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July 12, 1996

Docket No. 50-223
License No. R-125

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington D.C. 20555

Dear Reader:

SUBJECT: REQUEST FOR EXEMPTIONS FROM 10 CFR PART 36, "LICENSES AND RADIATION SAFETY REQUIREMENTS FOR IRRADIATORS" WHEN APPLIED AT THE UNIVERSITY OF MASSACHUSETTS LOWELL RESEARCH REACTOR (UMLRR).

This responds to a letter from T.S. Michaels dated October 5, 1995. It sets forth requests for exemption from certain parts of the regulation, the bases for such requests, and detailed information regarding the facility as requested by the October 5, 1995 letter.

This regulation was not originally intended to apply to the situation existing (and licensed under Reactor License R-125) at UMLRR. In fact, the regulatory analysis relied upon for the promulgation of 10 CFR 36 (58 FR 7727) specifically states, "Other utilization facilities such as fuel fabricators, power reactors, and research and training reactors will not be affected by the rule". Unfortunately, this research reactor <u>is</u> being affected by the rule. Further, the research and development uses at UMLRR are not those of a "large irradiator". The UMLRR facility is a small, flexible research reactor.

The principle affect on UMLRR results from the way in which the access controls formerly in 10 CFR Part 20.203 have been translated into Part 36. Part 36 implies that all irradiators have some type of electromechanical mechanism to control source movement. Nothing in the rule, the regulatory analysis, nor the statements of consideration alludes to manual movement of sources. Manual movement has been the licensed use at UMLRR since 1982. This makes applications for exemptions extremely awkward. Nonetheless, in response to your letter of October 5, 1995, here are a list of specific exemptions and a reiteration of the rationale for the exemptions requested for operation of the facility described as the Gamma Cave in the Updated Final Safety

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Analysis Report and the USNRC Safety Evaluation Report NUREG-1139, November, 1985 and licensed under R-125.

The UMLRR Cobalt-60 sources are a Pool Irradiator used both as an underwater irradiator and as a panoramic wet-source storage irradiator as defined by Part 36.

§36.23 Access Control

UMLRR meets the intent of this regulation by means different from the regulatory prescription. Exemption from provisions of §36.32 and substitution of UMLRR provisions for access control is sought as follows:

1. In addition to the mechanically locked entry barrier gate and locked Gamma Cave door, electromechanical locks which engage the entry barrier gate and cave door and deny entry into the access corridor and Gamma Cave when:

   a. The manual source handling tool is unlocked from its storage position preparatory to source movement. This action also causes a warning alarm in the access corridor and the control room.

   or

   b. A radiation monitor in the access corridor detects radiation levels higher than background (i.e., when sources are present on the Gamma Cave window).

Details can be found in correspondence dated April 11, 1994. Access to the overall facility is further controlled in accordance with the NRC-approved Security Plan for the UMLRR; this access control is more stringent than that of Part 36.

§36.27 Fire Protection

Exemption from the provisions of this section is requested.

The Gamma Cave is an 8 foot cubic concrete and steel room completely locked closed during irradiation. The only openings are around the door, cable and wire conduits and ports, and a six-inch diameter steel ventilation duct for a fan stopped during irradiation. Since these are openings to a very high radiation area, they are small and labarynthine The only combustible materials present are those being irradiated and the filter for the ventilation duct. Complete combustion of the air in the room with a high quality fuel such as plastic would release about 65,000 Btu into the concrete and steel room in the several minutes the fire would take to consume all the oxygen.

The fire would be separated from the Cobalt-60 sources by several sequential barriers: the Gamma Cave atmosphere, a 0.5" thick aluminum plate--the Gamma Cave window--and 0.75 inches of water due to the geometry of the source holder. The sources are immersed in and surrounded by the 75,000 gallon reactor pool. An analysis of this is attached to show that, except for damage to the paint in the Gamma Cave and whatever flammable material is consumed by the fire, there are no other consequences. Technical Specifications require NRC approval for introduction of explosive materials. Facility standing orders are more stringent and prohibit explosive materials, paraffin, and flammable bottled gases--including oxygen--from the reactor building. Personnel safety dictates that volatile materials not be used in the small confines of the Gamma Cave.

§36.29

Exemption from Section (a) is sought since this is not applicable. Exemption from Section (b) and substitution of facility Technical Specifications (TS) for detection and monitoring of radioactive contamination in pool water is sought since these TS were specifically modified for Cobalt source use in Amendment 5 to Facility License R-125 on January 15, 1982.

§36.31 Control of Source Movement

Exemption from these requirements is necessary since the regulation presumes movement of sources by mechanisms, whereas at UMLRR source movement is by operator manipulation.

UMLRR meets the intent of this part of the regulation by the following:

1. The source handling tool is secured by a single key fastened to the tool in its "No Movement" position. When key is removed, the tool may be used to place sources into the irradiation position. This key is a part of the exposure room access control; when the key is removed, indicating source movement imminent, electrically-operated latches are closed on the entry barrier gate and Gamma Cave door. If *either the door or the gate* is not closed as indicated by door position switches, a warning horn sounds in the access corridor and is audible throughout the building and a red light flashes at the pool level source handling area. This signals the operator to cease any source movement, return the source and handling tool to safe and locked positions and investigate. Since the actions are performed by operators, they are covered by procedures or standing orders. These accomplish the intent of the regulation to control source movement.

§36.33
Substitute facility Technical Specifications for pool construction, water level control, conductivity, pool barriers, and handling tools since TS are more stringent and apply to both reactor operation and cobalt-60 use.

§36.35

This section is not applicable at UMLRR and suitable relief is sought.

§36.37

Exemption from the provisions of this section is sought.

(a) The sources cannot be automatically returned to the shielded position. Since lighting would only be provided by emergency lights, manual movement would be difficult, so the sources should remain as is in event of power failure.

(b) The electrical locks will be deactivated by loss of normal power. The mechanical locks on the entry barrier gate and the Gamma Cave door will remain locked and prevent access without keys. The radiation detection system is powered from a source which would be supplied by an emergency generator after a 30 second delay, as is one set of emergency lights. A second set of emergency lights is battery-powered and comes on immediately with loss of normal power.

(c) Emergency operating procedures require the reactor operator to verify control blade insertion using a portable radiation monitor and flashlight to visually verify control blade position in event of failure of emergency power. Otherwise, the radiation monitoring system is powered and there is no need for this regulatory provision.

§36.59, Detection of Leaking Sources; 36.61, Operational Inspection and Maintenance; and 36.63, Pool Water Purity,

Exemption from these provisions and substitution of the UMLRR Technical Specifications (TS) for these is sought. The TS prescribe water purity, water condition monitoring, radiological monitoring, and building ventilation isolation suitable for operation of the research reactor which shares the irradiator pool.

