70-687

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Regulatory Docket File

December 28, 1977

Mr. Sheldon Meyers
Director Fuel Cycle
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attn: Mr. J. A. Power
Ass't Director Licensing, Safeguards

Subj: Request For Amendment To Special Nuclear Materials License 639.

Gentlemen:

It is requested that the subject license be amended as follows:

(a) The quantity of special nuclear material that is allowed in a single hot cell be limited to 2650 grams. (Change from 650 grams.)

(b) The special nuclear material that is contained in targets that have been irradiated for one 120 hour operating cycle in the Union Carbide Nuclear Reactor or waste solutions from such targets be considered self-protected material and therefore exempt from the 5 Kg formular quantity limitation in accordance with 10 CFR 73.6.b. The limit of total unirradiated material will be 3 Kg and the limit of the total irradiated, self-protected material will be 10 Kgs.

A criticality analysis in support of the requested change for the in-cell limit is enclosed (ENCLOSURE 1). This analysis shows that the granting of this amendment will not result in an unsafe condition.

An analysis of the radiation dose from irradiated targets is enclosed (ENCLOSURE 2) in support of the requested exemption of irradiated material from the 5 Kg limit. It is understood that the regulations of Part 73.50 must be adhered to if the 5 Kg limit is exceeded, regardless of the self-protecting nature of the material. The UCNR, licensed in accordance with 10 CFR 50, has had a Physical Security Plan (ENCLOSURE 3) in effect for several years. The hot laboratory building is adjacent to the reactor building and it has always been a part of the protected area under the plan in accordance with Part 50. Since operations with the material licensed under SNM-639 are conducted in both the reactor and hot lab buildings, a copy of this plan is submitted with this application to become an SNM-639 license requirement in the event the total SNM possessed under this license exceeds the 5 Kg formula quantity.

This license amendment is requested because of the quantum increase in production at our facility which has been required as a result of the GETR shutdown. We were also requesting the increased limit in the quantity of stored irradiated SNM in anticipation of transferring this material to the Savannah River Plant (SRP) for reprocessing. The ability to store irradiated material for up to 90 days prior to shipment to SRP will facilitate the salvage of this U-235.

Thank you for your consideration.

Very truly yours,

James J. McGovern
Manager
Radiochemical Production

JJMcG:js
Enclosures

ENCLOSURE 1

IN-CELL STORAGE OF SPECIAL NUCLEAR MATERIAL

Present In-Cell Storage:

Waste solutions of SNM (93%-enriched in U-235) are stored in borosilicate glass bottles. Up to 200 ml of aqueous solution, nominally 100 g/l of U-235 is contained in each bottle. Bottles are stored within a cell in a three-row linear array defined by a metal rack. Each hot cell is currently limited by license to a total of 650 g U-235.

Proposed In-Cell Storage:

While retaining the existing bottle storage it is proposed to add additional storage within each cell. The waste solutions from a number of bottles are to be combined and transferred to thick-walled metal cylinders (14.6 cm ID, 30 cm inside height, 5.6-liter volume), as shown in DWG. 101308 (enclosed). Cylinders will be held upright in a metal rack located so that cylinders are separated from the bottle storage area by at least 30 cm. Each cylinder is capped after filling. Cylinders are designed so they cannot be stacked vertically on top of each other. The contained solution may, or may not, be solidified through addition of portland cement or similar inert materials. Only ½ the volume of the cylinder is taken up by the contained solution, therefore the effective height of the cylinder is approximately 15 cm.

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Proposed In-Cell Storage: (cont'd)

A limit of 150 g U-235 in a single cylinder, and a total of 2000 g U-235 in all cylinders within a cell is proposed. These limits are in addition to those already existing for bottle storage. The combined storage limit for each cell will then be 2650 g U-235. The criticality safety of the proposed in-cell storage is examined below.

Criticality Safety Of In-Cell Storage:

The 30 cm separation between the cylinders and the bottle storage effectively decouples the SNM stored in the two areas (Ref. 1, p. 35; Ref. 2, Fig. 58) so that the SNM in the cylinders can be considered separately. With 150 g U-235 in a 5.6L(~3 liter effective) cylinder, the concentration is ~ 50 g U-235/liter, which is about equal to the normal concentration of the waste. The solution height is 15 cm (max.) and its diameter is 14.6 cm.

From Ref. 2, Fig. 58 (copy attached) the critical height for a water reflected 14.9 cm inside-diam. cylinder containing SNM of optimum concentration for minimum critical height (537.6 g/l) is 73 cm. The critical mass is therefore $\pi/4 \times 14.9^2 \times 73 \times .5376 = 6.84$ Kg. A 30 cm length would contain $6.84 \times 30/73 =$ 2.8 Kg and would be subcritical. The proposed 150 g limit for a single cylinder is a factor of almost 19 below this already subcritical limit. The normal waste concentration is less than 100 g/l which is considerably below the optimum of approximately 540 g/l for a 15 cm-diam. (6-in.) cylinder (Ref. 2, Fig. 57; Ref. 3, p. 29 - copies attached). Due to the fixed volume, double batching is not a consideration, but even if the U-235 mass in a cylinder could be doubled to 300 g, it would still be well below the subcritical 2.8 Kg.

