40-8188

FORM NRC-2
(7-77)
10 CFR 40

Approved by GAO
R0203

2D Renewal 12/31/78

U.S. NUCLEAR REGULATORY COMMISSION

APPLICATION FOR SOURCE MATERIAL LICENSE

RECEIVED 1978 NOV 29 AM 10 28

Pursuant to the regulations in Title 10, Code of Federal Regulations, Chapter 1, Part 40, application is hereby made for a license to receive, possess, use, transfer, deliver or import into the United States, source material for the activity or activities described.

1. (Check one)
- ☐ (a) New license
- ☒ (b) Amendment to License No. SMC-1181
- ☒ (c) Renewal of License No. SMC-1181
- ☐ (d) Previous License No.

2. NAME OF APPLICANT

Ledoux & Company

3. PRINCIPAL BUSINESS ADDRESS

359 Alfred Ave Teaneck, NJ 07666

4. STATE THE ADDRESS(ES) AT WHICH SOURCE MATERIAL WILL BE POSSESSED OR USED

Same as above

5. NAME OF PERSON TO BE CONTACTED CONCERNING THIS APPLICATION

Silve Kallmann Paul Blumberg

6. TELEPHONE NO. OF INDIVIDUAL NAMED IN ITEM 5

201-837-7160

7. DESCRIBE PURPOSE FOR WHICH SOURCE MATERIAL WILL BE USED

A) Storage of Ores containing more than 0.05% Uranium and/or thorium
B) Preparation of Uranium and/or Thorium samples for analysis and use as working standards
C) Analysis of Uranium and Thorium samples

8505300646 850514
REG1 LIC30
SMC-1181 PDR

8. STATE THE TYPE OR TYPES, CHEMICAL FORM OR FORMS, AND QUANTITIES OF SOURCE MATERIAL YOU PROPOSE TO RECEIVE, POSSESS, USE, OR TRANSFER UNDER THE LICENSE

(a) TYPE	(b) CHEMICAL FORM	(c) PHYSICAL FORM (Including % U or Th.)	(d) MAXIMUM AMOUNT AT ANY ONE TIME (kilograms)
NATURAL URANIUM	Metal, Oxide, Fluoride	from 0.05% to 100%	500
URANIUM DEPLETED IN THE U-235 ISOTOPE	Metal, Oxide Fluoride	Solids and solutions from 4% to 100%	50
THORIUM (ISOTOPE)	Metal or Oxide Th-232	Solid ore, concentrate or metal 0.05% to 100%	400

(e) MAXIMUM TOTAL QUANTITY OF SOURCE MATERIAL YOU WILL HAVE ON HAND AT ANY TIME (kilograms)

950

9. DESCRIBE THE CHEMICAL, PHYSICAL, METALLURGICAL, OR NUCLEAR PROCESS OR PROCESSES IN WHICH THE SOURCE MATERIAL WILL BE USED, INDICATING THE MAXIMUM AMOUNT OF SOURCE MATERIAL INVOLVED IN EACH PROCESS AT ANY ONE TIME, AND PROVIDING A THOROUGH EVALUATION OF THE POTENTIAL RADIATION HAZARDS ASSOCIATED WITH EACH STEP OF THOSE PROCESSES

A) Storage of Ores and concentrates - 400 Kg of Uranium and 350 Kg of Th
B) Blending, spiking with impurities, riffling, and packaging analytical samples. 100Kg of Uranium, 50 Kg of Depleted Uranium, 50 Kg of Th
C) Analysis of Uranium and Thorium samples, as needed under B above.

10. LIST THE NAMES AND ATTACH A RESUME OF THE TECHNICAL QUALIFICATIONS INCLUDING TRAINING AND EXPERIENCE OF APPLICANT'S SUPERVISORY PERSONNEL AND THE PERSON RESPONSIBLE FOR THE RADIATION SAFETY PROGRAM (OR OF APPLICANT IF AN INDIVIDUAL).

Silve Kallmann
Paul Blumberg

RECEIVED BY LFMB
Date NOV 30 1978
Nov P&5 Renewal
Orig. To
Action Compl. 12/11/78

Applicant
Check No. 77710
Amount/Fee Category #20 (2D)
Type of Fee Renewal
Date Check Rec'd. DEC 11 1978

11. DESCRIBE THE EQUIPMENT AND FACILITIES WHICH WILL BE USED TO PROTECT HEALTH AND MINIMIZE DANGER TO LIFE OR PROPERTY AND RELATE THE USE OF THE EQUIPMENT AND FACILITIES TO THE OPERATIONS LISTED IN ITEM 9. INCLUDE (a) RADIATION DETECTION AND RELATED INSTRUMENTS (including film badges, dosimeters, counters, air sampling, and other survey equipment as appropriate. The description of radiation detection instruments should include the instrument characteristics such as type of radiation detected, window thickness, and the range(s) of each instrument).

See Attachment

"OFFICIAL RECORD COPY"
11326

(b) METHOD, FREQUENCY, AND STANDARDS USED IN CALIBRATING INSTRUMENTS LISTED IN (a) ABOVE, INCLUDING AIR SAMPLING EQUIPMENT (for film badges, specify method of calibrating and processing, or name supplier).

