Form AEC-417 (4-68)

UNITED STATES ATOMIC ENERGY COMMISSION

COMPLIANCE INSPECTION REPORT

1. Name and address of licensee	2. Date of inspection
Mallinckrodt Chemical Works Mallinckrodt/Nuclear Box 10172, Lambert Field St. Louis, Missouri 63145	October 20-23, 1970
	3. Type of inspection Reinspection
	4. 10 CFR Part(s) applicable 20 and 30

5. License number(s), issue and expiration dates, scope and conditions (including amendments)

24-4206-1	10-8-58	10-31-60	Reinspection #18
Amendment No. 25 (amended in entirety)	10-14-68	10-31-73	
Amendment No. 26	7-14-69	10-31-73	
Amendment No. 27	6-6-70	10-31-73	

6. Inspection findings (and items of noncompliance)

The only items of noncompliance observed or otherwise noted as a result of this inspection are as set forth below:

10 CFR 20.105 (b)(2) - "Permissible Levels of Radiation in Unrestricted Areas" in that radiation levels on the roof of a building located in an unrestricted area north of the licensee's facilities were such that, if an individual were continuously present, he could receive a dose in excess of 100 millirems in any seven consecutive days. (See paragraph 49 of report details.)

10 CFR 20.201 (b) - "Surveys" in that surveys were not conducted of incoming waste received from customers to determine radiation levels or contamination on the waste packages. (See paragraph 27 of report details.)

(b) - in that radiation level surveys were not conducted on the roof of Building 100 above the solid active waste room to determine compliance with 10 CFR 20.203(b). (See paragraph 48 of report details.)

7. Date of last previous inspection	8. Is "Company Confidential" information contained in this report? Yes ☐ No ☒ (Specify page(s) and paragraph(s))
April 15, 1970	

DISTRIBUTION:

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James M Allan

Edgar C. Ashley
Radiation Specialist

Approved by James M. Allan

James M. Allan, Senior Radiation Specialist, Region III
(Operations office)

November 12, 1970
(Date report prepared)

If additional space is required for any numbered item above, the continuation may be extended to the reverse of this form using foot to head format, leaving sufficient margin at top for binding, identifying each item by number and noting "Continued" on the face of form under appropriate item.

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RECOMMENDATIONS SHOULD BE SET FORTH IN A SEPARATE COVERING MEMORANDUM

6. Inspection findings (and items of noncompliance).(Continued)

10 CFR 20.203 - "Caution Signs, Labels, and Signals"
(b) - in that the radiation area on roof of Building 100 above the solid waste room was not posted with the conventional radiation symbol in the colors of magenta (or purple) on yellow and the words "Caution (or Danger) - Radiation Area." (See paragraph 48 of report details.)

10 CFR 20.206 - "Instruction of Personnel"
(a) - in that an individual working in a restricted area was not adequately instructed in the precautions and procedures to be used to minimize exposure to concentrations of radioactive materials. (See paragraphs 42, 43, and 44 of report details.)

10 CFR 20.401 - "Records of Surveys, Radiation Monitoring, and Disposal"
(a) - in that records showing the radiation exposures of all individuals for whom personnel monitoring is required under 10 CFR 20.202 were not in all cases maintained. (See paragraph 34 of report details.)

10 CFR 20.405 - "Reports of Overexposures and Excessive Levels and Concentrations"
(a) - in that the extremity overexposures of two individuals during the 2nd Calender Quarter, 1970, as evidenced by wrist film badge results, were not reported to the Commission as required. (See paragraph 32 of report details.)

10 CFR 30.51 - "Records"
- in that records were not maintained to show the kinds and quantities of radioactive materials contained in waste received from customers. (See paragraph 26 of report details.)

- in that records were not adequate, in all cases, to show the kinds and quantities of radioactive material waste transferred to a commercial waste disposal agency. (See paragraph 24 of report details.)

License Condition 15

- in that radiation level surveys were not conducted by an individual as required by paragraph IV.B.1. of the licensee's Health Physics Procedures Manual contained in application dated October 1, 1968, and referenced in this condition. Failure to perform these surveys resulted in a wrist overexposure. (See paragraph 45 of report details.)

D E T A I L S

GENERAL INFORMATION

9. This was an announced reinspection of this byproduct material program conducted on October 20-23, 1970. Mr. Don Soldan, Radiation Safety Officer, was contacted in September and was advised that this inspection would be conducted some time near mid-October 1970.

10. Dr. E. A. Fulgrabe, State of Missouri Department of Health, was notified of this forthcoming inspection on October 15, 1970. The inspector was unaccompanied.

11. The following licensee personnel were interviewed and supplied the information contained in this report:

    Mr. Frank A. Schottelkorb, Director of Operations
    Mr. Marvin L. Murray, Manager, Administrative Services
    Mr. Richard L. Holgate, Manager, Manufacturing
    Mr. Mont G. Mason, Plant Engineer
    Mr. Donald W. Soldan, Supervisor, Health Physics, Radiation Safety Officer, and Chairman, Radiation Safety Committee

    In addition to those persons listed above, various other individuals were interviewed during visits to various parts of the licensee's facilities and discussions regarding the licensee's program. All information contained in this report is presented in substance unless otherwise indicated.

12. Reinspection No. 17 of this byproduct material program was conducted on April 13-15, 1970. No items of noncompliance were noted as a result of that inspection.

13. Reinspection No. 18 of this byproduct material program was conducted on October 20-23, 1970, and is the subject of this report.

14. Reinspection No. 18 was limited primarily to a review of the following items:

    a. Organization and administrative control.
    b. Facilities.
    c. Waste disposal.
    d. Personnel monitoring.
    e. Reported overexposures.
    f. Independent measurements.
    g. Management discussion.

ORGANIZATION AND ADMINISTRATIVE CONTROL

15. Dr. Werner Wahl has recently resigned from the position of Director of Operations for this byproduct material program to become a Vice President with Amersham/Searle Corporation. Dr. Wahl has been replaced by Mr. Frank A. Schottelkorb. Mr. Schottelkorb has been the General Manager for Mallinckrodt Chemical Works' Diagnostic Product Division. It is noted that Mallinckrodt/Nuclear Division is part of this Diagnostic Products Division. A corrected and current organizational chart under the Director of Operations is attached to this report as Exhibit A.

16. As noted on the organizational chart included as Exhibit A, Mr. Don W. Soldan, as Supervisor of Health Physics, reports directly to Mr. M. L. Murray, Manager, Administrative Services. Mr. Murray, in turn, reports directly to Mr. Schottelkorb, the new Director of Operations. Also noted on Exhibit A are the names of James Brown, Manager of Research, and James Woods, Director of Operations for Radiochemicals. Although Messrs. Brown and Woods are not organizationally located under the Director of Operations, they are responsible to Mr. Schottelkorb insofar as this licensed program is concerned. Both Research and Radiochemical Sections are physically located within the licensee's Maryland Heights, Missouri, facilities, and all byproduct material work performed under those two sections are performed under this license. By the same token, Exhibit A also includes the operations lineup for the Carlstadt, New Jersey, facilities of Mallinckrodt/Nuclear. Although organizationally located under Mr. Schottelkorb, the Carlstadt facility is operated under a separate AEC license.

