Form AEC-417 (4-58)

UNITED STATES ATOMIC ENERGY COMMISSION

L-F (one year)

COMPLIANCE INSPECTION REPORT

1. Name and address of licensee
U. S. Radium Corporation
Bloomsburg, Pennsylvania

2. Date of inspection
April 13 thru 17, 1959

3. Type of inspection Reinspection

4. 10 CFR Part(s) applicable
10 CFR 20 - 30

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

Number	Date	Exp. Date	Scope and Conditions
37-30-2	5/1/59	8/31/60	Scope: A. "Unspecified" as required, except no single discrete source procured under this license shall exceed 100 curies, any byproduct material between Atomic Nos. 3 and 83, inclusive, 1 curie Ac^{227}, 5,000 curies H^3, 10 curies Po^{210}, 1 millicurie Am^{241}, for research and development as defined in Section 30.4(k) of Title 10, Code of Federal Regulations, Part 30, "Licensing of Byproduct Material". Processing for redistribution to AEC licensees

Conditions: #11-Except as provided below, byproduct materia will be used at USRC facility located on R. D. #5, Bloomsburg, Pennsylvania. In accordance with the provisions out lined in application and letter dated February 15, 1957, and letter dated August 18, 1958, sealed sources may be used for demonstration purposes by the following salesmen:

Mr. W. C. Doran
5420 Vineland Avenue
North Hollywood, California

Mr. William Cordts
P. O. Box 104
Easton, Pennsylvania

(CONT'D)

6. Inspection findings (and items of noncompliance)
USRC produces instrument control dials in a variety of sizes, shapes, finishes and markings. Although plants are maintained in other locations, all work involving the use of radioactive materials is performed at Bloomsburg. Of a total force of 325 persons at Bloomsburg, 51 are associated in some way with work involving the use of radioactive materials. Two safety committees; the General Plant Safety Committee, and the Institutional Isotope Committee are maintained. E. M. Burtsavage, the RSO, has authority to recommend specific action relating to radiation safety to H. A. Vaughn, General Manager of the Bloomsburg plant. Radioactive materials are employed in the production of luminous phosphors, radioactive foils, sealed sources, and sealed light sources. In general, work involving radioactive materials is physically separated in terms of the isotope being employed and the specific use to which the isotope is being put. The licensee's instrumentation consists of numerous GM survey instruments, ion chamber survey instruments, and various types of laboratory instrumentation. Radiation safety instructions consist of an extensive course in the fundamentals of radiation given to all laboratory supervisors and most helpers. This course consists of two hours of lecture per week for a number of months. In addition, Burtsavage, the RSO, personally instructs for 6 to 8 hours all new employees who will be engaged in work involving the use of radioisotopes. Radiological safety procedures consist of the performance of numerous direct radiation surveys, smear sample surveys, and air monitoring surveys. All sealed sources fabricated at USRC are leak tested immediately upon manufacture and again after a period of not less than seven days. The entire USRC plant is under a 24-hour security system. Major areas of storage and use of radioactive materials are maintained locked when not in use. Personnel (CONT'D)

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:

~~1 cy. - Division of Licensing & Regulation, Hq.~~
1 cys - Division of Inspection, Headquarters
7 cys. - Inspection Division, NYOO

Bennett L. Harless, Richard S. Clevel
(Inspector)

Approved by: Robert W. Kirkman, Director
New York
(Operations office)

June 8, 1959
(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.

16—73314-2 U. S. GOVERNMENT PRINTING OFFICE

RECOMMENDATIONS SHOULD BE SET FORTH IN A SEPARATE COVERING MEMORANDUM

ITEM 5 CONT'D

Number	Date	Exp. Date	Scope and Conditions
37-30-2 (cont'd)			

Robert A. Masler
1405 Garland Drive
Oklahoma City, Oklahoma

Mr. R. E. Miller
P. O. Box 380
Bloomsburg, Pennsylvania

Mr. B. T. Schladcuhauffen
3230 Peachtree Road, N.E.
Atlanta 5, Georgia

Austin Goldmann
Selden Drive
East Northport, L.I., N.Y

Mr. Don Reagan
5942 W. Chicago Ave.
Chicago, Illinois

Mr. T. W. Taylor
Morristown, New Jersey

Ralph A. Obley
5420 Vineland Ave.
North Hollywood, California

John J. Shigo, Jr.
R. D. #5
Bloomsburg, Pennsylvania

Paul Van Orden
R. D. #1
Far Hills, N. J.

Mr. R. C. Ragon
1406 W. Idaho Avenue
St. Paul 13, Minnesota

Walter E. Heubrander
1494 Lincoln Avenue
Lakewood 7, Ohio

Andrew Sturz
Greenhaven Bay, R. D. #2,
Northport, L.I., N. Y.

Eugene Elstrom
289 Cayuga Street
Elmhurst, Illinois

Robert A. Latham
23 Arrow Street
Cambridge, Massachusetts

#12-Compliance with 10 CFR 20; #13-Byproduct materia shall be used by, or under the direct supervision of individuals approved by the Institutional Isotopes Committee, C. C. Carroll, Chairman; #14-All sealed sources, containing beta and/or gamma emitting byproduct material, manufactured under this license, shall be tested for contamination. Any sources foun to have contamination shall be decontaminated and re tested prior to being used or transferred to another person. The test shall be sufficiently sensitive to detect the presence of removable contamination in ex cess of 0.05 microcurie. All sources, other than th excepted below, shall be stored for a period of 7 da after having passed the contamination test, and then tested for leakage. Any source found to be leaking shall be repaired and retested as a new source prior to being used or transferred to another person. The test shall be as sensitive as that required above for the contamination test. Exceptions to the manufacturers leak test are those sources containing gas and byproduct material with a half life of less than 30 days; #15-All sealed sources, containing alpha emitting byproduct material, manufactured under this license, shall be tested for contamination. Any sources found to have contamination shall be deconta inated and retested prior to being used or transferr to another person. The test shall be sufficiently sensitive to detect the presence of removable contamination in excess of 0.005 microcurie. All sources shall be stored for at least 7 days after having passed the contamination test, and leak tested. Any

ITEM 5 CONT'D

Number	Date	Exp. Date	Scope and Conditions
37-30-2 (cont'd)			sources found to be leaking shall be repaired and retested as a new source prior to being used or transferred to another person; #16-All sources shall be tested within 30 days prior to being transferred to another person, and found to be free from leakage prior to being transferred to other persons. The test shall be as sensitive as that required for the contamination tests by Conditions 14 and 15; #17-The licensee shall possess and use byproducts described in Items 6, 7, and 8 of this license in accordance with statements, representations, and procedures contained in his application dated June 4, 1958, and in related documents and amendments as follows: (a) letter dated June 5, 1958, signed by C. C. Caroll and (b) letter dated August 18, 1958, signed by C. C. Carroll.
37-30-3	7/7/58	7/31/60	Scope: A. See Condition 13 for amount, H^3, B. See Condition 13 for amount, Po^{210}, for export to any foreign country except countries or areas now or hereafter listed as Subgroup A countries or destinations in Section 371.3 of the Comprehensive Export Schedule of the U. S. Dept. of Commerce (15-CFR-371-3). Conditions: #11-Byproduct materials shall be exported by or under the direct supervision of C. C. Carroll, Chairman, Isotopes Committee; #12-Compliance with 10 CFR 20; #13-The total quantity of H^3 (tritium) and Po^{210} to be exported under this license shall be limited to 100 curies for each byproduct material; #1 H^3 (tritium) shall be exported in the following form a) Tritiated titanium and zirconium metal targets and foils to be used as (1) targets for accelerators; (2) exciting agents for light sources; (3) ionizing agen in ion separators, static eliminators, and vacuum tu b) Light sources and vacuum tubes containing tritium c) Light sources containing tritium bearing phosphor d) Light sources containing tritiated organic materi #15-Po^{210} shall be exported in the following form: a) Metal foils used as (1) exciting agents for light sources; (2) static eliminators; (3) ionizing agents ion separators and vacuum tubes, b) Polonium-berylli neutron sources for experimental and commercial use; This license does not provide authority to procure 100 curies of H^3 (tritium) in excess of the quantiti licensed under License 37-30-2 issued 6/20/56 as ame #17-Reports of exports shall be submitted to the AEC Washington 25, D. C., ATTN: Isotopes Branch, DL&R, provided in Section 30.42 (10 CFR 30).
37-30-4	7/21/58	7/31/60	Scope: 5 millicuries, Ac^{227}, for export to Weizmann Institute of Science, Isotope Department, Rehovoth, Israel, for use by Dr. I. Dostrovsky in double beta scattering experiments. Conditions: #11-Compliance with 10 CFR 20; #12-Byprod material shall be exported by or under the direct

ITEM 5 CONT'D

Number	Date	Exp. Date	Scope and Conditions
37-30-4 (cont'd)			supervision of, C. C. Carroll, Chairman, Isotope Committee; #13-The total quantity of Ac^{227} to be acquired and exported under this license shall be 5 millicuries; #14-Reports of exports shall be submitted to the USAEC, Washington 25, D. C., ATTN; Isotopes Branch, DL&R, as provided in Section 30.42 (10 CFR 30).