Criticality Safety Of In-Cell Storage: (cont'd)

From Ref. 2, Fig 59 (copy attached), for a triangular, touching cluster of seven 14.9 cm-diam. cylinders containing optimum concentration SNM (537.6 g U-235/l), water-moderated and reflected, the critical height is shown to be 12 cm. The critical mass of this cluster is therefore $7 \times 12 \times 14.9^2 \times .5376 \times \pi/4 = 7.87$ Kg. Similarly, for a triangular cluster of 3 touching cylinders the critical height and mass are 17 cm and 4.78 Kg respectively. For two touching cylinders the critical height is 25 cm which is larger than the effective waste cylinder height - a 15 cm height would contain $2 \times 15 \times 14.9^2 \times .5376 \times \pi/4 = 2.81$ Kg and would be subcritical. It can be concluded that, subject to a 2-Kg total U-235 limit, any number of waste cylinders in any planar arrangement will be subcritical by a wide margin, even if submerged in water.

Criticality Safety Of Solution Transfer:

Any operations involving transfer of aqueous waste solutions to and from storage bottles or cylinders will be performed with lines or a transfer vessel of diameter less than 13.9 cm (Ref. 4, Table 1). No matter what the concentration or height, this diameter of solution will always be subcritical.

References:

1. Nuclear Safety Guide, TID-7016-Rev 1, Goodyear Atomic Corp. (1961).

2. H. C. Paxton et al, Critical Dimensions of Systems etc. TID 7028 (1964).

3. J. K. Fox et al, Critical Mass Studies, Part IX, ORNL-2367 (1958)

4. Nuclear Criticality Safety etc., ANSI N16.1, American National Standards Institute.

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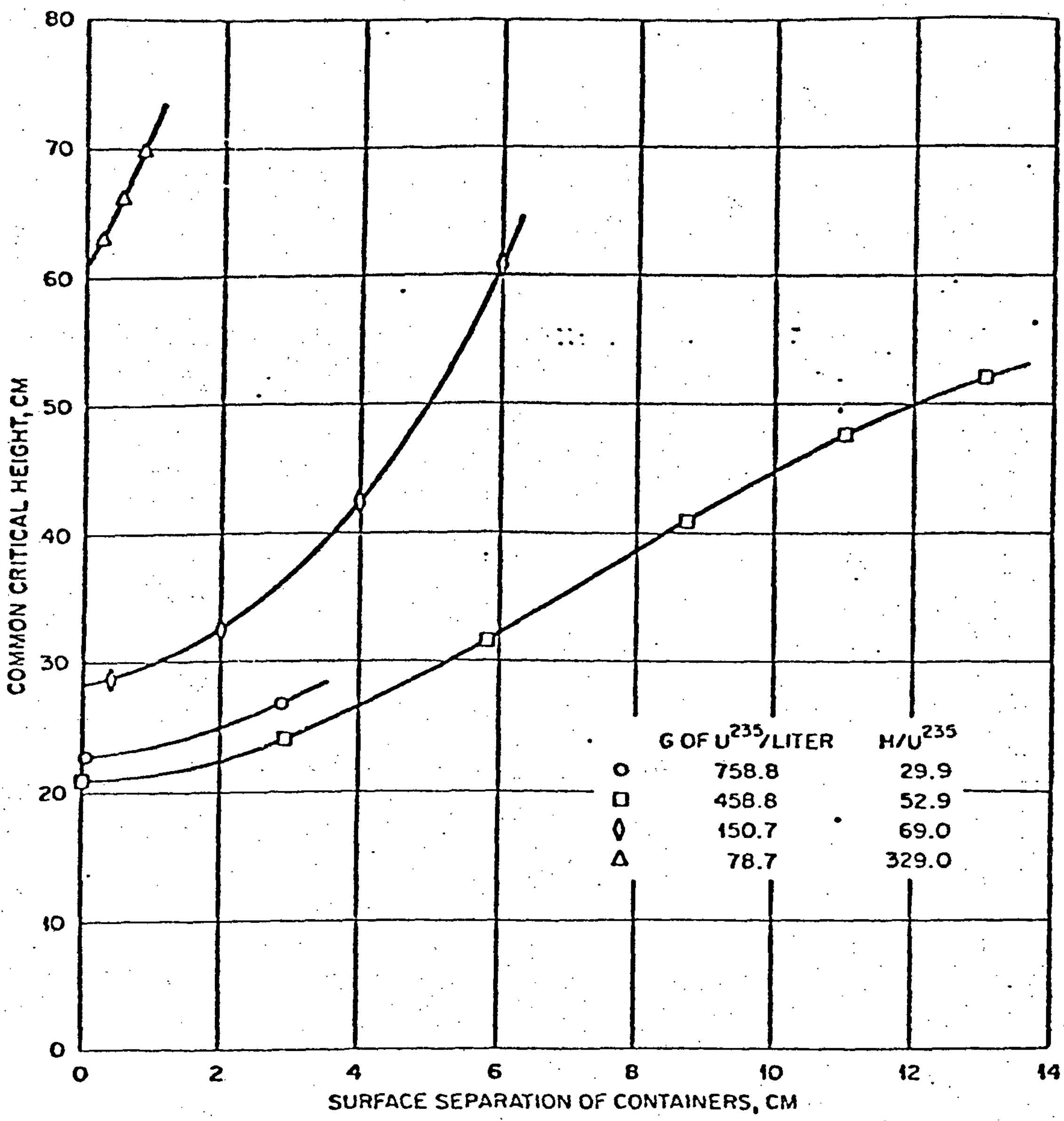