17. The organizational chart included as Exhibit A identifies the six members of the licensee's Radioisotope Safety Committee. This committee meets approximately two times per year, as needed. The committee is set up such that any member of the committee may call a meeting at any time to resolve any special problems which may arise within his particular area. Although the committee meets only approximately two times per year, Mr. Soldan meets with Mr. Murray every Tuesday and Friday of each week for the purpose of discussing radiation safety. In addition, the Health Physics Department submits a monthly health physics report which is distributed to all department managers and supervisors involved with the use of byproduct materials.

18. Health physics procedures have been written in the form of the Health Physics Procedures Manual dated October 1, 1968, and submitted to the Commission as part of license application on that date. Other health physics procedures are given to individuals by their supervisors through the Health Physics Department. Please see paragraphs 42, 43, 44, 45, and 46 for further information regarding health physics procedures and instructions.

FACILITIES

19. Since the last previous reinspection, the licensee has purchased adjacent property for the purpose of expansion of operations. Since the acquisition of this new property, the licensee's land site is now approximately four times greater than it was prior to the purchase of the property. Located on the new property are two buildings, one of which is a 15,000 sq. ft. concrete block building which is currently undergoing modifications by the licensee. When the modification operations are completed (scheduled for January 1, 1971), the building will be known as the Customer Service Center. This Customer Service Center will also be known as Building 300. Upon completion, Building 300 will house the entire Order Department, most of the Order Preparation Department, all of the Shipping Department, and most of the Receiving Department. In addition, the building will have office and other usable spaces, including storage in the rear area. The primary byproduct material uses designated for Building 300 will be the filling of orders of prepackaged radiopharmaceuticals as received from the present facilities. This function will be similar to that of a branch office receiving prepackaged single dose quantities from Maryland Heights. The order filling prepackaged handling section within this Building 300 is being modified to be within solid concrete block walls and it will consist of a room temperature storage area, a refrigerated storage area, and an order filling area. No special ventilation, such as hoods or glove boxes, will

be installed in this location. Health physics procedures being written for this new building will include the requirement that all bottles be enclosed within secondary containers at all times. Other procedures are being written to handle any other unforeseen accidental dropping of a bottle.

20. Located immediately west and connected to Building 300 is a second building known as Building 400. Building 400 is of lightweight construction and is 9500 sq. ft. in size. It is planned to use Building 400 for storage of miscellaneous material.

21. The original north half of the licensee's main building has been redesignated as Building 100 while the south of that facility has been designated as Building 200. Buildings 100 and 200 are connected on the upper or main floor only.

22. Solid radioactive waste storage and handling facilities will be discussed in paragraphs 28 and 29 of this report.

WASTE DISPOSAL

23. All liquid active waste goes to retention tanks. When a signal is received noting that one of these tanks is full, the contents of the tank are air jetted for mixing purposes and an aliquot of the tank contents is removed. A total activity analysis is made followed by isotopic analysis for iodine 125, iodine 131, and mercury 203. The remaining activity of the total, which is not included in the iodine and mercury analyses, is assigned to gold 198, which is the next most restrictive MPC. The results of these analyses are used to determine the amount of contained contents which can be dumped on that particular day, based on the known water usage of the facility from the water company meter readings. The licensee's liquid active waste records indicate that one dump is made approximately every three weeks. During 1970, a total of 623,345 uc of activity had been discharged from the tanks through October 14, 1970.

24. The licensee transfers all of his solid active waste to Nuclear Engineering Corporation. During 1970, the licensee has transferred a total of 5900 cubic feet of solid active waste to Nuclear Engineering. These transfers have occurred on 22 separate dates through September 29, 1970. A waste transfer record in the way of a standard form issued by the waste disposal agency is maintained for each solid active waste transfer. The licensee's record of this transfer is a second or third carbon copy of the standard form. In some cases, the notations regarding the number of curies in each package or the isotopic content of a particular package is either too faint to read or is missing altogether. The licensee representatives were advised that failure to maintain complete records of transfer constitutes noncompliance with 10 CFR 30.51 in that the record does not always indicate the isotope or quantities of radioactive materials transferred to another licensee for waste disposal purposes. Isotope notations which were noted on the forms include iodine 131, carbon 14, gold 198, mercury 203, selenium 75, and molybdenum 99.

25. According to the licensee's solid active waste transfer records, the maximum radiation levels noted at the various outgoing packages range up to 5 R/hr at the surface and 800 mr/hr at three feet from the package. These radiation levels are within the provisions of Department of Transportation Regulations 49 CFR 173.393(j).

26. Mr. Soldan stated that as a service to their customers, the licensee accepts miscellaneous byproduct material waste from their customers. According to Soldan, approximately 27 cubic feet of this miscellaneous waste was received each week from customers. Some of this miscellaneous waste being returned to the licensee from their customers was observed on the loading dock during this inspection by the inspector. Many of the cardboard boxes did not contain any information as to the contents of the package, nor was there any information as to the contents of the package on the shipping papers, which constitutes noncompliance with 10 CFR 20.51 in that records of receipt of this miscellaneous waste were inadequate to determine the isotope or quantity of radioactive materials contained in the waste packages being received. Also received from customers are spent or unused molybdenum 99/technetium 99 generators (kows). The licensees representatives advised that the normal weekly kow returns are averaging approximately 60 at the present time. The licensee reclaims the usable parts of the returned kows for future use. The licensee's record regarding these returned kows includes the customer's name, the original quantity of the molybdenum 99 when shipped, and the lot number.

27. In addition to not knowing the isotope or quantity of radioactive material contained in the miscellaneous waste packages being received from customers, these waste packages are not surveyed for radiation levels or contamination upon receipt, which constitutes noncompliance with 10 CFR 20.201(b).

28. The returned kows are taken to a basement room at the west end of Building 100, where the kows are dismantled and parts segregated. A solid block concrete cave has been built for this purpose. A spill tray is placed on the cave and the kow is set in the tray. Contaminated portions and the kow itself are removed from the lead shielding of the generator and placed in an 8" x 8" opening in the top of this solid concrete block cave. Beneath this opening is a stainless steel drum. All parts of the kow which are not supposed to be contaminated are surveyed and placed in boxes for ultimate disposal. The person doing this work wears plastic gloves and uses 18" tongs to remove the various parts from the kow. All reusable parts are surveyed for radiation levels prior to removal from this room. It was noted that one of the licensee's in-house air sampling stations is located in this room.

29. All of the licensee's solid active waste including that which was received from the customers is handled and stored in the high level active waste storage room or within structures located within a fenced-in area outside the northwest corner of Building 100. In this fenced-in area, the licensee has three solid waste storage structures. One of these structures is a tin building known as the block house. The north wall of this block house is shielded with solid concrete 24" thick and 5' high. Two other structures made of solid concrete blocks measuring 6' x 12' x 4 1/2' high complete the solid waste storage facilities. It is in these facilities that the licensee packages his solid waste and stores the waste awaiting pickup by the commercial waste disposal agency. The licensee representatives indicated that they hoped to be able to move most of these waste storage facilities to an inside location after Building 300 has been put into use, thereby making more room within Buildings 100 and 200. At the present time, Mr. Soldan advised that they have three or four plans under consideration as to where this waste storage will be moved.

