Form AEC-411 (4-58)

UNITED STATES ATOMIC ENERGY COMMISSION

2-24-60

COMPLIANCE INSPECTION REPORT

1. Name and address of licensee

Mallinckrodt Nuclear Corporation
Second and Mallinckrodt Streets
St. Louis 7, Missouri

2. Date of inspection

January 12 thru 14, 1960

3. Type of inspection Initial

4. 10 CFR Part(s) applicable

20 and 40

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

License No.	Date	Expiration	Scope and Conditions
C-4495 (C-4435)	1-1-59	1-31-60	Source material for further processing, for studies in connection with the preparation of reactor fuel elements, for research and development activities and for resale. This license extends to your Hematite Plant.

6. Inspection findings (and items of noncompliance)

The licensee conducts a source material and special nuclear material processing program under License Nos. SNM-33, SNM-230, C-2734 and C-4495. The program is conducted in the licensee's plant located at Hematite, Missouri. The radiological health and safety program at the Hematite plant is under the direction of appropriately trained and qualified personnel and appears to adequately protect the health and safety of licensee employees and the public from potential radiation hazards incident to the activity. Criticality control is the responsibility of the Plant Manager with assistance from personnel who have had a basic course dealing with criticality at Oak Ridge National Laboratory. Generous use is made of consulting services where criticality problems are involved. Adequate radiation monitoring equipment is available for use in the program. Material accountability is accomplished with an efficient control and record system. Personnel are monitored with a licensee film badge service and bio-assays that are commercially furnished. Surveys have been routinely made of airborne radioactivity, general and specific radiation levels and concentrations of radioactivity in the licensee's plant effluent. Records have been kept of the surveys and a review of the records revealed no levels or concentrations in excess of the limits specified in 10 CFR 20. The plant areas and containers are posted as required by 10 CFR 20.

No items of noncompliance were observed or otherwise noted during the course of this inspection.

7. Date of last previous inspection

None

8. Is "Company Confidential" information contained in this report? Yes ☐ No ☒
(Specify page(s) and paragraph(s))

DISTRIBUTION:

Division of Inspection
Washington, D. C.

Division of Licensing and Regulation
Washington, D. C.

William K. Beery
(Inspector)

Approved by:
Jack C. Sutherland
Oak Ridge Operations
(Operations)

February [illegible], 1960
(Date of report)

A-28

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DETAILS

I. GENERAL INFORMATION

9. On January 12 - 14, 1960 announced reinspection (1) was made of the special nuclear material and source material activities conducted by the Mallinckrodt Chemical Works and the Mallinckrodt Nuclear Corporation, under License Nos. SNM-33, SNM-230 and C-2734 at Hematite, Missouri. During the same dates an announced initial inspection was made of the source material program conducted, under License No. C-4495 by the Mallinckrodt Nuclear Corporation at Hematite, Missouri.

10. The inspection was conducted by John Sears, Inspection Division, NYOO and W. W. Peery, Inspection Division, OROO. Mr. Sears inspected the criticality aspects of the Licensee's special nuclear material program under License Nos. SNM-33 and SNM-230 and his findings are included as a part of this report. Licensee personnel interviewed and furnishing information during the inspection included the following:

    Dr. G. W. Tompkins, Manager, Research & Development
    Special Metals Division

    Dr. E. D. North, Manager, Hematite Plant

    Mr. J. W. Miller, Supervisor, Industrial Hygiene Department

    Mr. Jack Rosser, Process Engineer, Hematite Plant

11. Dr. W. M. Leaders served as Technical Director of Special Metals Division at the time of the last inspection. Dr. Leaders left the employ of the Licensee in the Summer of 1959 and accepted a position with the Spencer Chemical Company, Kansas City, Missouri. Dr. Tompkins is now responsible for those duties being performed by Dr. Leaders at the time he left the employ of the Licensee particularly with reference to criticality problems involving the Research and Development group. Dr. North is responsible for specific and over-all criticality problems at the Licensee's Hematite plant as well as for material accountability which was also previously a responsibility of Dr. Leaders.

