Form AEC-117 (4-58)

UNITED STATES ATOMIC ENERGY COMMISSION

COMPLIANCE INSPECTION REPORT

II-A-2 1701

1. Name and address of licensee

Lindsay Chemical Company
West Chicago,
Illinois

2. Date of inspection

December 3, 12, 1957 and April 9, 195

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)

R-106 5-1-56 5-1-58 Scope: Authorized to receive possession of and title to raw source material without limitation as to quantity during term of license from other AEC licensees, and through importation, for processing and resale. Further authorized to transfer and give possession of and title to source material to anyone licensed by AEC within limits of his license. Conditions: Required to maintain records of inventories, receipts and transfers of source material. - License subject to right of recapture or control reserved by Act of 1954. - Subject to all other provisions of the Act, as amended, and to all valid rules and regulations of AEC. - Neither license nor any right thereunder to be assigned or otherwise transferred.

R-106
Amendment #1 3-10-58 4-1-59 Scope: Additional authorization to above of approximately 10,000 pounds of refined source material containing an average of approximately 12% ThO_2 for use in the experimental development of recovery techniques. (Continued)

6. Inspection findings (and items of noncompliance)

Lindsay Chemical Company processes daily approximately thirty tons of monazite sand, average six per cent thorium oxide content, for the production of rare earth and thorium chemical compounds. A 10,000-ton monazite sand inventory is perpetually maintained to satisfy demand requirements. Approximately 6,000 tons of solid waste muds have accumulated from these operations since the inception of this company. The waste muds are stockpiled in a restricted storage area. Liquid process wastes are discharged to the plant sewerage system which empties into a large sump basin located within the restricted storage area. The area is posted with signs bearing the radiation caution symbol and appropriate radiological warning language. Access gates are equipped with chains and locks.

Facilities and equipment for chemical processing of monazite ores and operable radiation detection and measurement instrumentation for personnel monitoring and survey purposes are available. Material control, personnel monitoring, area and environmental survey records are maintained and are available in the offices of the Research Laboratory.

The entire plant is considered by the licensee to be a controlled area. All persons are subject to radiological monitoring control. Approximately 225 persons are provided with film badge service. In addition, self-reading pocket chambers and face-type dust respirators are made available to personnel engaged in operations where airborne radioactivity is known to exist. Film badge records furnished by R. S. Landauer, Jr. & Co. (Continued)

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:

Dr. Marvin M. Mann
Division of Inspection
Washington 25, D. C. (2 cys)

W. Kenneth Davis, Director
Division of Reactor Development
Washington 25, D. C.

Eugene E. Moretti and T. W. Brockett, Jr.
(Inspector)

Approved by:
Roy C. Hageman, Director
Inspection Division, COO
(Operations office)

(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

5. License Number(s), Expiration Date(s), Scope and Conditions (Continued)

R-106 Amendment #1	3-10-58	4-1-59	Conditions: Same.
R-106 Amendment #2	3-24-58	4-1-59	Scope: Changes 10,000 pounds to approximately 20,000 pounds of refined source material containing an average of approximately 12% ThO_2 for development of recovery techniques. Conditions: Same.

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

showed that the accumulated dosages were not in excess of the established limits set forth in 10 CFR 20 regulations. Access to the plant is through guard posts and only these points are posted with radiation caution signs one of which is described in Exhibit A, photograph 13.

DETAILS

9. Scope of Inspection

The following persons visited the facilities of the Lindsay Chemical Company on December 3, 1957:

Roy C. Hageman	Inspection Division, COO
Louis W. Mallott	Inspection Division, COO
Thomas W. Brockett	Inspection Division, COO
Eugene J. Moretti	Inspection Division, COO
Donald I. Walker	Inspection Division, IDO
Robert R. French	State of Illinois
Russell Courtney	State of Illinois

The purpose of the visit was to meet the management personnel, explain the functions of the AEC inspection program and to tour the facilities of the Lindsay Chemical Company.