Alpha equipment - Pu 239 Source + NBS 950 Uranium - Beta & Gamma equipment - Cs-137 Source Film Badge service - L. Landauer & Co.

ML18

11(c). VENTILATION EQUIPMENT WHICH WILL BE USED IN OPERATIONS WHICH PRODUCE DUST, FUMES, MISTS, OR GASES, INCLUDING PLAN VIEW SHOWING TYPE AND LOCATION OF HOOD AND FILTERS, MINIMUM VELOCITIES MAINTAINED AT HOOD OPENINGS AND PROCEDURES FOR TESTING SUCH EQUIPMENT.

See Attachments

12. DESCRIBE PROPOSED PROCEDURES TO PROTECT HEALTH AND MINIMIZE DANGER TO LIFE AND PROPERTY AND RELATE THESE PROCEDURES TO THE OPERATIONS LISTED IN ITEM 9; INCLUDE: (a) SAFETY FEATURES AND PROCEDURES TO AVOID NONNUCLEAR ACCIDENTS, SUCH AS FIRE, EXPLOSION, ETC., IN SOURCE MATERIAL STORAGE AND PROCESSING AREAS.

See Attachments

(b) EMERGENCY PROCEDURES IN THE EVENT OF ACCIDENTS WHICH MIGHT INVOLVE SOURCE MATERIAL.

See Attachments

(c) DETAILED DESCRIPTION OF RADIATION SURVEY PROGRAM AND PROCEDURES.

(Attached)

13. WASTE PRODUCTS: *If none will be generated, state "None" opposite (a), below. If waste products will be generated, check here ☐ and explain on a supplemental sheet:*

Radiation Safety Manual

(*a*) Quantity and type of radioactive waste that will be generated.

(*b*) Detailed procedures for waste disposal.

14. IF PRODUCTS FOR DISTRIBUTION TO THE GENERAL PUBLIC UNDER AN EXEMPTION CONTAINED IN 10 CFR 40 ARE TO BE MANUFACTURED, USE A SUPPLEMENTAL SHEET TO FURNISH A DETAILED DESCRIPTION OF THE PRODUCT, INCLUDING:

(*a*) PERCENT SOURCE MATERIAL IN THE PRODUCT AND ITS LOCATION IN THE PRODUCT.

(*b*) PHYSICAL DESCRIPTION OF THE PRODUCT INCLUDING CHARACTERISTICS, IF ANY, THAT WILL PREVENT INHALATION OR INGESTION OF SOURCE MATERIAL THAT MIGHT BE SEPARATED FROM THE PRODUCT.

(*c*) BETA AND BETA PLUS GAMMA RADIATION LEVELS (*Specify instrument used, date of calibration and calibration technique used*) AT THE SURFACE OF THE PRODUCT AND AT 12 INCHES.

(*d*) METHOD OF ASSURING THAT SOURCE MATERIAL CANNOT BE DISASSOCIATED FROM THE MANUFACTURED PRODUCT.

CERTIFICATE

(This item must be completed by applicant)

15. *The applicant, and any official executing this certificate on behalf of the applicant named in Item 2, certify that this application is prepared in conformity with Title 10, Code of Federal Regulations, Part 40, and that all information contained herein, including any supplements attached hereto, is true and correct to the best of our knowledge and belief.*

BY: [signature]
(Signature)