12. In a letter dated December 15, 1958, Mallinckrodt Nuclear Works informed the Division of Licensing and Regulation that all nuclear fuels business was being transferred to a wholly owned subsidiary, the Mallinckrodt Nuclear Corporation, and that it was therefore requested that License Nos. SNM-33, SNM-230 and C-2734 be issued to the Mallinckrodt Nuclear Corporation with an effective date of January 1, 1959. The Division of Licensing and Regulation revoked SNM-33 and SNM-230 with a letter to the Licensee dated January 26, 1959 and enclosed reissuances of License Nos. SNM-33 and SNM-230 in the name of Mallinckrodt Nuclear Corporation with an effective date of January 1, 1959. License No. C-2734 was not changed and it expired on November 30, 1959. The expiration of the license was discussed with Drs. Tompkins and North both of whom stated that the source material activities at Hematite are supposed to be conducted under License No. C-2734 and that their failure to attend to the matter of renewal of the license has been an oversight which will be corrected immediately.

However, it was understood that source material has not been received under C-2734 since its expiration.

13. The source material program under License No. C-4495 was a limited research program which involved the receipt by the Licensee on October 10, 1959 of 1720 lbs. of natural UF_6 for studies on the preparation of reactor fuel elements. This program was conducted in the same facilities and subject to the same radiation safety controls as those employed for the programs conducted under SNM-33 and C-2734 at Hematite, Missouri. The program under C-4495 is said to have been completed with the shipment of 245 lbs. of UO_2 to the General Electric Company. The remainder of the material is still on-hand. The program under SNM-230 involved research with a process for the direct conversion of UF_6 to UF_4. One order of 20 lbs. of contained U-235 as uranium enriched to about 20% and two orders of 40 lbs. of uranium of 20% U 235 enrichment were received, used in the research program and have since been processed to Hematite final product and shipped to licensed receivers. The direct conversion process is now a part of the over-all Hematite plant process under SNM-33 and no further work will be done under SNM-230. The same facilities and radiation safety program described in this report for SNM-33 and C-2734 apply to the program that was conducted under SNM-230.

II. ORGANIZATION

14. The Mallinckrodt Chemical Works is one of the older chemical companies in this country and has been commercially processing uranium and uranium compounds since 1942. The Company is a prime contractor of the U. S. Atomic Energy Commission and currently operates the Commission's uranium refinery plant at Weldon Springs, Missouri and formerly operated a similar plant for the Commission on Destrehan Street in St. Louis, Missouri.

15. The Licensee's program at Hematite is conducted by the Special Metals Division which is under the management of Mr. F. M. Belmore who reports to Mr. J. Fistere, President of the Company. Drs. North and Tompkins report to Dr. R. W. Shearer, Assistant Manager of the Special Metals Division who reports to Mr. Belmore. The Hematite process is supervised by two Process Engineers who have one plant foreman and three shift foreman reporting to them. At the time of the last inspection the total plant force consisted of 25 employees, this has increased to a total of 97 personnel. This total plant force includes operations, maintenance, guards and analytical laboratory personnel. A small research and development group is separate and reports to Dr. Shearer through Dr. Tompkins. Supervisory and key operating personnel at Hematite have had previous experience in processing normal uranium in the Licensee's facilities in St. Louis, Missouri.

III. PROCESS

16. At the time of the last inspection the plant process was one in which uranium dioxide (UO_2) was produced from normal and enriched grade uranium hexaflouride (UF_6) through an intermediate diuranate (ADU) step..

However, the original process for converting UF_6 to UO_2 by going through the ADU state has been superseded by a direct conversion process in which the UF_6 is reduced by an organic reductant to UF_4 which is filtered through a stainless steel filter onto trays 1 inch in depth. UO_2 powder is produced in batch safe quantities that may also be converted to UF_4 in a furnace into which HF is introduced. The UO_2 is placed on 1 inch deep trays in this furnace. UF_4 is converted to metal by placing it into a 5 inch id. sleeve which is placed in a reduction reactor which is ignited by a reduction coil thus reducing the UF_4 to uranium metal. Process scrap filter bags, clean-up scrap, rejected pellets, destructive test samples and analytical sample scrap is all re-processed and reclaimed product sent to the customer.

17. The Licensee's Hematite facility is located on a 150 acre tract of land which was formerly farmland. The plant site is ~ 40 miles south of St. Louis, Missouri, near the town of Hematite and is bound on the north by Missouri State Highway 21-A and on the south by Joachim Creek, and on the east and west by other private property. The plant is almost centrally located on the 150 acres and the nearest occupied property is a farm house located several hundred yards to the northwest of the plant.

