

Regulatory

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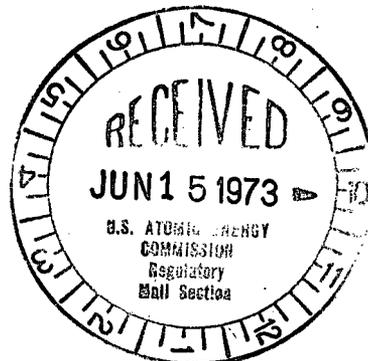
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STERLING FOREST
RESEARCH CENTER

June 13, 1973



U.S. Atomic Energy Commission
Division of Materials Licensing
Fuel Fabrication & Transportation Branch
Washington, D. C. 20545

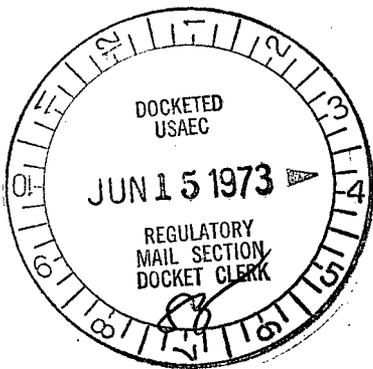
Attn: Mr. Ferman Stubblefield

Ref a.: UCC letter dated 2/8/73 of application for
amendment to SNM-639

Dear Mr. Stubblefield:

I have enclosed the additional information regarding our proposed license amendment (Ref a.) which was requested during our meeting of 6/1/73. This additional information consists of:

- (a) A description of the Hot Laboratory monitoring system.
- (b) An elaboration on the means of criticality control to be utilized in all phases of our operations with U-235 in the Hot Laboratory.
- (c) A copy of the Hot Laboratory evacuation procedure.
- (d) Current personnel biography of members of the Nuclear Safeguards Committee and Hot Laboratory supervisor.
- (e) Analysis of radiation levels at assembly areas in event of hypothetical criticality incident in upper level of Hot Laboratory.



It is anticipated that this information, in addition to previous submissions to the Commission under SNM-639 dated 5/21/69, 11/5/70, and reference A above, will satisfy the requirements of Sec. 70.24b of Title 10CFR.

Very truly yours,

J. J. McGovern
J. J. McGovern
Superintendent
Nuclear Operations

JJMcG:js
Enclosures

3891

A. HOT LABORATORY MONITORING SYSTEM

A senior Health Physicist is responsible for all phases of Health Physics, as well as the general safety procedures for the Reactor and Hot Lab areas. He supervises the activities of Health Physics technicians.

1. Health Physics Training

All personnel working with radioactive material in the Hot Lab receive basic radiation safety training. This initial radiation safety instruction is supplemented by on-the-job training during each new operation.

2. Personnel Monitoring

All personnel working in the Hot Lab wear a film badge and two pocket ionization chambers. The pocket chambers are read daily and the film badges are evaluated bi-weekly by an approved commercial laboratory. Bio-assay work are sent to an approved commercial laboratory for evaluation. Urinalyses on all Hot Laboratory personnel working with radioactive materials are made on a routine basis at least once each year. Additional samples will be taken as recommended by the Health Physicist.

3. Instruments and Equipment

All radiation detection and monitoring equipment are set and kept in proper operating condition by the Health Physicist.

a. Radiation detection and monitoring

Radiation detection instruments available for monitoring include at least (5) Ion Chamber Meters with range up to 50,000 mr/hr, (2) Geiger Detectors with range up to 20 mr/hr, (1) Alpha Scintillation Counter, (1) Atomic Model 1095 Scaler and End Window G.M. Counter, (1) Gas-Flow Proportional Counter with Tracerlab Ampliscaler, and (1) Atomic Model 520 Differential Pulse Height Analyzer.

Portable radiation detection equipment such as cutie-pies and G-M survey meters and alpha detectors are located at various points in the area and a Hand and Foot Counter is near the main exit from the Hot Lab. It is used by visitors and personnel before going to lunch or leaving the building.

b. Area monitrons

Area radiation monitrons are located in 15 different positions throughout the Hot Lab. Five are located in-cell (one in each cell), three in the charging area, two in the second level area above the cells, and one each at 1) south loading dock, 2) canal gamma facility, 3) ion exchange columns in Radioactive Waste Water Treatment System, 4) exhaust air filter room and 5) operating area. These monitrons have audio and visual alarms at the local point and at the main monitron control panel in the operating area of the Hot Lab. The two upper level monitrons are interlocked with a horn so that personnel on the lower level will be instantaneously warned of a possible criticality on the upper level.

