DECOMMISSIONING PLAN FOR THE UNIVERSITY OF VIRGINIA 100 W CAVALIER REACTOR

AND

APPLICATION FOR THE TERMINATION OF THE CAVALIER OPERATING LICENSE

NRC LICENSE No. R-123
DOCKET 50-396

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REACTOR FACILITY
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INTRODUCTION

The CAVALIER (Cooperatively Assembled Virginia Low Intensity Educational Reactor) first went into operation in October 1974, under facility license R-123, at a licensed power of 100 watts. The CAVALIER reactor has been used for reactor operator training and in the teaching of nuclear laboratory classes and undergraduate laboratory experiments, such as prediction of critical rod heights, rod calibrations and approach to critical. The operating license was renewed in May 1985, for a period of 20 years. The considerable expense of maintaining licensed operators, the ever increasing regulatory compliance load, the reduced nuclear engineering undergraduate enrollment, and finally the NRC Order to Convert to Low Enriched Uranium, convinced the facility managers to permanently cease CAVALIER operations in January of 1988.

The University of Virginia operates a second nuclear research reactor within the same building that houses the CAVALIER. It is expected that this 2 MW reactor, the UVAR, will remain in operation under License R-66 (Docket No. 50-62). The operating license for the UVAR extends until September 30, 2002 and it will likely be converted to LEU late in 1990. Since both reactors are located in the Reactor Facility building, the entire Reactor Facility is and will remain a restricted access area even after the CAVALIER has been decommissioned. Also, since the Broad By-Product Materials License for the Reactor Facility and the UVAR reactor will be maintained, an Environmental Report (EA) will not be filed with the decommissioning plan for the CAVALIER.

In 1988, the University of Virginia submitted a dismantling plan and a request to the NRC for a possession-only license for the CAVALIER. The present application amends and supersedes the reactor dismantling plan in its entirety, and also vacates the previous possession-only license requests. A termination of license application has been added (please see cover letter). The plan is being submitted to the NRC pursuant to the recently revised Section 50.82 of Title 10 of the Code of Federal Regulations and the final rule on "General Requirements for Decommissioning Nuclear Facilities", published in the Federal Register, Vol. 53, No. 123, Monday, June 27, 1988.

Since the CAVALIER permanently ceased operations before the decommissioning rule went into effect, a CAVALIER decommissioning plan would have been required only after the University of Virginia decided to terminate the license. However, that decision has been taken and so the plan is being submitted within the rule's two years following permanent shutdown time limit. Also, since the CAVALIER license expiration date is May 17, 2005, the submittal is in compliance with the rule's "no later than one year before license expiration date submittal" requirement.

The format for the plan has been taken from "Standard Format and Content for Decommissioning Plans for Nuclear Reactors", Draft Regulatory Guide, USNRC, September 1989. This guide was developed primarily for power reactors, but the NRC suggests that it should also be used by nonpower reactors except where it is clearly not applicable.

The CAVALIER Decommissioning Plan provides guidance for the dismantling and decommissioning of the University's 100 W CAVALIER reactor. The plan, when approved by the NRC, will be executed in a manner resulting in minimal impact on public and occupational health and safety, and on the environment.

LIST OF FIGURES AND TABLES

1. SUMMARY OF PLAN

The CAVALIER reactor decommissioning plan describes the actions that the licensee proposes to take to dismantle and dispose of the major CAVALIER reactor components. Also described are the financial and technical resources at its disposal to successfully and safely complete the proposed plan. The management of the Reactor Facility believes that the decommissioning of the CAVALIER can be accomplished by its regular full-time reactor staff in a safe, orderly, and expeditious manner, and in conformity with existing federal regulatory and its own procedural requirements. The decommissioning actions to be taken in accordance with this plan, upon NRC approval, are also believed to pose no unreasonable threat to the security, health and safety of the public.