18. The production facilities consist of two main buildings, each with several thousand feet of floor space. Located between these two buildings is an incoming storage and blending building as well as an outgoing storage building which is under construction. The outgoing storage building currently in use is located to the west of the two main buildings. The above described facilities are fenced with guards on duty 24 hours a day.

19. The westerly most of the two main plant buildings contains three separate process areas as follows:

A. 20% U 235 and higher - cermet type fuel elements and metal manufacturing is carried out here.
   Auxiliary areas to A are:
   (1) solvent extraction of enriched uranium from scrap.
   (2) soluble products area for the production of crystals or solutions of uranyl nitrate, uranyle sulfate and uranyl flouride.
   (3) process for the direct conversion of UF_6 to UF_4 from which the UF_4 is further processed to produce either metal or UO_2. This equipment was not present at the time of the last inspection.

B. Large scale production of low enrichment materials up to 5% U 235 with the end product being ceramic grade UO_2.

C. A third process area involves two sections as follows:
   (1) Solvent extraction of low enrichment uranium from scrap.
   (2) Manufacture of 5 - 20% U 235 compounds.

The easterly most of the main buildings contains the UO_2 pellet production facility which includes complete preparation and packaging of pellets. This is the more recently completed building and it also contains the majority of the research and development activities at the Hematite plant as well as an area used only for storage.

20. The incoming storage vault is a one-story reinforced concrete building with a concrete floor containing no drain. The vault is about equidistant between the two main buildings. The walls of the vault are equipped with chains and brackets to secure shipping containers for adequate and consistent spacing as well as grouping of material of same enrichment. Enriched material is said to be moved only with the knowledge and approval of Dr. North. The performance of this control procedure is the responsibility of process engineers and foreman.

21. The blending room is constructed of concrete block with dimensions of ~20' x 50' and is located south of and adjacent to the incoming storage vault. Blending equipment consist of ten equally spaced 15 gallon drums inside a dust control hood. The drums are separated by 1 ft. slabs of concrete.

22. The outgoing storage vault is a small building 10' x 20' built of reinforced concrete and located ~50 feet to the west of the two main plant buildings. This vault is equipped with chains and brackets to maintain proper spacing of containers.

23. Instrumentation for the Licensee's radiation safety program includes the following:

    2 Technical Associates Model No. 3 Juno (α,β,γ)
    3 Victoreen "Thyac" Model 389C survey meters (β,γ)
    3 Victoreen Model 356 survey meters (α,β,γ)
    2 Nuclear Measurements Corporation Model PC - 3A counters (α,β,γ)
    3 Hudson air samplers
    3 Gast air samplers
    1 Gelman portable battery-operated sampler

An emergency monitoring station has been established in a building located about 200 yards from the main Hematite plant buildings. Survey instruments available are: (1) Juno (5 r/hr max. range); (1) Juno (50 r/hr max. range). Both are periodically checked for operability. A Nuclear Measurements Corporation "Gammalarm", model GA-2, system has been installed in the Licensee's Hematite plant as required by 10 CFR 70.24. The alarm system appears to meet the requirements of this section of the regulations and fulfills the Licensee's obligation to install the system as described in his letter of January 22, 1959 to the Division of Licensing and Regulation and in Licensee drawing No. 3383-1 which is identified as having been formerly filed with the Commission January 26, 1959. The instrument system is calibrated at six-month intervals with an NBS calibrated radium source and is routinely tested at the same time each Monday morning with a 2.5 mr/hr gamma source for response and as a rough check on calibration. Emergency procedures have been drawn-up and distributed to employees relative to action to be taken in the event of a nuclear incident. The procedures consist of the following parts:

1. Emergency instructions to all personnel.
2. Emergency instructions to guard force.
3. Emergency instructions to emergency director.
4. "Plan A" (nuclear incident) for emergency director.
5. "Plan B" (suspected malfunction in nuclear alarm system) for the emergency director.

The emergency instructions were given to personnel with written instructions from Mr. North, plant manager, to study and know the instructions. The procedures were furnished to the Division of Licensing and Regulation with licensee letter dated June 5, 1959.

24. Complete protective clothing is furnished by the licensee to operating personnel. Clothing includes underwear, coveralls, shoes, caps and gloves. Research personnel and visitors are supplied laboratory coats and shoe covers. There are two separate clothing change rooms for operating personnel. The two change rooms are separated by a shower room so that operators can change company clothing in one room, shower and change personal clothing in the other. All company clothing is pre-laundered before being sent out to a commercial laundry. Mr. Miller stated that pre-laundry wash water has not been monitored but that it is not expected to significantly contribute to the radioactivity concentrations in the over-all plant effluent.

