

**Yale New Haven  
1826 Hospital**

20 York Street, New Haven, CT 06504

September 3, 1985

U.S. Nuclear Regulatory Commission  
Ms. Jenny M. Johansen  
Region I  
Nuclear Materials Safety Section  
631 Park Avenue  
King of Prussia, Pennsylvania 19406

RECEIVED BY LFMB

Date 9/16/85  
Log Sept 10 I  
By SK  
Orig. To .....  
Action Compl. 9/18/85

Dear Ms. Johansen:

In response to the conditions of Amendment No. 28 to license No. 06-00819-03, Docket No. 030-01244, dated March 6, 1985, the following information is supplied.

On July 25, 1985 a nominal 10 Curie Ir-192 source was delivered to Yale-New Haven Hospital. A survey of the shipping crate was performed using a Kiethley 36100 ion chamber survey meter. The highest exposure rate measured at contact was 5 mR/hr, found on the bottom of the shipping crate. At 3 feet from the shipping crate, the exposure rate was measured at 0.8 mR/hr.

The source was loaded into the GammaMed III by Felix W. Mick of Mick Radio-Nuclear Instruments, Inc. The serial number of the source was found to be #055 which agreed with the serial number on the packing slip.

The following measurements were made:

GammaMed III	Calibrated:	Kiethley 21-Feb.-85	Victoreen THYAC III 21-Feb.-85
In the middle at contact		4.5 mR/hr	6.0
Front end at contact		0.1	0.08
Back end at contact		0.1	0.06
In the middle at 1 meter		<0.1	--

The interlock systems were tested. With the room door open the source could not be activated. With the door closed and the source activated, opening the door caused the source to be automatically retracted. All radiation warning lights and "Beam-On" lights were checked and found operational. An "emergency" interrupt was done and the emergency retraction motor was found to be operational.

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FEE EXEMPT

*irradiation survey report*

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An output measurement was made of the source in the irradiate position. The radiation level was found to be 0.910 R/min. at 30 cm, using a Farmer type ion chamber with a Kiethley electrometer. Using this value and the gamma constant for  $^{192}\text{Ir}$ , the source activity was calculated to be 10.5 Curies on August 1, 1985.

A survey outside the 6 MeV Accelerator room with the source in the exposed position could find no areas greater than 0.1 mR/hr using the Kiethley Survey Meter (See diagram A for survey locations).

A survey outside the 4 MeV Accelerator room showed all areas except for an area near the room entrance door to be less than 0.1 mR/hr. The area near the door was found to have a radiation level of 0.5 mR/hr which went up to 1.5 mR/hr during retraction (see diagram B). It was discovered that the source was located such that the maze was not providing primary shielding for the door.

In a worse case study, the source was exposed 6 feet from the door. Radiation levels of 2.5 mR/hr at contact to the door (area 4) and 13.5 mR/hr at contact with the front edge of the door (area 5) were measured.

Also investigated, was the possibility of the source being used directly in line with a cable pipe through the wall at the console area (see diagram). Normally this would not be a problem as the source would normally be exposed obliquely to the hole. If the source was exposed directly in front of the pipe at 1 meter, radiation levels of 450 mR/hr could be measured at contact to the pipe.

To prevent the possibility of exposures in excess of the requirements, areas of the 4 MeV Accelerator room will be marked off to prevent use of the GammaMed III in these areas. With the source located obliquely to the cable pipe, radiation levels at the console were less than 0.01 mR/hr. As an extra precaution a lead shield will be constructed to prevent an unshielded beam from passing through the cable pipe. The following calculations were made to determine the distance between the source and area 5 needed to keep exposures within the guidelines stated in NCRP report No. 49.