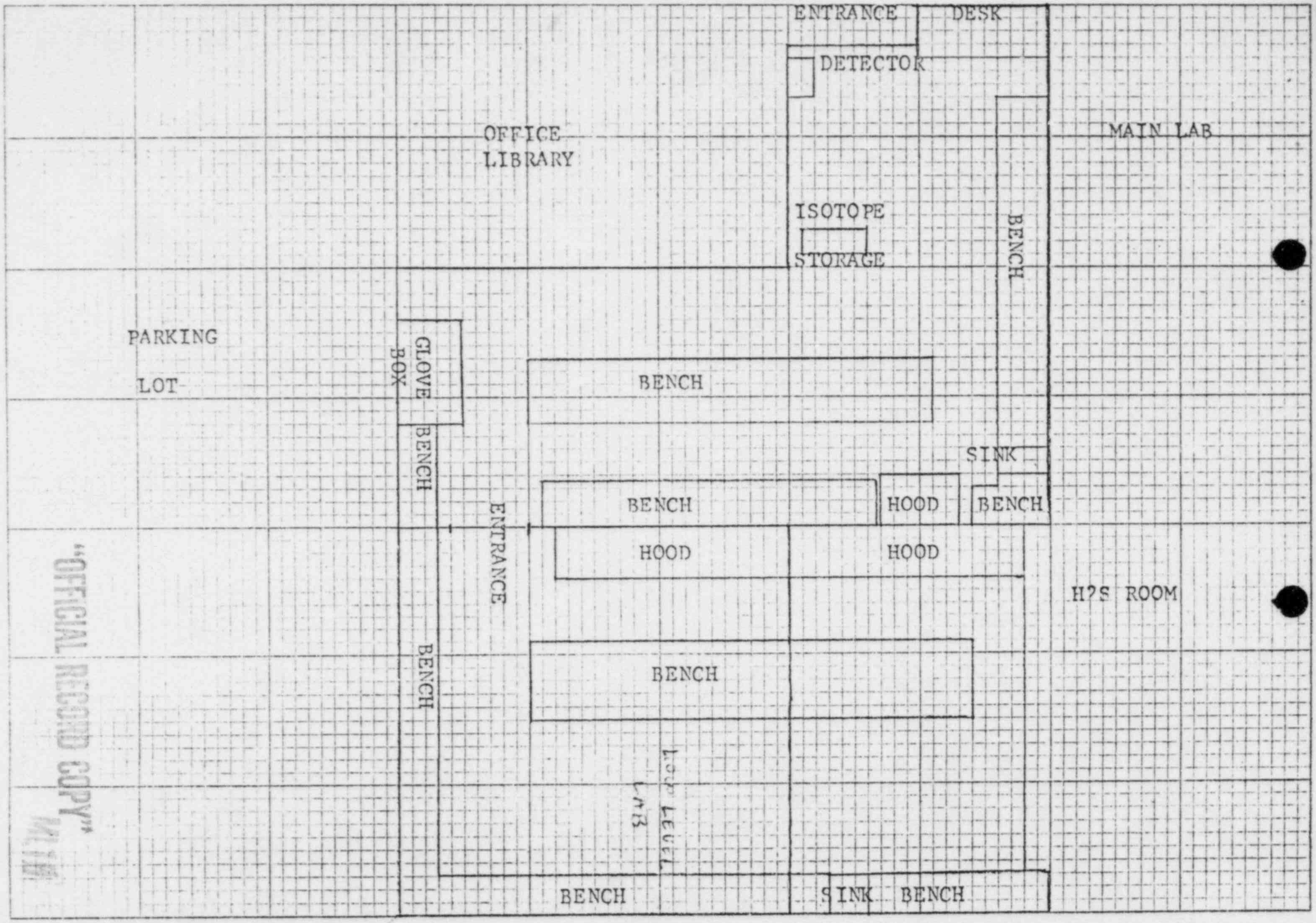
Dated Nov. 27, 1978

LOUIS ANDRE LEDOUX
(Print or type name)

PRESIDENT
(Title of certifying official authorized to act on behalf of the applicant)

WARNING: 18 U.S.C. Section 1001; Act of June 25, 1948; 62 Stat. 749; makes it a criminal offense to make a willfully false statement or representation to any department or agency of the United States as to any matter within its jurisdiction.

RADIOCHEMISTRY FACILITY



OUTSIDE

SILVE KALLMANN
Vice President - Technical Director

Mr. Kallmann is responsible for the direction of approximately 65 scientific and support personnel in the performance of all technical activities at Ledoux & Company. These activities include research and development projects and all phases of wet chemical, and instrumental methods of analyses.

Mr. Kallmann has been associated with Ledoux & Company since 1942 and has been Research Director since 1950. He is author or co-author of approximately 25 papers published in ANALYTICAL CHEMISTRY, Talanta, and Anal. Chim. Acta, covering a variety of analytical subjects. He also prepared two chapters in Kolthoff and Elving's "Treatise on Analytical Chemistry", a chapter on mineral analysis in Meites" "Analytical Handbook", a chapter on inert gas fusion analyses for a forthcoming volume of TECHNIQUES IN METAL RESEARCH edited by Bunshaw of Lawrence Radiation Laboratories, and a chapter of a book on Gases in Metal Analysis edited by Melnick of U. S. Steel.

During the last several years, Mr. Kallmann has been one of three United States representatives to the Advisory Group for Aeronautical Research and Development (AGARD) program of the North Atlantic Treaty Organization. For many years, he has been prominently active in the affairs of the American Society of Testing Materials. At the present time, he is Chairman of Analytical Subcommittee, E-16, chairman of six task forces in various ASTM committees, Vice-Chairman of Division M (Miscellan-

eous Metals), Division G (General) of ASTM Committee E-3 and Division I (Interstitials) of ASTM Committee E-3. He is also a member of the International Standards Organization. He was awarded the Lundell-Bright Award by the ASTM in 1970 for his outstanding contributions in the field of chemical analysis.

Prior to joining Ledoux & Company, he was employed in the Oppenheimer Laboratory, Dusseldorf, Germany, as an Analytical Chemist and also by Walker & Whyte, New York, a commercial testing laboratory.

Mr. Kallmann was educated at the University of Cologne, his education being equivalent to a Master of Science in Chemistry in the United States. He is a member of the American Chemical Society, American Nuclear Society, American Institute of Mining Engineers and the Association of Consulting Chemists. He is listed in American Men of Science.

Mr. Kallmann completed an extensive two-month course at Oak Ridge Consolidated Universities in 1955 on the safe handling of radionuclides, their detection and determination.

Resume of Paul J. Blumberg
Supplemental information to questions 8 to 10

Mr. Blumberg has completed the health physics training program at Manhattan College, Bronx, NY where he received formal courses which covered the items of 8a through 8d.

In addition, Mr. Blumberg has been working within the field since August, 1965.