Fig. 57 – Water-moderated and -reflected two-unit planar arrays of 15.2-cm-dia cylinders of aqueous $U(93.4)O_2F_2$ solution (1.6-mm-thick aluminum containers).

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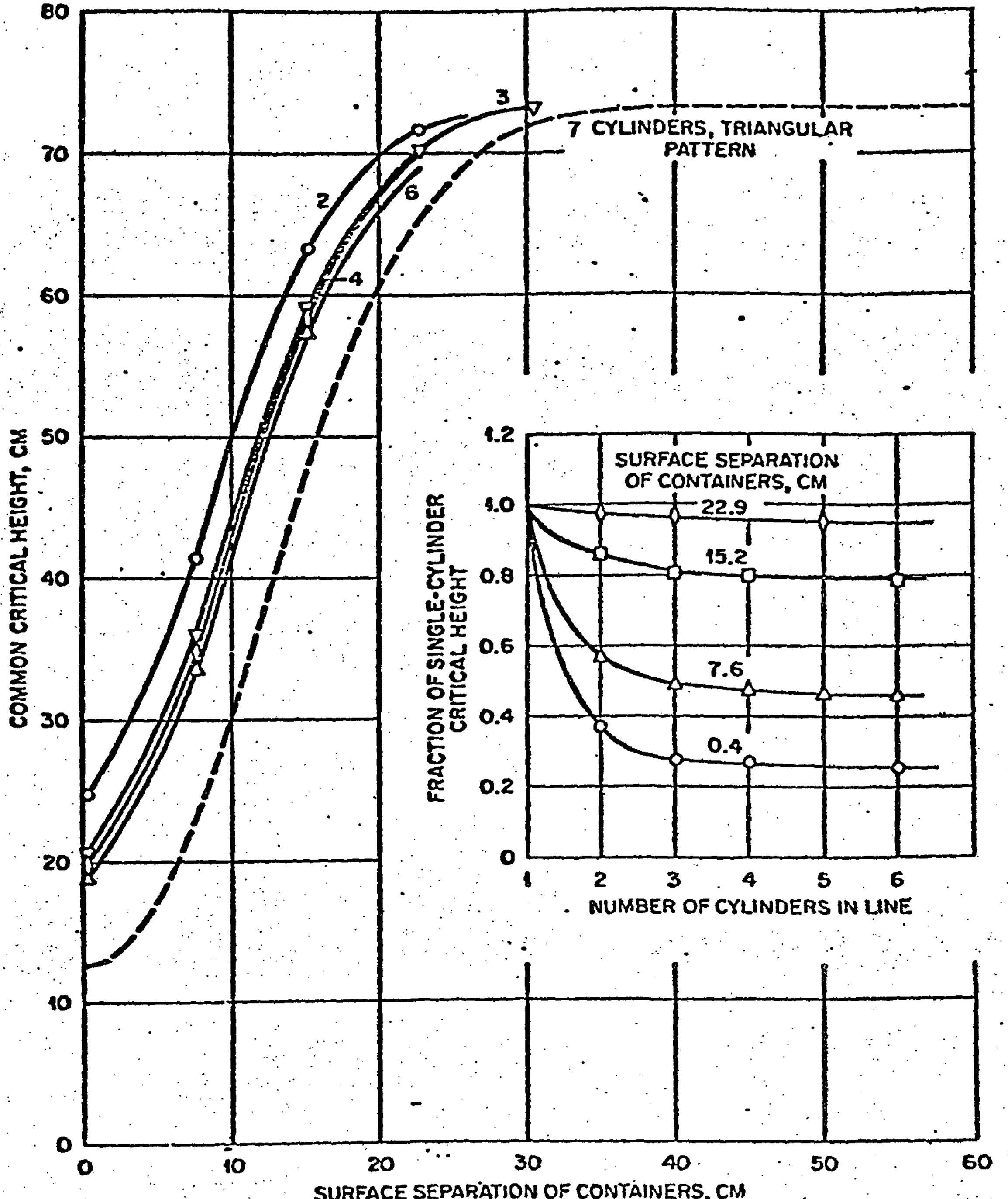

Fig. 58 — Water-moderated and -reflected linear arrays of 15.2-cm-dia cylinders of aqueous $U(93.2)O_2F_2$ solution. U^{235} concentration: 537.6 g/liter; $H/U^{235} = 44.3$. Containers: 1.6-mm-thick aluminum.