To support this request for exemptions, the following material is attached:

1. A detailed analysis of conformance to Part 36.

2. Procedures for performance and descriptions of Gamma Cave experiments.

3. Physical and electromechanical system descriptions of the Gamma Cave and interlocks.

4. Fire hazard analysis.

I trust you will grant the requested exemptions. Without the requested exemptions, extensive and expensive modification of systems, structures, and design of the facility would result from a new commission regulation effective July 1, 1993 imposed upon an activity already licensed by Amendment 5 to license R-125 on January 15, 1982. Should you need further information, please contact me or Mary Montesalvo, Radiation Services Manager.

Lee H. Bettenhausen

Lee H. Bettenhausen, P.E., Ph.D.
Reactor Supervisor

Attachments

1. Detailed Analysis of Conformance to Part 36.

2. Gamma Cave Operations: Procedures

3. Description of Gamma Cave and Experimental Setup

4. Gamma Cave Interlock System

5. Gamma Cave Fire Hazard Analysis

cc: Region I Administrator
USNRC Region I: Attention: Mr. T. Dragoun
Commonwealth of Massachusetts
City of Lowell, Law Department

G. Kegel
M. Montesalvo

ATTACHMENT 1
DETAILED ANALYSIS OF CONFORMANCE TO PART 36

Section 36.23(a)
It must not be possible to move the sources out of their shielded position if the door or barrier is open.

The UMLRR operation is reversed since all source movement is manually accomplished. However, it accomplishes the intent of the regulation - to assure that the source is not exposed when an individual is in its vicinity. UMLRR provides means to prevent entry to the radiation area and to assure that the source is not moved if access to the radiation area is available. Sources are in the form of stainless-steel-covered Cobalt-60 strips mounted in stainless steel racks. The racks are stored in specially designed crates. The sources at the UMLRR are stored at the bottom of the reactor pool. To use the sources(s) for irradiation levels in excess of 500 Gray in the irradiation room hereafter called the Gamma Cave, a crate of Cobalt racks is placed on a work platform 10 feet under water and the rack(s) desired for the irradiation are manually moved from the work platform to the source holder mounted on the pool side of the Gamma Cave window after the experiment to be irradiated is emplaced in the Gamma Cave. The sources remain in the pool at all times

Normally both the entry barrier and Gamma Cave door are closed and locked with the key to the entry barrier kept in the control room. A green light at the pool level indicating this status is clearly visible from the control room and from the source handling tool area. Opening either or both access barriers to the Gamma Cave causes the green light to shut off and a flashing yellow light to be lit. Therefore, there is clear indication at the pool level that shows that a barrier is open and the source should not be moved.

Opening the door or barrier while the sources are exposed must cause the sources to return promptly to their shielded position.

Again, the UMLRR situation is the reverse of this. However, it accomplishes the intent of the regulation - to assure that the source is not exposed if an individual attempts to gain entry into the radiation area. The UMLRR operation both through procedures (see Attachment 2) and two separate controls assures that the access barriers can not be opened while the source is being moved or is in the irradiation position.

The source handling tool is interlocked with both access barriers. Unlocking the tool's permanently attached key results in electrically actuated piston locks on both access barriers, thereby denying entry to the area. Securing the source handling tool will not automatically release the locks if a radiation source has been used; the radiation monitoring system must be manually cleared from its alarm condition to release the locks. The radiation monitoring system can only be cleared if it no longer detects radiation greater than a value determined by the strength of the source(s) in use.

Additional detail describing a typical experimental set-up in the Gamma Cave is given in Attachment 4.

Note: The radiation monitoring system is checked on a nearly daily basis as part of reactor operation. Additionally, the system is designed as fail-safe; the loss of a component or module results in the system failing in the alarm mode.

The personnel entrance door or barrier must have a lock that is operated by the same key used to move the sources.

The intent of Part 36 is to have a key at the source control console which can not be removed from the console to gain access to the radiation areas while the source is exposed. The UMLRR operation does not include a source control console, however it accomplishes the intent of Part 36 because by procedure the door to the irradiation room is closed and padlocked after an experiment is set-up (see Attachment 4). As already described, prior to any source movement, two locked barriers are in place to prevent access to the Gamma Cave. Unlocking the source handling tool from its storage position activates additional electro-mechanical interlocks to these already mechanically locked barriers. Additionally the radiation monitoring system which is set to trigger when the system detects radiation in the Gamma Cave is electrically tied into the interlocked barriers. Two conditions must be met in order to clear the interlocks to the Gamma Cave and use the keys to gain access. The source handling tool must be returned to its storage location, the "No Movement" position, and the radiation monitoring system must be manually cleared from its alarm condition to release the interlocks. The UMLRR set-up assures that entry cannot be gained into the Gamma Cave while the source is exposed, thereby effectively accomplishing the one key requirement of the regulation.

The doors and barriers must not prevent any individual in the radiation room from leaving.

The Gamma Cave facility is located within a controlled access reactor building. The Gamma Cave facility itself is normally closed and padlocked (keys controlled) when not in use, therefore access is very restricted. There is an override switch located in the access corridor to unbolt and exit the entry barrier gate. However, the Gamma Cave door is padlocked. There are two physical features of the Gamma Cave that would preclude anyone from inadvertly being locked in. First a technician alone setting up an experiment can not physically shut the Gamma Cave door from the inside and padlock himself in. Secondly, the dimensions of the Gamma Cave are 8 feet by 8 feet by 8 feet; it is impossible not to see someone in a room of this size and inadvertently shut and padlock the door. Additionally, there is an in-cave alert switch in the Gamma Cave by which an individual can signal with a flashing red light at the source control area and an audible danger horn , which can be heard throughout the containment building that an unsafe condition exists.

Once an experiment is in progress, electromechanical interlocks prevent entry to the area until the source is removed, the source handling tool is returned to its storage location, and the radiation monitoring system is manually cleared from its alarm condition.

No credible scenario has been formulated where someone would inadvertly be padlocked in the Gamma Cave. The main intent of the in-cave alert switch was to provide immediate

communication to the operation staff that a problem existed in the Gamma Cave or to release the cove door interlock if it had been inadvertantly triggered..

Section 36.23(b)
Detection of entry while the sources are exposed must cause the sources to return to their fully shielded position.

Since the sources are manually placed in a fixed position at UMLRR, this is not physically possible. However, UMLRR operation accomplishes the intent of the regulation by precluding entry into the radiation area. The UMLRR operation both through procedures (see Attachment 2) and two separate and independent barrier locks assure that the access barriers can not be opened while the source is being moved or is in the irradiation position.

The source handling tool is interlocked with both access barriers. Unlocking the tool's permanently attached key results in electrically actuated piston locks on both access barriers, thereby denying entry to the area. Securing the source handling tool will not by itself release the locks if a source had been placed in the radiation position; the radiation monitoring system also must be manually cleared from its alarm condition to release the locks. The radiation monitoring system alarm can only be cleared by operator action if it no longer detects radiation above a specific setpoint for the source(s) in use.