30. It was indicated that Buildings 300 and 400 will not be used for storage of radioactive waste in the foreseeable future.

PERSONNEL MONITORING

31. The licensee utilizes the R. S. Landauer film badge service for both whole body and wrist exposure monitoring. At the present time, there are 46 isotope workers on a weekly schedule and 67 administrative and supervisory people on a monthly schedule.

32. During the second calendar quarter of 1970 beginning with the week of April 6,1970, two isotope workers, namely [redacted] and [redacted] showed wrist badge exposures of 25.77 rem and 19.17 rem, respectively. The licensee has questioned the validity of these film badge readings. As a result, the licensee has not reported these wrist badge exposures as overexposures. The licensee has conducted studies in an attempt to show that film badges exposed to low energy gamma such as 77 kev of mercury 197 should have a much lower exposure indication from that which is reported by the film badge supplier. The licensee indicated that if this were true, the wrist badges of [redacted] and [redacted] would show much less than the 18.75 rem extremity exposure limit as set forth in 10 CFR 20. During these studies, the licensee has been in contact with the R. S. Landauer Company on numerous occasions to clarify this matter. As of the time of this inspection, no final conclusions have been drawn. The licensee representatives were advised that any film badge result which exceeds the exposure limits as described in 10 CFR 20 must be reported to the Commission within 30 days following the receipt of knowledge that the film badge exceeded the limit. In addition, the licensee representatives were advised that in a case such as this, the 30-day report could include an explanation of possible invalidity of the data and an indication that studies were being performed to verify the matter. The licensee representatives were, therefore, advised that the failure to make a 30-day report of the apparent wrist exposures received by Genova and Mills constitutes noncompliance with 10 CFR 20.405(a). In a letter to the Division of Compliance, Headquarters, dated October 21, 1970, the licensee submitted an explanation type report regarding these wrist badge exposures and exposures of 2 of their personnel assigned to the Carlstadt, New Jersey, facility (program conducted under separate license). In the October 21, 1970 report no information is given as to the identity of the persons receiving exposures or the amount of the exposures. Upon questioning during the inspection, Mr. Soldan advised that he would re-submit this report to include all information required by 10 CFR 20.405(a) and will furnish a report regarding this matter to the individuals in writing pursuant to 10 CFR 20.405(b). Soldan also advised that in each of these two reports, he will include the licensee's feeling that the total amount of the exposures are probably not valid with an indication that further information would be forthcoming upon their evaluation of the matter. Copies of the results of some of the licensee's evaluations and correspondence with R. S. Landauer and internal correspondence regarding this matter is attached to this report as Exhibit B. Ex 6

33. During the third calendar quarter of 1970, [redacted] Isotope Technician, received a wrist exposure of 46.32 rem. Of this total, 40.03 rem was received while [redacted] was using P-32 in a glove box during the week of July 20, 1970. This exposure to [redacted] was reported to the Commission pursuant to 10 CFR 20.405(a). This matter is discussed further in paragraphs 45 and 46 of this report.

34. A review of the licensee's film badge reports as received from the film badge supplier showed that no information is given for technicians [redacted] and [redacted] for the week of June 22 through 28. Also, the licensee had on hand for inspection the film badge reports for all

persons for the week of September 21 through 27, however, no report was on hand for inspection for any person for the week of September 14 through 20, 1970. The licensee was advised that failure to have on hand for inspection the results of all film badge results for those persons where personnel monitoring is required constituted noncompliance with 10 CFR 20.401(a). During the inspection, Mr. Soldan contacted the film badge supplier, who, in turn, advised that all missing exposure data would be sent to the licensee.

35. A review of the film badge reports for persons on a monthly exchange basis for 1970 showed the highest whole body exposure received by any one person on this schedule through August 31 was 3.32 rem while the highest wrist badge exposure received by any one person through August 31 was 9.66 rem.

36. Forms AEC-4 and equivalent Forms AEC-5 are maintained on all personnel.

37. The licensee occasionally uses part-time workers from a commercial manpower organization. Each of these temporary employees are assigned dosimeters. For each of these temporary employees, a card entitled, "Temporary Assignment of Personnel Monitors," is filled out and shows the person's name, social security number, date of birth, and date of assignment. A review of these personnel monitoring cards indicates that these temporary employees receive less than 100 millirem in any one week.

38. All iodine workers have their thyroid counted normally once per day, before beginning work. However, the person or persons assigned to work with or around the iodine capsule machine are thyroid counted every two hours during that work assignment throughout the day. During the week of June 15, 1970, [redacted] received an excessive thyroid burden. This overexposure was reported to the Commission in accordance with 10 CFR 20.405(a). Further information regarding this exposure is presented in paragraphs 42, 43, and 44.

39. Another isotope worker, [redacted], showed a thyroid burden during the week of August 3-9 of 23.14 x 0.14 uc of iodine 131 in the thyroid. It was determined that [redacted] had received a diagnostic capsule from his physician on August 5, 1970. In the licensee's records is a copy of a letter submitted to the licensee, at their request, from [redacted] doctor to that effect. Subsequent weekly thyroid counts for [redacted] showed that [redacted] thyroid burden had decayed to less than 1 x 0.14 uc during the week of September 7-13, 1970.

40. A review of the licensee's thyroid counting records shows that no other persons have received an excessive thyroid burden since the last previous reinspection.

41. Urine samples are collected from isotope workers on a routine monthly schedule. These samples are analyzed for carbon 14 or iodine 131. The licensee uses an in-house MPC for carbon 14 of 377 d/m/ml and for iodine, 222 d/m/ml. The highest single sample for carbon 14 has shown 2.93 x the licensee's MPC while the highest iodine 131 urine sample has shown 1.787 x the licensee's MPC. The quarterly average for all urine samples is a small fraction of the licensee's MPC.

REPORTED OVEREXPOSURES

42. In a letter dated July 16, 1970, the licensee reported an excessive iodine thyroid burden to one employee, as evidenced by thyroid counting, during the week of June 15, 1970. As the July 16 letter indicates, the iodine uptake occurred sometime between 7 a.m. and noon on June 18. During this inspection, the individual [redacted] was questioned regarding this matter. [redacted] advised that during the hand operation of preparing and filling Iodine 125 sodium iodide diagnostic capsules, she put her head in the hood, on one occasion, where the work was being done to be able to better read the contents in a graduated syringe. In addition, [redacted] stated that at one point she added stabilizing material to some iodine 125 biochemical grade on an open benchtop near the hood. It was stated that the reason [redacted] had her thyroid counted at noon after having it counted once in the morning was that [redacted] found herself contaminated when routinely surveying herself upon leaving the production area at lunchtime.

43. [redacted] supervisor and department manager advised that no specific instruction had been given to [redacted] prior to the time of the incident but that [redacted] has had extensive isotope handling experience in various parts of the Production Department. Following the incident involving [redacted] all production workers were reinstructed as to specific radiation safety problems regarding all jobs. During this inspection, the AEC inspector reviewed the iodine 125 sodium iodide capsule batch sheet which is a detailed step-by-step worksheet for making iodine 125 capsules. It was noted that this batch sheet did not give any radiation safety instructions for this particular operation. Mr. Marvin Murray, Manager, Administrative Services, advised that all isotope procedures have a similar batch sheet which is followed by the person performing the procedure. Mr. Murray advised that as a constant reminder, a cover sheet giving specific radiation safety instructions to the employee will be attached to each batch sheet for all isotope procedures.