V. RADIATION MONITORING

25. Mr. J. W. Miller is responsible for the Licensee's radiation safety program. Mr. Miller is Head of the Industrial Hygiene Department at the Mallinckrodt Chemical Works, St. Louis, Missouri and has responsibility for the over-all radiation safety programs in all of Mallinckrodt's commercial activities being conducted under AEC licenses. Mr. Miller directly supervises the radiological health and safety program at the Licensee's Hematite plant and he reports directly to Mr. Moore, Vice President in charge of Operations. Mr. Miller has his office at the Licensee's Euxenite plant in St. Louis, however he spends some part of each week at the Hematite plant. It is understood that Mr. Miller depends on and gets close cooperation from Dr. North, Manager of the Hematite plant, in matters pertaining to the radiation safety program at Hematite. Mr. Miller is a chemical engineer by academic background and he has had several years of experience in the radiation safety problems associated with uranium processing at the Mallinckrodt

Chemical Works plants in St. Louis, Missouri. Mr. Miller is assisted at Hematite by one technician. Drs. North and Leaders had responsibility for all criticality problems at the Hematite plant at the time of the last inspection however, since Dr. Leaders left, responsibility for criticality is now shared by Drs. North and Tompkins with Dr. North having primary responsibility.

26. Personnel are routinely monitored with a film badge program which is conducted entirely by the Licensee. At the time of the last inspection a film badge service supplied by St. John's X-ray Laboratory, Califon, New Jersey was being used, however, the service was not considered satisfactory and was, therefore, discontinued. In the present program the Licensee furnishes a stainless steel badge with open window and shielded reading capability and completely processes the badges and film. Film processing is done in a dark room facility in the Medical Department of the Mallinckrodt Chemical Works plant in St. Louis, Missouri. The procedure for film development, calibration and reading is patterned after the film badge program in effect at the AEC's Weldon Springs plant. The film is gamma calibrated with a radium source which has been calibrated by the National Bureau of Standards. A natural uranium source is used to calibrate the film for β. The film were processed on a weekly basis at the outset of the program but it was found that monthly processing of the film gave more nearly correct radiation exposure readings because the higher cummulative radiation darkening of the film increases the accuracy of the method for reading the lower exposures recorded on the film. Individual exposure records are maintained. During the period when a weekly film badge program was in effect the records reflect weekly and quarterly cummulative exposures. Records for the current monthly program show an average weekly exposure, monthly and quarterly cummulative exposures. The weekly records show exposures to 100 mrep β and the monthly record shows exposures to 240 mrep β with averages of 80 - 90 mrep. Gamma readings to 15 mrem for the monthly program are also recorded. The above quoted exposures are all for operations personnel while recorded exposures for pilot plant, laboratory and maintenance personnel have all been less. The records reflect no personnel exposures that have exceeded the permissible limits of 10 CFR 20. Film badges for the Licensee's program at Hematite contain Indium foil as an aid to segregation of personnel exposed as a result of an accidental criticality incident.

27. Licensee Hematite plant operating personnel submit urinalysis samples on a 3 - 6 months basis depending on job assignment. Records of urinalysis results since 1957 show a high of 329.9 d/m/l uranium α and a average of 3 - 5 d/m/l α as compared to a 45 d/m/l tolerance for such samples. Mr. Miller stated that in all cases where the count exceeded tolerance the individual involved has been required to re-sample under direct supervision to lessen the probability of sample contamination. The concentration under controlled sampling conditions has always decreased within three samplings to below the permissible 45 d/m/l concentration. Urinalysis is performed for the Licensee by the Nuclear Service and Engineering Corporation, Pittsburgh, Pennsylvania.