Section 36.23(d)
Before the sources move from their shielded position, the source control must automatically activate conspicuous visible and audible alarms. The alarms must give individual enough time to leave the room before the sources leave the shielded position.

Source movement is done manually. The source handling tool is locked with a restraint and key when sources are not in use. Unlocking the source handling tool under safe condions (all doors closed) causes a squee signal in the control room and a bell located within the access corridor area and audible throughout the containment building to sound for 3 seconds. The bell is a signal to the staff within containment that the sources will be moved.

If an unsafe condition existed (either access barrier doors open), a danger horn (not the bell) also located within the access corridor area and audible throughout the containment building would sound, as well as a flashing red light, visible from the source handling area and the control room. It should be noted that if either door had been open the operator would be aware of it prior to unlocking the source handling tool from the status of the lights at the source handling area (flashing yellow light lit, green light off). Procedures require a green light to be lit prior to unlocking the source handling tool and the bell to sound when the tool is unlocked

Manually moving the source requires several minutes. Unlocking the source handling tool does not begin an automation process, but rather it affirms the staus of the Gamma Cave. Again, a green light at the source handling tool area indicates a safe condition, unlocking the tool sounds the bell and squee affirming the safe condition. Unlocking the tool also actuates the door and barrier electromechanical interlock system, thereby preventing entry before the source is even moved.

Section 36.23(e)

Each radiation room of a panoramic irradiator must have a clearly visible and readily accessible contol that would allow an individual in the room to make the sources return to their fully shielded position.

Again, the UMLRR situation is the reverse of this. However, it accomplishes the intent of the regulation - to assure that the source is not exposed if an individual attempts to gain entry into the radiation area. The UMLRR operation both through procedures and two separate and independent controls assures that the access barriers can not be opened while the source is being moved or is in the irradiation position.

The source handling tool is interlocked with both access barriers. Unlocking the tool's permanently attached key results in electrically actuated piston locks on both access barriers, thereby denying entry to the area. Securing the source handling tool will not automatically release the locks; the radiation monitoring system must be manually cleared from its alarm condition to release the locks. The radiation monitoring system can only be cleared if it no longer detects radiation.

Section 36.23(f)

Each radiation room of a panoramic irradiator must contain a control that prevents the sources from moving from the shielded position unless the control has been activated and the door of barrier to the irradiation room has been closed within a preset time after activation of the control.

Again, the UMLRR situation is the reverse of this. However, it accomplishes the intent of the regulation - to assure that the source is not exposed if an individual attempts to gain entry into the radiation area. The UMLRR operation both through procedures and two separate and independent controls assures that the access barriers can not be opened while the source is being moved or is in the irradiation position.

The source handling tool is interlocked with both access barriers. Unlocking the tool's permanently attached key results in electrically actuated piston locks on both access barriers, thereby denying entry to the area. Securing the source handling tool will not automatically release the locks; the radiation monitoring system must be manually cleared from its alarm condition to release the locks. The radiation monitoring system can only be cleared if it no longer detects radiation.

Section 36.27(a)

The radiation room of a panoramic irradiator must have heat and smoke detectors. The detectors must activate an audible alarm. The alarm must be capable of alerting a person who is prepared to summon assistance promptly. The sources must automatically become fully shielded if a fire is detected.

The radiation room is a steel and concrete vault. The only combustible material present is that being irradiated. The sources which are configured in a planar array are located in a water pool adjacent to the radiation room. Therefore an experiment in the Gamma Cave is only irradiated from one side. The source and radiation room design is only adequate for small

experiments requiring a precise dose. The facility is not designed for bulk irradiation because of limited space and poor source to sample geometry. Facility Technical Specifications and Standing Orders prohibit explosives and most flammable materials from the reactor building.

In response to specific comments -

a)The radioactive sources are outside the exposure room in an adjacent water pool. There is no possible mechanism for the release of radioactive material since there is no radioactivity in the exposure room.

b) Any materials with the potential to affect the pool liner, i.e. explosives, are already prohibited from the containment building.

c) The Gamma Cave itself is a vault. The only combustible material present is that being irradiated and a ventilation filter. Given the source to room design, most samples are of small size.

d) Any material that did ignite in the Gamma Cave would be left to burn itself out (see Attachment 5). Smoke would be removed by the exhaust fan located in the room. Since the sources are in the water pool adjacent to the Gamma Cave, their physical condition and movement would not be affected by a fire.

e) Over the 13 years of Gamma Cave operation there has never been a spontaneous combustion. The installation of expensive and sensitive equipment such as fire and smoke detection in an intense radiation field would be of marginal benefit to the facility since intervention to fight fire would not be considered a logical course of action.

Section 36.27(b)

The radiation room of a panoramic irradiator must be equipped wilth a fire extinguishing ststem capable of extinguishing a fire without entry of personnel into the room.

See the discussion above.

Section 36.31(a)

The mechanism that moves the sources must require a key to actuate. Actuation of the mechanism must cause an audible signal to indicate that sources are leaving the shielded position. Only one key may may be in use at any time and only operators or facility management may possess it.

There is only one key permanently attached to the source handling tool that must be unlocked in order to move the source. This is the only key in use at any time that allows movement of the source. Unlocking the source handling tool under safe conditions (all doors closed) causes a squee signal in the control room and a bell located within the access corridor area and audible throughout the containment building to sound for 3 seconds. The bell is a signal to the staff within containment that the source will be moved.

Additional keys are needed to gain entry into the Gamma Cave. One key for the entry barrier and a different one for the Gamma Cave padlock are needed. Again, because of the interlock system these two keys will only release the barriers if two conditions are met; namely,

the source handling tool must be locked in its storage position and the radiation monitoring system must be manually cleared from its alarm condition. The entry barrier key, along with all facility keys are kept in a storage box in the control room. Keys are only accessible to reactor personnel in a controlled access area.

The key must be attached to a portable radiation survey meter by a chain or cable. The lock for source control must be designed so that the key may not be removed if the sources are in an unshielded position. The door to the radiation room must require the same key.

The justification for different keys is listed under section 36.23(a)3. However, the key to the padlock on the Gamma Cave door is permanently attached to a survey meter by a cable. The meter is kept on a storage shelf within the locked access corridor.

Section 36.31(b)

The console of a panoramic irradiator must have a source position indicator that indicates when the sources are in the fully shielded position, when they are in transit, and when the sources are exposed.