The purpose of the dismantling plan is to provide a general description of the process or methods by which the CAVALIER reactor will be safely defuelled, its console deconfigured, the component parts either re-used, stored or disposed of, the fuel transferred to the UVAR reactor, and the CAVALIER pit and cage decontaminated. In addition, the plan also contains description of the alternative decommissioning options not chosen; the controls and limits on procedures and equipment to protect occupational and public health and safety; a description of the planned final radiation survey; quality assurance and safeguards provisions, as appropriate; and a statement assuring the availability of funds for decommissioning.

While the new decommissioning rule clearly does not apply to the disposal of nonradioactive structures and materials beyond those necessary to terminate the NRC license, for clarity mention may be made in the plan of the probable disposition of some non-radioactive materials or components.

Following the CAVALIER decommissioning and termination of its operating license, the University of Virginia understands that authorization for possession of special nuclear material (10 CFR Part 70, "Special Nuclear Material"), byproduct material (10 CFR Part 30, "Rules for General Applicability to Licensing of Byproduct Material"), and source material (10 CFR Part 40, "Licensing of Source Material") under the CAVALIER license will not be retained. However, such authorization will be retained under the UVAR license.

It is emphasized that the CAVALIER facility "site" (defined as the CAVALIER's reactor pit, tank and cage area only, please see Figure 1) will not be converted to an unrestricted area following CAVALIER license termination, from both the physical security and radiological points-of-view. This is neither necessary nor desirable, given that the UVAR and CAVALIER are both located within the same building (named the Reactor Facility). Since the removal of radioactive materials to reduce radiation and contamination levels to permit unrestricted use of the CAVALIER site is mandatory for a full license termination, the licensee will take the necessary steps to meet this requirement, in the CAVALIER reactor pit, tank and cage, on a one time basis. Therefore, upon successful completion of the CAVALIER dismantling operations, a terminal contamination and radiation survey will be performed to document the release levels of the CAVALIER "site" for the purpose of CAVALIER license termination only.

It is anticipated that the present CAVALIER pit and cage could be used after decommissioning for experiments involving radioactive materials, and that the low levels to be verified in the terminal survey will not necessarily be maintained indefinitely.

The licensee does not expect to change this plan once it has been approved by the NRC, because it is general and not extremely detailed. It has been formulated to accommodate some change through implementing procedures and methods which do not require NRC approval. However, even the most perfect plan may need alteration in light of new facts. Changes to this plan which constitute unreviewed safety questions as defined in 10 CFR 50.59 will be made only with the specific approval of the NRC Division of Reactor Licensing. Changes which do not constitute unreviewed safety questions as defined in 10 CFR 50.59 may be made if the proposed changes are reviewed and approved by the Reactor Safety Committee. Minor changes which do not change the original intent of this plan may be made with the approval of the Reactor Director, who will describe these minor changes in a follow-up information memoranda to the Reactor Safety Committee.