28. The facilities in the Licensee's Hematite plant were designed and installed with the philosophy that the best approach to airborne radioactivity control is the isolation and containment of specific parts of the process on equipment that are apt to contribute to and collectively cause airborne activity problems in the general plant processing areas and adjacent areas. The development of the above philosophy in the Licensee's plant appears to have accomplished an acceptable degree of control and protection of Licensee personnel and the public from airborne radioactivity incident to use of the licensed material. A complete airborne radioactivity study has been made of specific jobs as well as general air concentrations inside and outside the plant area. Based on sample results inside the plant a factor has been derived and assigned the various areas sampled. This factor is used to determine personnel over-all exposures to airborne activity. Records of personnel airborne radioactivity exposures for the period from May 1959 to January 1960 have not exceeded 5.0×10^{-11} μc/ml for 40 hr. week except in a few isolated cases where the value was up to 5.6×10^{-11} μc/ml/40 hr. week. The method of determining personnel exposures would not be expected to be accurate enough to determine definitely that in these few cases (~ 4) that the exposures did in fact exceed 5.0×10^{-11} μc/ml/40 hr. week. Further, Mr. Miller stated that periodic re-evaluation is made of the exposure factors assigned a given area based on the most recent air sampling data. The more recent, and considered more valid factors, when applied to the same exposure circumstances that resulted in the above slight overage bring the personnel exposures to within the 5.0×10^{-11} μc/ml/40 hr. week permissible level. During the period from October 1958 to October 1959, 86 samples taken in unrestricted areas around the Hematite plant gave a high of 3.15×10^{-12} μc/ml α and a low of none detectable with an average of 0.2×10^{-12} μc/ml α. Milling hood stacks were sampled on October 11, 1958 with gross α results as follows: (1) 7.89×10^{-10} μc/ml; (2) 7.38×10^{-11} μc/ml; (3) 3.27×10^{-11} μc/ml. Mr. Miller stated that these samples were taken to determine uranium process losses. Although potential airborne radioactivity producing operations are enclosed in filters hoods, masks were observed being worn by personnel when actual entry into walk-in hoods is necessary.

29. Routine radiation surveys are made of the Hematite plant area with portable radiation survey instruments. Results of the surveys are recorded on floor plans. These surveys are usually made weekly by the health physics technician but the frequency has varied depending on the work load of the technician. Records of the surveys show almost all readings to be < 2.5 mr/hr gamma with an occasional beta plus gamma reading recorded as 20 +. Mr. Miller stated that instruments with 20 mr/hr maximum range have been used for the surveys and that the readings recorded as greater than 20 mr/hr would not be expected to exceed 20 mr/hr to a significant extent. Mr. Miller stated that no readings in excess of 2 mr/hr have been observed outside the Hematite restricted area.

30. Liquid waste from the Licensee's Hematite plant is primarily contaminated with ammonium diuranate. These solutions have been treated with lime to precipitate the uranium and flouride content then the slurry is brought to boiling to remove the ammonium while the filtrate is filtered. The filter coke is stored for reprocessing. The filtrate, which is primarily

pure water is released to the process sewer line. Ninety-nine percent of the ammonium flouride liquors come from a plant section that handles only up to 5% enrichment materials. All Hematite process wastes are discharged due west through a sewer that empties in a stream which flows south through the Licensee's property. Since the last inspection this stream has been dammed, below the point of entry of the plant effluent, such that the resultant small lake has backwater which extend to the source of water feeding the lake which is a natural spring located within the Licensee's restricted property. Construction of the dam has given the Licensee better control and sampling of the liquid effluent. All water flowing over the dam passes through a Weir box type sampling arrangement which takes a continuous sample of a known volume. The effluent flows several hundred feet from the dam into Joachim Creek which is not on Licensee property. Joachim Creek empties into the Mississippi River several miles from the confluence of the Licensee's waste stream and the creek. Grab samples taken, during the period from 4-24-59 to 6-19-59, at the same location as the continuous sampling station showed alpha activity of 4.51×10^{-9} to 3.2×10^{-7} μc/ml. Grab samples prior to that, on August 14, 1958 showed gross α of 2.96×10^{-8} μc/ml and gross β of 1.5×10^{-5} μc/ml. More recent sampling for the period from 8-17-59 to 12-31-59, with periods of sampling from 3 to 7 days, showed 1.26 - 8.25×10^{-7} μc/ml alpha and 1.33 - 9.37×10^{-7} μc/ml beta activities. Samples have been taken of the spring water which feeds the licensee's effluent stream. Samples are said to have been taken at a point where only the natural radioactivity content of the spring water would be present. Sample results for the spring water showed the following: Maximums: 1.15×10^{-8} μc/ml alpha and 2.37×10^{-7} beta; Averages: 3.82×10^{-7} μc/ml alpha and 3.40×10^{-7} beta. In 1957 the licensee established 4 effluent sampling stations as follows: (1) spring stream several hundred feet south of entry of licensee plant effluent; (2) upstream on Joachim Creek several miles from confluence of spring stream and Joachim Creek sample taken at bridge across Joachim Creek near Hematite, Missouri; (3) approximately 100 ft. below the point of entry of spring branch into Joachim Creek; (4) several hundred yards downstream on Joachim Creek from confluence of the spring stream and Joachim Creek. Sample results (gross alpha) (1) 1.44×10^{-7} μc/ml; (2) 1.26×10^{-7} μc/ml; (3) 1.84×10^{-7} μc/ml; (4) 1.89×10^{-7} μc/ml. The licensee's method of analysis is said to be capable of determining radioactivity concentrations in the effluent down to 5.0×10^{-9} μc/ml. Mr. Miller stated that the permissible concentration for uranium in effluent, 7×10^{-6} μc/ml as specified in Appendix B of 10 CFR 20, is applied since the radioactivity contained in the effluent is identified.