There is no control console, since movement is done manually. However the intent of the regulation - assure personnel know the status of the source(s) is met by the illumination of different lights. A staff member prior to using the entry barrier key, is aware of the status of the source from the radiation monitor meter and status lights located in the access corridor. One indicator (meter reads in mr/hr), marked as "CAVE DOOR LEVEL", has a green and red light. The red light indicates one of two things: the radiation monitor is detecting radiation in the Gamma Cave (the field can be determined by reading the meter), or that the Q radiation monitoring channel in the control room has not been manually cleared. Regardless of the source of the red light, the interlock to both access barriers is activated and access is precluded.

Section 36.31(c)

The console of a panoramic irradiator must have a control that promptly returns the sources to the shielded position.

Again, this is not possible since there is no control console and the source is moved manually. See Section 36.23(a)2 above.

Section 36.31(d)

Each console for a panoramic irradiator must be clearly marked as to its function.

Again, this is not possible since there is no control console and the source is moved manually.

ATTACHMENT 2

GAMMA CAVE OPERATIONS

STANDING ORDER #10

GAMMA CAVE OPERATION AND ALARM SETPOINTS

1.0. SETTING UP IRRADIATION

1.1 Obtain key to gamma cave entry barrier from control room (3rd floor).
1.2 Assure that the source handling tool is secured by its key lock and the wall mounted interlock light is green (3rd floor).
1.3 Prior to opening entry barrier, assure that all indications on the radiation monitor in the access corridor are green (1st floor).
1.4 Unlock entry barrier, pick up radiation survey meter with attached gamma cave padlock key from storage shelf. Survey area. Unlock and open gamma cave door.
1.5 Set up experiment in gamma cave.
1.6 Clear gamma cave, assure all personnel are out, close and padlock gamma cave door. Return survey meter with attached key to storage shelf.
1.7 Clear access corridor, close entry barrier; assure that all barriers are properly closed as indicated by a yellow light on the radiation monitor in the access corridor.
1.8 Prior to unlocking the source handling tool key, assure that the wall mounted interlock light is green (3rd floor)
1.9 Unlock the source handling tool, note that the warning bell sounds, pick appropriate cobalt source(s) from storage rack, and place source on window of gamma cave. Return entry barrier key to control room. Assure that the radiation monitor channel Q in the control room has alarmed high. Adjust setpoint if necessary per Section 3.0

2.0. SECURING IRRADIATION

2.1 Upon completion of irradiation, remove cobalt from gamma cave window and return source(s) to storage rack.
2.2 Return source handling tool to its storage location and relock the key. In the control room, clear channel Q on the radiation monitor from its alarm condition, and obtain key to the entry barrier.
2.3 Follow steps 1.3, and 1.4.
2.4 Retrieve experiment from gamma cave, follow steps 1.6 and 1.7.
2.5 Return entry barrier key to control room.

3.0 ADJUSTING ALARM SETPOINT

The decay of the cobalt-60 source necessitates the constant review of the alarm setpoints used in the Gamma Cave Interlock System. Because of this review

RF14, in regard to Channel Q, reads "set alarm points as per current standing order".

Low Level Trip Value, mR/hr = 0.3
High Level Trip Value, mR/hr = 0.5

If the rack used is not of sufficient strength to reach these levels (i.e. Rack #158) the High Level Trip Value should be lowered so as to engage the interlock. This setpoint should be returned to its normal value at the end of the experiment.

Approved by: Lee Bettenhausen, Reactor Supervisor

RO-16 MOVEMENT OF CO-60 SOURCE IN THE REACTOR POOL

1. A Senior Operator or an individual designated by the Reactor Supervisor will supervise all movement of the cobalt source. The designated supervisor shall apprise the control room operator of all anticipated Co-60 movements.

2. Under no circumstances will any portion of the Co-60 source be moved into the reactor end of the pool while the reactor is in operation.

3. Whenever possible, the Co-60 strips will only be moved while they are housed in the appropriate frames. Individual strips shall not be moved or handled while the reactor primary coolant system is in operation.

4. Frames will not be handled when the Primary Coolant Sytem is in operation without the approval of the reactor SRO (as designated in reactor operating log).

5. All handling of the source will be performed at least 8 feet below the surface unless a dedicated radiation monitor is present.

6. Before the designated supervisor allows any cobalt-60 movement, he/she will personnally assure the following:

   A. The Gamma Cave door is closed and locked.
   B. The Gamma Cave gate is closed and locked.
   C All experimenters are aware of Co-60 movement.

END

SYSTEM TEST FOR THE GAMMA CAVE INTERLOCK SYSTEM

1.0 Purpose

1.1 The interlock system for the Gamma Cave is designed to prevent inadvertant radiation exposure, or any other unsafe condition with the Gamma Cave system.

This test will demonstrate that all conditions of the Gamma Cave system will indicate the appropriate warning.

2.0 Equipment Required

2.1 Small gamma source.

3.0 References

3.1 Gamma cave interlock system schematic

4.0 Procedure

4.1 Follow the outline given on reactor form RF-SP1A.1(Sysytem Test for the Gamma Cave Interlock System).

4.2 End.

System Test for the Gamma Cave Interlock System

1. Verify that the facility is in the following initial conditions:
   A) Gate Door Shut
   B) Cave Door Shut
   C) Gamma Radiation Monitor Module With No Alarm
   D) Tool Key In Storage Position
   ________ Green Light On
2. Open the outer gate and verify the following:
   ________ Green Light Off
   ________ Yellow Light Blinking On
3. Shut Gate Door and verify the following:
   ________ Green Light On, Yellow light stops blinking

Note: Ensure Proper Radiological Precautions Are Taken For Step 4

4. Open Cave Door and verify the following:
   ________ Green Light Off
   ________ Yellow Light Blinking On
5. Enter Gamma Cave and Shut Gamma Cave Door. Turn Tool Key To Move Pole, then verify the following:
   ________ Bell Sounds for Approximately 3 Seconds
   ________ Cave and Gate Interlocks Energize
6. Operate Test Switch Inside Gamma Cave and verify
   ________ Danger Horn Sounds
   ________ Cave Interlock Piston Clears
7. Open Cave Door, Then Operate Test Switch Inside Gate Area on side of horn and verify
   ________ Danger Horn Sounds
8. Shut Cave Door (stay in gate area) and verify
   ________ Green Light On
9. Turn Tool Key To Move Pole, then verify the following:
   ________ Squee Sounds for Approximately 3 Seconds
   ________ Cave and Gate Interlocks Energize
10. Push Gate Overide Button, and verify
   ________ Gate Interlock Clears

11. Open Gate Door, and verify

________ Danger Horn Sounds

________ Yellow Light Blinks On

________ Red Light Blinks On

12. Shut Gate Door and return key to storage position, then verify

________ Green Light On

13. Energize Gamma Module High Alarm, then verify the following:

________ Bell and Squee Sounds for Approximately 3 Seconds

________ Cave Interlock Energizes

________ Gate Interlock Energizes

14. Clear Gamma Module High Alarm, open gate door and then turn key to move pole. Then verify the following:

________ Danger Horn Sounds

________ Yellow Light Remains Blinking

________ Red Light Blinks On

15. Turn Key to Storage Position, then open cave door, and shut the gate door, then verify the

________ Yellow Light Blinking On

Turn key to move pole.Then verify the following:

________ Danger Horn Sounds

________ Yellow Light Remains Blinking

________ Red Light Blinks On

Technican________________________ Review (CRO) ________________________________

ATTACHMENT 3

DESCRIPTION OF
GAMMA CAVE
EXPERIMENTAL
SETUP

Gamma Cave Experimental Set Up

Two staff members are primarily responsible for the operation of the Gamma Cave facility. However, the Gamma Cave is an integral part of the reactor's experimental facilities; therefore all licensed operators are familiar with all aspects of the Gamma Cave operations. The following is a summary of an experimental set up in the Gamma Cave and the series of events and interlocks that are activated.