On December 12, 1957, T. W. Brockett, Jr. and E. J. Moretti, together with Louis E. Gager, Engineering and Construction Division, COO, revisited the Lindsay Chemical Company for the purpose of further reviewing the records and facilities and also to have Mr. Gager take pictures, for inclusion with the final inspection report, of the various processing areas involved in the production of thorium compounds.

On April 9, 1958, T. W. Brockett, Jr. and E. J. Moretti, made a supplemental visit to the Lindsay research facilities to obtain additional information regarding personnel monitoring and area survey records. At this time, a discussion was also held in regard to the possible changes, if any, that would occur should the stockholders vote favorably for the merger of the Lindsay Chemical Company interests with those of the American Potash & Chemical Company.

During this visit Dr. Kremers and Mr. Maryniw informed the Inspectors that new airborne concentration and area survey data had been obtained and would be provided to the Inspectors at a later date. The evaluations would represent the present conditions existing at the plant.

10. The following Lindsay Company personnel were contacted during the visits listed in Item 9:

December 3, 1957

Dr. Howard E. Kremers	Technical Assistant to the President
Mr. Edward B. Maryniw	Radiological Safety Officer
Mr. Richard Vedder	Plant Supervisor
Mr. Lloyd H. Hansen	Purchasing Agent
Dr. R. F. Landauer, Sr.	Radiological Consultant to Lindsay

December 12, 1957

Dr. H. E. Kremers
Mr. E. B. Maryniw

April 9, 1958

Dr. H. E. Kremers
Mr. E. B. Maryniw

10. In addition to the above contacts, Dr. Kremers visited the offices of the Inspection Division, GOO, on January 8, 1958, for the purpose of reviewing the photographs taken on December 12, 1957, to delete photographs or portions of photographs that might reveal company confidential information regarding processing techniques used by Lindsay.

11. Organization

Lindsay Light Company was established in 1902 to produce gas mantles. In 1935 the corporate name was changed to Lindsay Light and Chemical Company to reflect more properly the nature of its business. In 1952 the name was changed to Lindsay Chemical Company. If the stockholders approve a proposed merger during a meeting in April 1958, the Lindsay Chemical Company will become a subsidiary of the American Potash & Chemical Company.

The Company's business is concerned with the production of rare earth and thorium chemical compounds. This work involves the use of large quantities of monazite sand. The production at the present time is based largely on shipments of monazite sand from the Union of South Africa.

The technical aspects of the Lindsay operations are under the direction of Dr. Howard A. Kremers, Technical Assistant to the President, who is a Fellow of the American Institute of Chemists.

Mr. Edward B. Maryniw is the Radiological Safety Officer. He conducts all radiological surveys and is responsible for the maintenance of the records for area surveys, air monitoring and personnel monitoring. Mr. Maryniw received his radiological training in 1956 under the supervision of Dr. Francis Shonka, Physicist, St. Procopius College, Lisle, Illinois.

Dr. R. S. Landauer, Jr., Radiological Consultant, is retained by the Lindsay Chemical Company on a consultant basis to advise and assist the Company on radiological protection matters.

12. Scope of Program

Monazite, a rare earth thorium orthophosphate, found as monazite sand in stream and beach placers in the Union of South Africa, is concentrated by gravity concentration methods. It is milled to a minus 200 mesh product and packaged in 100-pound bags for shipment.

The light brown sand product is used as a source for cerium, rare earth and thorium chemical compounds which the Lindsay Chemical Company produces for a variety of chemical and industrial users. About 97 per cent of Lindsay's business is concerned with the production of these chemical products.

Approximately thirty tons of monazite sand, analyzing on the average six per cent thorium oxide and 45 per cent rare earth oxides, is used daily in the production of rare earth and thorium compounds. Approximately 0.1 per cent of the monazite sand contains uranium as a metallic value. The uranium is not extracted during the processing at Lindsay but is discharged with the solid wastes which are stored within a fenced restricted storage area under the licensee's control.

Monazite sand shipments to Lindsay are scheduled in such a manner that a stockpile inventory is perpetually maintained at a 20,000,000-pound level. This inventory is part of the licensee's long-range planning program, whereby enough source material is on hand to satisfy demand needs and to assure industrial users of a steady supply of cerium, rare earth and thorium compounds.