ITEM 6 CONT'D

monitoring is accomplished through the use of film badges, pocket ionization chambers, and routine bio-assays. Waste disposal is accomplished primrily by transfer to authorized waste disposal concerns such as ORNL and Atomic Energy Waste Disposal Service in Oakland, California. Most areas, where radioactive materials are stored and used, are posted with proper radiation caution signs and symbols. Most containers of radioactive material were properly labeled. Sealed light sources produced by USRC are labeled with radiation caution sign and symbol and the type, assay and date of assay of the materials contained therein. Records are maintained of all isotope procurements, inventories, and waste disposals to commercial disposal concerns. Records showing the sales and exports of radioactive materials are maintained. Records of film badge results, dosimeter results, urinalysis results, radiation survey results and leak test results are maintained. The following items of noncompliance were noted:

20.201 "Surveys" (b) - in that complete evaluations of the releases of radioactive materials to the sanitary sewerage system have not been made (See Item 16 of report details).

20.201 "Surveys" (b) - in that the licensee's survey procedures (see Item 17B) do not include routine bio-assay procedures for the analysis for Sr^{90}, Cs^{137}, and Po^{210} (See Items 9 and 17B of report details).

20.201 "Surveys" (b) - in that the licensee has not performed routine air surveys in unrestricted outside areas around the USRC plant to detect inadvertant losses of radioactive material through ruptured or damaged filters in exhaust systems, etc. (See Item 16 of report details).

20.202 "Personnel Monitoring" (1) - in that film rings or other appropriate personnel monitoring devices to completely evaluate the hand exposures received have not been supplied individuals working with radioactive materials in various hoods and glove boxes and with radioactive foils (See Item 17A of report details).

20.203 "Caution signs, labels and signals" (f)(4) "Containers" - in that some containers housing radioactive materials in excess of the quantities specified in Appendix C of 10 CFR 20 were not labeled with radiation caution sign and symbol or with the type, assay, and date of assay of the materials contained therein (See Item 18 of report details).

20.203 "Caution signs, labels and signals" (c)(2) "High Radiation Areas" - in that the solution storage area and the silo storage area where radiation levels in excess of 100 mrem/hr exist, were not equipped with a visible and/or audible alarm signal (See Items 18 and 20A of report details).

20.401 "Records of Surveys, Radiation Monitoring and Disposal" (c) - in that no records of waste disposals accomplished by release to the sanitary sewerage system are maintained (See Item 19E of report details).

PART 30 INSPECTION

United States Radium Corporation
Bloomsburg, Pennsylvania

Date of Inspection: April 13 thru 17, 1959

Persons Accompanying Inspectors:

None. Mr. E. V. Barry, Pennsylvania Department of Health, was notified of this inspection; however, no state representative accompanied the inspectors on this visit.

Persons Contacted and Titles:

Mr. W. E. Umstead, Assistant General Manager
Mr. C. C. Carroll, Manager of Engineering, Chairman, Institutional Isotopes Committee
Dr. J. G. Mac Hutchin, Director of Radiochemical Research
Mr. David Prosser, Chief Chemist
Mr. H. H. Dooley, Assistant to Sales Manager
Mr. E. M. Burtsavage, Health Physicist
Mr. A. J. Cyganowski, Supervisor of H^3 Lab, Kr^{85} Lab, H^3 Gas Production Facility, and Cs^{137} Hot Cell
Mr. G. E. Widger, Supervisor of General Laboratory Area and Sr^{90} Lab.
Mr. D. B. Cowan, Supervisor of Research & Development Labs.
Mr. Ralph Hess, Supervisor of Radium Labs and Polonium Lab.
Mrs. Ruby Work, Plant Nurse

9. Organization and Administration

A. General

United States Radium Corporation (USRC) was incorporated in the State of Delaware in 1917. The home office is presently located in Morristown, New Jersey. In addition to the Morristown office, United States Radium maintains plants in Bloomsburg, Pennsylvania, North Hollywood, California, Whippany, New Jersey, and Bernardsville, New Jersey. Sales offices are maintained throughout the United States. All work involving the use of radioactive materials is performed at the Bloomsburg, Pennsylvania plant which was the only facility visited during this inspection.

The Bloomsburg Division of the United States Radium Corporation (henceforth abbreviated USRC) employs approximately 325 persons. Of these, approximately 51 are associated in some fashion with work involving the use of radioactive materials. According to Carroll, all operations at USRC may be divided into five general areas:

1. The Silk Screen Plant
2. The Edge Lighted Plastic Panel Plant
3. The Etching Plant
4. The plant for application of radium to dials
5. The laboratory devoted to research and production using radioactive materials.

USRC produces instrument and control dials in a variety of sizes, shapes, materials, finishes, and markings. Marking techniques consist of screening; photo marking lithography; engraving; and etching. Dials produced by the Corporation are illuminated in several ways including fluorescent; phosphorescent, radium excited and edge lighted.

Fluorescent dials are those which emit light when stimulated by an external source of ultra-violet or visible light. The emission of light ceases abruptly upon removal of the external light sources. Phosphorescent dials are illuminated by materials which emit light when stimulated by an external source of ultra-violet or visible light. The phosphorescent material continues to emit characteristic light after stimulation by external light sources has been discontinued. Radium dials are excited by a mixture of radium sulfate and phosphorescent materials which in combination glow continuously without stimulation by external light. Edgelighted dials may be illuminated by means of incandescent lights or by means of radioactive materials incorporated into or adjacent to phosphorescent materials.

B. Safety Committees

The Bloomsburg Division maintains two safety committees: the General Plant Safety Committee and the Institutional Isotopes Committee.

1. The General Plant Safety Committee, which meets monthly and maintains minutes of all meetings is charged with the responsibility for making recommendations directly to the General Manager for correction of any unsatisfactory conditions involving phases of plant safety including radiation safety. This committee has the authority to shut down any unsafe operation. Members of the General Plant Safety Committee are as follows:

   Mr. H. A. Vaughn, General Manager, Chairman
   Mr. C. C. Carroll, Manager of Engineering
   Mr. Anson Woodring, In charge of production control for the laboratory
   Mr. E. M. Burtsavage, Radiation Safety Officer
   Mrs. Ruby Work, Plant Nurse

2. The Institutional Isotopes Committee, which meets monthly and maintains minutes of all meetings, is a committee separate from the General Plant Safety Committee. This committee does not have the direct authority to shut down any given operation. If such action were necessary, the Institutional Isotopes Committee would work through the General Plant Safety Committee. The chief functions of the Isotopes Committee are to consider purchases of isotopes and review all new procedures or changes in procedures involving uses of radioactive materials. The Institutional Isotopes Committee is composed of the following members:

   Mr. H. A. Vaughn, General Manager
   Mr. C. C. Carroll, Manager of Engineering, Chairman
   Dr. J. G. Mac Hutchin, Director of Radiochemical Research
   Mr. H. H. Dooley, Assistant to Sales Manager
   Mr. E. M. Burtsavage, Radiation Safety Officer

C. Radiation Safety Officer

E. M. Burtsavage, the Radiation Safety Officer, has the authority to recommend any specific action relating to radiation safety he deems necessary directly to Mr. H. A. Vaughn, General Manager of the Bloomsburg plant. Burtsavage has no formal training in the use of radioactive materials with the exception of a radiological safety course taken while he was in the Air Force and a radiological safety course given by NYU's Bellevue Medical Center. Burtsavage, who has considerable self-education, has been on-the-job at USRC for over 6 years and has been Radiation Safety Officer for approximately 2 years. He is aided by one full-time assistant, Mr. S. L. Cope, and by one 3/4-time assistant, Mr. R. E. Carl. Both Cope and Carl attended the USRC "Radioisotope Techniques Course" and received on-the-job training from Burtsavage.

D. Areas Where Radioactive Materials Are Used

Work involving the use of radioactive materials may be divided into several separate laboratories or entities as follows: the general laboratory area; the tritium and Kr^{85} laboratory; the tritium gas production facility (which is part of the general laboratory area); the Sr^{90} laboratory; the Cs^{137} hot cell; four research and development laboratories; the radium laboratory; the polonium laboratory; the dial painting shop; the tritium building; and the isotope storage areas. In addition to these facilities, several small use and storage areas are also available.

E. Supervisory Personnel and their Assistants

Supervisory personnel having responsibility for radiation safety in various laboratories, their assistants, and the training and experience of these persons are as follows:

1. Mr. A. J. Cyganowski is supervisor of the tritium-Kr^{85} laboratory, the tritium gas production facility, and the Cs^{137} hot cell. Cyganowski's training consists of the USRC "Radioisotope Techniques Course", taught by personnel of USRC. This course consists of two hours of lecture per week for 16 to 18 weeks. (See Item 15A for complete discussion of material covered in this course) In addition, Cyganowski received on-the-job training at USRC for approximately 4 years. Working with H^3 under Cyganowski in the tritium-krypton laboratory are Mr. R. E. Bickert, Mr. E. Fisher, Mr. C. G. Berlin, and Mr. T. W. Hesketh. All of these individuals took the USRC Course and in addition, received on-the-job training under Cyganowski. In the H^3-Kr^{85} laboratory, C. G. Berlin and R. E. Bickert work with Kr^{85} under the supervision of Cyganowski. In the tritium gas production facility, Bickert, Fisher, Berlin, and Hesketh work under Cyganowski's supervision. Most of the work in the Cs^{137} hot cell is performed personally by Cyganowski.