These area monitrons, excluding the in-cell units, are normally set to alarm at 5.0 mr/hr.

c. Constant air monitors

Two constant air monitors are located in the Hot Lab. The monitors can be set to draw air (via a vacuum pump) past filter paper at a flow rate ranging from 1 to 10 cu.ft/min. A G-M tube is located above the filter paper and measured activities are continually recorded.

d. Stack monitors

The exhaust air from both the Reactor and Hot Laboratory are continuously monitored for radioactive particulate matter and for gaseous activity. This monitor is equipped with a recorder and alarm circuits to indicate high activity or equipment failure. It is checked on a routine basis at least once a day. An accumulative weekly sample is analyzed for alpha activity.

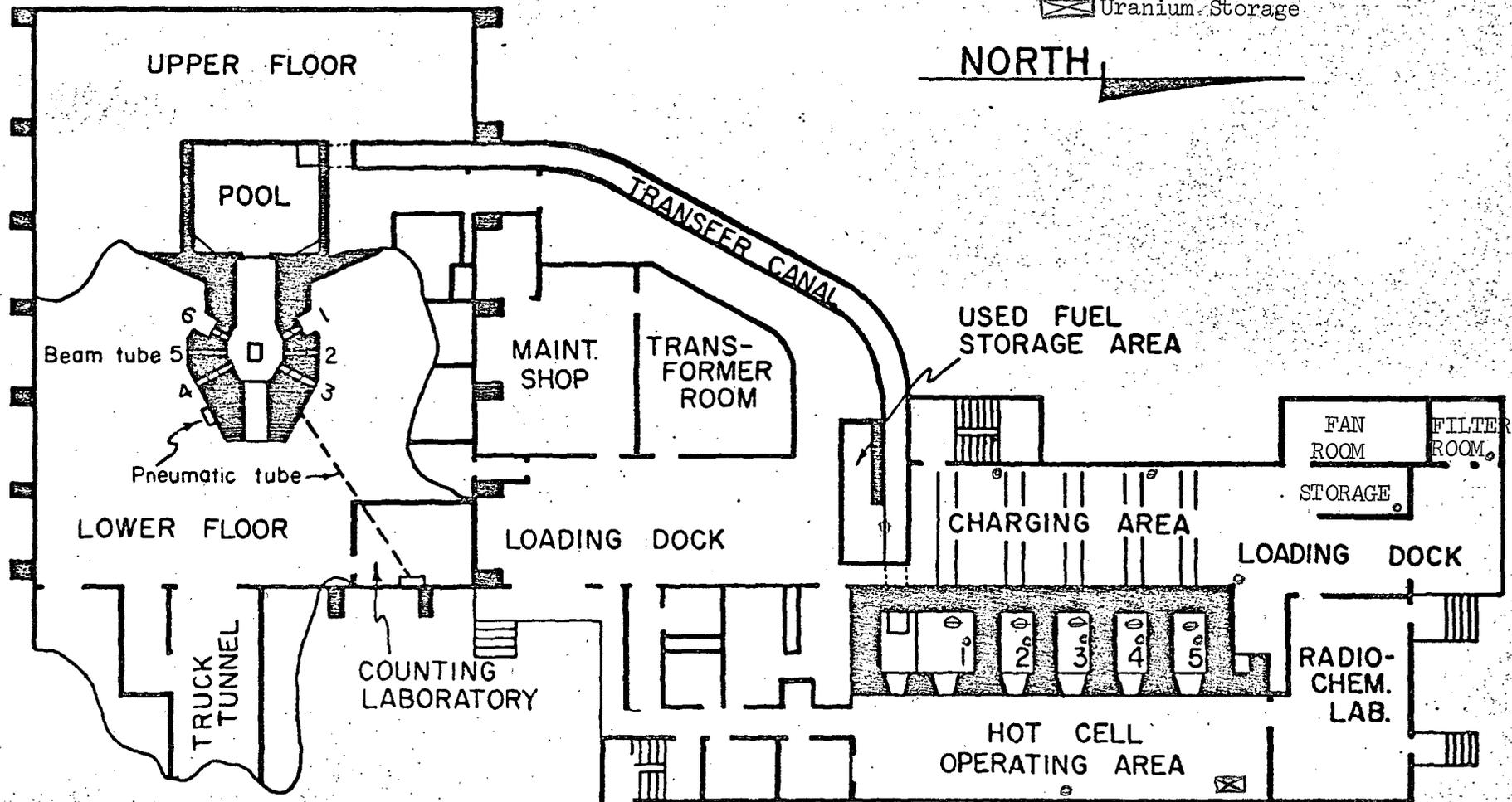
e. Hot Lab evacuation system

In the event of an alarm from (a) two area monitors (b) an area monitor and a constant air monitor or (c) an area monitor and the stack monitor the evacuation alarm will be sounded. An intercom system is in operation with units located in every major area of the Hot Lab. Auxiliary amplifiers have been provided and tests have proved that an evacuation alarm announced over this system from the front office on the first floor can be clearly heard in any area. This is utilized as the evacuation alarm system and all personnel have been instructed in the use of the system.