Ex 6

44. The licensee is in noncompliance with 10 CFR 20.206(a), in that an individual [redacted] working in a restricted area was not adequately instructed in the precautions and procedures to be used to minimize exposure to radioactive materials.

45. In a letter dated September 4, 1970, the licensee reported to the Commission a wrist exposure of 40.03 rem to one employee for the week of July 20-26, 1970. As stated in the September 4 letter, the licensee received this exposure information by telephone from the film badge supplier on August 7, 1970. Of the total 40.03 rem exposure, 39.32 rem was due to beta. The exposure resulted from a spill of P-32 on one of the glove box gloves during the production of chromic phosphate 32. The first indication that a radiation problem existed was at the end of the day of the occurrence when the Production Supervisor made a routine survey of the area and detected the gross contamination on the right hand glove box glove. The contamination was cleaned the following day. During this inspection, the person involved, [redacted] was interviewed and he stated that he realized that he did not make periodic surveys during his work with the P-32 on that day like he knew he was supposed to. This constitutes noncompliance with License Condition 15 which references procedures contained in application dated October 1, 1968. Paragraph IV.B.1 of the licensee's Health Physics Procedures Manual, dated October 1, 1968, states, "All individuals working in radiation areas perform radiation level surveys at periodic intervals during each work day in the particular areas in which they are working."

46. Following [redacted] wrist exposure, the licensee has made up survey acknowledgement cards which have been placed in all specific work areas. This card requires the individual worker to acknowledge that he made a survey of his work area at the beginning and at the end of each workday. [redacted] stated that although the card shows that he has to acknowledge these surveys at the beginning and end of the workday, he has been told that he must make several surveys throughout the workday. Space is available on this survey acknowledgement card for health physics personnel to make independent audits of these surveys.

INDEPENDENT MEASUREMENTS

47. Using a licensee portable survey instrument, with a range of up to 200 mr/hr, the waste storage area outside of the Building 100 and the roof of Building 100 were surveyed during this inspection. The maximum radiation level noted within the outside waste storage area was 6-7 mr/hr at the surface of the unshielded tin roof of the block house. The radiation level at the surface of the solid concrete block walls lining the three storage areas was less than 0.5 mr/hr. On the roof of the high bay section of Building 100, the air handling system and filter housings serving the east half of the hot cell (gold 198 and molybdenum 99) showed a radiation level of 80 mr/hr at the surface and between 20 and 30 mr/hr at three feet. Also on the high bay section of the roof, the air handling system and filter housings serving the west half of the hot cell and all iodine handling areas within the building, including mercury 203, showed a radiation level of 200 mr/hr at six inches from the charcoal filter and between 70 and 80 mr/hr at 18" from the charcoal filter. Please note that the charcoal filter is sandwiched between two absolute filters. The radiation level at the north edge of the high bay section of the roof was between 4 and 6 mr/hr. The wall mounted ladder leading up to that high bay section of the roof was posted with a conventional radiation symbol in colors of magenta on yellow background and the words, "Caution - Radiation Area."

48. The regular roof area which serves the remaining portions of the building was surveyed and the area just north of the high bay section, which is directly over the solid active waste storage room within the building, showed a radiation level of 15 mr/hr at the roof surface and 10 mr/hr at approximately 3' above the roof floor. The north end of this roof area showed a radiation level of 9 mr/hr at approximately 3' above the roof level. This portion of the roof of Building 100 and an attached wall ladder were not posted with any radiation area warning signs, which constitutes noncompliance with 10 CFR 20.203(b). It is noted that a person must climb this wall ladder and pass this point in order to gain access to the high bay area, which is posted. Also, the licensee is in noncompliance with 10 CFR 20.201(b) in that surveys have been inadequate to determine the need for a radiation warning sign on the roof area above the solid active waste storage room.

49. As part of the Commission's Independent Measurements Program, a TLD station was set up on the roof of a building in an unrestricted area immediately across a driveway which runs along the licensee's north boundary fence. This is known as location #1, Bennett Box Company. The results of the TLD measurements for the 30-day period between April 11 and May 11, 1970, showed a total of 536 mr. Five hundred thirty six (536) mr over a period of 30 days is equivalent to 0.75 mr/hr continuous for the entire 30-day period, which constitutes noncompliance with 10 CFR 20.105(b)(2), in that radiation levels on the roof of the

building north of the licensee's property line and located in an unrestricted area were such that if an individual were continuously present in the area, he could receive a dose in excess of 100 mr in any seven consecutive days. A copy of the results of the TLD's for the period January 9 through July 18, 1970, are attached to this report as Exhibit C.

MANAGEMENT DISCUSSION

50. The new Director of Operations for this licensed program, Frank A. Schottelkorb, was not available for interview on the last day of this inspection (October 23). As a result, a management discussion was held on October 22. Those items which were noted during the inspection up to that time were discussed. In addition to Mr. Schottelkorb, those in attendance at this meeting were Richard Holgate, Manager of Manufacturing, Mr. Marvin Murray, Manager of Administrative Services, and Mr. Donald Soldan, Supervisor of Health Physics.

51. Each of the items of noncompliance noted during this inspection up to the time of this meeting were summarized individually. Corrective action regarding each of the items of noncompliance which had been stated earlier in the inspection were reiterated at this time. Regarding the licensee's film badge problems with their current film badge supplier, in this case, R. S. Landauer, the licensee representatives advised that they are seriously thinking of switching film badge suppliers and are negotiating with one or two different suppliers at the present time.

52. The forms in which the results of an AEC inspection may take were discussed with Mr. Schottelkorb during this management discussion meeting. This included Form AEC-591, Form AEC-592, and Form AEC-417 procedures. In conclusion, Mr. Schottelkorb was advised that the licensee may expect to receive further communication from the Commission regarding the results of this inspection.

53. The items of noncompliance noted as a result of independent measurements on the roof of Building 100 and interviews with previously reported overexposed personnel, which took place on October 23, were discussed with Mr. Schottelkorb by telephone subsequent to the inspection. Also discussed were specific radiation safety instructions to be attached to production batch sheets.