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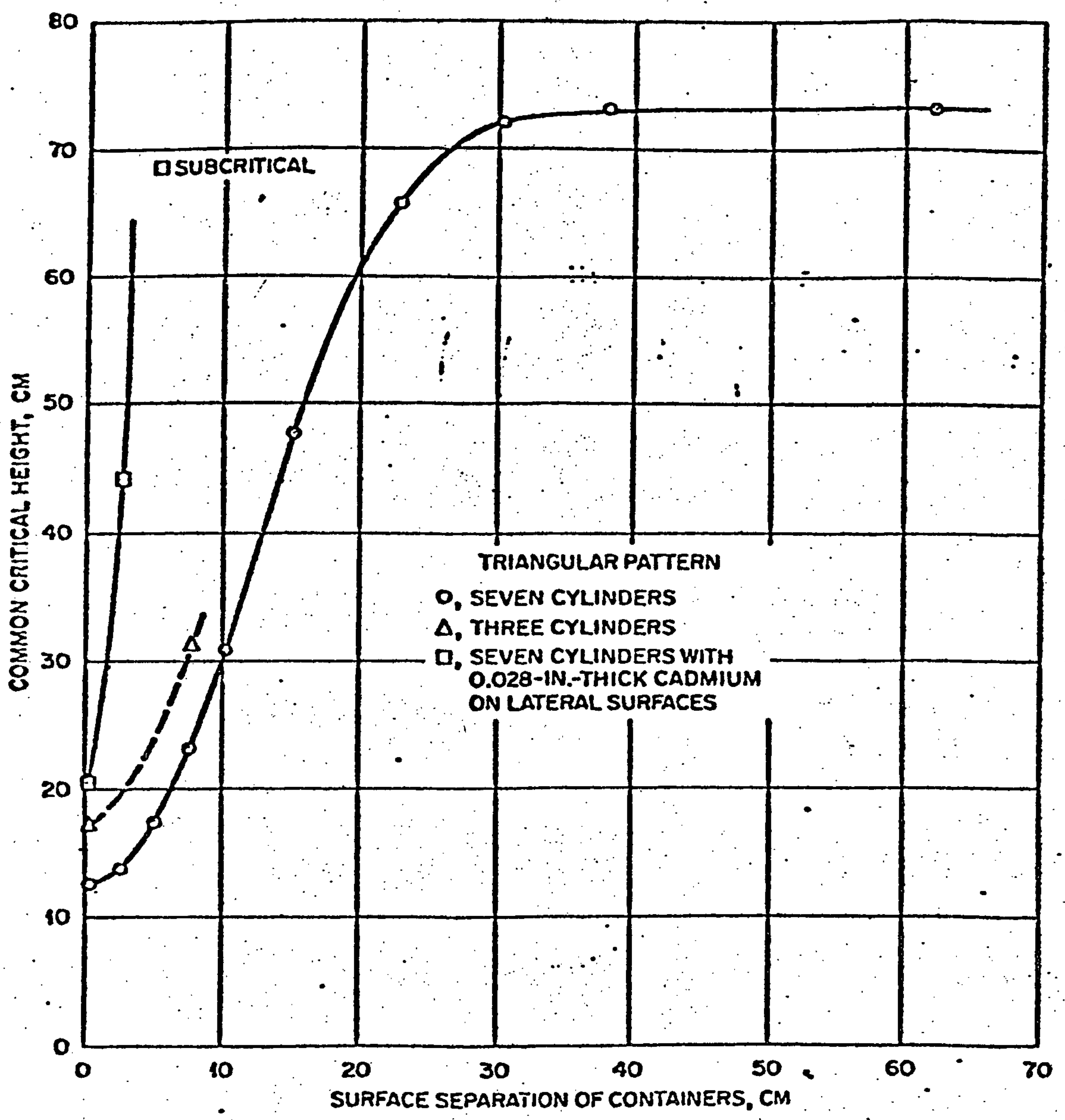

Fig. 59 — Water-moderated and -reflected planar arrays of 15.2-cm-dia cylinders of aqueous $U(93.2)O_2F_2$ solution in triangular patterns. U^{235} concentration: 537.6 g/liter; H/U^{235} = 44.3. Containers: 1.6-mm-thick aluminum.

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SELF-PROTECTION IN FISSION PRODUCT WASTE

Definition:

In the following discussion, special nuclear material (SNM) that is self-protecting means that the SNM is not readily separable from other radioactive material and exhibits a total external radiation dose rate in excess of 100 R/hr. at a distance of 3 feet without shielding. This coincides with the provisions contained in Code of Federal Regulations Title 10, sect. 73.6(b).