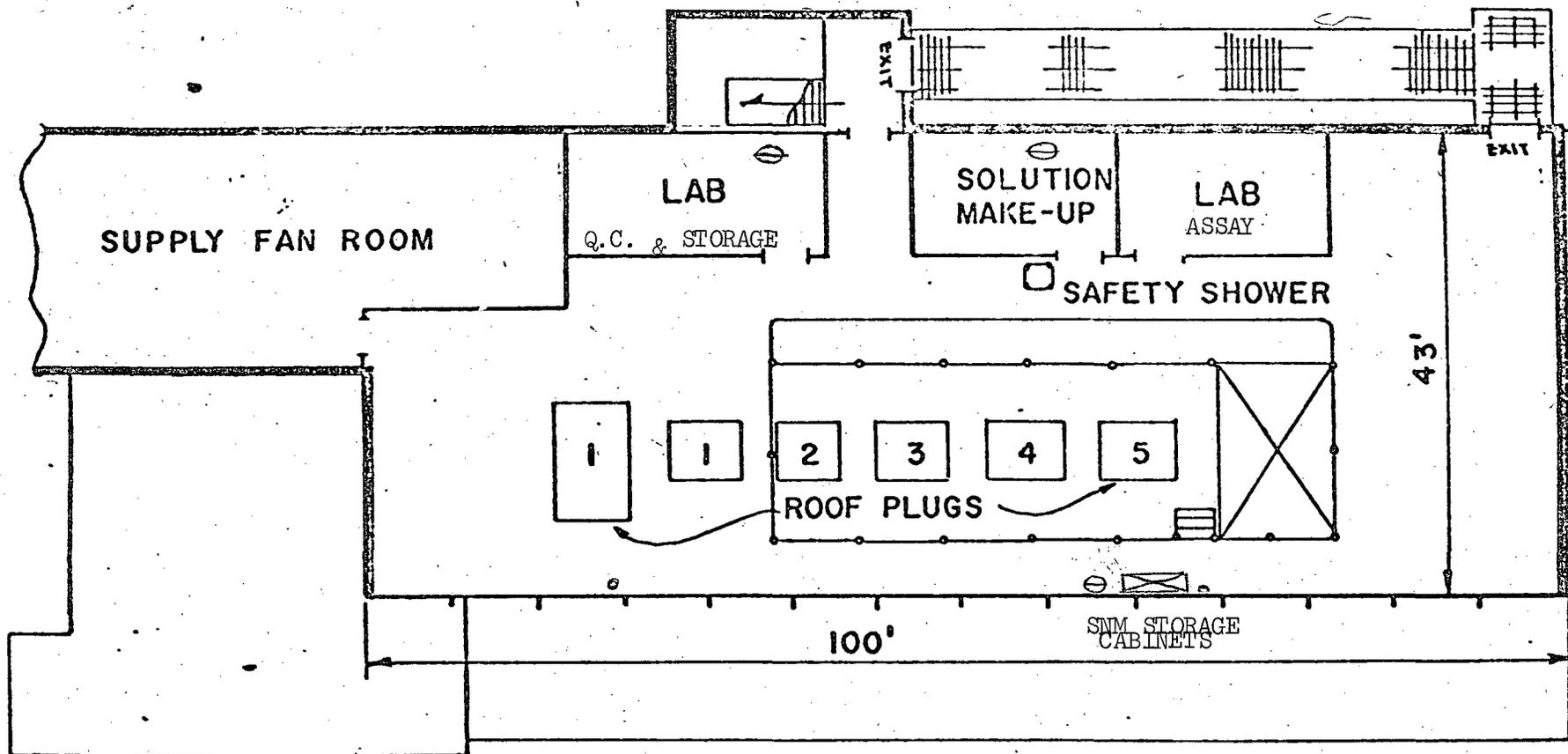
f. Wipe tests

Wipe tests are made of the floors daily and analyzed for beta, gamma or alpha activity as appropriate. Wipe tests are made on all sealed sources at intervals not to exceed 6 months. All equipment and materials require Health Physics approval before being removed from a controlled area. All materials packaged for off-site shipment are checked by Health Physics to insure that all appropriate shipping regulations have been followed.

- ⊙ Area Monitor
- ⊠ Area Monitor Control Panel
- ⊖ Criticality Control Zone
- ⊞ Uranium Storage



PLAN OF REACTOR AND HOT LABORATORY
FIGURE 1



HOT LABORATORY · FLOOR PLAN · UPPER LEVEL

B. CRITICALITY CONTROL

Criticality control is a concern in three general areas of operations at the Sterling Forest Research Center:

(a) Storage for use in a chemistry laboratory or irradiation in the Nuclear Reactor.

(b) In process in a chemistry laboratory (includes storage of un-irradiated uranium for disposal).

(c) In process in a hot cell (includes storage of irradiated uranium for disposal).

(a) Criticality control in storage areas

Uranium in solid form (usually UO_2) is stored in storage compartments in the upper level of the hot laboratory (Fig. 1A). Storage compartments are of fireproof construction. A minimum separation distance of three feet is maintained between compartments by fastening them to prevent inadvertent movement. All storage compartments are locked and access keys are in the custody of the SNM custodian. The primary criticality control is implemented thru control of the quantity of uranium in a single compartment to 650 gms. This limit allows a safe margin below the single parameter limit of 700 gms. as shown in the Accountability Errors analysis of the amendment proposal dated 2/8/73. Since the quantity of SNM purchased on any occasion is limited to 650 gms. and each storage compartment is only large enough to contain a typical shipping container, it is not credible that double batching would occur in storage especially in light of the administrative controls outlined in the Accountability procedures mentioned in the amendment proposal of 2/8/73. In the unlikely event that double batching does occur the resultant mass would be much less than the maximum storage limits for spherical units of U-235 specified in Nuclear Safety Guide TID-7016-Rev 1., Table IV, P. 26.