A sample for gamma irradiation is given to a staff member/reactor operator. The operator calculates the distance from the source the sample needs to be placed in order to obtain the requested total dose. He obtains the entry barrier key from the key box in the control room, checks that the source handling tool is in the storage location and a green light is indicated on the wall mounted interlock lights (figure 1). He proceeds to the 1st floor (figure 2). Prior to opening the entry barrier he checks the gamma cell monitor panel (figure 3) in the access corridor. He sees two green lights: one is marked "IN CAVE ALERT", the other is marked "CAVE DOOR LEVEL". If either of these lights had been red, the interlock would have been activated and the electromechanical lock would preclude entry.

When he opens the entry barrier, the yellow door closed light on the Gamma Cell Monitor Panel goes off and the red door open light is lit. At the same time on the 3rd floor, the wall mounted signal green light goes off and a flashing yellow light is lit. This signals to facility staff on the 3rd floor that one or both access barriers to the Gamma Cave are open. The operator picks up the survey meter with its attached key from the storage shelf, surveys the area, and uses the attached key to unlock the Gamma Cave door padlock. He enters the Gamma Cave with the survey meter, places the sample at the appropriate distance and shuts and padlocks the door. He replaces the survey meter and shuts the entry barrier. Before walking away, he checks that the door status light on the gamma cell monitor panel indicates both doors are properly closed.

On the 3rd floor, he requests help from a staff member to assist and observe him move the source and start a stopwatch to time the irradiation. Prior to unlocking the source handling tool, he looks up at the signal lights to make sure that the green light is lit and the flashing yellow light is off. Unlocking the source handling tool, a bell sounds for 3 seconds, indicating that he can proceed. It takes approximately 5 minutes to move the source handling tool to the storage basket in the pool, pick the appropriate source frame of Co-60 and then manually walk it to the fixed position of the Gamma Cave window. Once the source is positioned on the window, he walks over to the control room, returns the entry barrier key, and assures that channel Q on the radiation monitor panel is tripped high (illuminates a red light). If the high trip has not occurred, the red monitor setpoint is lowered to lock in a trip condition.

When the timed irradiation is completed, he removes the source from the window to the storage basket and replaces the source handling tool at its storage location. He locks the key attached to source handling tool. At this point, the interlock system is still actuated. When he obtains the key for the entry barrier from the control room, he manually clears the alarm trip on the Q channel of radiation monitor. The two conditions to deactivate the interlock system have now been met. He proceeds to the 1st floor and repeats the steps described above to gain entry to the Gamma Cave and retrieve the irradiated experiment.