From August 1965 to February 1968, Mr. Blumberg was employed by E.R. Squibb and Sons Radiopharmaceutical Branch in the quality control section. Here he worked with several millicuries of the isotopes H-3, Na-22, P-32, Co-57, Co-60, Se-75, Mo-99, Te-99m, I-125, I-129, I-131, Cs-137, Ir-192, Au-198, Hg-197, and Hg-203. Since that time, Mr. Blumberg has been employed at Ledoux & Company where he has gained experience with smaller quantities of several other isotopes including C-14, Ni-65, Na-24, Co-58, Sr-85, Sr-89, Sr-90, Y-88, Y-90, Zr-95, Nb-95, Ru-106, Ba-133, Cs-134, Ce-144, and Bi-210.

Mr. Blumberg also participated in submarine start-up programs on 17 submarines in 1971 and 1972 where he worked on several short-lived fission products in primary coolant solutions at up to 100% power levels of the reactor.

Mr. Blumberg graduated from Rutgers in 1976 with a B.A. in Chemistry and a graduate course in Nuclear Physics.

Supplemental Attachment for #11.

Equipment:

Tracerlab, Inc.
Alpha, Beta, Gamma Survey Meter Model SU-14

Beckman Wide Beta II Flow Proportional Counter

Eberline Model RM-15 Radiation Monitor with Alpha Probe Model AC-3-7/AC-3B-7 with 1.5 mg/cm^2 aluminized mylar window which is used as a personnel monitor. It also has an attachable Beta-gamma probe Eberline Model No. HP-177C with wall thickness of 30 mg/cm^2. The meter reads from 0 to 500 counts per minute with times 10 and 100 settings. Approximately 1400 cpm from Co.60 equals 1 mR/hr.

Attachment For 11 (c)

Uranium and thorium is worked on and analyzed in the Radiochemistry facility or the UF_6 facility. The UF_6 facility has two hood areas an one exhaust system with a filter between the hoods and the fan. Monthly air samples are taken after the filter to determine alpha and beta activity released. The radiochemistry facility has one hood in the main laboratory and three hoods in the low level lab. Any work which will involve preparation of standards will take place in the main radiochemistry facility. The ores and concentrates are stored in the main warehouse in a designated area.