In the event of a fire, there is no automatic extinguishing equipment. All accessible portable fire fighting equipment utilizes CO_2 as the extinguishing agent. Fire fighting procedures call for direct guidance of technical personnel familiar with the hazards of SNM. The probability of an extensive fire requiring great quantities of extinguishing agents is greatly reduced since the accumulation of combustible material in the SNM storage area is not in accordance with general practice in the Hot Laboratory.

Since there are no operations performed on this SNM material other than transfer from shipping container to storage and from storage to chemistry laboratory or other location, it is not credible that any SNM can be spread to filters or other scavenger equipment in the Hot Laboratory.

(a) Criticality control in storage areas (cont'd)

There are two other locations where SNM, for which we are accountable under SNM 639, is stored. The materials involved and their locations are as follows:

(a) Approximately 8 gms. of U-235 is contained in 3 fission chambers. These fission chambers are used as instrumentation for the nuclear reactor and are kept in the reactor building.

(b) Approximately 80 gms. of Pu-239 is contained in a sealed Pu/Be source. This source is stored in a vault inside the reactor building.

(b) Criticality control in Chemistry Laboratory

Uranium is used in solid or liquid form (aqueous solution) in a chemistry laboratory. The chemistry laboratories are located in the upper level of the Hot Laboratory (Fig. 1A). Work with special nuclear material is performed by authorized personnel in accordance with procedures approved by the Nuclear Safeguards Committee.

The primary criticality control is effected thru control of the quantity of uranium permitted in a single chemistry laboratory, (solution make up lab. Fig. 1A) to 300 gms. This limit allows a safe margin below the single parameter limit of 700 gms. in any form even if the unlikely event of double batching were to occur. Uranium encapsulated for irradiation (UO_2) will be stored in the Q.C. and Storage Lab. The total quantity of uranium in this form is to be limited to 650 gms. As in the afore mentioned SNM storage compartments, criticality would not result in the event of double batching in this laboratory.