The transmission factor of the existing shielding was calculated as follows. Using pythagorean's theorem, the distance between the source and area 5 (during the measurement which resulted in the 13.5 mR/hr) was calculated to be 2.41 m. Using the inverse square relationship the unshielded output of the source was calculated as follows:

$$\begin{aligned} X &= \frac{(0.30)^2 \text{m}}{(2.41)^2 \text{m}} \times 0.910 \text{ R/min} \times 60 \text{ min/hr} \times 1000 \text{ mR/R} \\ X &= 844 \text{ mR/hr} \end{aligned}$$

Therefore the shielding factor can be calculated as follows:

$$B_{ug} = \frac{13.5 \text{ mR/hr (shielded)}}{844 \text{ mR/hr (unshielded)}} \quad B_{ug} = 0.016$$

The weekly workload factor was estimated. Assuming an output of 5 R/hr/Curie @ 1 meter, 12 Curies and one hour use in the 4 MeV room per day, 5 days per week = 300 R/wk @ 1 meter

Since the area adjacent to area 5 is a hallway of low use an occupancy factor of 1/4 was used. Because the GammaMed III source is not columnated a use factor of 1 was assigned to the walls. The available data is summarized below.

Distance from radiation source.....	$d_{pri}$	= ???
Weekly design exposure rate.....	P	= 0.1 R
Weekly workload with GammaMed.....	W	= 300 R
Use factor.....	U	= 1
Occupancy factor.....	T	= 1/4
Transmission Factor.....	$B_{ug}$	= 0.016

Using this equation from NCRP 49:

$$B_{ug} = \frac{P (d_{pri})^2}{WUT}$$

Rearranging to solve for  $d_{pri}$ :

$$d_{pri} = \sqrt{\frac{B_{ug} WUT}{P}}$$

$$d_{pri} = \sqrt{\frac{0.016 \times 300 \text{ R} \times 1 \times 0.25}{0.1 \text{ R}}}$$

$$d_{pri} = 3.46 \text{ meters}$$

$$d_{pri} = 11.4 \text{ feet}$$

Using these calculations, it was determined that if a distance from the door of 12 feet could be maintained the guidelines in NCRP 49 regarding the 100 mR/wk limit would be accomplished.

Regarding the 2 mR/hr limit, the following calculations were made. Assuming the maximum activity would be 12 Curies in use at any one time the calculated radiation level at area 5 using the 6

foot test setup would be 15.4 mR/hr at 241 cm. Also using the assumption that the GammaMed source will only be exposed for a maximum of 15 minutes in any one hour, we can calculate the distance needed to keep radiation levels at 2 mR/hr in area 5 using the inverse square law.

$$D_2 \text{ mR/hr} = \sqrt{\frac{15.4 \text{ mR/hr} \times 0.25 \text{ hr} \times (2.41)^2 \text{ m}}{2.0 \text{ mR/hr}}}$$

$$D_2 \text{ mR/hr} = 3.34 \text{ m}$$

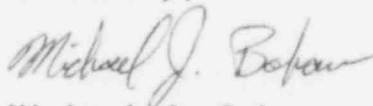
$$D_2 \text{ mR/hr} = 11.0 \text{ ft}$$

Therefore, by maintaining a distance greater than 12 feet from area 5 we can insure that the 100 mR/wk and 2 mR in any one hour guidelines will be followed. Adding an extra foot to this 12 feet will allow an additional buffer zone to keep exposures below the guidelines. To insure that the GammaMed IIIi will not be used closer than 13 feet from the door markings will be placed on the floor designating the area allowed for gammaMed IIIi use.

The irradiator treatment timing device was found to be in error after delivery of the source. The main electronic board was replaced and the timing device was found to be accurate and in agreement with three other timing devices. After the board was replaced, all interlock and warning devices were checked and found to be operating properly.

Please excuse the lateness of this report. Because this was the first delivery of the source and because of the subsequent findings of the 4 MeV shielding problems and timing errors, an extended period was required to test and analyze the situation. If you have any questions please feel free to contact me at (203) 785-2950.