2. Mr. G. E. Widger is supervisor of the general laboratory area, the Ni^{63} plating operation, and the Sr^{90} laboratory. Widger, who has been with USRC for 7-1/2 years, took the USRC "Radioisotope Techniques Course". In the general laboratory area, Mr. J. W. Morrison works on the C^{14} phase, the Tm^{204} phase, the U^{238} phase, and the Ni^{63} phase of the work. Mr. E. Fisher works with Widger on the tritium phase. Mr. J. W. Morrison and Mr. F. W. Carl work in the Sr^{90} laboratory under the supervision of Widger. All of these men took the USRC "Radioisotope Techniques Course" and received on-the-job training from Widger.

3. Mr. D. B. Cowan is supervisor of the research and development laboratories. Cowan, who has been with the USRC for approximately 2 years took a course in radiation safety in the United States Army and took the USRC "Radioisotope Techniques Course". Berlin, R. E. Bickert, E. Fisher, and Mr. Frank Buck work in the research and development laboratories under the supervision of Cowan. All of these men were trained under Cowan and took the USRC "Radioisotope Techniques Course".

4. Mr. Ralph Hess, supervisor of the radium laboratories and the polonium laboratory, has been with USRC for approximately 10 years and took the "Radioisotope Techniques Course". Working under Hess in the radium laboratory are the following individuals: Mr. Dave Derr; Mr. C. G. Berlin; Mr. R. DeFrain; Mr. Carter; and Mr. W. O. Seltzer. All of these men have trained on-the-job under Hess. Derr and Berlin have had the "Radioisotope Techniques Course".

Dave Derr works under the supervision of Ralph Hess in the polonium laboratory.

5. Mr. I. Allam, supervisor of the tritium building, took a four-month course at Chalk River in radiation safety; took the USRC "Radioisotope Techniques Course"; and has been with USRC for approximately 2 years. G. E. Widger and Mr. M. Kishbaugh work under Allam's supervision. Kishbaugh received on-the-job training from Allam but has not taken the "Radioisotope Techniques Course".

6. Mrs. Hilda Gunther, supervisor of the dial painting shop, has been with USRC and engaged in dial painting activities for approximately 30 years. She took the USRC "Radioisotope Techniques Course". Seven to twelve dial painters and four dial painters using automatic dial painting machinery work under the supervision of Mrs. Gunther. According to Burtsavage, dial painters have an average of 10 years dial painting experience at USRC.

10. Uses of Byproduct Material

The major uses of radioactive materials at USRC are as follows:

A. C^{14} is incorporated with phosphor, primarily zinc sulfide, for the production of low luminous intensity light sources; eg. luminous markers. C^{14} is chosen specifically since it produces low intensity sources without deteriorating the phosphor. A maximum of 2 millicuries of C^{14} is used per source.

B. Cs^{137} is used in the production of irradiators having strengths varying from 100 uc to 1 curie each. According to Burtsavage, all cesium sources are sealed when shipped to customers.

C. Co^{60} in the form of metallic pellets is encapsulated into sealed sources having strengths varying from 3 curies down.

D. Kr^{85} is used in the production of irradiators having strengths varying from 0.1 mc to 2 curies. These sources are usually formed by encapsulating Kr^{85} inside a metal pipe. Kr^{85} is also used in the production of light sources wherein the krypton is used to activate a given phosphor. Light sources each contain from 20 mc to 800 mc of krypton.

E. Ni^{63} is plated on metallic ribbon, segments of which are used as ionization sources in electric tubes. Specific activities of the ribbons vary from .005 uc per square inch to 1 uc per square inch.

F. Pm^{147} is used in the production of beta gauge sources varying in strength from 1 mc to 300 mc per source and for the production of light sources having strengths from 30 uc to 2 mc per source. Promethium sources are produced by the electro-deposition of promethium on metallic planchets.

G. Ru^{106} has not been used for approximately two years. At one time ruthenium was used in the production of sources by electrodeposition of Ru onto metal planchets.

H. Sr^{90} is used in the production of Sr^{90} foils having specific activities varying from less than 1 uc to approximately 60 mc per square inch, and in the production of light sources containing from 50 uc to 4 mc per source. Sr^{90} foils and light sources are supplied to customers as sealed sources.

I. Tl^{204} is used in the production of irradiators each containing approximately 200 mc of Tl, and in the production of sealed light sources containing from 1 to 4 mc per source.

J. Tritium as a gas is incorporated into glass tubes coated on the inside with various phosphors to produce light sources. Each source contains between 200 mc and 2 curies of tritium. Tritium as tritium foil when purchased by USRC is used in the production of ionization devices containing approximately 250 mc per device. The ionization devices are shipped to customers as sealed sources.

K. Po^{210} is used in the production of polonium foils having specific activities ranging from 0.1 uc per square inch to 1 mc per square inch. Some of the foil produced is incorporated into USRC ionotrons which are used as ion sources for controlling the effects of static electricity in various devices. Polonium foils are also sold to various customers to be used in activating phosphors.

L. Ra^{226} is used in the production of luminescent compounds containing up to 50 uc of radium per gram and in the production of of light sources containing up to 100 uc of radium per source. In addition to producing luminous compounds for sale, USRC paints Ra^{226} phosphors onto various dials and sells these dials. Burtsavage stated that a gram of luminescent phosphor is sufficient for painting approximately 1,000 watch dials. Radium is also used in the production of Ra-Be neutron sources containing up to 200 mc of radium per source. Burtsavage stated that in the past year, fifteen 5 mc sources were produced.

11. Isotope Inventory

Exhibit A is an inventory of radioactive materials on hand as of March 1959. The quantity of materials on hand may be summarized as follows:

36.8 mc	C^{14}
30,000 mc	Cs^{137}
4,411 mc	Co^{60}
231 c	Kr^{85}
17 mc	Ni^{63}
61,450 mc	Pm^{147}
30.7 mc	Ru^{106}
2,382 mc	Sr^{90}
1,939 mc	Tl^{204}
3,445.5 c	H^3 as tritium gas

412 square inches of tritium foil containing a maximum of 1000 mc of tritium per square inch.

Exhibit A does not show the quantity of radium on hand. On January 1, 1959, the total inventory of radium was as follows: Approximately 200 mc of radium sulfate as radium compacts; approximately 43 mc of Pb^{210} (RaD compacts); approximately 635 mc of radium as radium sulfate in the form of radium foil scrap; approximately 45 mc as standard concentration radium foils; approximately 41 mc as special radium foils, approximately 18 mc as radium foil sources; approximately 28 mc as radium foil of special concentrations and widths; approximately 35 mc as RaD foil; approximately 133 mc as returned radium sources; approximately 6 mc of radium foil; and approximately 53 mc of radium in various other forms.

Exhibit B is an inventory of radioactive materials on hand as of January 1, 1959. This inventory shows the quantity of material on hand by isotope; the type of device into which this material is incorporated; the form of the material if same is not encapsulated; the type of closure used on sealed sources; and various other descriptive remarks. The inventory is broken down into sections showing quantity of each isotope stored in any particular area of the USRC Bloomsburg plant.

12. Facilities

Radiation work is conducted in a number of different areas of USRC's plant, but the bulk of the work is done in the same general area in the main plant building. The layout of this area is shown in Exhibit C. Movement of personnel in and out of this area is limited to one entrance, which connects with the sales and administrative office area near this entrance. Immediately inside this entrance is a constant monitor end window G-M count rate meter used for contamination checks of all personnel leaving this area. Connecting with this entryway is a locker room, where radiation workers leave their outside clothing and pick up their work clothes. Connecting with this locker room is a change room, where shoe covers are put on upon entry or removed upon exit. This room is equipped with racks of laboratory coats to be worn over regular clothing by all employees or visitors entering the work area, who are not otherwise required to be completely dressed in work clothes. A sink is provided for personnel to wash hands before leaving the area, and a constant monitor end window G-M count rate meter is used in checking for hand and foot contamination. The locker room and change room are respectively about 10 x 12' and 10 x 10' in size.

A. H^3-Kr^{85} Laboratory

The change room leads to an entryway connecting with the large general laboratory area. Immediately off this entryway is a separate room (the H^3-Kr^{85} laboratory) devoted to the handling of gaseous H^3 and Kr^{85}. This gas handling room is about 12 x 15' and is equipped with one large hood about 12' long, plus a sink, several work tables and a desk. A door in the northeast corner of this room serves as an exit to a non-radiation work area in another part of the plant, but this door is never used for other than emergencies. Closed gas handling systems and associated vacuum pumps are located in the hood. These systems are used for transferring H^3 and Kr^{85} gas from shipping containers to various sealed tubes where the isotopes are used to excite phosphors or otherwise serve as radiation sources. A maximum of 500 curies of Kr^{85} and 1,000 curies of H^3 are reportedly handled at any one time in these systems. Materials on hand at the time of the visit were estimated as 100 curies of H^3 and 70 curies of Kr^{85}.

Present operations were described as involving the filling of glass tubes about 5" long by 1/4" in diameter containing luminous phosphors with between 500 and 2,000 millicuries of H^3 gas as an activating agent. These tubes were to be used in luminous signs manufactured for United Airlines. Personnel working in this area wear rubber gloves and a complete set of work clothes acquired in the change room. The face of the hood is equipped with large horizontally sliding panels of 3/8" thick lucite. Additional shielding is provided by sheets of lead 20 x 14 x 1" thick, located in front of the Kr^{85} apparatus. A heavy lead pot was also provided to hold Kr^{85} shipping containers, and an end window G-M count rate meter was installed in the exhaust duct to observe possible high concentrations of Kr^{85} in the effluent. Air flow through the hood exhaust was rated as 3,000 cfm.