12. Scope of Program (Continued)

Approximately 225 persons are engaged in the production of rare earth and thorium compounds from monazite sand at the Lindsay Chemical Company.

Recent arrangements have been made by the Lindsay Chemical Company for the procurement of 20,000 pounds of sump cake, a thorium bomb reduction scrap residue from the NLO at Fernald, Ohio. The sump cake is to be used for experimental work in the Lindsay pilot plant to determine its adaptability to chemical processing, the thorium recovery factor, and process cost data. The contemplated extraction process will be essentially the same as that used in the present production. If the sump cake research work proves satisfactory, the Lindsay Chemical Company anticipates the procurement of an additional 520,000 pounds of the cake material for production purposes.

13. Description of Extraction Process

The rare earth and thorium values are extracted from the monazite sand ore by use of batch type processing methods and equipment. The extraction process consists of four steps essentially: 1) opening of ore by chemical digestion; 2) separation of thorium; 3) isolation of rare earths; and 4) separation of cerium from the rare earth fraction. This inspection report will consider only those steps relating to the production of thorium compounds.

Monazite sands are first roasted in rotary type furnaces to oxidize the sulfides commonly found in the sand ores. The roasted sand is then transferred to the fourth floor of the thorium building and dumped into a feed storage hopper from which batches are made up preparatory to chemical processing.

One-ton batches of monazite sand mixed with barium carbonate are fed from a hopper-type feed bucket into externally heated cast-iron acid digestion pots, fitted with cast-iron covers and motor-driven anchor-type stirrers. The addition of sulfuric acid completes the pot charge. The charge is allowed to react for a period of 24 hours to allow for complete digestion. The pot covers are equipped with vents so that sulfuric acid fumes generated during the acid digestion reaction can be drawn off and recovered.

The monazite sand is opened up by the chemical digestion reaction to release the thorium and rare earth values in a product called "pot cake," a gray, viscous mud. The pot cake is transferred in tote boxes to rotary feed tanks which are used to meter out the pot cake to the leaching tanks located on the third floor of the thorium building.

The pot cake is leached with water under controlled conditions to form a slurry product which is pumped to centrifugal separators where the thorium liquid fraction is separated from the rare earth (RE) solid fraction. The thorium liquor is pumped to holding tanks.

The RE solid fraction is leached with water to form a slurry which is pumped to plate and frame filter presses where the RE liquid fraction is removed from an insoluble solid residue called "first gray mud." The gray mud is discharged to the solid waste piles located within the Company's 12-acre restricted storage area. The gray mud contains approximately 1.5 per cent thorium oxide and the 0.1 per cent originally contained uranium. The recovery of these metallic values is not considered economically feasible by Lindsay.

14. Facilities and Equipment (Continued)

A twelve-acre plot of land adjoining the plant area is used for storage purposes. Incoming monazite shipments, semi-processed rare earth salts, and gray mud wastes are stored within this area. A large sump basin, 50 feet in diameter and 25 feet deep, located in this area is used for discharging all waste process waters. The area is a fenced-in area which is posted with signs bearing the radiation symbol and appropriate radiation warning language. The area is designated as a restricted area by the licensee. Gates to the area are equipped with chains and locks. (See Exhibit A, photographs 11, 12.)

An adjoining twelve-acre plot of land is reserved by the licensee for future storage purposes.

Operable radiation detection and measurement equipment is available for use for air monitoring, area survey and personnel monitoring purposes. Face-type dust respirators are available for use by personnel engaged in calcining and roasting operations. Plant areas are posted with large radiation warning signs informing personnel of the hazards involved within the plant area. (See Exhibit A, photograph 13.)

15. Personnel Monitoring

Film badges are made available to approximately 225 plant workers on a weekly basis. In addition to film badges, personnel engaged in calcining and roasting operations are provided with self-reading pocket chambers for on-the-spot observation of accumulated dosages received during these operations.