Attachments:
Exhibits A thru C-2

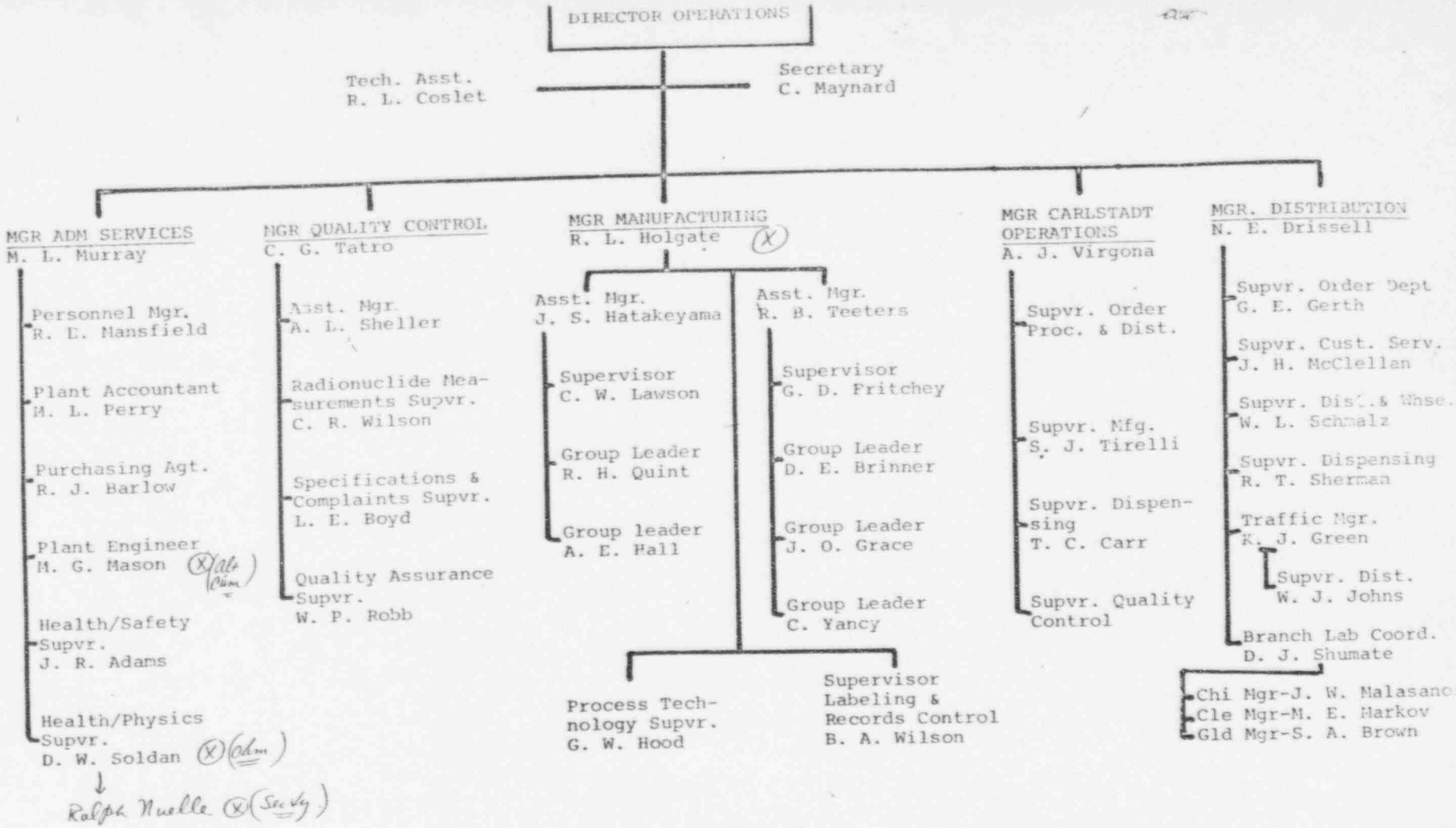

EXHIBIT A

[(X) = Member of Radioisotope Safety Committee]

JAMES BROWN, Mgr on Permit ~~Supvr, R&D~~ (X)

JAMES WOODS, Dir. of Oper. Radio Chemicals (X)

Mallinckrodt NUCLEAR BOX 10172 LAMBERT FIELD • ST. LOUIS, MISSOURI 63145 • 314 AX 1-0540

July 2, 1970

Mr. R. S. Landauer, Jr.
R. S. Landauer Jr. & Company
Glenwood Science Park
Glenwood, Illinois 60425

Dear Bob:

I am returning to you the film holders which we found to be missing one or more lead filters. We do need replacement holders. A list of the defective holders is enclosed.

The device used to check the holders consists of a compartmented dual source container (one of our standard lead safes), loaded with approximately 15 mc of Hg-203 (279 Kev) and 3 mc of I-125 (32 Kev) in flame sealed glass ampules. Two ¼ inch holes in the safe lid permit the low energy gammas to beam through the aluminum filters and the high energy gammas to beam through the lead filters. A detector mounted above the device measures the transmission of both gamma beams, simultaneously. A fixture on the safe lid permits exact positioning of the holders.

The absence of either aluminum or lead filters results in an increase in the countrate. A set of data is enclosed for your information. The readings varied from +10 to -9 %, including a 0.95 error of + 2 % for counting statistics. The deviation from badge to badge is then about +8 % to -7 % from our "standard" badge.

One "odd ball" turned up while checking our holders. The countrate was only 43% of the "standard". Upon opening the badge, we found three lead filters and only one aluminum filter. This holder is enclosed for your inspection.

EXHIBIT B-1

We are in the process of exposing some film with holders having both lead filters missing. I hope these will help you interpret the films worn by Rodon and Daniels at Carlstadt, whose holders were missing both front and back lead filters. It is urgent that we have something to tell the Commission before the thirty (30) day reporting period elapses.

Thanks again for your cooperation.

Sincerely yours,

MALLINCKRODT CHEMICAL WORKS
MALLINCKRODT/NUCLEAR

Donald W. Soldan, Chief
Radiological Protection Officer

DWS:cm

enc. 2

cc: Dr. W. H. Wahl
M. L. Murray
M. G. Mason

EXHIBIT B-2

Mallinckrodt NUCLEAR
BOX 10172 LAMBERT FIELD • ST. LOUIS, MISSOURI 63145 • 314 AX 1-0640

July 16, 1970

Mr. R. S. Landauer
R. S. Landauer, Jr. & Company
Science Road
Glen Science Park
Glenwood, Illinois 60425

Dear Bob:

The most recent phase of our exposure study has been completed. All the films have been sent and should have been received by you. A master list is attached to this letter which relates the film date and number to the specific exposure conditions. I have not sent this master list along with the film because I did not want your personnel to be influenced by such preknowledge.

The exposed experimental badges are dated June ~~28~~ 29 and July 6 and are numbered 8001 - 8024, 8101 - 8124 and 8201 - 8224. Please have these films developed and read out as quickly as possible.

We have not yet received the official film badge reports for the end of the quarter. However, according to telephoned results, two of our employees have exceeded the regulatory limit for extremities exposure. [redacted] has 28,470 and [redacted] has 19,140.

[redacted] received 11.9 rems for the weekly period starting 5-25-70. I strongly suspect that she was wearing one of the wristbadges with the lead filters missing that particular week, although I have no means of proving this. Could you personally inspect that particular film with this possibility in mind? Her principle exposure that week was from Hg-197 (77 Kev) and Tc-99m (140 Kev) as per our production schedule records. We have no wrist exposure data for [redacted] as measured by pocket chamber. [redacted] was restricted from further exposure during the week of June 8 upon receipt of the May 25 exposure by telephone.

[redacted] principle exposure during the quarter was to Hg-197, as indicated by reported filmbadge results.