B. General Laboratory Area

The general laboratory is a large open area about 50 x 35'. Immediately inside the entrance from the change room are three glove boxes plus several open work benches. These three glove boxes are constructed of wood and provided with transparent plastic faces. Materials are placed in each box through an air-locked entrance compartment, which is not provided with filters. Air flow through the exhaust is rated as about 30 cfm per box. Each exhaust is equipped with a fiber glass pre-filter plus an absolute filter. Activities conducted in these three boxes are reportedly limited to work with relatively low energy beta emitters.

The first box is currently used for work with tritiated compounds which mostly involves trimming of triated titanium foils. About 50 curies of tritium was present at the time of the visit.

The second box has been used for work with C^{14} labeled compounds, and about 23 millicuries was present when inspected.

The third box is used for a variety of activities, mostly for work with Tl^{204} and Pm^{147}, which was not current when visited.

A large hood about 3' wide and 15' long, open on both sides, was located in the southwest area of the general laboratory. This hood was similar in design to that in the gas handling room and was also equipped with horizontally sliding lucite face panels. This hood was occupied by another tritium gas handling system and was used for filling of various tritium containing tubes. The hood was also equipped with a Nuclear Measurements Corporation gas proportional counting chamber connected to a Nuclear-Chicago count rate meter. This detector was set up so that sealed tubes can be positioned so that any leaking tritium gas would be introduced into the counting chamber and thereby give evidence of tube leakage. All tritium gas sealed light sources are given their initial and final leak tests in this unit. This hood is the only air exhaust other than the glove boxes in this room. It is rated as drawing 6,000 cfm, and the exhaust is not monitored.

Located between the glove boxes and the large tritium gas handling hood at the south end of the general laboratory was an apparatus for the plating of Ni^{63} on a metallic ribbon. The apparatus was set up to feed a continuous metal ribbon through the electroplating solution located within a plastic shielded box, past an end window G-M tube which monitors the amount of deposited activity, and then to a notching device and a take-up reel. No more than 2 millicuries of Ni^{63} was reportedly in process at any one time. No airborne activities were expected from this operation and it was not ventilated. Most of the remainder of the general laboratory was occupied by other work benches and storage cabinets used for non-radioactive materials.

Sealed sources fabricated in this area are taken to the northeast portion of the general laboratory where they are transferred through a pass window into the leak test room. This room is separated from the rest of the General Laboratory by an 8' high partition. Sources are monitored for leakage in this room and, after checking out satisfactorily, transferred thru another pass window to the high level counting room. This room is located outside the regular area for handling radioactive materials. The door from the general laboratory to the corridor running past the high level counting room is not regularly used and is set up to be used only as an exit from the radiation work area. The high level counting room is about 12 x 16' and its walls consist of concrete blocks to a height of about 8'.

Sources kept here are stored in a bin at one end of the room. This bin is about 2½ x 3' surrounded by 8" thick concrete block walls about 3' high. Completed radiation sources are calibrated in this room prior to transfer to customers.

C. Radium and Polonium Laboratories

Opening off the north end of the general laboratory area is a door to an anteroom leading to the radium and polonium laboratories. This anteroom is provided with a shoe cover change station, a sink for washing of hands prior to exiting from the area, and a constant end window G-M monitor used in checking for hand and foot contamination. This anteroom opens into a large open area used for processing radium compounds and fabrication of sources. A separate laboratory in the southwest corner of this area is set aside for processing polonium compounds. This latter laboratory is about 15 x 20' and is equipped with two glove boxes and a large hood. Shipments of $PoNO_3$ crystals from Mound Laboratory are placed in the first glove box, where the material is converted to a solution. $BiNO_3$ is added to the solution, after which powdered Ag is added. The active material plates out on the Ag, the solution is filtered, and the filtrate is dried. After drying, the material is transferred to the second glove box, where it is ground into a powder. Then it is transferred to the hood, where the material is placed in a die and pressed into a compact. This compact is annealed in an oven, after which an Ag overcoat is placed about the compact. This material is again annealed and then rolled out into foils, whose activity varies from 75 to 2,000 microcuries per square inch. These foils receive further processing in the open bench area in the northern part of the radium laboratory.

A group of utility and storage rooms are located in the central portion of the radium laboratory. A number of radium handling hoods and glove boxes are located around this central area. A radon safe is located in the center of the east wall of this section between two hoods. Ra^{226} in solution as a bromide in amounts up to 200 millicuries is placed in a vacuum apparatus in this safe and the radon gas is pumped out of the solution and exhausted through the roof to the outside of the building. This operation reportedly removes approximately 50% of the radon from a 200 millicurie radium solution over a two hour period. This operation is performed about twice a month. Radium solution from which radon has been largely removed, is then processed in the combination hood-glove boxes along the south side of this center area. The radium is converted to a sulfate and is mixed with appropriate phosphor for use in light sources. Radium impregnated foil is also produced in this area.

A room located off the northwest part of the radium laboratory is used for weighing of radium activated phosphor employed for various light production purposes, principally for painting luminous dials. A long, ventilated work table is provided for manipulating these radium phosphors. Hoods and glove boxes in the radium and polonium laboratory exhaust into a common blower system rated at 10,000 cfm. This exhaust is provided with a pre-filter and an absolute filter.

D. Strontium Laboratory

A corridor leading from the southwest corner of the general laboratory gives access to the entrance of the laboratory in which Sr^{90} is processed. The Sr^{90} laboratory is entered through an anteroom which separates it from the corridor. A shoe cover change station is located here. The strontium laboratory itself is about 15 x 20'. It is equipped with 8 glove boxes and two hoods around the walls, plus another hood in the center of the room. The exhausts from these hoods and boxes are equipped with pre-filters and absolute filters. The air flow to the exhaust from each glove box is rated at about 45 cfm. Total air flow through the common exhaust from this laboratory is rated at 4,000 cfm.

The three glove boxes along the east wall of this room are connected internally and with the hoods so that materials may be transferred from one to the other without bringing them out into the room. A shipment of Sr^{90} is placed in the northern most of these boxes, where initial transfers and dilutions are performed by remote handling equipment. Maximum amount of activity usually processed at any one time is about 100 mc. Working solutions are transferred to the middle box where centrifuging and Y^{90} removal operations are conducted. Precipitation and drying of the material are conducted as part of the operations in this box. Dry processed material is transferred to the third box where it is placed in a die, compressed, and baked in an oven. Material is made into a brick form here and sandwiched within gold overlays. This material is then transferred to the adjoining hood where it is compressed in a Watson Stillman press until it becomes a solid metallic form. This is then sandwiched between additional gold or silver, heated in an oven and again pressed into a compact form. Compacts are next removed from the hood and processed in the press and rolling machine located at the end of the central hood. The foil sources so prepared are then transferred through a window from the last hood in this line into the hood in the leak testing room, where preliminary checks are made of the integrity of protective covering of the foil sources.

The interconnected row of glove boxes along the north wall of this room are used for processing strontium into luminous phosphors. Shipments are introduced into the eastern most of these boxes, where remote handling equipment is used for pipetting and diluting transfers. In the second box, the Sr^{90} is precipitated out of solution by mixing with $BaSO_4$. After filtration of the precipitate and combination with the phosphor material, the Sr^{90} is transferred to the third glove box, where brightness tests are conducted. This material is then removed from the glove box and transferred to the southern most of the glove boxes on the west wall of the room. Here, the strontium activated phosphor is mixed with the appropriate adhesives and binders and placed in an oven which serves as a closed connection between these two boxes. After baking, the material is brought into the second of these glove boxes, placed in its final housing and sealed, and given a preliminary leak test. The hood in the center of the room is primarily used for storage of material when it is desired to have a positive flow of air away from occupied areas and over the stored items.

The glove boxes in this room were constructed by the licensee and are made of wood. All boxes are equipped with lucite windows at least 1/2" thick and with at least 1/4" of lead sheeting on the outer walls. The boxes are also designed so that supplementary lead brick shielding can be placed along the front of these boxes to provide additional protection for the operators. Specially designed tote boxes of heavy lucite were available for transferring strontium sources in such a manner that direct beta radiation is not released into the room. Strontium handling operations reportedly are conducted 60% of the time. Work usually involves only one, but occasionally two, persons at a time. No more than about 3 curies of Sr^{90} is processed into finished devices per month.

E. Research and Development Laboratories

A corridor leading from the general laboratory past the strontium laboratory goes to the research and development wing. This consists of three general R&D laboratories and a hot cell facility for handling curie amounts of Cs^{137}. Each of the R&D laboratories is about 16' square.

The hoods in these rooms exhaust through a common stack rated as discharging about 6,000 cfm. All exhausts are equipped with prefilters followed by absolute filters. R&D #2 is equipped with two hoods, a sink, and several tables, work benches and storage shelves. Current materials in this room were reportedly about 5 mc Ni^{63} and 1 mc Co^{60}. The only current activities were described as low level development studies on processing and use of these materials. R&D #3 is laid out in a manner similar to that of R&D #2. Materials noted on hand at the time of the visit were several jars holding a large number of H^3-activated sealed tubular light sources with the total activity being about 500 curies. Activities here were described as including preliminary leak testing of these sealed sources. R&D #4 was laid out in a manner similar to the other two R&D laboratories, except that it was equipped with a large gas handling hood in the center of the room. Gas handling operations with H^3 and Kr^{85} are conducted in these hoods. Materials noted on hand included around 60 curies H^3 and 90 curies Kr^{85}.