Personnel film badge exposure records are furnished weekly by R. S. Landauer, Jr. & Company. These records are reviewed by the Radiological Safety Officer. Personnel receiving accumulated dosages approaching the weekly or quarterly maximum permissible limits are rotated in plant duties as a standard precautionary measure by the licensee. A review of the 1957 film badge records showed that there were no 13-week accumulated readings in excess of 3,000 millirems.

Plant supervisory personnel are routinely advised by the Radiological Safety Officer of the accumulated dosages for those individuals under their jurisdiction. Lists are prepared for the supervisors showing film badge readings greater than 100 millirems per week. Supervisors are able, by this method, to schedule the individuals concerned to other duties in other areas of the plant where radioactive material is not being processed. Plant personnel are permitted access to their accumulated dosage records.

Although the main portion of the plant work force is composed of Spanish-speaking people, enough English-Spanish speaking members are available for use as interpreters for the instruction of the others regarding the radioactive hazards associated with the various processing operations within the plant. Training films and descriptive posters accentuating radiological safety information are being contemplated to supplement the verbal instructions now given. These posters will be placed at strategic locations throughout the plant.

The accumulated dosage records for each individual subject to radiological monitoring are maintained by the Radiological Safety Officer. A review of the film badge records for the period December 24, 1957 through March 24, 1958, showed the highest reading to be 270 millirems per week.

13. Description of Extraction Process (Continued)

Small fractions of thorium carried over with the RE separation are recovered by precipitation with pyrophosphate ion, and this is added to the thorium solution in the holding tanks for further processing.

The thorium solution in the holding tanks is treated with hydrofluoric acid to yield thorium fluoride, the basic chemical compound from which all other thorium compounds are derived. Other thorium compounds are produced by treatment with various chemical reagents. Liquid wastes are discharged to the plant sewerage system which empties into a large sump basin located within the 12-acre restricted storage area.

The main production is being directed toward thorium nitrate at the present time. Thorium nitrate is made in various grades of purity. Purification is accomplished by crystallization methods.

High grade thorium oxide is produced by treating crude thorium nitrate solution with oxalic acid to form thorium oxalate. The thorium oxalate is dried and calcined in a rotary type calcining furnace to form a fine thorium oxide powder product. Production of thorium oxide is on an as-needed basis.

Thorium compounds are packaged in plastic bags placed in paper shipping drums labeled in accordance with ICC standards.

14. Facilities and Equipment

Lindsay Chemical Company has a variety of chemical processing and material handling equipment available for use in the production of rare earth and thorium compounds. Only that equipment relating to the production of thorium compounds will be considered in this report. Photographs of the processing equipment are attached to this report as Exhibit A, photographs 1-13.

Separate research and pilot plant facilities are located in the downtown area of West Chicago, Illinois, where pilot plant studies and some production of rare earth compounds are undertaken.

The roaster building is equipped with externally gas-fired rotary-type furnaces for roasting the monazite sands. The furnaces are equipped with canopy-type hoods which are vented to a large bag-type dust collector unit located on the roof of the roaster building. This dust collector unit, Dr. Kramers stated, has materially reduced the airborne concentration of monazite dust inherently associated with the handling of the sand during roasting operations. In addition, face-type dust respirators are provided to personnel engaged in the roaster operations as an additional precaution against ingestion into the body. One end of the roaster building is used to store bags of monazite sand used in the roasting operations. (See Exhibit A, photographs 1, 2, 3.)

Roasted monazite sand is transferred to the thorium building by means of steel tote boxes. A custom-designed feed hopper is used to transfer one-ton batches of sand to the digestion pots. Steel tote boxes are available to transfer the pot cake to the rotary feeders. Manually operated overhead cranes are used to handle tote boxes and feed hopper in all loading and unloading operations.

The thorium building is equipped with a variety of processing equipment for the conversion of monazite sand into rare earth and thorium compounds. These consist of acid digestion pots, leaching, holding and treatment tanks, centrifugal separators, plate-frame and rotary filters, crystallization kettles, calciner furnace, weighing and packaging equipment. (See Exhibit A, photographs 4 to 10 inclusive.)

