two days of non-exposure represented a total radium burden in bone of approximately 0.2 μg of Ra; however, AEC had then decided to use an RBE of 20 for alpha to bone marrow and a skeletal weight of 7 kg as agreed on at the September 1949 Chalk River Conference, to give 1600 mrem/week to bone for each 0.1 μg Ra deposited (AEC 1950a).

Whole body and lung counts appear to have been performed rarely if at all, since workers had to be sent to sites outside Missouri for this to be done or a mobile counter would have had to be brought to St. Louis. Hence there were evidently so few such counts done as to be of little use in reconstructing individual doses, except possibly for those individuals actually counted. However, even individual whole body and lung count data appear to be unavailable

5.4 EXTERNAL DOSE CONSIDERATIONS

External doses for Mallinckrodt workers varied widely depending upon the activity they performed. Operations at the refinery (Plant 6) involved primarily gamma radiation, while operations at the metal plants (i.e., Plant 4 and later 6E) entailed primarily beta radiation (AEC 1949).

There is little information about conditions in Plants 1 and 2 during the wartime startup: no dose rate measurements from 1942-1946 appear to have survived and as noted previously, film badging did not start until late 1945, when Plants 1 and 2 were in the process of shutting down. Doses might have been somewhat higher due to greater manual involvement and probably somewhat greater bodily proximity to sources, but on the other hand the quantities involved were much lower. It should be noted, for application to external exposure, the era of pitchblende use (early 1945 on) was mostly covered by film badge monitoring. Thus it is considered to be conservative to assume that the doses at Plants 1 and 2, for the same type of work, were not greatly different from those at Plant 4 and Plant 6 around 1948.

According to MCW (1955), at least late in the life of the site, gamma surveys were done bimonthly in most Plant 6 processing areas and monthly at the vent ducts in the digest area. However, these reports do not appear to be available.

5.4.1 Gamma, Beta (Electron), and Nonspecific Beta-Gamma Exposures

After high-grade pitchblende ores began to be used, refinery workers were exposed to high levels of energetic photons from radionuclides in equilibrium with U-238 and U-235. Ra-226, through its Pb-214 and Bi-214 daughters, contributed energetic gammas to workplaces where ore was stored or processed. Upon removal of the uranium daughters, processed material became radiologically innocuous until the passage of time resulted in the ingrowth of Th-234 and Pa-234m and the consequent domination of the dose profile by electrons. Mallinckrodt worker dose records demonstrate this difference, with significant doses for mixed photons and electrons in the refinery operations and high electron doses with little photon dose in the metal plants. Dose reduction measures in plants and equipment resulted in low doses in Plants 6E and 7 compared with the mixed beta-gamma doses in the refinery operations.

The gamma dose rate could be as high as 50 mR/hr near stacks of drums of Belgian Congo ore at 25% concentration and with a radium content of about 100 mg/ton (Eisenbud 1975). Dose rates at points adjacent to stacks of drums of radium-bearing residues (precipitates) could run as high as 100 mR/hr adjacent to stack of drums (~ 300 mg Ra/ton) (Eisenbud 1975, Table 2). In addition, a 1958 AEC report on uranium mills gave dose rates of 0.8 to 8.0 mR/hr, with an average of 3.0 mR/hr, as the gamma dose rate at three feet from bulk ore concentrates (AEC 1958, Table XI); these dose rates are assumed to be for domestic ores. AEC (1948a) gave the gamma contact dose rate with the (Ra-containing) Feinc filtrate sludge under equilibrium conditions as over 300 mR/hr; however, they stated, they had no way of knowing how close to equilibrium it was.