31. Mr. Miller directed the organization of the radiological health and safety program at the licensee's Hematite plant. Routine daily functions of the program, such as air sampling, radiation surveys, etc., are carried out by a technician who reports to Mr. Miller. Compliance by Hematite personnel with the over-all program is indirectly supervised by Mr. Miller through Dr. North who promotes and requires compliance with the program through process engineers and foremen. Mr. Miller indicated that he has always received reasonable cooperation and support from Dr. North in promoting and maintaining the radiation safety program at Hematite.

Dr. North stated that enough basic facts, concerning the nature of accidental criticality, have been given to personnel to nurture a respectful understanding of the potential radiation hazard involved.

32. The licensee has a problem with storage of outgoing material at present time due to the inability of some customers to accept materials as soon as Mallinckrodt has them ready. This has resulted in one large storage room being completely filled with five gallon pails filled with material ready for shipment. The pails are stored on the floor with spacing of 2 feet on centers. Dr. North demonstrated the proposed shipping container which he stated has been licensed by the AEC on a short-term basis. This shipping container consists of a 5 gallon can with a rubber gasketed lid held in place by an angle iron framework in the center of a 55 gallon drum, which is also sealed by a rubber gasketed lid. Use of these containers was approved by the Division of Licensing and Regulation for one shipment and approval was extended for a six-month period and this was then extended to a year. Dr. North stated that he could not understand why the Division of Licensing and Regulation would not approve his most recent request to further approve use of these shipping containers. Dr. North stated that the AEC had expressed concern about the possible double stacking of the containers. Dr. North stated that double stacking of the containers has not been done and that they do not intend to in the future.

VI. <u>POSTING</u>

33. Shipping containers are monitored by Health Physics to assure compliance with ICC Regulations and labeled externally with ICC labels. A color coded card system is used on containers to identify categories of enrichment. In conjunction with this coding system, one part of each card is devoted to posting and labeling as prescribed by 10 CFR 20 which assures that proper labeling will be affixed to the containers. Plant areas are posted as required by 10 CFR 20.

VII. <u>MATERIAL ACCOUNTABILITY</u>

34. Effective material accountability procedures are directed and carried out by Dr. North. Cylinders of UF_6 are weighed upon receipt and the weight recorded in a log book kept in Dr. North's office. The cylinders are assigned a number at this time which identifies the material all the way through the process. Material being processed is weighed after each step in the process and amounts recorded on process flow sheets which serve as a check against other accountability records. Primary responsibility for accountability rests with Dr. North who submits periodic accountability reports to the AEC on Form #578.

VIII. <u>NUCLEAR SAFETY</u>

35. General
Dr. North is responsible for the enforcement of criticality procedures at the Hematite Plant. Dr. North said that three engineers from Mallinckrodt had attended the Criticality School at Oak Ridge last fall. One man was from his Manufacturing Section, one man from the

Research and Development Department under Dr. Tompkins, and one engineer from the Design Section in Mallinckrodt's Chemical Department at St. Louis. Dr. North said that any new process will be reviewed independently for criticality hazards by each one of these three men, and also by Dr. Tompkins and by himself. If after this review, outside consultation is felt necessary, Mallinckrodt Nuclear will call upon people at Oak Ridge and/or Rocky Flats, for review of the proposed operation.