In the event of a fire, there is no automatic extinguishing equipment installed in chemistry laboratories. All accessible portable fire fighting equipment utilizes CO_2 as the extinguishing agent. Fire fighting procedures call for the direct guidance of technical personnel familiar with the hazards of SNM. The probability of an extensive fire requiring great quantities of extinguishing agents is greatly reduced since the accumulation of combustible material in chemistry laboratories is not in accordance with general practice in the Hot Laboratory.

Operations with SNM in chemistry laboratories can result in scrap material of both solid and liquid forms. Material of solid form (UO_2) is recycled into the process carried on in a particular laboratory. Some solid material (milligram quantities) may accumulate on filters in the exhaust ventilation system however, in the normal course of events these filters are changed at maximum intervals of one year.

Material in liquid form is retained in containers until it is no longer useful at which time it is put into solid form, encapsulated and disposed of at approved waste disposal facilities. Small quantities of UO_2 in aqueous solution may be inadvertently passed to the liquid waste treatment system via the hot sink drain in the laboratory. All liquid wastes are stored in a 7000 gallon storage tank and subsequently evaporated whereby the vapors and condensed, deionized and stored for analysis prior to release to unrestricted areas.

(b) Criticality control in Chemistry Laboratory (cont'd)

The concentrate from the evaporation process is drained off and solidified for disposal in an approved manner. There is a thru-put of about 3000 gallons per week in the liquid waste treatment system. There are no organic solvents used in any of the routine processes in the Hot Laboratory. Whenever organic solvents are used, the organic waste is retained and disposed of with other organic waste material. It is not introduced to the main liquid waste treatment system. Solids are removed from the liquid waste treatment storage tanks periodically as required.

(c) Criticality Control In Hot Cells

Uranium which has been irradiated in the nuclear reactor core is used in both solid and liquid form in a hot cell (Fig. 1). The quantity of uranium handled in a batch is limited to less than 15 grams. Scrap uranium from operations in a hot cell is stored in that hot cell in liquid form (aqueous solution, 200 ml per batch, up to 0.1 gm/ml), in plastic coated glass bottles. A maximum quantity of 650 gms. of uranium will be allowed in a hot cell. Primary criticality control is effected thru rigid administrative control, as outlined in the accountability procedures of our amendment proposal of 2/8/73. This 650 gm. limit allows a safe margin below the single parameter limit of 700 gms. as shown in the Accountability Errors analysis of this amendment proposal. In the unlikely event that this limit is inadvertently exceeded criticality can be avoided in that the glass storage bottles containing the uranium in the cells are composed of Boro silicate-glass (11.5% B₂O₃). This glass would consist of ≥ 24 vol. % of the material in storage. According to ANSI N16.4-1971, Use of Boro Silicate-glass Raschig Rings As a Neutron Absorber In Solutions of Fissile Material up to 270 gms./liter of enriched uranium can be stored in an infinitely large volume without incidence of criticality.

Fire fighting in the hot cells is handled in the same manner as in other areas of the Hot Laboratory except that the extinguishing agent is water. The uranium in storage is > 3 feet above the floor of the hot cell. Combustible materials are limited inside the hot cells to such an extent that only a small amount of water would be required to extinguish a fire.

Uranium is handled in such a way in the hot cell so that it is kept in sealed containers at all times. This handling procedure minimizes the possibility of uranium scrap finding its way to the exhaust filtering systems. If material is collected on ventilation filters it would only amount to milligram quantities. This material could not accumulate to a substantial amount in that it would be removed during routine filter replacements. There is no connection of the hot cells with any liquid waste disposal system. If a small quantity of uranium in solution were spilled it would be cleaned up immediately by an operator or if it were an unnoticed spill, it would most probably be removed in a routine clean up operation performed weekly.

Interaction Between Sub-Critical Units

The sub-critical units are defined as a hot cell, chemistry laboratory or storage compartment, and are shown in Fig. 1. The operations performed in any one of these areas are totally independent of operations in other areas. Material may be transported from one of these areas to another, but this would only be accomplished in accordance with the administrative controls outlined in the accountability procedures of this amendment proposal.