Discussion:

Hot waste solutions from the processing of irradiated U-235 containing capsules (FPM capsules) contain all of the SNM and most of the fission products produced in the irradiation. Only the Mo-99 and volatiles are removed. The radiation level of these irradiated SNM solutions is sufficiently high that they are self-protecting for a considerable period. For a given irradiation history, it is possible to specify the length of time for which a given quantity of SNM will remain self-protected. This follows because each capsule is designed to produce the same quantity of fission-products in a fixed irradiation period.

Basis of Self-Protection Estimate:

The standard FPM capsule containing 15 g U-235 irradiated for just one 120 hour reactor cycle is considered. This capsule yields 170 Curies of Mo-99 at the end of the irradiation. (The same capsule, if irradiated for 2 cycles, would yield 200 Curies Mo-99 and twice the quantity of long-lived fission products of a single cycle capsule. For conservatism, only 1- cycle capsulesare considered).

Basis of Self-Protection Estimate: (cont'd)

The fission-product inventory and the gamma-ray emissions are calculated using the FPIC computer code[1] using Meek and Rider's updated values of fission yields.[2] Gamma ray flux-to-dose conversion factors are taken from the published results[3] of Claiborne and Trubey. Corrections for the Mo-99 and volatile fission products removed in the chemical processing are applied when significant.

Results of Calculations:

For decay times of 1-20 weeks after irradiation the dose rates from a single batch containing 15 g of U-235 are calculated. In addition the amount of irradiated U-235 that results in a dose rate of 100 R/hr. at 3 feet in air (the "self-protecting" dose rate) is calculated. These results are shown in the table given below and in the attached graph. It can be seen, for example, that a combined batch of waste from 10 standard capsules, containing 150 g U-235, is self-protecting for close to 12 weeks.

Decay Time (Weeks)	Single Capsule Dose Rate (R/hr. @ 3')	U-235 Mass for 100 R/hr. @ 3' (g)
1	130	12
2	83	18
3	55	27
4	40	37
5	31	49
10	12	125
15	7	205
20	5	294

NOTE: For 2-cycle irradiations the above dose rates (column 2) will be approximately doubled.

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Results of Calculations: (cont'd)

Since FPM waste solutions are combined (approximately 100 to 150 gms per batch), solidified, and shipped to a disposal facility or reprocessing facility within ~90 days after irradiation it is concluded that FPM waste solutions will always be within the definition of self-protected material.

References:

1. FPIC - Fission Product Inventory Code, ER-6906, (Lockheed-Georgia Co. 1964).

2. M. E. Meek and B. F. Rider, Compilation of Fission Product Yields, NEDO-12154, (General Electric Co. 1972).

3. H. C. Claiborne and D. K. Trubey, Nuc Sci Eng 8, 450 (1970).

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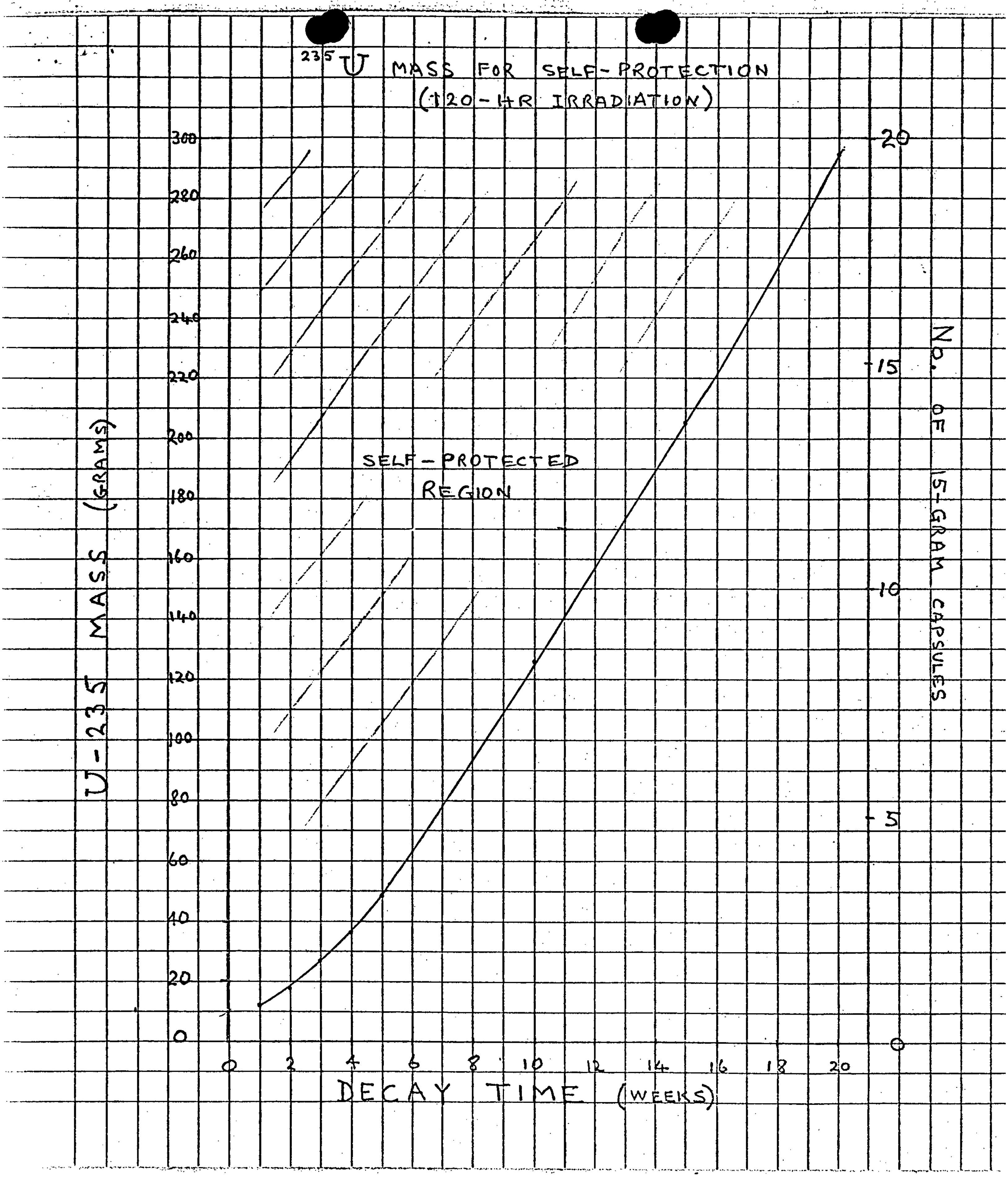
235U MASS FOR SELF-PROTECTION
(120-HR IRRADIATION)
U-235 MASS (GRAMS)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
SELF-PROTECTED REGION
No. OF 15-GRAM CAPSULES
0
5
10
15
20
0 2 4 6 8 10 12 14 16 18 20
DECAY TIME (WEEKS)