Some more specific information regarding gamma doses in the ore, refinery, and metal processing areas are shown in Tables 33-35. Dose rates from drums and railcars are shown in Table 33; from ore storage in Table 34, for Middlesex workers (comparable to ore storage areas at Mallinckrodt); and for various Plant 6 locations in Table 35, particularly for GLC (gangue lead cake or K-65, the radium-containing residue). It should be noted that operations that were particularly manual were the various dumping, scooping, and scraping operations in which feed, UO_2, UO_3, UF_4, and dust were handled or crucibles and furnaces were cleaned; the "plowing" (scraping) of the centrifuges; and the scraping of cake off the Feinc filter cloths (this was the pitchblende cake during the pitchblende years). Thus significant external dose reduction usually followed any mechanization of these processes.

Because the gamma dose arose mainly from the radium and its daughters, the gamma dose was significant only in those areas where the source material had not yet had the radium separated; where radium-bearing residues were present; or where uranium products were stored for long enough periods of time that the daughters built up again. This meant that the gamma doses tended to be highest in Plant 2 and later in Plant 6 (AEC 1949), especially around ore drums and storage areas for the radium-bearing residue, K-65. Shielding had been designed into Plant 6 and more was added in 1948 in some areas (AEC 1949). As noted in Section 5.2 above, there was also up to 2.6 mCi of radium built up in the residue that was processed in 1955-1957 to concentrate thorium, although this was distributed in the 350 tons that was processed into the 3600 gallons of solution sent to Mound (Tables 4 and 6).

Doses registered on film badges worn by people not working directly with the U and equipment, such as guards and office workers, was more likely from gamma exposure than from beta exposure. This is because they were usually at some distance away from the source (the uranium and its daughters). It is true that the dust was found throughout the plant to varying extents, but that would likely not contribute to the external dose rate much in or near buildings where there was a substantial Ra content in any uranium product or residue.

A 1958 AEC report on uranium mills gives 1.5 to 25 mrep/hr, with an average of 15.5 as the beta dose rate at three feet from bulk ore concentrates (AEC 1958, Table XI). AEC (1948a) gave the beta contact dose rate with the (Ra-containing) Feinc filtrate sludge (K-65) under equilibrium conditions as over 500 mrem/hr; however, they stated, they had no way of knowing how close to equilibrium it was. AEC estimated the dose to an operator's hands from removing lids from ore drums at 200-300 mR/day, even after a proposed body shielding window was erected (AEC 1948b).

Regarding experience at the Paducah site, Baker (1958) reported that the Th-234/Pa-234 combination (from U-238 and U-234) produced about 1500 alpha dpm/mg U and 1500 beta dpm/mg U at equilibrium, producing 240 mrad/hr at the surface of U metal, 208 mrad/hr at the surface of UO_3, and 183 mrem/hr at the surface of UF_4. Further, during UO_3 prep by "our suppliers" (e.g., Mallinckrodt), much of the beta-active material was removed, but built back up to 50-100% by the time it got to the UF_6 production facilities (Baker 1958). This suggests that significant buildup could occur before the UO_3 left the Mallinckrodt facilities since the storage time might be weeks and the transport time was likely less than a few days. Eisenbud (1975) points out that 90% of equilibrium beta activity is restored by 90 days after vacuum casting. Eisenbud (1975) reports high dose rates, up to 1 rad/week to the body and even more to the hands, from loading of UF_4 into UF_6 reaction vessels. This too implies that if enough time elapsed, UF_4 loaded at Mallinckrodt into the bombs could also produce relatively high beta dose rates. Metallic uranium in equilibrium with Th-234/Pa-234 could produce up to 235 mrad/hr to the basal epithelium when the metal was in contact with bare skin; heavy gloves would significantly reduce this (Eisenbud 1975).

In addition to the beta dose rate from the uranium as natural uranium, uranium oxide, etc., there were two waste concentrates that produced high beta dose rates. First, when ether was used with the uranyl nitrate to extract the uranium, Th-234 and Pa-234 (also called UX1 and UX2 respectively) were left in the aqueous phase (also called the aqueous uranium tails) (Eisenbud 1975). This aqueous solution was filtered, resulting in a residue (cake) containing the beta emitters.