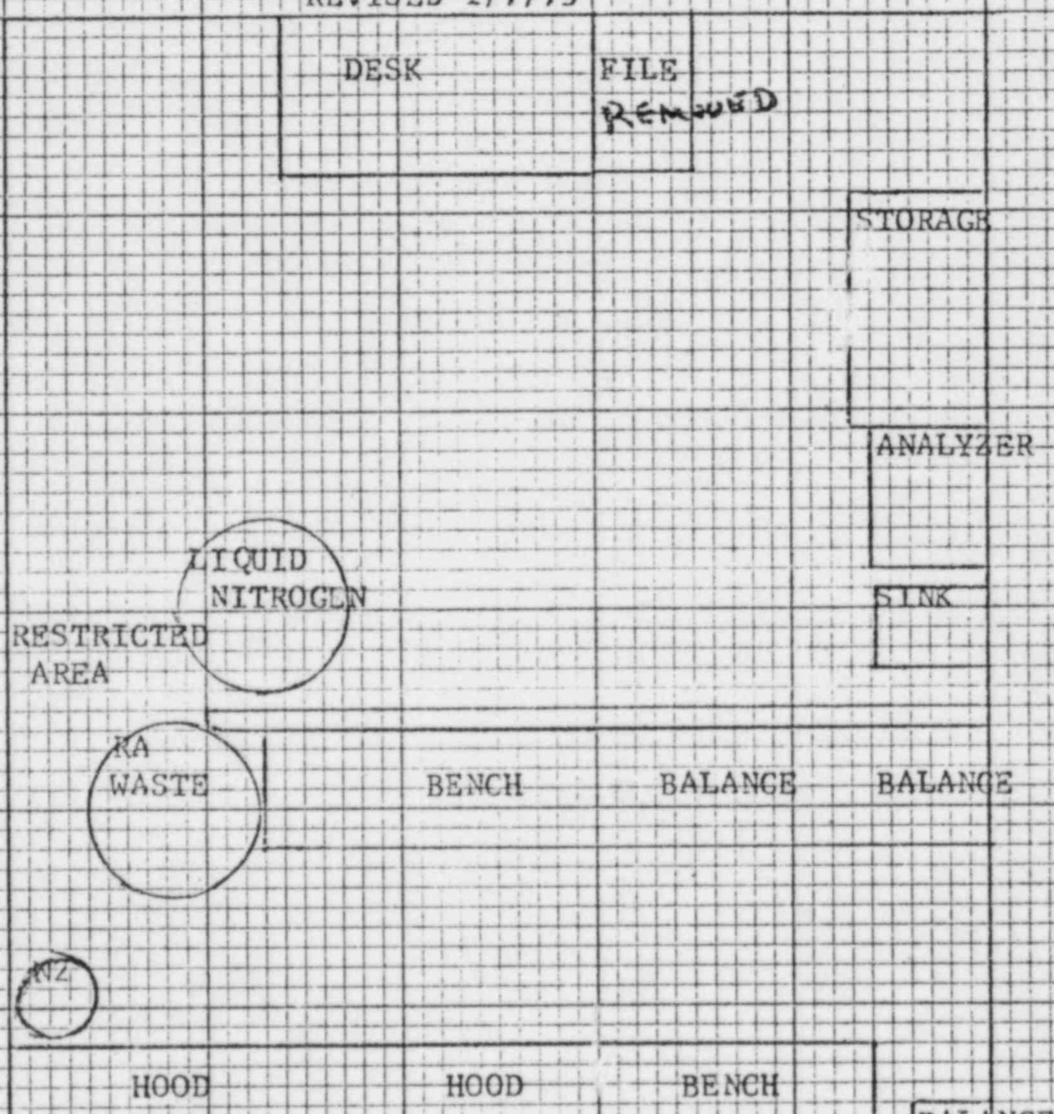
Attachment for 12

A) The storage and laboratory areas are all sprinkler equipped. Flamable liquids are not stored in these areas, while small amounts of flamable reagents are used and kept in the radiochemistry facility. The storage area itself has no flamable or explosive material.

B) All areas are properly marked for evacuation, with exit signs lighted and emergency lighting provided to aid in evacuation. The local fire department is informed of the existing activities and various personnel from this fire department make routine visits to familarize themselves with our operation. Radiation detection instrumentation is kept in three different areas so that there should be detection equipment available in case of emergency where access to one or more areas is cut off.

C) Radiation Manual describes the survey program and procedures at Ledoux & Company.

UF$_6$ FACILITY
REVISED 1/7/75



LEDOUX AND COMPANY RADIATION MANUAL

The scope of this manual is to establish working procedures with radioactive material as well as to make employees aware of the hazards involved in the use and handling of radioactive materials. At present, our AEC licenses limit the amount of radioactive materials to fairly low levels so that hazards from external radiation are small. These hazards are covered as a general outline for good practice in handling any amount of radioactivity. Of much greater concern for Ledoux and Company should be internal exposure. Internal exposure results from the deposition of radioactive material within the body through inhalation, ingestion, or absorption. Internally deposited radiation is extremely hazardous since it produces continuous radiation exposure until it decays or is removed from the body through excretion. Internal radiation exposure can be controlled only by preventing the entry of radioactive material into the body. It is essentially a problem of contamination control.

If we were to analyze all of the many thousands of materials so familiar to us in our daily lives, we would find that they are all mixtures of chemical combinations of a relatively few basic materials called elements. Examples of these elements are carbon, oxygen, iron, hydrogen, and zinc. The smallest "piece" of an element that can exist and still keep the identity of that element is called an atom (a very small particle indeed, far smaller than we can see even with the aid of the most powerful

microscope). The atoms, then, may be considered the basic building blocks from which all matter is constructed. For example, water is a chemical combination of atoms of oxygen and atoms of hydrogen; table salt is a chemical combination of sodium and chlorine atoms.

At one time it was believed that an atom could in no way be divided. However, research has revealed that all atoms (no matter if they are hydrogen atoms, sodium atoms, etc.) are composed of three basic atomic particles: electrons, protons, and neutrons. Each atom has a densely packed center called the nucleus, which contains the protons and the neutrons, and the electrons revolve around this nucleus in orbits.

Once radiation is released from a redioactive nucleus, what happens to the ejected particles and energy?

1. Radiation particles and energy do interact with and affect surrounding atoms. Just as a bullet will affect a board it strikes, radiation particles and energy will strike and perhaps change atoms in their path.
2. The distance that radiation and energy will travel depends on the energy of the particle or gamma ray when it is emitted and on the frequency with which it interacts with the atoms along its path. For particulate radiation this fréquency, as a rule of thumb, depends on the size of the radiation particle. For example, the heavy alpha particle will usually not penetrate an ordinary sheet of paper, but to stop the much lighter (smaller) beta particle will require a sheet of aluminum. Gamma radiation, having no

mass, can be stopped only by thick sheets of lead or concrete.

A fourth type of radiation involves the release of neutrons from atomic nuclei. This is a rather unusual type of radiation generally associated with reactors and accelerators and will not be discussed in a detailed manner in this manual.

Radiation Effects

If radiation had no effect on the surrounding material, we might regard it merely as an interesting phenomenon. But radiation does affect the material exposed to it; this fact becomes very important when the exposed material is a person.

The problem of exposure of personnel to radiation is twofold. First there is the problem of external radiation, that is, radiation received from sources outside the body. External alpha radiation presents little hazard because the alpha particles usually cannot penetrate the outer layer of dead skin. Since the outer skin layer is composed of dead skin, the amount of radiation it receives is little cause for concern. Beta radiation, on the other hand, can penetrate far enough to damage living tissue. The even more penetrating gamma radiation will reach much more important organs such as the blood-cell-producing bone marrow.

The second problem is internal deposition of radioactive material. Since the body cannot distinguish chemically between radioactive and non-radioactive isotopes of the same element, radioactive material can be chemically incorporated into the body if they are swallowed or inhaled. The result is a problem of

radiation from sources internal to the body. If this happens, alpha radiation becomes very important; internally deposited alpha-emitting radioisotopes can be a problem. Beta radiation is also frequently a more severe problem when the radiation source is internally deposited. Gamma radiation is a problem whether the source is external or internal.