15. Personnel Monitoring (Continued)

The thorium nitrate packaging area is considered the area of highest potential exposure for an employee. The highest reading that has been received for an employee in this area since film badges have been used was 360 millirems for Estil E. Vest during the week of February 11, 1957. A thirteen-week exposure record was maintained for Mr. Vest after this reading was obtained, and the total accumulated dosage for that period was 1975 millirems.

16. Plant Monitoring

A modified air sampling unit is used routinely to check the concentration for airborne radioactivity at selected locations within the plant area. The method of air sampling is similar to the technique used by the New York Operations Office, Health and Safety Division. The frequency of sampling is dependent upon the type of work done in these selected locations. Particular attention is given to the calcining and roasting operations where the airborne radioactivity hazard is most likely to be present during these operations.

Approximately 1,200 air samples have been taken by the licensee at these locations. The sampling technique consists of drawing air at the rate of 35 liters per minute through the air sampling unit for fifteen minutes and collecting the airborne particulates on a 1¾-inch-diameter Whatman #41 grade filter paper. The filter paper is counted in an alpha scintillation counter. Airborne concentration results are recorded on a radiation air monitor sample and counting record form for each location. (See Exhibit C.)

A radiation monitor report for airborne thorium concentrations is made for each location and provided to supervisory personnel concerned with these locations. Attached to this report is a sketch of the area sampled and a radiation air monitor sample and counting record. (See Exhibit D.)

17. Environmental Monitoring Evaluations

Evaluation of the air sampling results obtained by the licensee have shown that the areas of greatest concern have been the calcining and monazite roasting operations.

Airborne radioactivity concentrations measured during thorium oxide calcining on July 12, 1957, was found to be approximately fifty-six times the maximum permissible concentration specified in Appendix B, Table I, Column 1, 10 CFR 20. These conditions, Dr. Kremers stated, prompted corrective action; since that time, through equipment modification and improved handling techniques, the airborne concentrations have been reduced to a level which is about eight times the maximum permissible limit specified in the regulations. Face-type respirators are provided for personnel engaged in this operation.

Additional study of the calcining operations is being made, Dr. Kremers stated, to determine if it is possible to further reduce these limits in compliance with the regulations.

The roasting operations have undergone similar modification and improvement since July 1957. A large bag-type dust collector unit has been installed on the roof of the roaster building to reduce the dust concentrations inherently associated with the monazite sand roasting and handling operations.

17. Environmental Monitoring Evaluations (Continued)

Dr. Kremers stated that the bag collector unit has been materially useful in reducing the airborne concentrations during roasting operations. Sampling records maintained on roasting operations have shown that the airborne radioactivity concentrations have been reduced to about nine times the maximum permissible limits specified in the regulations. The inherent nature of the sand product still presents a dust problem when the bags are opened for use in the roaster operations. Dr. Kremers stated that this has been alleviated by providing face-type respirators to personnel engaged in roasting operations to reduce the possibility of ingestion into the body. In addition, self-reading pocket chambers are provided to all persons so that they can constantly check the gamma radiation exposure levels during the working period.

The calcining and roasting operations are batch-type processes which do not require the full time employment of any individual. Dr. Kremers stated that individuals are employed about one-tenth of the time in these operations.

Airborne concentrations are measured at the breathing zones of the individuals while wearing face-type respirators during these operations.

Airborne sampling results averaged over the number of hours in any week during which the individuals are in these areas do not exceed an average concentration in excess of the limits specified in Appendix B, Table I, 10 CFR 20. Recorded air sampling results show that limits of 0.4 to 0.6 of the maximum permissible concentration have been encountered during these operations.

These operations are being constantly reviewed by the supervisory personnel and every effort is being made to reduce the airborne radioactivity concentration levels associated with these operations to permissible limits in compliance with the regulations. Dr. Kremers stated that there was some doubt in his mind whether compliance with the present permissible limits could be met owing to the inherent nature of materials being handled.

Environmental airborne concentration checks within a twenty-five mile radius of the Lindsay Chemical Company plant area during production conditions have been made. These checks were made to determine if the Company production contributed any additional airborne radioactivity to the surroundings. Dr. Kremers stated that the results recorded for this survey indicated that the Lindsay operations did not contribute any significant amounts of activity to the surroundings. The highest count obtained during this test was found to be 62 disintegrations per minute per cubic meter. This count was obtained after a rainfall.