REACTOR CONTAINMENT - 3RD FLOOR

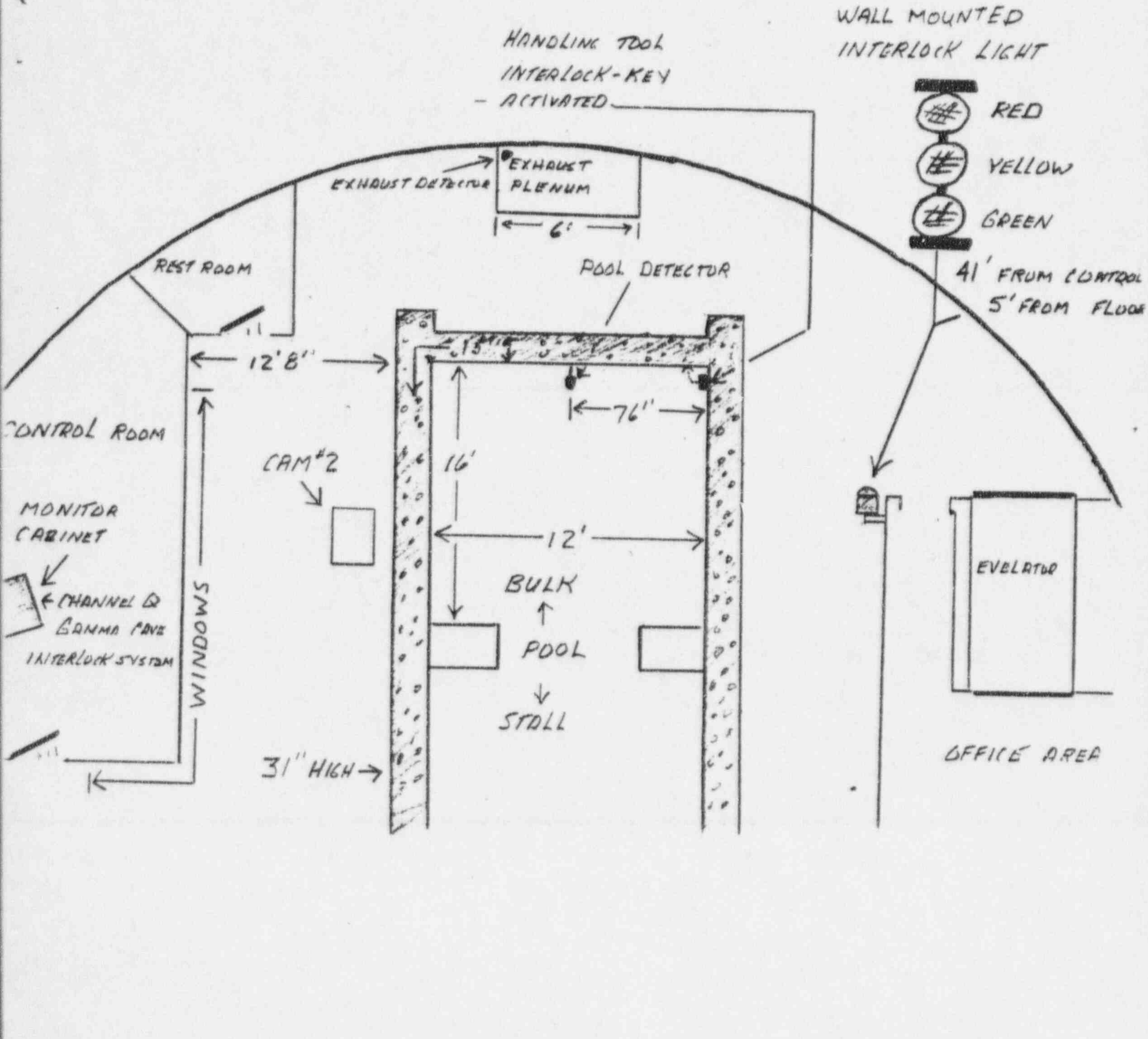


FIGURE 1

REACTOR CONTAINMENT - 1 FLOOR

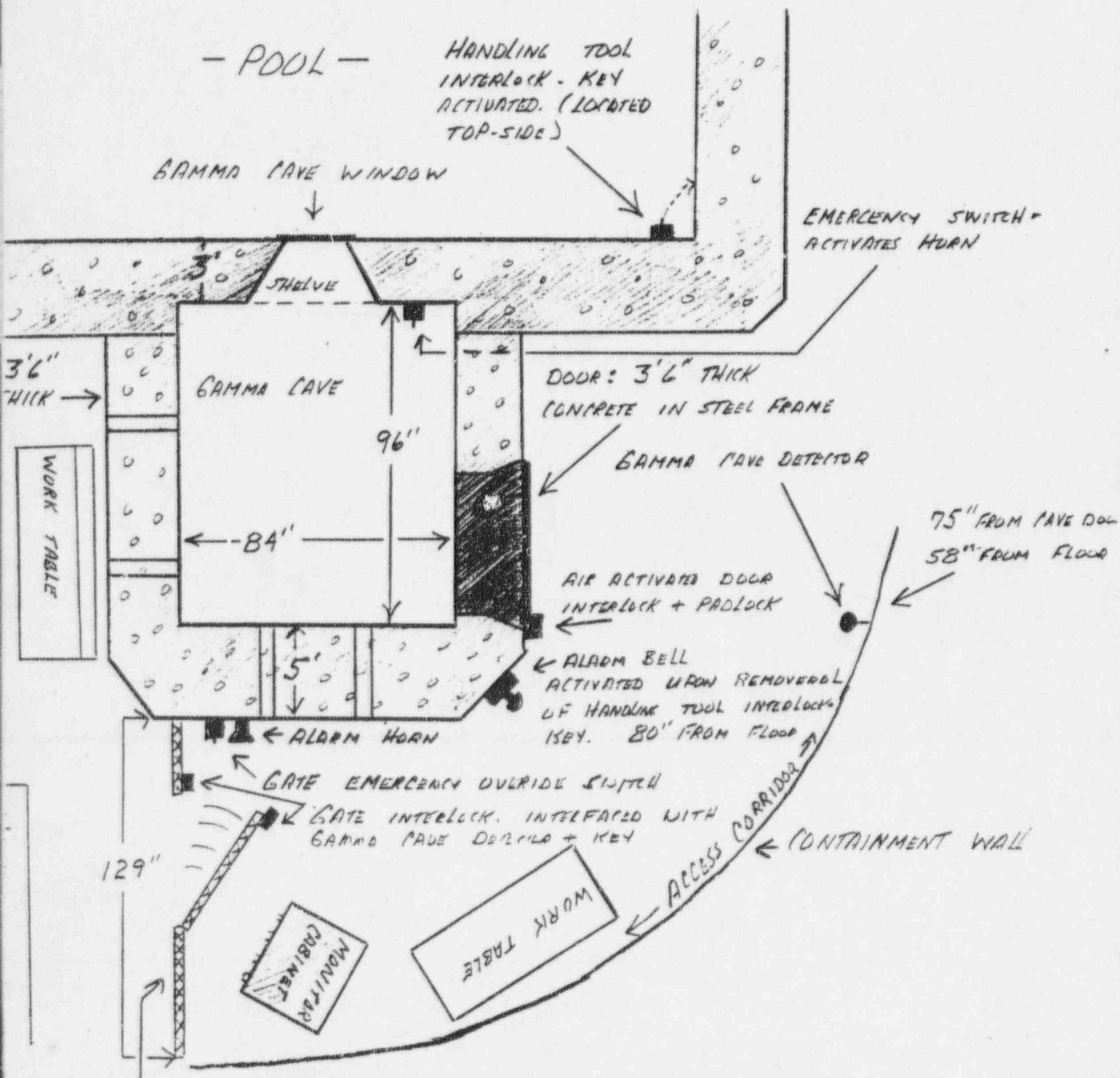


FIGURE 2

RADIATION MONITOR (LOCATED IN ACCESS CORRIDOR)