Units of Exposure and Dose

Three units commonly used to measure radiation exposure and dose are the roentgen, the Rad, and the Rem.

The roentgen, is applied only to x or gamma radiation, whereas the Rad and the Rem may be used to measure any type of ionizing radiation. The Rem is a special unit that takes into account the different biological effects of various beta and neutron dose. For most practical applications, one Rad equals one roentgen equals one Rem when only beta and gamma radiations are being considered. Because these are rather large quantities of radiation, doses and dose rates are often given in terms mR, mRad, and mRem("m" being the abbreviation for milli, which means one-thousandth of). Dose rates refer to the dose received per unit time. Thus we have mR/hr, mRads/hr, and mRems/hr to measure dose rate.

Exposure of personnel to ionizing radiation must be kept to a safe level (just as must any other industrial hazard such as toxic chemicals or fumes). Of course, it is quite impossible to draw a sharp, definite line that separates "safe" radiation doses from those causing measurable harm. As a result most of the recommenda-tions for control of radiation dose received by personnel are de-

signed to be well on the safe side. The fact that someone exceeds the recommendations, then, is not a cause for alarm but often signifies a breakdown in controls.

Radiological Controls

With the brief background on atomic structure, effects of radiation and familiarization of units of exposure and dose, we shall continue into the main purpose of this course manual - Radiological Controls as they apply in the Laboratory. Initially, however, a restatement of an important concept is in order. To understand and implement controls it should be clear that we are controlling two basic types of radiological hazards; External and Internal radiation hazards.

An external radiation hazard is one where the source of radiation is external to the body and the radiation interacts with the body by passing through it. An internal radiation hazard is when the radioactive material is deposited within the body and the body tissue is irradiated from within. This type of hazard in many cases is the most serious since the radioactive material is actually within the body and can remain there for extended periods of time, days to months, depending on the specific type of radioactive material. What methods can we use to protect ourselves against these two type of hazards?

Controls for Reducing and Minimizing Exposure to External Radiation

Three basic techniques may be used to control this type of hazard; time, distance, and shielding.

<u>Time</u> Since the total dose one receives is related to the amount of time he is exposed to a given field of radiation by simply reducing the time spent doing a task we are able to control the total dose received.

For example, if we have a dose rate of 1Rem/hr and we want to limit exposure to a total dose of 100 mRem (0.1 Rem) the time must be limited to 6 minutes (0.1 hrs).

Dose (Rem) = Dose rate (Rem/hr) x Time (hrs)

0.1 Rem = Rem/hr x T

$$\frac{0.1}{1.0} = T$$

0.1 hr or 6 minutes = T

What can be done to reduce the amount of time doing a job in a radiation field? First, plan the job and second, where applicable, go through a dry run.

<u>Distance</u>

It is known that radiation intensities decrease with the distance from the source. Therefore, distance may be used to reduce one's exposure. Often when we speak of using distance to control radiation exposures we tend to think of complicated remote handling tools. However, handling a highly active piece of radioactive material with six inch pliers rather than the bare hand will reduce the dose to the hands significantly. Especially when the source emits a great deal of beta radiation. Also if one extends their arm rather than handling a source close to the body it can reduce the dose to the body by a factor of ten.

Shielding

The third control measure which can be utilized to reduce exposures to external radiation is shielding. As indicated earlier,radiation does interact with matter. It is absorbed to some extent in matter. The more dense (heavier) the matter the more absorption takes place. The two most common heavy materials used for shielding are concrete and lead. When radiation is absorbed it is said to be "Attenuated"/ One inch of lead can attenuate most common types of gamma radiation by a factor of ten or more. For example, a small source of Cs-137 produces a dose rate of 1R/hr three feet from the source. If one inch of lead is positioned between the source of the person being exposed the radiation level (dose rate) will be reduced to 0.1 R/hr. For each inch of lead added the dose is reduced by ten. Such that the addition of two inches of lead in this case results in a reduction of 100 (10^2) in the dose rate to 0.01 R/hr.

GENERAL WORKING CONSIDERATIONS

I. In any area where radioactive material is being used, there is to be no eating, drinking, smoking or cosmetic applications. Established maximum levels of contamination are not to be exceeded in controlled areas. Surveys are used to determine base levels. The frequency of surveys is to be determined by the workload. In general, smears are to be taken after completion of a project, and air samples are to be taken while work is in progress. Before leaving a controlled area, the worker is to monitor himself. If protective clothing is required for that work, it shall be kept in the controlled area and treated as being radioactive.

II. a) Area smear surveys

1. Surveys are to be taken using 1 square inch Whatman #42 paper discs.
2. The area smeared should be 100 square centimeters.
3. Every surface used should be smeared at least once.
4. Smears are to be submitted to radiological control for evaluation.

b) Air monitoring

1. The object of air monitoring is to establish working levels and to determine hazard to the worker.
2. The air is to be monitored for particulate and/or specific element concentrations.
3. The Whatman #41 filter paper OF 11 centimeters diameter is used to collect particles greater than ten microns in diameter. At least 400 cubic feet of air are necessary for a representative sample size.