F. Cesium 137 Hot Cell

A constant monitor end window GM count rate meter with the detector tube shielded by a lead cylinder about 1" thick and a shoe cover change station were located outside the entrance to the cesium laboratory. The entrance to the cesium laboratory was equipped with an interlock alarm, activated upon opening the door. Controls for deactivating this alarm are located inside the cesium laboratory. The cesium cell is an open topped cubicle with walls of 16" thick concrete on all sides other than the operating face, which is constructed of 6" thick lead bricks. Lead glass viewing ports were provided in this operating face, which was located on the side by the room entrance. The walls of the cell were about 7' high. An air exhaust canopy leading to a stack through which the flow was rated at about 4,000 cfm was located directly above the cell.

Cs^{137} as a chloride is placed in this cell as received and converted to a sulfate. This material is then absorbed on an ion exchange resin so as to reduce its capability to leak out of the sealed sources and become airborne. Resin material holding the cesium is used to fill various capsules which are sealed and sold as discrete sources. The handling capacity of the cell is rated as about 20 curies. All operations in the cell are conducted by use of a master slave manipulator, whose mechanical linkage passes over the open top of the cell wall.

A chute connects from the back corner of the cell to a shielded glove box in the southwest corner of this room. Here, small cesium sealed sources and/or miscellaneous contaminated equipment can be checked for leakage and processed for decontamination.

G. Radium Dial Shop

On the second floor area of the main building of USRC is located a dial painting shop employing approximately twelve radium dial painters. Each dial painter occupies a separate desk and uses approximately 50 microcuries of radium activated phosphors at any one time. Each 50 microcurie batch of phosphors is sufficient for the production of 2,000 watch dials or 1,000 watch hands. In addition to the hand painting operations, six automatic silk screen dial painting devices are located in this shop. Each of these devices is enclosed in a lucite shield having a front flap which lifts up to permit access to the machine. Each machine is ventilated from the rear at an estimated flow rate of 25 cfm. Drying ovens for radium dials are located in a separate room nearby on the second floor.

H. New Tritium Building

A separate building, approximately 20 x 40' was recently constructed by USRC and has been in use for approximately two weeks for special tritium handling operations. Access to the tritium laboratory portion of this building may be gained only by passing through a clothing change area provided with complete protective clothing and shower facilities.

The tritium laboratory is equipped with three glove boxes, each having a rated air flow of 45 cfm. The three glove boxes are interconnected in such a fashion that materials may be passed from one to the other without being removed from the glove boxes. 8 x 12" titanium tritide foils, as received in sealed containers by USRC, are placed in glove box No. 1, which is used as a clean transfer box. The foils are then passed to glove box No. 2, where they are checked to determine the active area, and then cut into 1/4" square pieces. The 1/4" pieces of foil are then passed to glove box No. 3, where they are assembled into "Wesix" air ionization devices which will be supplied to a customer of USRC. The "Wesix" devices are sealed and tested for leakage before removal from glove box No. 3. Each "Wesix" device contains between 200 - 300 millicuries of tritium.

The tritium laboratory is also used by the research and development group of USRC in an attempt to perfect a method whereby USRC may produce its own foils. The laboratory is provided with an Atomic Accessories, Inc. TSM-91 tritium monitor having ranges from 0 - 100 through 0 - 100,000 uc of tritium per cubic meter of air. According to Burtsavage, the instrument is sensitive to several influences other than H^3 contaminated air, and is unsatisfactory.

I. Isotope Storage Areas

Four separate buildings, as well as the various laboratory facilities already described, at USRC are used for the storage of radioactive materials. (See Exhibit B for quantities and storage locations of radioactive materials on hand as of 1/1/59.)

Building No. 1, the Radium Storage Vault, approximately 18 x 25' is used primarily for the storage of radium. This building is exhausted by a large fan which reportedly drains 2,000 cfm.

Building No. 2, the Strontium Vault, approximately 20 x 15', which is used as a storage area for radioactive solutions, contains quantities of a number of isotopes.

Building No. 3, the Sealed Sources Vault, a small cinder block shed, is used for the storage of standard and sealed sources.

Buildings No. 1, 2, and 3 are enclosed by a sturdy, 5' wire mesh fence. All gates to the fence and all building doors are kept locked in the absence of responsible personnel.

Building No. 4 is a silo, approximately 9' high and 8' in diameter, used for the storage of radioactive waste materials. At the time of this inspection, the silo housed a 55 gallon drum containing Sr^{90} on ion exchange resins. A 5' high fence surrounds the silo at a distance of approximately 40'. The fence gate and the silo door are maintained locked.

J. Additional Facilities

In addition to the facilities previously described, a number of auxiliary facilities are available at USRC. These consist of two research and development dark rooms, a low level research counting room, a health physics counting room, and a tritium light source assembly and inspection shop.

13. Instrumentation

At the time of the inspection the licensee had on hand the following instruments:

A. Survey Instruments

One Beckman MX2
One Beckman MX3
One Beckman MX4
One Technical Associates SRJ-1
Two Technical Associates Junos
Three Tracerlab "Cutie-Pie's"
One Universal Atomics GM survey instrument
One Nucleonic Corporation of America GM survey instrument
Two Detectron scintillation survey meters

B. Laboratory Instruments

Two Radiation Counting Laboratory proportional counters
One Nuclear Measurement Company PCC-10 proportional counter
One Nuclear Measurement Company PCC-12 proportional counter
One Nuclear Measurement Company PC-2B proportional counter
Three Nuclear Instrument and Chemical Company GM counters
Two Atomic Instrument Company GM counters
Three Nuclear-Chicago count rate meters with windowless proportional detectors

C. Other

One Keithley Electrometer
One Nuclear-Chicago radiation analyzer
One Carey-Reed electrometer
One electroscope
Miscellaneous other equipment

14. Procurement Procedures and Control

All requisitions for the purchase of radioactive materials must be signed by C. C. Carroll, Manager of Engineering, Chairman of Institutional

Isotopes Committee, before the purchasing department will order the material requested.

All incoming shipments containing radioactive materials come directly to the receiving department. Burtsavage monitors these shipments, before turning them over to the person originally requesting the material.

15. Radiological Safety Precautions and Procedures

A. Instructions

All new employees who are to work with radioactive materials spend from 4 to 8 hours with Burtsavage, who instructs them in the fundamentals of radiation, radiation safety and health physics.

In addition to the above instruction given to new employees, isotope laboratory supervisors and most helpers have taken the USRC "Radioisotope Techniques Course". This course consists of two hours of lecture per week for 16 - 18 weeks and is taught by Burtsavage and other USRC personnel; each instructor covering material in his own field.

The following lectures are presented during the "Radioisotope Techniques Course":

Introduction to Radioactivity
Alpha and Beta Radiation - Theory
Gamma Radiation - Theory
Alpha Radiation - Shielding and Absorption
Beta Radiation - Shielding and Absorption
Gamma Radiation - Shielding and Absorption
Neutron Radiation
Natural Isotopes
Pile Produced Isotopes
Instrumentation
Measurement Methods
Pulse Height Analysis
Foil Production
Health Physics

Copies of the above lectures are incorporated into the licensee's file.

Written administrative instructions (copies of which are incorporated into the licensee's file) are supplied individuals working with radioactive materials. These instructions consist of "USRC Laboratory Operating Rules", "Emergency Procedures", "Laboratory Safety and Operating Rules", and appropriate staff memorandums. These documents discuss clothing change, entry to processing area, personnel monitoring, survey, posting, labeling, record keeping, waste disposal, and emergency procedures. Instructions requiring the use of respirators and/or rubber gloves for specific operations and numerous other procedures applicable to good radiation safety practices are included.

B. Surveys

I. Direct Radiation Surveys

Surveys of direct radiation levels in working areas are conducted routinely by both health physics personnel and by workers in the particular laboratories concerned. Formal surveys are conducted by the health physics staff in all work areas on a weekly and/or bi-weekly basis. The principal areas checked are those in front of hoods or glove boxes, or other areas where workers spend a considerable portion of their time. Ten to thirty specific positions are monitored in each laboratory. Measurements include intensities due to both beta and gamma radiation in all laboratories. Surface contamination readings, including alpha readings are also taken in the laboratories using alpha emitting materials.

The main objective of these surveys is to keep track of specific sources which tend to raise general laboratory backgrounds and to handle these sources in such a manner that the stray radiation levels do not exceed 3 mr/hr at 1' from any glove box, hood, pig, or closet containing radioactive material. The formal surveys by the health physics staff are supplemented by continual measurements made by the workers in each area. Each section is furnished with its own survey meter, usually a Juno or Cutie-Pie, and the area supervisors are responsible for having surveys conducted in their own sections.

II. Equipment and Area Contamination Surveys

Formal area and equipment contamination smear surveys are conducted on a daily basis by both the health physics department and the staff of each working area. A total of upwards of 200 smears are taken throughout USRC's facility each day. All types of surfaces, including floors, stools, bench tops, glove box faces, hood surfaces, remote handling controls, and door knobs are checked.