Audits

Audits are performed at least once each 6 months by a person outside of the Nuclear Operations line organization. The auditor would be designated by the Nuclear Safeguards Committee and a report of his findings is made to that committee.

Drills

Drills of the Hot Laboratory evacuation procedure will be conducted semi-annually.

C. HOT LABORATORY EVACUATION PROCEDURE

An evacuation of the Hot Lab shall be sounded if:

- (a) Two area monitors alarm simultaneously and/or the sounding of the horn alarm at the upper level
- (b) An area monitor and constant air monitor alarm simultaneously
- (c) A constant air monitor and stack monitor alarm simultaneously

or any condition which would result in the overexposure or injury to personnel within the building.

When an evacuation alarm has been sounded all personnel must leave the building by the nearest exit and assemble at the south loading dock. All access doors and windows must be closed when building is evacuated.

Immediately: (a) make sure that the Hot Laboratory supervisor, Radiation Safety Officer and Superintendent of Operations have been informed of the evacuation, (b) set up warning at the north loading dock and in the reactor building to prevent inadvertent entry into the Hot Laboratory, (c) monitor areas where people have assembled for radiation and or contamination (see attached analysis of radiation dose to individuals in assembly areas in the event of a hypothetical incident), and (d) monitor people in assembly area for contamination and/or radiation from neutron activation. Commence necessary decontamination and/or first aid as soon as possible.

When the above duties have been accomplished subsequent operations shall be performed under the direction of the senior member of the operations staff present. Notification of additional plant personnel, civil and regulatory authorities shall be made in accordance with the emergency call list located in the emergency equipment locker. Complete surveys of all areas surrounding the Hot Laboratory building. If necessary personnel should be evacuated to the secondary assembly point in Building 4.

Decontamination and first aid for the injured must be commenced immediately. Save and identify all contaminated articles and body excretions, if possible, for future analysis. If it is necessary to send contaminated people to the hospital for medical treatment a staff member familiar with radiation safety must accompany the victim.

If surveys indicate that an exclusion area should be set up beyond the boundaries of the Hot Laboratory, the subsequent actions shall be taken as outlined in the Reactor Operations Hi-Level Radiation Incident emergency procedure.

D. DOSE FROM CRITICALITY INCIDENT

Reports of criticality incidents in the Nuclear Safety Guide (TID 7016) indicate that in the unlikely event of such an incident in the Sterling Forest Laboratory it would result in $\sim 10^{17}$ fissions.

The accumulated neutron flux at the source assuming a point source, will be on the order of:

$$2.5 \times 10^{17} \text{ N/cm}^2$$

There is a minimum distance of 100 feet of air and 20 inches of concrete structure between the source of radiation resulting from such an incident on the upper level of the Hot Laboratory and the designated areas where personnel are to assemble on an evacuation of the buildings.

The reduction in neutron dose due to scattering thru 100 feet of air will be 10^{-8} (Ref a.).

The reduction in neutron dose due to perturbation in the concrete walls of the building will be:

$$e^{-\Sigma_r t}$$

Substituting and evaluating:

$$e^{-0.08 \cdot 50 \text{ cm}} \approx 2 \times 10^{-2}$$

When Σ_r is the effective removal cross section of ordinary concrete for fast neutrons (Ref b.).

If $3 \times 10^7 \text{ N/cm}^2$ give a dose of 1 Rem, then the total accumulated dose from neutrons in the assembly area throughout the entire criticality incident would be:

$$\frac{2.5 \times 10^{17} \times 10^{-8} \times 2 \times 10^{-2}}{3 \times 10^7} \approx 2 \text{ Rem}$$

Ref a.) Blizard, Reactor Handbook Vol. III, Part B, p. 250, Fig. 15.64, air scattered fast neutron flux as a function of distance from a 1 Mev isotropic source.

Ref b.) Blizard, Reactor Handbook Vol. III, Part B, p. 94, Table 9.15.

D. DOSE FROM CRITICALITY INCIDENT (Cont'd)

The accumulated gamma dose at a distance of 100 feet during this hypothetical criticality incident would be:

$$\frac{(10^{17} \text{ fissions}) \times (7.2 \text{ Mev} \cdot \text{fission}^{-1})}{(2.9 \times 10^9 \text{ Mev} \cdot \text{cm}^2 \cdot \text{Rad}^{-1}) \times (4 \pi r^2)}$$

Substituting and evaluating this:

$$\frac{10^{17} \times 7.2}{2.9 \times 10^9 \times 1.25 \times 10^8} = \frac{7.2 \times 10^{17}}{3.6 \times 10^{17}} \approx 2 \text{ Rad}$$

The reduction in gamma dose due to attenuation in the 20 inches of concrete walls of the building will be:

$$e^{-ut} \quad u = \text{linear attenuation coefficient} \\ [\sim .07 \text{ (Ref c.)}] \text{ for concrete.}$$

t = thickness of concrete.