Plan View of CAVALIER Room and Pit

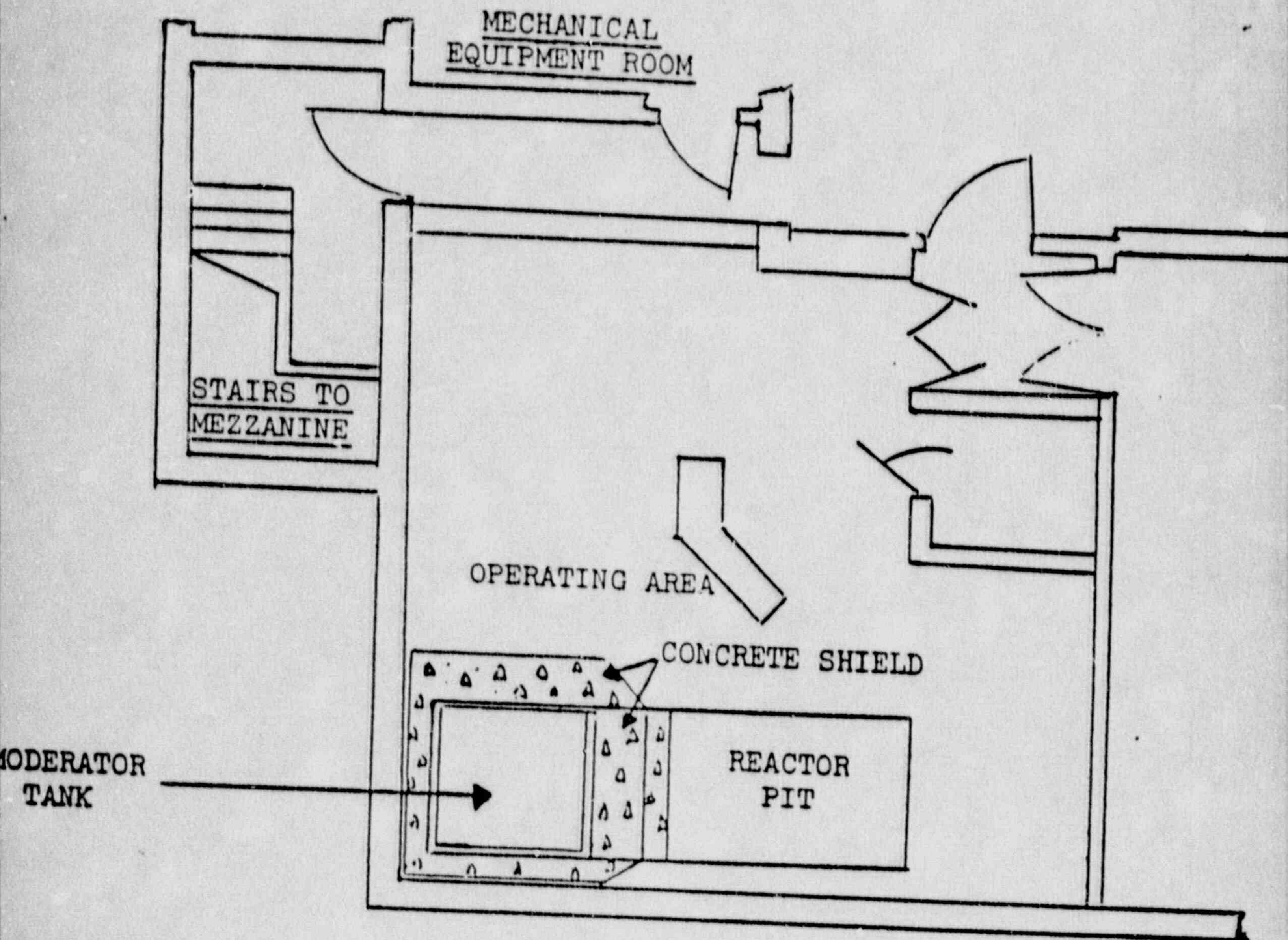


Figure 1

2. CHOICE OF DECOMMISSIONING ALTERNATIVE AND DESCRIPTION OF ACTIVITIES INVOLVED

2.1 Decommissioning Alternatives

The three decommissioning alternatives acceptable to the NRC are called DECON, SAFSTORE and ENTOMB.

DECON is the alternative in which the equipment, structures, and portions of a facility and site containing radioactive contaminants are removed or decontaminated to a level that permits the property to be released to unrestricted use shortly after cessation of operations.

SAFSTORE is the alternative in which a nuclear facility is placed and maintained in a condition which allows the facility to be safely stored and subsequently decontaminated to levels that permit release for unrestricted use.

ENTOMB is the alternative for decommissioning in which radioactive contamination is encased in structurally long-lived material, such as concrete. The entombed structure is appropriately maintained and continued surveillance is carried out until the radioactivity decays to a level permitting unrestricted released of the property.