Surfaces are monitored by smearing with Q-tip swabs that have been dampened with water. The activity picked up on these swabs is checked with an end-window G-M count rate meter. All smears are counted in the same manner, but several different counters are used, depending upon the area in question. The smear sample is placed about 1 millimeter from the end-window of the count rate meter's G-M tube, whose window thickness varies from about 1.4 to 1.8 mg/cm^2. A counting efficiency of 50% has been assumed for beta activity. The efficiency for alpha radiation has not been determined. Cleanup action is scheduled if smears in the radium laboratory or cesium laboratory exceed 500 cpm when beta-gamma activity is believed present, while 1000 cpm per smear is the limit for the other radiation work areas for beta-gamma activity. If alpha activity is believed present, cleanup action is initiated for samples showing more than 100 cpm. No contamination levels above background are acceptable in non-radiation work areas, and immediate cleanup is scheduled if any is found.

Formal surveys are conducted by a health physics staff member each morning between 7:00 and 8:00 a.m. prior to the commencement of the normal work day. Thirty-one locations throughout the main plant facility are checked for floor contamination. These checks are required to be supplemented by the supervisor of each work room during the work day, except that an additional survey is not needed if no work has been done there since the last check. About 25 different surfaces per area are smeared and counted. Special tote boards for holding the swab samples and special record sheets have been drawn up for use by the laboratory personnel. The specific surfaces checked are reportedly varied from day to day. The results of the formal surveys by the health physics department are reported to the plant manager each day, and the appropriate area supervisor is requested to immediately clean up any high levels found. Cooperation was reported by Burtsavage to be fairly good with respect to the individual area personnel immediately cleaning up any contamination they find themselves.

The health physics department's surveys occasionally turn up levels up to 5000 cpm on the floors, which have then been immediately cleaned up. Records for the surveys by laboratory personnel for 1958 showed the following results. Maximum smear activity noted in the general laboratory area was 750 cpm. Very few contaminated samples were found in this area. Maximum activity in the radium, polonium, and weighing rooms was about 25,000 cpm with the usual high levels running around 2000 cpm and with about 95% of all these smears being reported as background. The cesium laboratory was noted to have been checked with great thoroughness with 25, and occasionally with 50 or more, swab samples being taken per day. Most smears showed background (background with the count rate meter used for this area is around 200 - 300 cpm), with a few smears showing up to a few thousand cpm. The research and development laboratories usually have 25 - 50 smears made per day, with maximum activity noted of a few hundred cpm. Numerous daily smears taken in the Strontium 90 laboratory show maximum recorded activity to be about 3,000 cpm. The general non-radiation office areas are given a formal check about once a year, with no contamination reportedly found.

III. Air Monitoring Surveys

Samples of in-plant airborne radioactive particulate matter are collected using Watman No. 41 filter paper in a Staplex high volume sampler. Samples of 10 cu meters or more are taken at the rate of about 20 cfm. About 60 such samples are recorded as having been taken during the first 3-1/2 months of 1959, and about 1/3 of the samples were taken in the Radium Laboratory. The activities collected on the filter paper are analyzed for beta-gamma (and alpha, if appropriate) activities by means of a Nuclear Measurements Corporation internal gas flow counter. There is usually about a 1-day delay between collection of the sample and receipt of the counting results. When high concentration levels are indicated, investigation of the cause is conducted and the operations are reviewed so as to determine the maximum creditable personnel exposure for the actual work time involved. No excessive exposures to personnel were reportedly found. Most beta-gamma activities have been recorded as less than 1.5×10^{-11} uc per ml, with some levels running as high as 3×10^{-10} uc per ml. Most alpha activities were recorded as less than 1.5×10^{-11}, with a maximum recorded as 4×10^{-10} uc per ml.

A constant air monitor was acquired for H^3 analyses. This is an Atomic Accessories, Inc. tritium meter, Model TSM-91 and is designed with 4 recording ranges of 0 - 100 to 0 - 100,000 uc per cu meter. This unit is in use in the Tritium Laboratory Building, but has been acting erratically, and its results have not been regardded as reliable. Levels indicated by this unit during April 1959 have ranged from 17 to 120 uc H^3 per cu. meter.

No air surveys have been performed in unrestricted areas around the plant to detect inadvertant releases of radioactive material through ruptured or damaged filters in exhaust systems, etc.

C. Leak Tests

All sealed sources fabricated by USRC are subjected to leak test procedures. In general, sources are given a rough check (e.g. swab) before removal from the glove box or other fabricating area.

Routine leak test procedures for sealed sources containing radioactive materials in any form other than as a gas or as H^3 foil, consists of rubbing the source with a swab wet with MEK (methyl-ethyl-ketone) and counting the swab in front of an end window GM detector (~1/16" from the window) operating into a Nuclear-Chicago rate meter. Tritium foil sources are checked by rubbing the source with a dry filter paper and counting the filter paper in an internal proportional counter. Sources containing tritium or Kr^{85} gas are placed inside glass tubes and a counting gas is passed over the source under check. This counting gas then passes into an internal proportional chamber where it is counted for contained krypton or tritium.

All sealed sources fabricated by USRC are given initial leak tests and then held in storage for a period in excess of sevem days, after which they are given a follow-up leak test to assure the integrity of the seal. All sources are checked within 30 days prior to shipment. Tolerance for leak test results on sources to be sold by USRC has been set up as zero removable contamination.

Cesium and Cobalt sealed sources are swabbed and swabs checked for gross contamination in the cesium hot cell. Swabs are then counted in the low level counting room. High level sources (>20 mc) produced in the general laboratory area, the Sr^{90} lab, the polonium lab, or the radium lab, are swabbed in the leak test room of the general laboratory area (See Item 12B). Low level sources produced in these areas and H^3 foil sources are swabbed and the swabs counted in the low level counting room.

D. Locking of Areas

The entire USRC plant is under a 24-hour security system. Access to all working areas where radioactive materials are employed may be gained only by passing through one or more clothing change areas. Security is maintained in working areas on the basis of a personnel recognition system. The cesium hot cell and the Sr^{90} laboratory are maintained locked at all times when not in use. The major areas where radioactive materials are stored are secured by locking and in addition, are surrounded by substantial fences to a minimum height of 5'. Access gates to all fences are maintained locked.

16. Waste Disposals and Process Losses

Radioactive waste materials are disposed of by transfer to commercial disposal agencies and ORNL and by release down laboratory drains to environmental ground waters. Total disposals in 1958 were .34 c Ra^{226}; 5.86 c Sr^{90}; 4.72 kc Cs^{137}; 1 mc Tl^{204}; 5.97 c Pm^{147}; 3.1 c Kr^{85};

25 uc Ni^{63}; and an estimated 30 mc U^{238} as unrefined ore. All materials were transferred to ORNL except for the Ra^{226}, which was transferred to the Atomic Energy Waste Disposal Service, Oakland, California.

Additional transfers in 1959 included 26 drums shipped 2/19/59 to Nuclear Engineering Co., Inc., Building No. 2, U. S. Naval Reserve Industrial Shipyard, Kearny, New Jersey. This material totaled 7,528, 93840 mc composed of about 3 c H^3; 3 c Kr^{85}; 1 c Sr^{90}, and smaller amounts of C^{14}, Tl^{204}, Pm^{147}, and Ra^{226}.

All high level liquid wastes generated in various processing operations reportedly are passed through an ion exchanger and then mixed with a clay ion exchange material. This latter mixture is evaporated to dryness and disposed of as dry waste by transfer. Low level activities from washing operations on glassware and laboratory clothing are released down drains to a sump and then to an old canal bed located behind the company's plant and about 50 feet from the Susquehanna River. Water flow down the company's drains is reported as 22,000 gallons per day. This water empties into the old canal bed which usually maintains some accumulation of water as a small pond. Water in this canal bed drains through the ground to the Susquehanna River. Burtsavage strongly believes that total activities released down the plant drains do not exceed ten times the quantities for the various isotopes specified in Appendix "C" of Part 20. The water effluent monitoring program has not been very comprehensive to date, and he conceded that he has no definite information as to the total amounts of activities released in effluents to the ground water. Periodic samples have been made of effluents from the drains from the cesium cell, the Research and Development labs, and the Sr^{90} laboratory. These have shown no concentrations in excess of about 10^{-5} uc per ml. Burtsavage stated his feeling that these concentrations were due to Cs^{137}, as no Sr^{90} work was in progress at the time. He further reported that representatives of the Pennsylvania State Health Department had made surveys of river water concentrations and taken general environmental samples without finding any results greater than background.

Radioactive materials are also released as effluents to the environment through gas-handling process losses. Known and recorded radioactive gas losses for 1958 amounted to that volume of material equivalent to 19 c Kr^{85} and 160 c H^3. Burtsavage estimates that 50% of the gas volume containing H^3 was due to He^3 contaminant and that the actual quantity of H^3 released was probably nearer 80 c. These releases were through a common stack having an estimated flow rate of 6000 cfm. Although the exact rate of release is unknown, the total release was over a period of one year. Removal of radon gas from radium solutions results in discharge of an estimated 2-1/2 c Rn^{222} per year at a rate not exceeding 100 mc/day through a filtered exhaust having an air flow of 10000 cfm. No air surveys have been performed in unrestricted areas around the plant to detect inadvertent releases of radioactive material through ruptured or damaged filters in exhaust systems, etc.