Substituting and evaluating:

$$e^{-.07 \cdot 50 \text{ cm}} \approx 2 \times 10^{-2}$$

The attenuation coefficient used here is conservatively chosen as that for a gamma ray photon energy of 6 Mev. The resultant dose after applying this attenuation factor then become ~ 40 mr.

It can be seen from this analysis that if personnel were in these assembly areas throughout the entire criticality incident their exposure would only amount to ~ 2 Rem.

Ref c.) Etherington, Nuclear Engineering Handbook, p. 7-112, Table 22.

- 1959-1962 New York University
Adjunct Assistant Professor of Physics, Graduate School of Arts and Sciences; taught Reactor Theory.
- 1958-1962 City College of New York
Physics Department. Lecturer, Graduate School of Engineering; taught Nuclear Physics and Reactor Theory.
- 1956-1958 New York University
Physics Department. Principal investigator on project to establish a set of operating computer codes applicable to various types of nuclear reactor theory problems.
- 1953-1956 Curtiss-Wright Corporation
Nuclear Power Department. Various problems in shielding and reactor technology.
Programming and use of IBM 701, 704.
- 1950-1953 New York University
Research Assistant, Physics Department

Research Specialties Include:

Theory of radiation transport; nuclear reactor theory; computing machine methods; fast reactor safety; radiation shielding; direct energy conversion methods.

Professional Societies:

Sigma Xi	American Nuclear Society
Tau Beta Pi	New York Academy of Sciences
	American Association of Physics Teachers

Reports and Publications

J. Agresta, "Space-Dependent Prompt Kinetics of a Sub-Critical Reactor", Trans. Am. Nucl. Soc., Vol. I, No. 2 (December 1958), p. 49.

J. Agresta et al., "Numerical Integration of the Spherical Harmonic Equations", Trans. Am. Nucl. Soc., Vol. II, No. 1 (June 1959), p. 234.

J. Agresta and L. B. Borst, "Space-Dependent Prompt Kinetics of a Sub-Critical Reactor", Nucl. Sci. and Eng. 7, 64 (1960).

J. Agresta et al., "Validity of Diffusion Theory for Shielding Analysis", Trans. Am. Nucl. Soc., Vol. V, No. 1 (June 1960), p. 67.

J. Agresta and N. Tralli, "Solution of the P-3 Equations in Finite Cylindrical Geometry and Application to the Calculation of Thermal Utilization", Trans. Am. Nucl. Soc., Vol. IV, No. 1 (June 1961)

N. Tralli and J. Agresta, "Spherical Harmonic Calculations for a Cylindrical Cell of Finite Height", Nucl. Sci. and Eng. 10, 132 (1961)

H. Waldinger, J. Agresta and G. Goertzel, "Numerical Integration of the Spherical Harmonics Equations", Nucl. Sci. and Eng. 18, 459 (1964).

J. Agresta et al., "Validity of Diffusion Theory for Shielding Analysis", NDA 2130-2 (December 31, 1959).

M. Abrams and J. Agresta, "Multi-Group Treatment of the 2.8 Kev Sodium Resonance", Trans. Am. Nucl. Soc., Vol. I, No. 2 (December 1958)

N. Tralli, J. Agresta, and W. Seibyl, "Multi-Group Diffusion Calculation of k_{oo} for D₂O Lattices", Nucl. Sci. and Eng. 6, 157 (1959)

J. Agresta et al., "A Method for Calculating the Reactivity of Simple D₂O Moderated Natural Uranium Lattices", NDA 2131-20 (Sept. 30, 1960).

J. Agresta, "A Status Report on Reactivity Coefficients in Fast Reactors and Methods of Investigating their Effects on Stability", NDA 2147-3 (March 1, 1961).