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PHYSICAL SECURITY PLAN

1. OBJECTIVE

This Physical Security Plan (PSP) establishes the requirements set forth in 10 CFR 50.34(c), 73.40, and 73.60 for the Union Carbide Corporation Research Reactor (R-81).

2. PHYSICAL PROTECTION OF PLANT AND MATERIALS

2.1 Purpose

This part prescribes requirements for physical protection of the reactor and of the special nuclear material in reactor fuel elements at the UCC's Sterling Forest Research Center. Protection of reactor fuel elements is established and maintained by:

(1) protective barriers and intrusion detection devices, and

(2) liaison and communication with law enforcement authorities.

2.2 Definitions

2.2.1 The terms used are defined in 10 CFR 73.2.

2.2.2 "Protected Area" means the Reactor Building and Hot Laboratory and physically attached structures designated as Building No. 1 and 2 as shown on the attached sketch: Plan of Hot Cell and Reactor.

2.3 Design Features

The essential equipment within the Protected Area includes the reactor, the reactor pool, the reactor control room, and the pump room.

3. ORGANIZATION AND ADMINISTRATION

3.1 The SFRC Security Officer is responsible for the physical protection of the Protected Area.

3.2 During non-working hours:

(a) 2 security watchmen are assigned to make periodic tours of the Protected Area and to respond to intrusion alarms at the central watch station (see Section 4.7). The watchmen also are required to patrol the outside areas, open and close the main gate and, to check employees in and out.

4. PHYSICAL PROTECTION OF THE PROTECTED AREA

4.1 The Protected Area physical barrier consists of building walls constructed of concrete and cement block with doors locked, barred, or manned when opened for transfer activities.

4.2 The Protected Area is designated as a "Restricted Area" and admittance is controlled.

4.3 At no time is the Research Center site left unattended. The admittance during working hours of employees (Section 7.3) to the Protected Area is by a receptionist and/or mechanical lock. The admittance of employees during non-working hours is controlled by the security watchmen (Section 4.7). Unauthorized entry is detected by the Intrusion Alarm System. Identification of employees is through a picture I.D. card.

4.4 The Intrusion Alarm System is a wired electrical system consisting of switches on all access points (doors) and accesible windows. These doors are indicated by the numerals 1 through 14 on the attached building plan. Accessible windows are those less than 15 ft. above grade. Opening of any of these doors or windows, or breaking of glass, activates the alarm which is annunciated remotely from the Protected Area in a nearby building that houses the central manned watch station. The Alarm System is energized only during non-working hours (approximately 24 hours each week). During working hours, when the Protected Area is manned and access controlled by locks and the receptionist, the Alarm System is de-energized. The Alarm System is activated through a key switch whose key is under the control of the security watchmen.

4.5 All visitors, vendors, and other individuals not employed by the Licensee are escorted by an employee while in the Protected Area. Prior to entry into the Protected Area all parcels and packages are searched or left with the Receptionist.

4.6 All external doors are equipped with cylinder locks, mechanical locks, or barred from the inside. The keys to the locks and combinations to mechanical locks are the responsibility of the Maintenance and Engineering Manager. The keys are signed out by the watchman. The keys must be returned prior to the individual leaving the site. The keys are inventoried daily and the loss of a key is reported to the Maintenance and Engineering Manager. If the lost key is not promptly located and security is suspected to be compromised, the locks are changed. Combinations to the mechanical locks are issued to employees and are changed at least annually.