Sincerely,



Michael J. Bohan  
Health Physicist

Attachments (2)

10 feet of earth

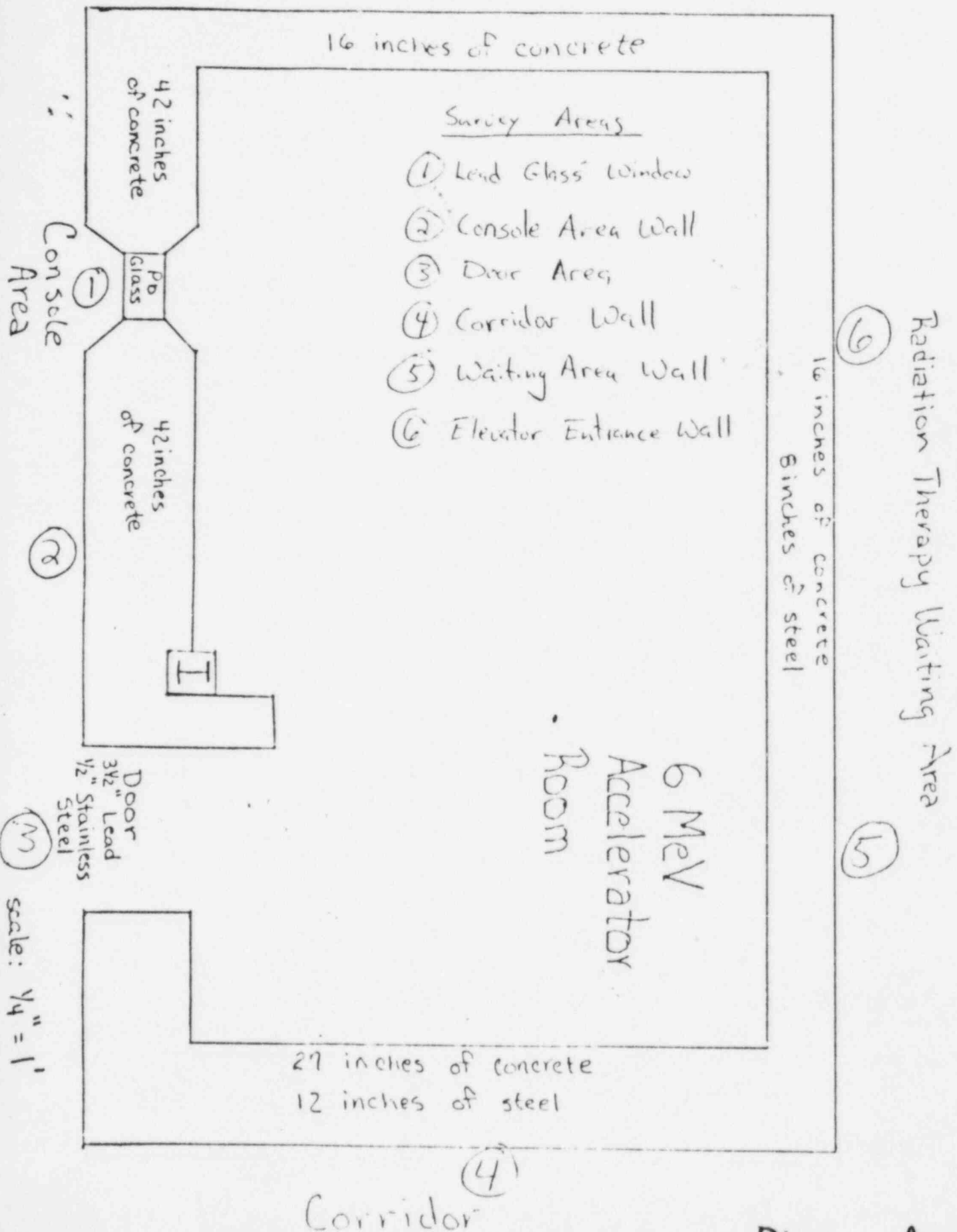


Diagram A

- ① Modulator Room
- ② 4 MeV Operator's Console
- ③ Closet
- ④ 4 MeV Room Door

- ⑤ "10" Spot In Wall
- ⑥ Sagittaire Hallway Wall
- ⑦ Sagittaire Operator's Console

## 4 MeV Accelerator Room

Building Foundation

20 inches of concrete

Area of Gammaned Use

16 inches of concrete

13 Feet

32 inches of concrete

32 inches of concrete

Cable Pipe

20 inches of concrete

Console Area

Door

Closet

Hallway

Scale  
1/4" = 1 Foot

Basement of Hunter Radiation Therapy Center

Diagram B