J. Agresta, "Stability Studies on Fast Reactors with Delayed Reactivity Coefficients", NDA 2147-7 (August 15, 1961).

J. Agresta and L. Wills, "Preliminary Study of Power Excursions for Potentially Unstable Reactors", UNC-Memo-5039 (September 30, 1962).

J. Agresta, "X-Ray Energy Deposition Code", UCRI 65-107, March 29, 1965.

J. Agresta, "X-Ray Air Penetration Studies", UCRI 65-102, Feb. 23, 1965.

J. Agresta, "Tissue Response Function for Photons from 0 to 100 MeV", UCRI 311, August 24, 1965.

C. D. Zerby, J. Agresta, et. al. "PHOTRAN, a General Purpose Photon Transport Program in Complex Geometry", UCRI 316, March 1966.

Volume I Theory and Users Manual
Volume II Detailed Program Description
Volume III Applications Studies

(Also issued as AFWL-TR-65-171)

- 1950-1951 Ballatine Laboratories, Boonton, N. J.
Developed precision electronic instruments for measurement of AC voltage.
- 1949-1950 Health Radiation Branch, Atomic Energy Project, Chalk River Canada
Provided health physics services for project.
- 1948-1949 Sperry Gyroscope Co., Great Neck, N. Y.
Developed electronic circuits for new radar equipment for marine navigation.
- 1944-1948 Technical Physics Group, Atomic Energy Project, Chalk River, Canada
Did research on effects of radiation on gases and crystals; developed ion chamber and counter radiation detectors for reactor control and for health physics use.
- 1942-1944 N. Z. Scientific Liaison Office, Washington, D. C.
Exchanged technical information between New Zealand and laboratories in U.S. and Canada on developments in radar and other scientific defense techniques.
- 1940-1942 Radio Development Laboratory, New Zealand
Did research and development on radar.

Professional Societies:

- Member, American Physical Society
Member, American Nuclear Society

EXPERIENCE: (continued)

1957-1959 Third Mate, Gulf Oil Corp.

Duties included:

- (a) Safe navigation of the vessel underway.
- (b) Responsible for loading and discharging liquid cargo consisting of mixed grades of petroleum products.
- (c) Instruction of personnel in handling hazardous cargo.
- (d) Maintenance of navigation, cargo handling and life saving equipment.

PERSONNEL BIOGRAPHY

NAME: Clifford John Konnerth POSITION: Health Physicist

AGE: 42

ADDRESS 5 Hillside Terrace
Monroe, New York

PHONE: (914) 783-4768

EDUCATION: B.S. - Physics - Hofstra College, Hempstead, N.Y. - 1953
Graduate Study, AEC Radiological Physics Fellowship - 1959 (1 yr.)

EXPERIENCE:

1959-1973 Health Physicist - UCNC, Tuxedo, New York
Instructs personnel on radiation safety. Conducts routine and special radiation surveys of UCNC site. Controls the discharge of radioactive wastes. Maintains records of personnel radiation exposure. Maintains and calibrates all radiation measuring and meteorological equipment.

1958-1959 AEC Fellowship Student, Rochester, New York
Graduate study in radiological physics at the University of Rochester under AEC Radiological Physics Fellowship. Three months in the Health Physics Training Program at Oak Ridge National Laboratory.

1956-1958 Health Physicist - BNL
Supervisor in Charge of Health Physics activities at BNL "Hot" Laboratory. Had health physics responsibility for the following: 4 hot cells, 30,000 curies of Co⁶⁰, alpha facility, waste treatment plant, gamma irradiation facility, 20 megawatt air-cooled reactor stack monitoring. Also performed health physics duties during periodic reactor shutdowns. Worked on design and fabrication of stack and area monitoring systems.

1955-1956 Health Physics Surveyor - BNL
Received health physics training under Dr. F. P. Cowan. Performed health physics survey work at the 20 megawatt air-cooled graphite reactor. Conducted all types of Radiation surveys, including neutron flux measurements and gamma spectrometry.

1953-1955 Instructor - U.S. Army Signal Corps., Ft. Monmouth, N. J.
Instructor of High Altitude Meteorology.

EXPERIENCE: (continued)

1950-1958 Public Service Testing Laboratories, Inc., N.Y. - Chief Chemist

Career developed with this company and rose to the position stated. Supervision of the chemical and physical Testing Laboratories staff in routine chemical and physical testing of ferrous and non-ferrous alloys and related materials.

MILITARY SERVICE: U.S. Air Force (36 months)