4. PHYSICAL PROTECTION OF THE PROTECTED AREA (cont'd)

4.7 During non-working hours two men are assigned for the security of the Site and the Protected Area:

(a) One is assigned to the central watch station, located in a building about 200 ft. from the Protected Area. This station contains the remote annunciator for the Intrusion Alarm System, the communication system, the keys, the key log and the watchman's log.

(b) The second man is assigned to patrolling the area, including the Protected Area and the site outside the building on a 2-hourly frequency.

4.8 Training is provided for the security personnel before these personnel are assigned to duty. Training includes requirements for site security: The Physical Security Plan, and the site Emergency Action Plan.

4.9 Arrangements with the local law enforcement authorities include aid in event of a security violation. The local law enforcement authorities are expected to respond within 1/2 hour of receipt of a telephone call from the central watch station or any one of several telephones located in the Protected Area.

4.10 During non-working hours, the security watchmen check the essential equipment of the reactor (Section 2.3) at least once every two hours. During working hours, the surveillance of essential equipment is the responsibility of the NRC-licensed reactor operators.

4.11 The site security procedures include the site Emergency Action Plan. The procedures include:

(1) Response by security personnel to unauthorized intrusions of Protected Area.

(2) Reporting of security violation by employees.

(3) Duties of security personnel to bomb threats and civil disorders.

4.12 The security program is reviewed once every two years by the SRFC Security Officer.

5. PHYSICAL PROTECTION OF REACTOR FUEL ELEMENTS IN STORAGE

5.1 Reactor fuel elements other than those that have been irradiated are stored in a vault-type room located within the Protected Area and designated a Material Access Area (see attached Plan). The single door to this room is equipped with an intrusion alarm, a keylock, and a push-button mechanical lock. This intrusion alarm is continuously operative and is annunicated in the always-manned watchman's station in a nearby building. The storage vault is not used for any other activity.

5.2 Admittance to the storage vault is under the control of only the following Authorized Individuals:

Manager, Radiochemical Production
Reactor Supervisor
Assistant Reactor Supervisor
Chief Reactor Operator
Project Engineer

5.3 Access to the storage vault is limited to individuals who require such access in performance of their reactor operations duties. All such individuals are NRC-licensed.

5.4 All packages taken into or out of the storage vault are searched, and all movement of fuel elements to and from the vault is under the personal observation of one of the Authorized Individuals (Section 5.2). Fuel elements are large (3 feet long), easily observed, and cannot be concealed.

5.5 The total quantity of special nuclear material (93% enriched U-235) in the storage vault is less than 5000 grams.

5.6 Reactor fuel elements that have been irradiated are stored in the reactor storage pool under 30 feet of water pending shipment to a reprocessing facility. This pool is within the Protected Area. The majority of the fuel within the pool complies with 73.6(b). A small fraction of the stored fuel elements, principally control elements with lower fuel content (e.g., 60 grams U-235 per element), may have smaller radiation levels that do not comply with 73.6(b). This level is estimated to be no lower than 50 R/hr. at 3 feet. In view of the difficulty of access to this fuel, its still high radiation level, the need for heavy shielding for its removal, the difficulty of distinguishing it from it more highly-irradiated neighbors, and the general degree of protection afforded the area, this fuel is included in this provision.

5. PHYSICAL PROTECTION OF REACTOR FUEL ELEMENTS IN STORAGE (cont'd)

5.6 (cont'd)

The storage pool is therefore not designated as a Material Access Area. Other activities, including operation of the reactor and transfer of irradiated samples, are performed in the storage pool.

5.7 Special nuclear material possessed in accordance with SNM-639 license will be stored, transferred, and handled in accordance with the Fundamental Nuclear Materials Control Plan of 7/1/75 which is the basis for the MPP-2 Amendment to the subject license.

6. TESTING AND MAINTENANCE

6.1 The Fuel Element Storage Vault Intrusion Alarm is tested at intervals not exceeding seven (7) days.

6.2 Functioning of the Protected Area Intrusion Alarm is checked at intervals not exceeding seven (7) days. An exception to 73.60(d) (2) is requested in that each individual door switch be tested at intervals not exceeding one month. These switches are each rigidly mounted in a location on the door protected from abuse or damage. The switches are Honeywell microswitches specified for 10 million operations and are considered are considered more reliable and less subject to damage than magnetic switches. Surreptitious defeat of switches, e.g., by taping closed, by visitors is unlikely due to the escort system (Section 4.5).