Ex 6

Continued -

EXHIBIT B-3

July 16, 1970
Mr. R. S. Landauer
R. S. Landauer Jr. & Company
Science Road
Glen Science Park
Glenwood, Illinois 60425

FILMBADGE DATE	FILMBADGE EXPOSURE	PERFORMED Hg-197 PREP	POCKET CHAMBER EXPOSURE (1)
4/6	320	no	----
4/13	2,650	yes	140 + 340 (2)
4/20	400	no	----
4/27	2,300	yes	----
5/4	400	no	----
5/11	3,490	yes	358
5/18	1,150	no	----
5/25	1,700	yes	70 (3)
6/1	5,700	yes	270
6/8	1,030	no	----
6/15	0	restricted	----
6/22	0	from further	----
6/29	0	exposure	----
TOTAL:	19,140		

Ex 6

(1) Two additional pocket chambers were issued to the individuals assigned to produce Hg-197 Chloromerodrin. One pocket chamber was attached to the wrist band of the filmbadge and the other was attached to a wristband worn on the other hand. Readings were taken at several steps along the 28-step production procedure. Values recorded under the Pocket Chamber Exposure heading are total exposure in mr. The exposures to the right and left hand were approximately equal.

(2) The Chloromerodrin procedure was performed twice this week by [redacted]. The 140 mr was due to a run made on 4/15 aborted at step 24. The 340 mr was due to a complete 28-step run performed on 4/16.

(3) Only steps 24 through 28 were performed by [redacted] this week.

Please note the following from the above tabulated data:

1. Periods of high reported exposure correlate in time with Hg-197 Chloromerodrin production by [redacted]

2. Periods of lower reported exposure correlate in time with no Hg-197 Chloromerodrin production by [redacted]

3. The average weekly exposure during periods when [redacted] did not produce Hg-197 Chloromerodrin was 660 mrem, as reported by filmbadge results.

Continued -

EXHIBIT B-4

1970
S. Landauer
Landauer Jr. & Company
Science Road
Glen Science Park
Glenwood, Illinois 60425

If the conservative assumption is made that, in addition to any exposure from Hg-197, [redacted] received one rem of exposure from her other duties, an estimate of the exposure due to Hg-197 as measured by filmbadge results can be made. This allows us to make a comparison of exposure to Hg-197 as measured by filmbadge and pocket chamber results.

DATE	FILMBADGE	POCKET CHAMBER	RATIO FB/PC
4/13	1650	480	3.4
5/11	2490	358	7.0
6/1	4700	270	17.4
TOTAL	8840	1108	8.0

It would appear that the contribution to extremities exposure from Hg-197 as measured by filmbadge would be eight times as great as measured by pocket chamber.

We have also checked the calibration of all our pocket chambers against a Victoreen Radocon-555 and a Victoreen R-Meter using I-1[illegible] Tc-99m and Hg-197 gammas. These two Victoreen instruments were also used to determine the exposure to the 8000 series experimental filmbadges sent to you.

You mentioned in your July 7 letter that you would await further information from me before taking any action on evaluating the badges worn during the last quarter ending July 5 by two individuals at our Carlstadt facility. All the information I have is as follows: E.6

During the week of June 8, a telephone report was received at Carlstadt for the films dated May 4 and May 11. The exposure reported for Rodon was 1120 mrem for the May 4 badge. A suggestion was made that perhaps the high reading was a result of missing lead filters in the badge. Mr. DeBonis checked all badges at that time and found that the badges worn by [redacted] and [redacted] during the entire quarter were indeed missing both lead filters. These badges were removed from service at that time. I do not know if the filters worked loose during the quarter or if they were missing since the start of the quarter on April 6. Both of these individuals work only with Xe-133, Tc-99m and Mo-99/Tc-99m in equilibrium. We have not received any written reports to date on exposures for Carlstadt personnel since April 6. The exposures listed under the Filmbadge heading below are all telephoned results. Please note that the total filmbadge results differ from the total pocket chamber results by a factor of 4. Individual results vary from a factor of 2 to a factor of 9.

Continued -

EXHIBIT B-5

16, 1970
Mr. R. S. Landauer
R. S. Landauer Jr. & Company
Science Road
Glen Science Park
Glenwood, Illinois 60425

EXPOSURE - [redacted] - 0017

FILMBADGE DATE	FILMBADGE	POCKET CHAMBER	RATIO FB/PC
4/6	----	65	----
4/13	260	140	1.9
4/20	290	127	2.3
4/27	270	112	2.4
5/4	1120	225	5.0
5/11	730	173	4.2
5/18	920	150	6.1
5/25	490	56	8.8
6/1	260	116	2.2
6/8	240	153	1.6
6/15	----	98	----
6/22	----	70	----
6/29	----	92	----
SUBTOTAL	4580	1252	3.7
TOTAL	----	1577	----

Ex 6

Continued -

EXHIBIT B-6

S. Landauer
Landauer Jr. & Company
Science Road
Glen Science Park
Glenwood, Illinois 60425

EXPOSURE - [redacted] 0039

FILMBADGE DATE	FILMBADGE	POCKET CHAMBER	RATIO FB/PC
4/6	----	95	----
4/13	570	112	5.1
4/20	450	121	3.7
4/27	330	69	4.8
5/4	360	104	3.5
5/11	600	123	4.9
5/18	670	75	8.9
5/25	130	85	1.5
6/1	330	112	2.9
6/8	160	84	1.9
6/15	150	48	3.1
6/22	----	37	----
6/29	----	49	----
SUBTOTAL	3750	933	4.0
TOTAL	----	1114	----

Ex 6

Continued -

EXHIBIT B-7

Ex 6

10, 1970
R. S. Landauer
R. S. Landauer Jr. & Company
Science Road
Glen Science Park
Glenwood, Illinois 60425

Based upon our discussions when I visited you on June 26, the additional information contained in this letter and the results of the experimental badges, I trust you are now in a position to reevaluate the extremity badges worn by [redacted] and [redacted] from our St. Louis facility and the body badges worn by [redacted] and [redacted] from our Carlstadt facility.

I do not plan on submitting overexposure reports to the Commission for these individuals before you have had an opportunity to reevaluate the films and unless the final values are in excess of the regulatory limits.

Your suggestion that TLD's be added to several wrist and body badges to independantly obtain additional exposure information is an excellant one. I am most eager to see the results.

Incidentally, we found that two of the special badges to which the TLD's were taped were missing filters when we received them. We removed the TLD's from those badges and taped them on good badges.

On the basis of your filmbadge results, independant of our pocket chamber data, I restricted six individuals from further exposure for a total of 40 working days of lost time during the past quarter. Five additional individuals were limited in what particular jobs they could perform also because of high reported filmbadge exposure.

I am confident that the steps you have taken will help resolve the difficult interpretation problem when films worn under actual exposure conditions are compared to films calibrated under the NSF "ideal" conditions.