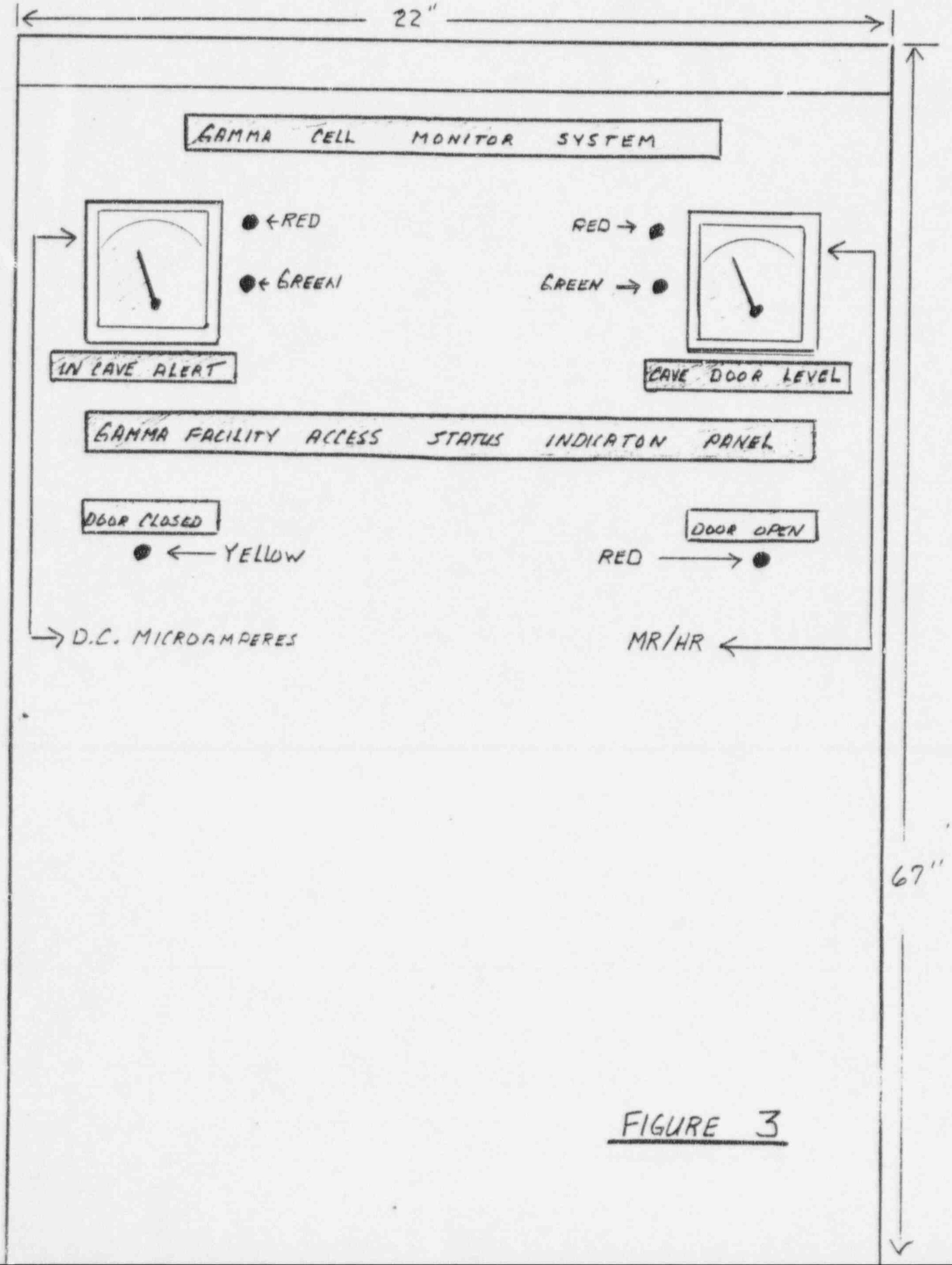


FIGURE 3

ATTACHMENT 4

GAMMA CAVE INTERLOCK SYSTEM

DESCRIPTION OF THE GAMMA CAVE INTERLOCK SYSTEM

The gamma cave area consists of an inner cave and cave access corridor. The purpose of the Interlock System is to prevent an unsafe condition in cither area. Cobalt-60 (Co-60) may only be moved from the shelf to the gamma cave window when both the cave door and entry barrier gate are closed. If Co-60 is on the window and either door is accessed, an audible and visible alarm will energize. If either door is open when a Co-60 move is attempted, the alarm will energize.

The primary indication of the status of the interlock system is a group of three lights at the pool level. The lights are green, yellow and red. When the green light is on, Co-60 can be moved safely; this means the cave door and entry barrier gate are both closed.

When both door and gate are shut, the gate switch and cave switch will close, which will energize relay K1. Contacts K1A and K1B will open, and contact K1C will close. Contact K1C will energize relay KG. Contact KG will close which will then energize the green light at the pool level.

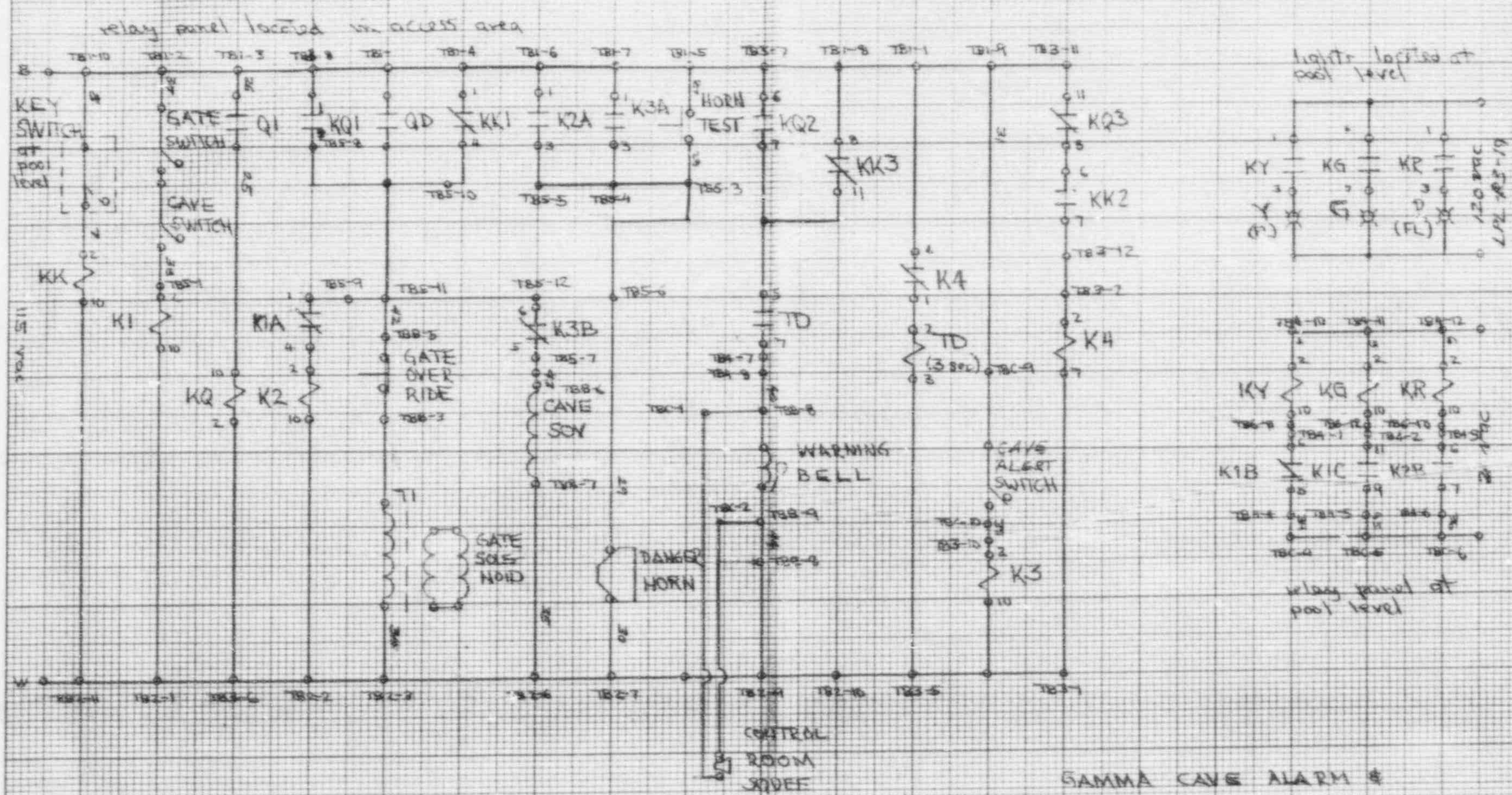
When one of the doors are open, relay K1 will de-energize. Contacts K1A and K1B will close and contact K1C will open. Contact K1B will then allow relay KY to energize; this will shut contact KY, then the yellow light will blink on or off.