7. RECORDS

7.1 The names and addresses of the individuals who are authorized access to the storage vault are maintained.

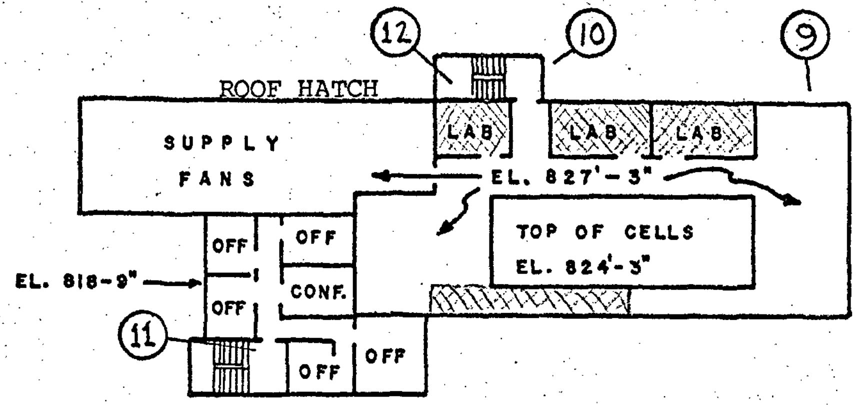
7.2 The Reactor Fuel Element Storage Vault Log is maintained indicating individual's name, time of entry, time of exit, and reason for entry.

7.3 The names and addresses of all individuals who are authorized access to the Protected Area is maintained and updated annually.

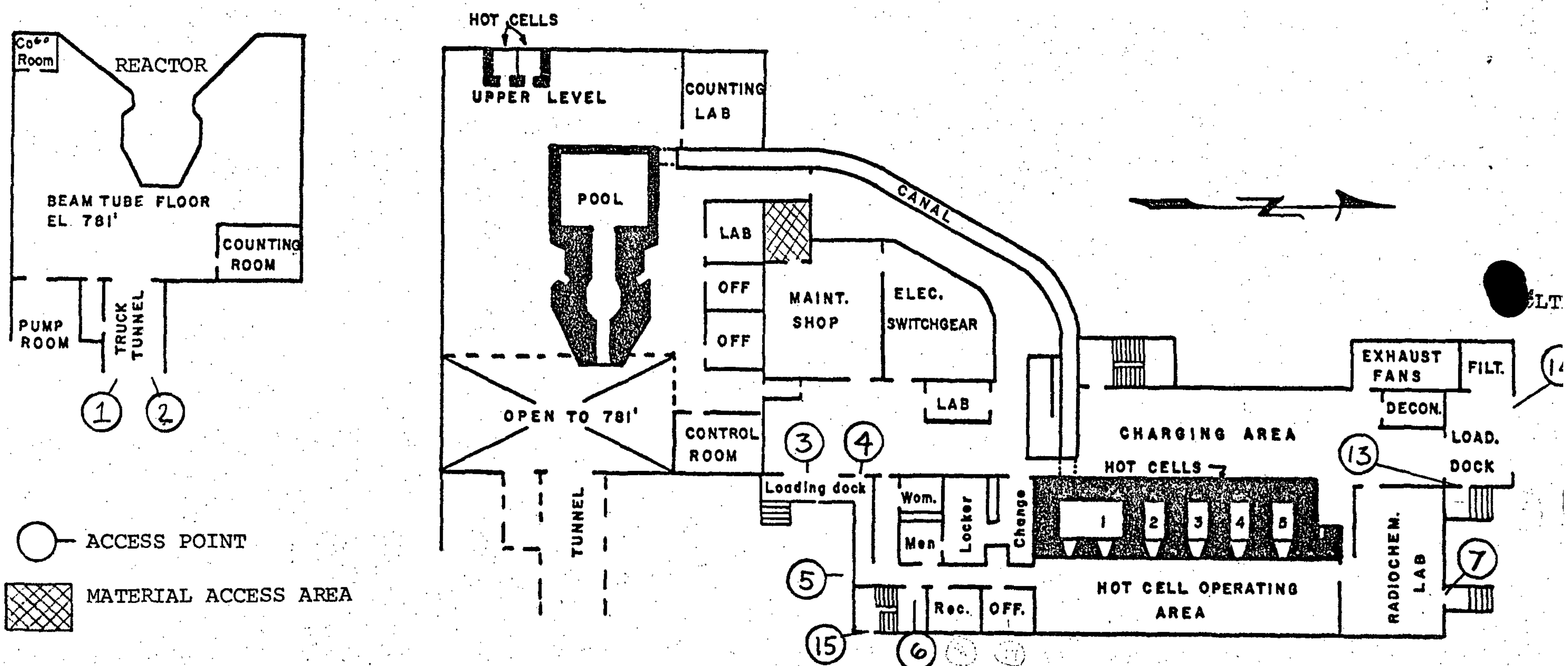
7.4 A register of visitors, vendors, and other individuals not employed by the Licensee is maintained showing name, date, time, purpose of visit, employment affiliation, citizenship, and name of person visited.

7.5 During non-working hours, a Report of Security Inspection is completed at least once per shift by the security watchmen.

7.6 A watchman's log is maintained which records each onsite intrusion alamr annunciation, whether false or real, with action taken.



UPPER FLOOR LEVELS — BLDG. 2



PLAN OF HOT CELL AND REACTOR OPERATING FLOOR

ELEVATION 808'