Sincerely yours,

MALLINCKRODT/NUCLEAR

Donald W. Soldan, Chief
Radiological Protection Officer

/mt

cc: M. L. Murray
Dr. W. H. Wahl
T. C. Carr
A. J. Virgona

EXHIBIT B-8

EXPERIMENTAL [illegible]

Dated June 29 (Low Exposure)

	(1)	mrem	(2)	mrem	(3)	mrem
	8001	250	8002	2270	8003	470
	8004	300	8005	2260	8006	270
	8007	190	8008	2230	8009	280
Hg-197	8010	230	8011	2250	8112	340
(77Kev)	8113	290	8114	2500	8115	420
	8116	320	8117	2200	8118	310
150.5 mrem	8119	280	8120	1600	8121	400
	8122	310	8123	2800	8124	300
	Ave.	271	Ave.	2263	Ave.	348
	8201	160	8202	450	8203	180
	8204	170	8205	430	8206	150
	8207	120	8208	430	8209	170
Tc-99m	8210	150	8211	460	8212	210
(140 Kev)	8213	180	8214	460	8215	150
	8216	100	8217	440	8218	170
150 mrem	8219	120	8220	450	8221	180
	8222	160	8223	400	8224	160
	Ave.	145	Ave.	440	Ave.	172
	8101	170	8102	170	8103	150
	8104	170	8105	180	8106	180
	8107	190	8108	200	8109	170
I-131	8110	200	8111	210	8012	180
(365Kev)	8013	180	8014	190	8015	170
	8016	190	8017	180	8018	160
172 mrem	8019	160	8020	190	8021	160
	8022	200	8023	200	8024	170
	Ave.	182	Ave.	190	Ave.	167

Dated July 6 (High Exposure)

	(1)	mrem	(2)	mrem	(3)	mrem	
	8101	1150	8102	19500	8103	4020	
	8104	2150	8105	21300	8106	4020	
	8107	1230	8108	19100	8109	2120	
	8110	1850	8111	17500	8112	2050	
Hg-197	8113	1530	8114	20600	8115	3370	
(77Kev)	8116	2200	8117	17500	8118	1600	
	8119	1850	8120	23200	8121	2080	
1520 mrem	8122	1730	8123	23700	8124	19500	as 1950
	Ave.	1711	Ave.	20300	Ave.	4845	265
	8201	900	8202	4020	8203	1020	
	8204	1100	8205	4300	8206	1050	
	8207	990	8208	4020	8209	920	
	8210	800	8211	2300	8212	990	
Tc-99m	8213	800	8214	3800	8215	1280	
(140 Kev)	8216	790	8217	3800	8218	910	
	8219	770	8220	3800	8221	1230	
1112.5 mrem	8222	820	8223	3800	8224	1250	
	Ave.	871	Ave.	3730	Ave.	1081	
	8001	1190	8002	1280	8003	1190	
	8004	1320	8005	1290	8006	1070	
	8007	1220	8008	1420	8009	1050	
	8010	1070	8011	1230	8012	1050	
I-131	8013	1370	8014	1130	8015	950	
(365Kev)	8016	1100	8017	1190	8018	980	
	8019	890	8020	1050	8021	920	
1525 mrem	8022	1100	8023	1080	8024	1030	
	Ave.	1157	Ave.	1208	Ave.	1030	

All sets of badges were suspended in a circular array equidistant from a source suspended from the center of the circle.

(1) Badges with all four filters intact; fixed in planes perpendicular to lines from the source to the badges.

(2) Badges with both lead filters missing; fixed in planes perpendicular to lines from the source to the badges.

(3) Badges with all four filters intact; allowed to rotate randomly around the long axis of the badges.

EXHIBIT B-9

EXPERIMENTAL BADGES CODE 1501

Dated June 29 (Low Exposure)

	(1)		(2)		(3)	
Hg-197 (77Kev) 151 ± 7% mrem	8001	1.7	8002	15.1	8003	3.1
	8004	2.0	8005	15.0	8006	1.8
	8007	1.3	8008	14.8	8009	1.9
	8010	1.5	8011	14.9	8112	2.3
	8113	1.9	8114	16.6	8115	2.8
	8116	2.1	8117	14.6	8118	2.1
	8119	1.9	8120	10.6	8121	2.7
	8122	2.1	8123	18.6	8124	2.0
	Ave.	1.8	Ave.	15.0	Ave.	2.3
Tc-99m (140 Kev) 150 ± 7% mrem	8201	1.1	8202	3.0	8203	1.2
	8204	1.1	8205	2.9	8206	1.1
	8207	0.8	8208	2.9	8209	1.1
	8210	1.0	8211	3.1	8212	1.4
	8213	1.2	8214	3.1	8215	1.0
	8216	0.7	8217	2.9	8218	1.1
	8219	0.8	8220	3.0	8221	1.2
	8222	1.1	8223	2.7	8224	1.7
	Ave.	1.0	Ave.	2.9	Ave.	1.1
I-131 (365Kev) 172 ± 7% mrem	8101	1.0	8102	1.0	8103	0.9
	8104	1.0	8105	1.0	8106	1.0
	8107	1.1	8108	1.2	8109	1.0
	8110	1.2	8111	1.2	8012	1.0
	8013	1.0	8014	1.1	8015	1.0
	8016	1.1	8017	1.0	8018	0.9
	8019	0.9	8020	1.1	8021	0.9
	8022	1.2	8023	1.2	8024	1.0
	Ave.	1.1	Ave.	1.1	Ave.	1.0

Dated July 6 (High Exposure)

	(1)		(2)		(3)	
Hg-197 (77Kev) 1520 ± 7% mrem	8101	0.8	8102	12.8	8103	2.6
	8104	1.4	8105	14.0	8106	2.6
	8107	0.8	8108	12.6	8109	1.4
	8110	1.2	8111	11.5	8112	1.3
	8113	1.0	8114	13.6	8115	2.2
	8116	1.4	8117	11.5	8118	1.1
	8119	1.2	8120	15.3	8121	1.4
	8122	1.1	8123	15.6	8124	1.3
	Ave.	1.1	Ave.	13.4	Ave.	1.7
Tc-99m (140 Kev) 1113 ± 7% mrem	8201	0.8	8202	3.6	8203	0.9
	8204	1.0	8205	3.9	8206	0.9
	8207	0.9	8208	3.6	8209	0.8
	8210	0.7	8211	2.1	8212	0.9
	8213	0.7	8214	3.4	8215	1.1
	8216	0.7	8217	3.4	8218	0.8
	8219	0.7	8220	3.4	8221	1.1
	8222	0.7	8223	3.4	8224	1.1
	Ave.	0.8	Ave.	3.4	Ave.	1.0
I-131 (365Kev) 1525 ± 7% mrem	8001	0.8	8002	0.8	8003	0.8
	8004	0.9	8005	0.8	8006	0.7
	8007	0.8	8008	0.9	8009	0.7
	8010	0.7	8011	0.8	8012	0.7
	8013	0.9	8014	0.7	8015	0.6
	8016	0.7	8017	0.8	8018	0.6
	8019	0.6	8020	0.7	8021	0.6
	8022	0.7	8023	0.7	8024	0.7
	Ave.	0.8	Ave.	0.8	Ave.	0.7

All sets of badges were suspended in a circular array equidistant from a source suspended from the center of the circle.

(1) Badges with all four filters intact; fixed in planes perpendicular to lines from the source to the badges.

(2) Badges with both lead filters missing; fixed in planes perpendicular to lines from the source to the badges.

(3) Badges with all four filters intact; allowed to rotate randomly around the long axis of the badges.

EXHIBIT 8-10

INTER-OFFICE MEMO

Mallinckrodt NUCLEAR

July 7, 1970

TO: M. L. Murray

FROM: D. W. Soldan

Preliminary Report - Exposure Studies

Initial exposure studies performed early in the quarter with R. S. Landauer filmbadges and Mallinckrodt/Nuclear pocket chambers showed that under "ideal" exposure conditions the two types of devices gave essentially the same results over a range of energies and exposures. These results were very perplexing in that when the devices were worn by personnel under actual exposure conditions, the results were widely divergent. Certain generalities were drawn from the available information.