17. Personnel Monitoring

A. Monitoring Devices

Personnel monitoring is routinely accomplished by use of pocket dosimeters and film badges. A body badge and ring badge service is provided on a weekly basis by Radiation Detection Company of Palo Alto, California. Fifty-one persons are on the beta gamma body badge service. Three of these persons are on the beta-gamma-neutron body badge service, ten are on the beta-gamma ring badge service, and three are on the neutron ring badge program.

Body badges are worn during all operations involving the use of radioactive materials.

According to Burtsavage, film rings are worn during all operations involving the fabrication or handling of Kr^{85} sources. During all Kr^{85} productions, lead gloves are worn.

Ring badges are not worn routinely during Sr^{90} phosphor and foil production operations. All work involving Sr^{90} fabrication procedures is performed in ventilated hoods or glove boxes and the operator wears lead gloves beneath rubber gloves. Assembly of completed Sr^{90} foils into devices is accomplished by means of tongs used behind 1/2" lucite shielding.

In the production of radium foils and phosphors, the operator does not routinely wear ring badges or lead gloves. The only protection the operator has is heavy rubber gloves. All phosphor and foil production operations except those performed on completed phosphors and foils are performed inside ventilated hoods or glove boxes.

Burtsavage stated that at one time he had five of the radium dial painters wear ring badges and that weekly exposures usually ran around 100 mr. No excessive exposures were detected.

Film rings are not worn during the production of polonium foils. All of this production work, which involves the handling of material in forms other than as completed foils, is performed inside ventilated hoods or glove boxes.

Film badge records maintained by Burtsavage show the total dose received by the individual from beta radiation, plus gamma radiation, plus neutron radiation, plus the estimated internal exposure determined from bio-assay procedures. Exhibit "F" is a summary of 1958 personnel exposures, and total accumulated personnel exposures of USRC employees. Records of film badge results were reviewed back to January 1958. The maximum whole body exposures recorded were less than 900 mr/wk with the average exposure well below 300 mr/wk. The maximum 13 week cumulative exposure was approximately 2,500 mrem. The maximum ring badge exposure was recorded as 5,000 mrem. This particular exposure resulted when the badge was accidentally left near a Kr^{85} source. It was noted that the maximum 13 week cumulative exposure at this time for the individual involved was 742 mrem. Approximately six months later, the same individual received a ring badge exposure of 2,300 mrem with a maximum 13 week total for periods including this week of 6,130 mrem. This individual's weekly exposure henceforth did not exceed 140 mrem. There have been no ring badge exposures exceeding 4,500 mrem per week and no cumulative 13 week exposures exceeded 15,000 mrem.

Personnel dosimeters are used as a supplement to film badges. Records of dosimeter results were not examined.

B. Bio-assays

Personnel working with significant quantities of H^3 other than in sealed sources are routinely monitored for internal body contamination.

Upwards of a dozen personnel are covered by this program, the number depending upon the current workload. Urine samples are collected and analyzed on the usual frequency of once per week, with occasional deviations to more and/or less frequent samples. The analytical methods employed are those described and discussed in AEC Reports LA-1894 and LA-2163. A urine concentration of 85 microcuries H^3 per liter of urine is regarded as indicating a body burden sufficient to yield a dose rate of 300 mrem per week. The maximum recorded concentration for all personnel monitored for the period November 1957 to the date of the inspection is 66 uc per liter. Usual recorded results are 10 uc per liter and under. A level of 20 uc per liter or greater is cause for an investigation. Several such levels were recorded, along with discussions of investigations of these incidents and several other incidents involving accidental releases of H^3 in the laboratory. The investigation summaries included discussions of the operational procedures leading to the high exposures and/or accidental releases and corrective measures taken. The corrective measures usually involved use of hoods or glove boxes for operations previously conducted in the open. Subsequent routine urinalyses resulted in a demonstration of lowered body concentrations.

Urinalyses for other radioactive materials have been done only infrequently and on an experimental basis. Procedure for analysis of Sr^{90} in urine samples is being developed following the general techniques proposed in AEC Report ORNL 1932. The only reported Sr^{90} results were for two measurements made on 3/31/58 which indicated 9.1 and 1.6 x 10^{-5} uc Sr^{90} per 24-hour excretion sample for two personnel. Urinalyses for Cs^{137} have been conducted on up to four personnel from November 1957 to the date of the inspection. The procedures for these analyses were not felt to be well established and Burtsavage had some doubts as to the accuracy of the results. The measurements generally showed concentrations of around 10^{-5}uc per ml or less. Only a very few samples have been analyzed for Cs^{137} since early 1958 on an infrequent basis. Burtsavage plans to institute procedures for analyzing Po^{210} in urine. He has not made any Po^{210} bio-assays to date.

Breath samples have been routinely collected once each six months on about 40 personnel over the past few years and analyzed for radon. The samples are submitted for analysis to Dr. B. F. Hess, Department of Physics of Fordham University, New York City. Dr. Hess has also performed whole body radiation measurements on a yearly basis on the few personnel who showed the highest breath concentrations. The breath analysis were recorded as showing concentrations of .03 to 3.56 x 10^{-12} curies per liter or less. Burtsavage stated his understanding that one micromicrocurie of radon per liter of expired air indicates the presence of one micromicrocurie of radium fixed in the body.

18. <u>Posting and Labeling</u>

Areas of use and storage of radioactive materials were noted to be routinely posted with radioactive material and high radiation area caution signs bearing a standard symbol. The Solution Storage area and the Silo Storage area, where radiation levels in excess of 100 mrem/hr (See Item 20A) existed were not equipped with visible and/or audible alarm signals. No airborne radioactivity signs were noted or reported to be posted. Most storage containers were noted as properly labeled with all required information. Deficiencies were noted, however, in a number of the labels, and a few examples are set forth below:

A shipping container stored in the hood of the H^3 and Kr^{85} Gas Handling Room and estimated by Burtsavage to hold 40 millicuries H^3 bore no labels to identify its contents. Another container stored in the same hood bore a label with all required information to show contents of 70 curies Kr^{85} except that "Radioactivity" was used in place of "Radioactive Materials". Several jars holding hundreds of small tubes of tritium-activated phosphors totaling about 500 curies and stored in a hood in R&D Lab No. 3 bore no labels to identify the contents other than some processing notations. A barrel of multi-millicurie amounts of a variety of wastes kept in the silo storage area bore no labels to show type, amount and date of assay of the contents. Several completed Kr^{85} light sources in storage lacked complete information on their labels as to type, amount, and date of assay of the units' contents.

Burtsavage stated that all sealed sources and containers of radioactive material shipped to USRC's customers bear labels stating "Caution Radioactive Material", the type, assay, and date of assay of materials contained therein and displaying the standard radiation symbol. Representative labels supplied this office by the licensee were noted to display the above information, and in addition, show the company name, source serial number, and other pertinent information.

19. Records

A. Records of all isotope procurements, including original orders, packing slips and a running log of receipts by isotope are maintained. These records show the isotope, quantity of material received, and the date of receipt.

B. Running inventories of all isotopes, showing the quantity of material on hand at any given time may be deduced from records of purchase, sales and waste disposals. In addition, summaries showing the quantity of each isotope on hand and the place of storage are compiled periodically.

C. Sales records show the type and quantity of material shipped, the date of shipment and the customer's name and address.

D. Records of exports of radioactive materials are maintained showing the country to which material is exported, the name of the recipient, the type and quantity of material, and the date of shipment. From 1/1/59 to the date of this inspection, exports consisting of 4.532 c of H^3, 7.036 c of Kr^{85}, and 1.1 c of Sr^{90} made to Switzerland, Canada, Japan, Belgium, and England. On 8/5/58, 3.7 mc of Ac^{227} was shipped to Israel.

E. Waste disposal transfer records are maintained which show recipient, packages shipped, contents of each package by type and amount of radioactive material, date of shipment, and means of transportation. Records of waste disposals accomplished by release to the sanitary sewerage system were not available.

F. Gas handling process loss records are maintained which show type, amount, date, location, and personnel involved in each significant release of material reported.

G. Records of film badge results showing the name of the individual exposed, the date of exposure, the radiation dose received each week, and thirteen week cumulative doses are maintained.

H. Records of dosimeter results, showing the name of the individual exposed, the date of exposure, and radiation dose received are maintained.

I. Urinalysis records are maintained for each individual checked for H^3 showing all information indicated on the form in Exhibit "D". Results are interpreted in accord with the procedures set forth in AEC report LA-2163.

J. Direct radiation survey records are maintained for the formal checks made by health physics representatives. These records show date, time, instrument, laboratory, specific position checked, and observed intensity. The intensities are reportedly recorded in units of mreps/hr with the beta component included, but no units were included in the written records examined.

K. Contamination smear survey results are maintained for checks performed by both health physics personnel and regular laboratory workers. These records show date, specific location, activity on smear, background and identify instrument used.

L. Air survey records for airborne particulates are maintained showing all information indicated on the sample form in Exhibit "E". H^3 gas monitoring results are recorded only by informal notations in a lab record book of concentrations observed and the date.

M. Records of all leak tests showing source number, date of test, and test results in counts per minute and/or dis per minute are maintained. Results of leak tests are supplied to each customer in terms of the date of the test. The presence on the "Customer Data Sheet" of the date of performance of the leak tests indicates that the source showed no leakage or removable contamination.