4. Scrub solutions thru which air is bubbled to remove a specific radionuclide is to be used where the airborn radiation hazard is known. Bubble at least 100 cubic feet of air thru two successive traps. The concentration of radioactive elements in the solutions is to be determined by chemical and radioactive analysis.
5. Limits for concentrations of radionuclides in air are listed in 10CFR20, appendix B, Table II, Column I.

c) External Radiation Levels

1. Each radiation control area is to be evaluated every week for radiation levels in work areas.
2. Waste disposal and isotope storage areas should be checked each work day these facilities have been used.
3. Caution, Radioactive Material signs shall be posted in all areas where radioactive material is stored or used and where the radiation background is two mr/hr or less.
4. Caution, Radiation Area signs shall be posted in all areas where there is a background radiation level in excess of two mr/hr. Such areas are to be conspicuously marked, and the actual levels are to be posted.
5. Radioactive material is to be stored in such a manner that no radiation area of greater than 50 mr/hr on contact is created.

III. Survey Evaluation

A. SNM Handling facility

1. The special nuclear materials handling facility is divided into two zones:

a) Radiation Area

b) Uncontrolled Area

2. Radiation Area

a) Smears are to be taken daily in the radiation area if work is carried on within that area.

b) Smears are to be counted on Eberline Radiation monitor RM-15. Each ten alpha counts represents 0.1 mg of U (natural) up to 1.5 mg of U (natural). The Pu isotope efficiency is 12.8% for the 1" diameter filter papers.

c) The RM-15 is to be stationed between the two areas of the facility and is to be used as a personnel monitor before exiting from the radiation area.

3. Uncontrolled Area

a) Smears are to be taken monthly and counted on the Beckman low-background alpha and beta proportional counter.

b) Levels in all uncontrolled areas are to show a beta activity of $<$ 2.0 cpm and an alpha activity of $<$ 0.3 cpm on the Beckman instrument (beta eff: $\sim$40%, alpha eff $\sim$ 30%).

B. Radiochemistry and Low Level Labs

1. The radiochemistry and low level labs are to be classified as a Radioactive Materials Area.

2. Smear limits are those of paragraph A3b of this section above.

3. Air samples are to be taken quarterly on Whatman #41

IV. Personnel Monitoring

a) People working with radioactive material or X-ray generating equipment are to be issued film badges.

b) Film badges are to be used only during working hours and are to be kept in a rack with the control badge when not being used.

c) The film is processed quarterly unless exposure levels indicate the need for more frequent processing.

V. Location and Storage of Radioactive Materials

a) Radioactive samples received by the company are to be smeared for purposes of leak detection and external contamination.

b) Labelled radioactive packages are to be surveyed for external hazards and are to be stored in a locked container or room designated for that purpose.

c) Storage areas are to be assigned throughout the laboratory so that all people are aware of the location of radioactive samples.

APPENDIX 1

Emergency Procedures are required to (1) minimize injury to personnel and (2) minimize destruction of Laboratory property and (3) prevent release of radioactivity to uncontrolled areas. Knowledge of emergency procedures is an important responsibility of each individual at the Laboratory.

Spills - In the e ˆ radioactive liquids or solid (including finely divided particles which may disperse rapidly in air) are spilled, the general procedures outlined below should be followed. Since each spill will require different detailed actions for effective control and recovery, personnel should take appropriate actions to minimize the spread of contamination.

Stop the Spill - If the spill is from a system which may have more material to leak out, promptly stop the leak if possible. If the spill is from an overturned container, try to set it upright if the contents have not all escaped. The amount of time spent stopping a difficult leak should depend upon the radiation level involved, the possibility of inhaling airborne radioactivity from the spill, and the consequences of not making a prompt closure. In some cases, a prompt closure may not be practical.

Warn other personnel. Other personnel who may become contaminated by the spill or who may be able to help control it should be alerted immediately. Contact Radiological Control Engineering personnel.

Isolate the area. Keep unnecessary people away from the area affected by the spill to minimize the spread of contamination. This action may require closing doors, roping off the area, or verbally warning approaching personnel.

Minimize your own exposure. Move to the edge of the affected area, taking care to minimize the spread of contamination. It may be advisable to step outside the room where the spill occurred and seal off the access. Remain in the immediate area of the spill until Radiological Control personnel advise otherwise.

Shut off ventilation from the spill area other than filtered exhausts. It may be desirable also to shut down exhaust systems in adjacent areas to ensure that air flows into rather than away from the spill area. Filtered exhausts should be shut down if necessary to minimize spread of high levels of radioactive contamination.

Measure activity levels. Measure contamination on personnel who have been exposed. Make contamination surveys in adjacent areas, determine magnitude and extent of surface contamination in the spill area; when appropriate, measure airborn radioactivity inside and outside the spill area and measure radiation levels in ventilation filters.

Clean-up actions. Subsequent radiological control and clean-up actions should be in accordance with other appropriate Radiological Control procedures. Consideration should be given to radioactive waste disposal and internal and external exposure of personnel.

For locations where spills are most probable or would have the worst consequences, detailed spill procedures should be prepared and appropriate personnel should be trained to control and recover from radioactive spills.