1. The filmbadge results for Production Department personnel were more divergent from pocket chamber results than for other departments.

2. Those production personnel working with low energy gamma emitters had the highest divergence of results. (The pocket chamber values ranged from a low of 45% to 65% of the filmbadge results.)

3. The filmbadge results for personnel working with low gamma energies were annotated high energy on the written reports.

4. Good agreement between filmbadge and pocket chamber results were found for personnel principally exposed to high energy gamma emitters. (The pocket chamber values were 75% to 95% of the filmbadge values).

5. The reported exposures were, almost without exception, gamma exposures rather than beta exposures.

6. Occasional inexplicably high gamma exposures were reported. (The filmbadge results were 3 to 4 times higher than the pocket chamber results.)

7. When exposed under "ideal" conditions (with a film in a plane perpendicular to a line drawn from a point source

EXHIBIT B-11

to the badge) the filmbadge results were in good agreement with pocket chamber values independent of gamma energy.

One possible explanation for the above contradictory results was that under actual exposure conditions the area under the lead and aluminum filters was being exposed to low energy gammas entering the badge from the edges or top of the badge, thus not being stopped by the filters. This would result in little difference in darkening of the filtered and unfiltered areas of the film. Such an exposure would be interpreted as having been due to high energy gammas. The calibration factor for conversion from film density units to exposure is larger for high energy than for low energy. This effect (and ensuing error) should be inversely proportional to the energies of the gammas from the source and directly proportional to the angular deviation from the perpendicular.

A series of experiments were begun to confirm the above supposition. Two groups of filmbadges were hung in a circular array approximately equidistant from a source hung from the center of the circle. Half of the badges were fixed in vertical planes perpendicular to lines drawn from the source to the badges. The other half of the badges were alternately suspended in vertical planes by threads. A fan was used to used to cause random rotation of those badges suspended by threads. Iodine-131 was used as a high energy gamma source for the first experiment. One set of badges received about 200 mrem and the second set about 2 rem. As expected the rotating badges did read somewhat higher than the fixed badges.

Mercury-197 was used as a low energy gamma source for the second experiment. The above exposures were repeated. The results of this experiment were not available to me before the trip to Landauer.

Upon arriving at Landauer, I requested and received the experimental results which had been calculated only that morning. As anticipated, the recorded values for the films exposed under the "ideal" conditions were only 63% of the values recorded for the rotating films simulating actual exposure conditions. This error was in good agreement with the error found between filmbadge and pocket chamber results when worn by our personnel.

Additional calibration data has been obtained on each of our 58 pocket chambers as a function of energy. The absolute exposures have been measured using both the Victoreen R-meter and the Victoreen Radocon 555 as secondary standards.

EXHIBIT B-12

Current exposure studies include a repeat of earlier experiments adding Technetium-99m under more exact conditions to check not only relative but also absolute values.

In addition to the fixed and rotating badges, I am also exposing badges with missing filters. I suspect that the previously inexplicable spikes which occurred on occasion were due to filmbadges with missing lead filters. I expect that an error factor of 3 to 4 will be demonstrated upon completion of the current experiment.

The device described in the July 2nd letter to Bob Landauer has been very useful in detecting faulty filmbadge holders. Approximately 10% of the holders were found to be defective and have been removed from service. This check has been added as a permanent step in filmbadge handling procedure.

Sufficient data should soon be available to present a strong case to the Commission.

D. W. Soldan

DWS:cm

cc: W. H. Wahl

EXHIBIT B-13

M/N TLD DATA[a]

January - March 1970

Exposure Period	Location	Average Net Dose (mrad ± E)	Ave. Net Dose Rate (mrad/30 days)
1/9 - 2/7/70	#1, Bennett Box Co.	427 ± 26	442
(29 days)	#2, Dorsett Rd. Fire Station	<1	-
	#5, M/N N Perimeter Fence	90 ± 6	93
	#6, M/N E Perimeter Fence	4 ± 2	4.1
	#7, M/N S Perimeter Fence	4 ± 2	4.1
	#8, M/N W Perimeter Fence	7 ± 3	7.9
2/7 - 3/7/70	#1, Bennett Box Co.	261 ± 40	279
(28 days)	#2, Dorsett Rd. Fire Station	<4	-
	#5, M/N N Perimeter Fence	56 ± 7	60
	#6, M/N E Perimeter Fence	<6	-
	#7, M/N S Perimeter Fence	<[illegible]	-
	#8, M/N W Perimeter Fence	<6	-
3/7 - 4/11/70	#1, Bennett Box Co.	272 ± 26	233
(35 days)	#2, Dorsett Rd. Fire Station	No results	
	#5, M/N N Perimeter Fence	80 ± 5	69
	#6, M/N E Perimeter Fence	3 ± 2	2.6
	#7, M/N S Perimeter Fence	<2	-
	#8, M/N W Perimeter Fence	9 ± 2	7.7

[a] The results are the average measured doses to TLD 700 tissue equivalent material minus the average measured dose at the background location. A "t" test is performed on the results from the groups of dosimeters close to the plant to determine if their exposures are significantly different from the background exposure at the 98% confidence level. If a significant exposure is received by a group of dosimeters, the statistical uncertainty of the average net dose is also reported. The uncertainty is calculated using the formula $E = S_p t(\frac{1}{N_B} + \frac{1}{N_{SL}})^{1/2}$ in which S_p is the pooled standard deviation of the N_B background and N_{SL} field sampling location dosimeter readings. The value of t used is the tabulated value at the 98% confidence level for the appropriate number of degrees of freedom. If the average net dose to a group of dosimeters is not significantly different from background, the quoted result is <E.

EXHIBIT C-1

Exposure Period	Location	Average Net Dose (mrad ± E)	Avg. Net Dose Rate (mrad/30 days)
4/11 - 5/11/70	#1, Bennett Box Co.	536 ± 30	536
(30 days)	#2, Dorsett Rd. Fire Station	<3	-
	#5, M/N N Perimeter Fence	113 ± 6	113
	#6, M/N E Perimeter Fence	<4	-
	#7, M/N S Perimeter Fence	<3	-
	#8, M/N W Perimeter Fence	5 ± 4	5
5/11 - 6/15/70	#1, Bennett Box Co.	318 ± 35	273
(35 days)	#2, Dorsett Rd. Fire Station	<2	-
	#5, M/N N Perimeter Fence	95 ± 2	81
	#6, M/N E Perimeter Fence	3 ± 3	2.6
	#7, M/N S Perimeter Fence	3 ± 2	2.6
	#8, M/N W Perimeter Fence	7 ± 2	6.0
6/15 - 7/18/70	#1, Bennett Box Co.	381 ± 13	346
(33 days)	#2, Dorsett Rd. Fire Station	<2	-
	#5, M/N N Perimeter Fence	71 ± 9	65
	#6, M/N E Perimeter Fence	Missing	-
	#7, M/N S Perimeter Fence	3 ± 2	2.7
	#8, M/N W Perimeter Fence	8 ± 2	7.3

EXHIBIT C-2