36. Criticality Control Procedures
The criticality control procedures vary according to the process and the area in the plant. All of the procedures have been written and published, and Dr. North keeps a copy of each procedure in his desk. The procedures have not been combined into a safety manual. Some of the procedures have been amended since they were originally formulated. They are amended by the issuance of an Amendment Sheet which is reviewed by, at least, Dr. North and the engineer on his staff who has attended the Criticality School. The procedures are not issued to the workmen on the job for fear of over-burdening them with an avalanche of information which may not be related to the particular operation that each man performs. Instead, the particular written procedure for each individual operation is kept by the Process Engineer who instructs the foreman and the operators under his supervision. Process flow sheets and instruction sheets are issued to the operators but these sheets contain only manufacturing information - there is no data on the sheets pertaining to the safe batch limit or the criticality hazards of the operation. There is a Process Engineer in charge of each one of the rooms in which various operations are performed, and it is his responsibility to see that safe procedures are followed.

In general, criticality control is obtained by safe geometry, by limited safe mass batches, or by administrative control, or in some cases, by combinations of any of these controls.

37. Criticality Control in Specific Operations

1. Storage
Uranium coming into Mallinckrodt Nuclear Corporation is received in UF_6 cylinders from Oak Ridge. These cylinders are held in always safe open framework welded angle-iron bird-cages. The highly enriched material cylinders are taken immediately out of the bird cages and placed in racks in the storage vault, one cylinder to a rack location. Rack locations are two feet apart. There are nine such locations. However, they are so made that it could be possible for more than one cylinder to be placed in a particular rack. Dr. North said that this is controlled by the Process Engineer and the Foreman of the highly enriched room, who personally unload new cylinders of highly enriched material when it arrives. When the cylinders are received they are locked into position in their racks by a chain and a lock. The key for this lock is then kept by the Process Engineer in the highly enriched room. Cylinders of low enriched material are kept in a separate part of the storage vault in bird cages, until they are needed in the manufacturing process.

When a new cylinder of highly enriched material is required, written permission must first be obtained from Dr. North before this cylinder may be moved from the storage vault. Dr. North keeps a shipping record of each cylinder received from Oak Ridge. These cylinders are stamped with an identifying number by Oak Ridge. The key to unlock the required cylinder is then gotten from the Process Engineer resulting in a double check on the procurement of highly enriched material. Dr. North said that no attempt is made to assay the enrichments of the UF_6 as it is received from Oak Ridge. They depend solely and completely upon Oak Ridge records. According to Dr. North he is aware of only two instances in which Oak Ridge had made a mistake in labeling the enrichment of the material in these cylinders, and these two fiascos occurred quite a few years ago. He said that he had checked with Oak Ridge people during the last two years and that he had been assured by them that there are so many checks on the enrichment of a particular cylinder that a mistake is impossible.

2. Highly Enriched Area (Red Room)

Criticality control in the highly enriched room is attained and maintained by safe geometry. The only apparatus in this room, observed during a very thorough inspection, which was not of a safe geometrical design, was the drying oven which could conceivably hold more than one tray having a limited safe batch. All pipes and cylinders in this room were five inches and under. There were no open beakers of more than one-gallon capacity.

In addition to safe geometry as the control in this room, safe batch limits are also employed. When a cylinder of UF_6 is brought into the room, it is weighed and a batch which contains only .7 pound of U_{235} is allowed to go through the process. This batch is given an identifying letter and number which follows it all the way through the process until the material is put into a shipping container.

3. Medium Enrichments and Low Enrichments Room

Batch control is employed in these rooms. The batch control starts by the review of a proposed job by Dr. North, who plans the process from a manufacturing viewpoint. In his planning, he will state a particular safe batch for the stated enrichment of material in this job. Dr. North said that he gets all of his safe batches from the charts in K-1019. When a Process Engineer then gets the instructions to proceed with a particular job, the Process Engineer must write an amendment to the published procedures for a particular batch for this enrichment. This means that the Process Engineer must also check the safe batch size for this enrichment. The amendment sheet is countersigned by Dr. North. If a cylinder of UF_6, as received, contains more than one safe batch, it is subdivided into individual safe batches in cylinders before they are allowed into the process room.

In the process itself, criticality control is achieved by keeping individual batches separate and distinct. Each batch is labeled as it goes through a particular operation. In the low enrichment room, Dr. North said that two jobs involving different enrichments may be allowed. In such a case, however, the length of time for each operation is such that there will be a definite division between the two enrichments. The UF_6 to ADU process and the drying ovens are all on one side of the plant. The reduction furnaces and the coolers are on the other side of the plant. Materials of different enrichments are kept separated.