Area surveys measuring the gamma radiation levels at various locations, including the monazite sand storage shed, were made by the Radiological Safety Officer and confirmed by the Inspectors. The measurements made at the monazite storage shed, which contains a pile of monazite sand bags 175 feet long, 56 feet wide, and 14 feet high, were recorded as follows:

Distance (meters)	Reading* (mrem)
1	5-6
2	3-4
3	1.8-2
4	1.3-1.5

*Readings were made normal to the width of the pile.

17. Environmental Monitoring Evaluations (Continued)

Distance (meters)	Readings* (mrem)
Single monazite bag*	
At surface	6.5-6
At 1 meter	0.4

*One cubic meter contains 72 bags of monazite sand.

Other gamma radiation measurements at various locations within the plant area are described in Exhibit B, Drawings 1 to 7.

Evaluations are in progress and are being contemplated to determine possible material losses due to leaching into the soil, runoff due to rain, and wind effects on waste stockpiles.

18. Records

Appropriate material control records are maintained by the licensee. These records are used in the yearly audits. Inventory records are maintained on a perpetual basis to assure proper source material stock levels to satisfy demand requirements. Stock levels of monazite sand are maintained at the 10,000-ton level.

Film badge exposure records are maintained for each individual subject to radiological monitoring control. These records are available on a weekly, quarterly and yearly basis. Area survey records are available for various plant areas considered by the licensee to be a potential radiation hazard. Measurements are recorded on the radiation monitor report for gamma-ray levels, a form used by the licensee for this purpose.

Plant airborne radioactivity concentration checks are routinely made. Measurement results are recorded on the radiation air monitor sample and counting record and on the radiation monitor report for airborne thorium concentrations on forms used by the licensee for this purpose. Attached to the latter report is a sketch of the area sampled. Records of all sampling runs made by the licensee are available at the offices of the Research Laboratory.

Meteorological data is recorded daily by the Radiological Safety Officer during production.

19. Waste Disposal

Solid wastes are disposed to waste piles located within the twelve-acre restricted storage area under the control of the licensee. Approximately 6,000 tons of solid mud wastes have been piled in this area. Liquid process wastes containing trace amounts of thorium are discharged through the plant sewerage system which empties into a large sump basin located in the restricted storage area.

Liquid or solid plant wastes are not disposed of in any manner to the sanitary sewers.

An additional twelve-acre plot of land adjoining the present restricted storage area has been acquired for use for future waste disposal and storage purposes.

20. Comments

Airborne concentrations exceeding the permissible limits specified in the 10 CFR 20 regulations have been discussed with the licensee. Statements referring to the problems associated with this noncompliance item have been discussed in other parts of this report.

Enclosures:
Exhibit A (Photographs 1 - 13)
- Photo 1 - Roasting Furnaces
- Photo 2 - Monazite Storage
- Photo 3 - Dust Collector Unit
- Photo 4 - Acid Digestion Pots
- Photo 5 - Leaching Tanks
- Photo 6 - Plate-Frame Filter Presses
- Photo 7 - Crystallization Kettles
- Photo 8 - Thorium Oxide Dryers
- Photo 9 - Thorium Oxide Dryer
- Photo 10 - Thorium Nitrate Packaging
- Photo 11 - Restricted Storage Area - West Side
- Photo 12 - Restricted Storage Area - East Side
- Photo 13 - Typical Radiation Warning Sign

Exhibit B (Drawings 1 - 7)
- Drawing 1 - Radiation Levels at Fence
- Drawing 2 - Roaster Building
- Drawing 3 - Thorium Building, 1st Floor
- Drawing 4 - Thorium Building, 2nd Floor
- Drawing 5 - Thorium Building, 3rd Floor
- Drawing 6 - Pot Cake Feeder Tanks
- Drawing 7 - Hooded Areas

Exhibit C - Radiation Monitor Report
Exhibit D - Radiation Air Monitor Sample and Counting Record

SEE BLACK BINDER