The pole which is used to move Co-60 from the shelf to the gamma cave window has a key attached to it by a short steel cable. This key fits into a key box on the pool wall by the pole storage position. When the pole is stored the key is inserted into the box and turned to the "stored" position. The pole can not be used to move Co-60 without removing the key from the box. The key can only be removed from the box by turning it to the proper position.

With a green light the Co-60 is allowed to be moved. The key will be turned which will de-energize relay KK. This will cause contact KK1 and KK3 to close and contact KK2 to open. Contact KK1 will energize the cave door solenoid operated air valve and will also energize the transformer for the gate solenoid which will cause the solenoid for the gate to energize. These solenoids are the physical interlocks for the two doors to prevent opening while Co-60 is being moved or is on the window. Contacts Q1 and QD will cause the same effect as contact KK1. Q1 is closed when the radiation monitor in the access corridor is tripped. QD is tripped by an in-cave monitor.

If either door or gate is open or opened while contacts Q1, QD, or KK1 are shut, which would indicate Co-60 is on the window or the pole is out of the storage position, relay K1 will de-energize. When relay K1 de-energizes, contact K1A will close causing relay K2 to energize. When relay K2 energizes, contacts K2A and K2B will close. Contact K2A closing will supply power to the Danger Horn. Contact K2B closing will energize relay KR. This will cause contact KR to close which will energize the red light at the pool level. The red light will blink on and off.

If the alert switch in the cave is thrown on, K3 will be energized, closing contact K3A with a resulting Danger Horn and opening K3B which deenergizes the cave door soleniod air valve in event of inadvertant operation.



GAMMA CAVE ALARM & INTERLOCK SYSTEM

Q1 is high alarm contact on access area radiation monitor
QD is high alarm contact on in-cave detector

redrawn & verified
6/7/96 [illegible]

ATTACHMENT 5

FIRE HAZARD ANALYSIS

FIRE HAZARD ANALYSIS

GAMMA CAVE

Consider that, despite prohibitions against flammable materials in the reactor facility, and the insult to personal safety by placing a volatile fluid in a small enclosed volume, and no prior history of irradiating flammables, and no ignition source in the 8' cube Gamma Cave, some experimenter places a sizable sample of a flammable liquid such as xylene, methyl alcohol, or ethylene on the experimental shelf and by some means it ignites during the course of an irradiation when the cave is closed, locked, and interlocked. The quantity of flammable liquid will be limited by the practical considerations of experiment size. The limitation of the amount of oxygen present in the closed Gamma Cave with only air seepage around the door and the few unsealed instrument penetrations will limit combustion.

The amount of oxygen present in the 8 ft cube will support combustion of 1.4 kg of ethylene[1], for example. So let us consider a typical 3 liter container of flammable liquid with dimensions 20 cm high by 15 cm diameter placed 30 cm from the window on the shelf of the Gamma Cave.

Since the combustion would occur at the liquid-air interface, the burning rate can be estimated as 0.2-0.3 cm/min [2] and of the radiant energy released by the fire, 2 $kcal/cm^2 \cdot min$ is radiated from the flame. The surface area of the container is 175 cm^2, so the radiant energy is 350 kcal/min. Assume a plane flame confined in the shelf area; then half (or less) of the radiated energy is directed at the 2 foot square, 1/2" thick Al window or Q=175 kcal/min = 44 Btu/min= 2646 Btu/hr

Since the window is thin relative to area and highly conducting, ignore temperature differences across it. On the other side is a 75,000 gal pool of water at a nominal 70F and 26' water head (Tsat=236F). A heat transfer coefficient for vertical convection is given [3]as

$$h = b\,(DT)^{m}\,L^{3m-1} \text{ in BTU/hr ft}^2\text{ F}$$

Since b is 26, m is 1/4 and L is the characteristic length of the heat transfer surface, 2 ft, a temperature difference of 15F is sufficient to remove the radiant heat load by natural convection of the water on the plate. The air in the Gamma Cave would also heat up and provide an additional heat source. This would act in a longer time but be greater in overall magnitude than the radiant component (5.1 $kcal/cm^2 \cdot min$ vs 2

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[1] Marks, Mechanical Engineers' Handbook, McGraw-Hill, 1958, p.472

[2] "Radiation from Pool Flames", Heat Transfer in Flames, Scripta, Washington DC, 1974, pp. 413 ff.

[3] Perry, Chemical Engineers' Handbook, Section 10.

kcal/cm^2 min). Taking the mass of air in the cave and ignoring formation of H_2O and CO_2,

delta Q = 89250 kcal and c_v = 0.3039 kcal/gm C with 14.7 kg air in the cave, the final air temperature rise in the cave is 15 C or 28 F.
For conservatism, take a heat flux comparable to the radiant flux directed to the aluminum plate "window". Then Q_{in} = 5292 Btu/hr and delta T = $(60.5)^{5/4}$ = 27 F,

The temperature is still well below the ONB, so convective cooling is sufficient to cool the plate.

If the situation got to the boiling point, the ONB heat transfer coefficient for the UMLRR [4] is

h = 250 Btu/hr ft^2 F; thus delta T at boiling would only be 2.65 F

so heat removal by boiling onset would occur at the pool-window and, since the fluid-to-vapor enthalpy change of water under these conditions is 970 Btu/lb, only a few pounds of water would boil to keep the plate temperature well below 300 F.

As a second check, use the correlation described in Glasstone and Sesonske[5], For free convection with a vertical surface, obtain the Grasshof and Prandtl numbers for the water conditions of 80F and a 2 ft square plate to be:

Gr = 27.76E9 and Pr = 4.403 and use in the correlation Nu = $0.55(Gr\ Pr)^{0.25}$ = 325.2

and since Nu = hx/k, h = 61.3 BTU/hr ft^2 F, a slightly larger value than that used earlier

Thus, for a fire involving the amount of a volatile fuel of the quantity which would consume all ofthe oxygen in the Gamma Cave if quickly combusted, the rate of burning dictated by physics of combustion results in a temperature rise in the aluminum pool liner window of 15-30 F, since the pool side of the window is immersed in a 75,000 gal water pool. The stainless-steel encapsulated sources are separated from the window by a 3/4" water space and would be heated a few degrees only by the convective water movement about them. A fire in the Gamma Cave has little impact on the cave itself since it is a concrete and steel structure and only a small effect on the Cobalt-60 sources immersed in the 75,000 gallon pool of water and separated from the fire by a 1/2-inch thick aluminum plate..

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[4] Updated Final Safety Analysis Report for University of Lowell Reactor, 1985, Section 9

[5] Nuclear Reactor Engineering, Glasstone and Sesonske, Van Nostrand, 1962, pp 378-379