APPENDIX 2

Personnel Decontamination

Decontamination processes consider two factors: the effective removal of the contaminants, and the effect of the decontamination process on the skin and hair. Soap and water is to be tried first. Wash for two minutes and monitor again to establish a decontamination factor, D.F. = INITIAL ACTIVITY/FINAL ACTIVITY. A brush may be necessary to clean behind finger nails and for more effective abrasive action. If soap and water prove inadequate, a concentrated detergent paste can be used. Add a little water to a detergent and use a mild scrubbing action. Chemicals and other skin irritants should be avoided.

Area and Material Decontamination

Area and material decontamination should be accomplished by Radiological Control. Removal of material from a controlled area should be under Radiological Control supervision. Smears are to be taken and recorded, and the items removed are to be identified.

APPENDIX 3

RADIOLOGICAL UNITS

Multiply # of → / to obtain # of ←	by	→ to obtain # of / ← Divide # of
curies	3.700×10^{10}	dis/sec
curies	2.220×10^{12}	dis/min
curies	10^{3}	millicuries
curies	10^{6}	microcuries
curies	10^{12}	picocuries
curies	10^{-3}	kilocuries
dis/min	4.505×10^{-10}	millicuries
dis/min	4.505×10^{-7}	microcuries
dis/sec	2.703×10^{-8}	millicuries
dis/sec	2.703×10^{-5}	microcuries
kilocuries	10^{3}	curies
microcuries	3.700×10^{4}	dis/sec
microcuries	2.220×10^{6}	dis/min
millicuries	3.700×10^{7}	dis/sec
millicuries	2.220×10^{9}	dis/min
R	2.58×10^{-4}	C/kg of air
R	1	esu/cm^3 of air (s.t.p.)
R	2.082×10^{9}	ion prs/cm^3 of air (s.t.p.)
R	1.610×10^{12}	ion prs/g of air
R (33.7 eV/ion pr.)	7.02×10^{4} 7.02×10^{4}	MeV/cm^3 of air (s.t.p.)
R (33.7 eV/ion pr.)	5.43×10^{7}	MeV/g of air
R (33.7 eV/ion pr.)	86.9	ergs/g of air
R (33.7 eV/ion pr.)	2.08×10^{-6}	g-cal/g of air
R (33.7 eV/ion pr.)	≈98	ergs/g of soft tissue
rads	0.01	J/kg
rads	100	ergs/g
rads	8.071×10^{4}	MeV/cm^3 of air (s.t.p.)
rads	6.242×10^{7}	MeV/g
rads	10^{-5}	watt-sec/g

APPENDIX 4

I. INTERNAL RADIATION DOSAGE

(1) Biological Half-Life

$$T_b = \frac{0.693}{\lambda_b}$$

where λ_b = biological decay constant

T_b = biological half-life

(2) Effective Half-Life

$$T_{eff} = \frac{(T_{\frac{1}{2}})(T_b)}{T_{\frac{1}{2}} + T_b}$$

where T_{eff} = effective half-life

$T_{\frac{1}{2}}$ = radioactive (physical) half-life

T_b = biological half-life

(3) Beta Emitter Dose

$$D = 73.8\ E\ T_{eff} C\ (1 - e^{-\lambda_{eff} t})$$

where D = dose (rads)

E = average energy of beta particle (MeV)

T_{eff} = effective half-life

C = µCi/gm of radionuclide in tissue

λ_{eff} = effective decay constant (day^{-1})

t = time (day)

DECONTAMINATION FACTOR

$$D.F. = \frac{\text{Initial Activity}}{\text{Final Activity}}$$

RADIOLOGICAL SAFETY TERMINOLOGY

Radiological: Pertains to the study and use of radioactive materials and radiation-generating apparatus.

Radioactivity: That property of a substance which causes it to emit ionizing radiation. This property is the spontaneous transmutation of the atoms of the substance.

Radiation: The propagation of energy through space radially from the point of origin. The types of radiation of concern in radiological safety are those which generate ionization as they dissipate their energy in the matter through which they pass.

Gamma - and X-ray Radiation: Electromagnetic quanta of wavelengths less than ultraviolet, travelling with the speed of light, and each conveying energy proportional to their frequency.

Alpha Particle: A helium nucleus, consisting of two protons and two neutrons, with a double positive charge. A strongly ionizing and weakly penetrating radiation.

Beta Particle: A charged particle emitted from the nucleus of an atom and having a mass and charge equal in magnitude to those of the electron. More penetrating but less ionizing than an alpha particle.

Neutron Radiation: A neutron is a chargeless particle of mass similar to that of the hydrogen ion. Fast neutrons convey energy from their source by virtue of the velocity at which their mass travels. Slow neutrons may be termed "thermal" neutrons when

their kinetic energy is equivalent to that of the thermal motion of the atoms among which they diffuse; thermal neutrons no longer convey significant energy from their origin but are capable of releasing energy as a consequence of the transmutation which occurs when they are captured by absorber nuclei.

Contamination: An impurity which pollutes or adulterates another substance. In radiological safety, contamination refers to the radioactive materials which are the sources of ionizing radiation.

SURVEY AND AIR SAMPLE RECORD

	DATE	AREA SURVEYED	SAMPLE SIZE	DPM (per 100 cm^2) (per ml)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				

Surveyed by ______________________________

Counted by ______________________________