20. Independent Measurements Made by Inspectors

Independent surveys and measurements made by the inspectors consist of: A. direct radiation surveys; B. smear sample surveys; C. air surveys; D. radon sample surveys; and E. measurements of hood flow rates. Direct radiation measurements were taken using NYAEC Juno No. 1629, calibrated 1/23/59; and NYAEC end-window G-M survey instrument No. 5583, calibrated 2/6/59. Smear samples, air samples, and radon samples were evaluated by the Health and Safety Laboratory, NYOO. Air samples were collected using Staplex air samplers NYAEC No. 4503 and NYAEC No. 4512 in conjunction with 1¼" diameter Whatman 41 filter papers. Linear air flow rates at USRC hood faces were measured with an Alnor Velometer, Jr. having ranges of 0 - 500 and 0 - 2500 cfm.

A. Direct Radiation Surveys

Area	Location	Radiation Level	Instrument
Change Room	near Gen.Lab.area	0.25 mr/hr	NYAEC end-window GM
Change Room	at sink trap	background	"
Gen.Lab.Area	by door to Ra area	0.5 mr/hr	"
Sr^{90} Lab.	by emergency exit	8 mr/hr	"
Sr^{90} Lab.	gen.room background	up to 10 mr/hr	"

Area (cont'd)	Location	Radiation Level	Instrument
Sr^{90}	at sink by door	1 mr/hr	NMC end-window C
Sr^{90}	at sink trap	background	"
Polonium Lab.	gen. background	0.6 mr/hr	"
Polonium Lab.	at sink trap	background	"
Radium Lab.	gen. background	3 mr/hr	"
Radium Lab.	at sink trap on E. side of center section	background	"
Radium Lab.	at sink trap in N.W. corner	background	"
R&D Lab. #2	gen. background	0.4 mr/hr	"
R&D Lab. #2	at sink trap	background	"
R&D Lab. #3	gen. background	1.1 mr/hr	"
R&D Lab. #3	at sink trap	background	"
R&D Lab. #4	gen. background	4 mr/hr	"
R&D Lab. #4	at sink trap	background	"
Cesium Hot Cell	gen. background	11 mr/hr	"
Cesium Hot Cell		background	"
Solution Storage area	at glove ports to hot glove box	~300 mrad/hr	Juno (B & γ shield open)
Silo Storage Area	approx. 1' from drum of waste materials	~500 mrad/hr	"

Other than in the Solution Storage Area and the Silo Storage Area, as noted above, no radiation levels in excess of 100 mr/hr were noted in accessible areas.

B. Smear Sample Surveys

Results of smear sample surveys in disintegrations/minute/sample are summarized below:

(1) Administrative Office Areas — Total Number of Smears: 6

	0 - 50 d/m	50 - 100 d/m	100 - 200 d/m	590 d/m
Bγ	2	2	1	1
α	5	1	0	0

(2) Locker Room — Total Number of Smears: 10

	0 - 50 d/m	50 - 100 d/m	100 - 200 d/m
Bγ	5	4	1
α	9	0	1

(3) Radium Phosphor Weighing Room — Total Number of Samples: 7

	0 - 50 d/m	50 - 100 d/m	100 - 500 d/m	510 d/m
Bγ	0	2	4	1
α	7	0	0	0

(4) Radium Room — Total Number of Smears: 31

	0 - 50 d/m	50 - 100 d/m	100 - 200 d/m	200 - 500 d/m
Bγ	5	3	5	11
α	6	4	8	9

(4) Radium Room (cont'd)

	500 - 1000 d/m	1000 - 5000 d/m	Other
Bγ	2	4	1 (10,800 d/m)
α	1	2	1 (8,100 d/m)

(5) Research & Development Lab. #3 Total Number of Smears: 12

	0 - 50 d/m	50 - 100 d/m	100 - 200 d/m	200 - 500 d/m
Bγ	3	2	4	3
α	12	0	0	0

(6) Research & Development Lab. #4 Total Number of Smears: 6

	0 - 50 d/m	50 - 100 d/m	100 - 200 d/m	241 d/m
Bγ	3	1	1	1
α	6	0	0	0

(7) Strontium 90 Lab. Total Number of Smears: 12

	0 - 50 d/m	50 - 100 d/m	100 - 200 d/m
Bγ	1	1	1
α	12	0	0

	200 - 500 d/m	500 - 1000 d/m	1000 - 5000 d/m
Bγ	1	4	4
α	0	0	0

(8) Radium Dial Shop Total Number of Smears: 12

	0 - 50 d/m	50 - 100 d/m	100 - 200 d/m
Bγ	3	2	1
α	4	2	2

	200 - 500 d/m	500 - 1000 d/m
Bγ	3	3
α	2	2

(9) General Laboratory Area Total Number of Smears: 22

	0 - 50 d/m	50 - 1000d/m	100 - 200 d/m
Bγ	7	7	4
α	22	0	0

	200 - 500 d/m	500 - 1000 d/m	1100 d/m
Bγ	2	1	1
α	0	0	0

(10) Cesium 137 Cell Total Number of Smears: 13

	0 - 50 d/m	50 - 100 d/m	1D0 - 200 d/m	200 - 500 d/m
Bγ	0	0	2	5
α	11	1	0	1

(10) Cesium 137 Cell (cont'd)

	500 - 1000 d/m	1000 - 5000 d/m	Other (1 sample)
B	1	4	328,000 d/m
α	0	0	0

C. Air Surveys

Sample Number	Location	Sample Volume	α d/m/m^3	uc/cc	B d/m Sample	uc/cc
563	Sr^{90} Lab.	1500 l	≤ 4	2×10^{-12}	0	——
564	Cs^{137} cell(monitor point)	1410 l	≤ 4	2×10^{-12}	36	1×10^{-11}
565	Cs^{137} cell	1380 l	10	5×10^{-12}	36	1×10^{-11}
972	in pass window between Gen.Lab.area and leak test room	1020 l	≤ 4	2×10^{-12}	20	1×10^{-11}
973	Po^{210} Lab.	450	≤ 4	2×10^{-12}	4	4×10^{-12}
974	In Ra^{226} Lab.at door to weigh room	840	26	1.4×10^{-11}	45	2.4×10^{-11}
909	In cold shop adjacent to Kr^{85} Lab.	660	≤ 4	2×10^{-12}	23	1.6×10^{-11}
910	In change Room leading to Gen.Lab.Area	630	1	5×10^{-13}	24	1.7×10^{-11}
912	At door to locker room leading to Gen.Lab.Area	480	1	5×10^{-13}	21	2×10^{-11}

D. Radon Sample Surveys

Four radon samples, collected by means of Radon flasks and analyzed by NYOO - HASL, were taken in the following areas:

Area	Sample #	Radon Concentration
Health Physics Office	1	$4\text{-}12 \times 10^{-9}$ uc/ml
Entrance to Polonium Lab.	2	Background
Radium Lab.	3	$5\text{-}15 \times 10^{-9}$ uc/ml
Weighing Room	4	Background

E. Hood Flow Rates

Results of measurements of hood flow rates in various areas at USRC are as follows:

General Lab. Area - 12' H^3 Hood; 1/2 open; bottom 100-150 lfm; top 200-300 lfm

Strontium Lab. - Center Hood; Hood face full open; bottom = 125 lfm; top = 200 lfm

Strontium Lab. - Hood on west wall; 1 x 3' opening; bottom = 200 lfm;top = 200 lfm

Polonium Lab. - main hood; 3 x 10' face - half open; 50 - 100 lfm top & bottom

Radium Lab. - 4 x 5' hood West end, North side of center section; face 3/4 open ~50 lfm

Radium Lab. - 1½ x 4' hood North end, West side of center section; face full open ~100 - 150 lfm

Radium Lab. - 3 x 6' hood West end, South side of center section; face 1/2 open ~200 - 250 lfm

Radium Lab. - 2½ x 6' hood East end, South side of center section; face 1/2 open ~150 lfm

Weighing Room - 1x 16' work table with canopy - slight negative pressure not measurable with velometer. Low flow rate is maintained to prevent scattering of phosphor during weighing.

Research & Development Lab.#2 - 2 section hood; each section 1/2 open left section; bottom 80 - 150 lfm; top 100 - 125 lfm; right section; bottom 100 - 150 lfm; top 200 lfm
Research & Development Lab. #3 - 7' hood; 1/3 open; 300 - 350 lfm

Research & Development Lab. #4 - South wall hood; 9 square foot opening; 150 - 700 lfm

21. Type "C" Radiation Incident

As reported to Division of Civilian Application by letter dated November 12, 1957, from C. C. Carroll, Chairman, Isotopes Committee, USRC was involved in a radiation incident involving contamination of a Cs^{137} hot cell, an adjacent krypton and tritium handling area and several USRC personnel. A complete report of the circumstances surrounding this incident was submitted with the above letter and is attached as Exhibit "G" to this report. Additional information, including bioassay date on the exposed individuals was submitted with letter dated 1/9/58 from E. M. Burtsavage, RSO of USRC to DCA and is included as Exhibit "H" to this report. Investigation of this incident failed to reveal any information in addition to that submitted in USRC's initial incident report and supplementary bioassay information. No items of noncompliance appear to have contributed to the cause of the incident. The corrective action taken by the licensee is outlined in detail on Page 5 of Exhibit "G".