4. Blending

In order to get a homogeneous blend of UO_2 powder, the UO_2 is blended in the Blending Room. This blending room is in a separate building. Ten empty 15-gallon drums are placed in each of ten holes in a long stainless steel plate in a hooded dry box. In the rear of this dry box, a single drum containing a limited safe batch of UO_2 powder will move on a dolly past each of the drums. An operator transfers a scoopful, by volume, from the drum on the dolly to each of the stationary drums. When the stationary drums are 65% filled, they are then taken from this dry box, sealed, weighed, and transferred to another hooded dry box where they are tumbled. The criticality control in this room depends upon correct procedure by the individual operator during the blending process, and also in storing cans of powder on 2' centers on the floor.

5. Pellet Plant

Control in the Pellet Plant is by a combination of batch control and procedure. Individual batches of UO_2 powder are brought into the pellet plant by the operator from the blending room. By procedure, the pellet room operator is not permitted to bring powder cans into the room. They go through the whole pelletizing process as an individual batch. UO_2 is in definite batches in the mixer, where the lubricant and the binding material are added to the powder. This material is then fed to the granulating equipment, a drying oven and to the pellet press in a continuous process in individual batches. As the pellets discharge from the press, they fall to a moving tray which takes them through a drying oven. The height of the sides of the tray in the oven is one inch. There is an electrical interlock between the pellet press and the motor drive on the belt, so that if the belt should fail, the press would stop, and there would be no pile-up of pellets after discharge from the press. At the discharge end of this drying oven, the pellets are taken by hand and placed into trays in batch lots. Batches discharging from the pellet press through the oven are separated by means of a molybdenum strip, which is placed on the moving belt after each batch lot. The pellets are then fed through a sintering oven and, still in individual batch trays, finally fed to a spiral hopper which feeds them through a grinding machine. They are taken by an operator from the discharge end of the grinding machine, and placed on a corrugated sheet in a single layer for inspection.

6. Criticality Control in Solutions

Analytical samples are taken from many processes and studies in the laboratory. Any samples which assay at 5% or more are returned to the highly enriched red room in solutions, in one gallon polyethylene bottles. These bottles are clearly labeled with a red tag which states the assay and the amount of uranium in the bottle. After a particular job is finished in the highly enriched red room, all of the apparatus is cleaned with nitric acid. The cleaning solutions, which now contain a small amount of highly enriched uranium, are stored in five-inch polyethylene cylinders which are placed in racks separated by two feet. In order to recover the uranium in these solutions, they are processed through a solvent liquid-liquid extraction. The medium is tributyl phosphate and kerosene. Three cylinders are employed in the extraction, each of which is less than 5 inches inside diameter. Furthermore, a strict batch control is maintained in this process. The volume of solution put through the extraction process is limited to 1-1/2 liters in each batch. Dr. North stated that the average concentration in the solution to be reclaimed has been 100 grams per liter, with a maximum of 200 grams per liter. The precipitate is drained off the bottom of the extraction cylinders in one gallon stainless steel open beakers. The beakers are moved to another hood where the precipitate is further filtered. No more than three batches are allowed within the hooded area of this filtering process at one time and operators have been instructed to maintain 2 feet separation of these batches.

To insure strict administrative control over this process, Dr. North said that three of his best operators had been trained for this job and they alone perform this particular operation. This job is done only on the day shift, so that there can be stricter supervision. Dr. North said that he had selected one operator for training in this job, and that another man with more seniority had insisted that the position should be given to him. North said that the case had finally gone to arbitration, with a decision rendered that the more highly skilled operator, chosen by Dr. North, would be given this job.

7. Waste Recovery

Dr. North stated that there is a strict accounting of all material charged to Mallinckrodt all throughout every process, so that they then are certain that they know the assay of any scrap or residue. Thus, they can be sure of the assay when they put it through a solvent extraction process. As far as criticality is concerned, all material which is to be reclaimed in the highly enriched red room is assumed to be fully enriched.

Scrap material which is accepted for uranium recovery from clients outside of the Mallinckrodt organization is always sampled and analyzed for enrichment before the material is introduced into the recovery process. One of the reasons for this, according to North, is that for accountability purposes he wishes to check the customer's evaluation of the assay. This gives a double check on the assay for criticality control also. In the low enriched room, there is a solvent extraction recovery process for scrap material in which batch control is employed. The batches are calculated by North on the basis of the assay of analytical samples.