Generally, the NRC appears to favor the DECON option, under which site release is most quickly accomplished. Another option may be chosen by the licensee, however only if it better serves to protect the health and safety of the public, when taking into account site-specific characteristics and on a case-by-case basis. Factors not related to protection of health and safety are not included in the consideration of the decommissioning alternatives. For example, alternatives which significantly delay the completion of decommissioning, such as the use of a storage period for radioactive decay, will be acceptable only if sufficient benefit results. Since the dismantling of the CAVALIER can be accomplished immediately without affecting the safety of the adjacent reactor, and there is no lack of waste disposal capacity, University of Virginia is submitting a decommissioning plan under the DECON option.

The following regulations (Code of Federal Regulations, CFR) or guidance, in total or in part, have been identified as possibly pertaining to the dismantling of a non-power reactor such as the CAVALIER:

Title 10 of CFR	Subpart and Section
Part 2	Subpart A 2.100 (a)(1); Subpart B 2.204; Subpart G 2.701, 2.708);
Part 20	20.101, 20.103, 20.105, 20.301-311,
Part 40	40.44;
Part 50	50.82, 50.4(b)(1), 50.33, 50.34, 50.36, 50.54, 50.56, 50.59, 50.64, 50.90, 50.91(a), 50.92;
Part 51	51.20(b)(5), 51.23;
Part 70	70.24, 70.34, 70.42, 70.54,
Part 72	72.18, 72.38, 72.39, 72.51, 72.52, 72.54;
Part 73	73.60;
Part 170	

* 49 CFR, Parts 173 through 178.
* Also NRC Generic Letter No. 84-18 from Darrell Eisenhut, dated July 6, 1984.
* Additionally, "Guidance and Discussion of Requirements for Application to Terminate a Non-Power Reactor Facility Operating License", Rev.1, Sept. 15, 1984 by Div. of Licensing, NRC.

The ANSI/ANS-15.10-1981 guide on the decommissioning of research reactors, and ANSI N13.12, have also been consulted for the formulation of this decommissioning plan.

2.2 Decommissioning Activities, Tasks, and Schedule

The area located within the confines of the CAVALIER cage will constitute the CAVALIER "site" for purposes of decommissioning. The wire screen cage surrounding the tank is not contaminated and will likely remain in place. There are physical security alarms installed at or within the cage which could be deactivated once the operating license has been terminated. As there is a strong possibility that the CAVALIER tank will be left in place in the present CAVALIER pit area for possible use in other radiation experiments, energetic efforts will be made to decontaminate the tank, by chemical and/or other means.

The fuel storage room should remain as it is at present. The barriers to entry into this room and into the CAVALIER room should remain in place after the CAVALIER dismantling. These barriers, with their penetration alarms, are described in the physical security plan for the Reactor Facility. This plan was updated by the reactor staff and the changes reviewed and approved by the Reactor Safety Committee, to take into account the planned effect of a CAVALIER decommissioning.

Also left in place, in a corner of the CAVALIER room not part of the CAVALIER site, is the natural uranium subcritical assembly.

Dismantling activities will be performed during normal single 8-hour shifts, 5 days per week. A total staff effort of about 2 man-years is estimated for the completion of the decommissioning plan. The activities do not involve major construction or demolition aspects. The disposal of systems normally associated with larger research reactors, such as activated/contaminated beam tubes, rabbit systems, thermal column, primary system piping, resin demineralizer system, heat exchanger system, radwaste storage room &/or tank, cooling tower, graphite reflector elements, emergency discharge basin, hot cells and laboratory hoods, will not be necessary in the CAVALIER decommissioning, because they do not exist. Explosive techniques, or remote cutting apparatus will not be needed.

The required essential support systems and services for the CAVALIER dismantling such as power, heat, water, communications, safety, security, etc... will be maintained by virtue of the continuation of operations of the UVAR reactor in the Reactor Facility.

Written and approved procedures, including checklists when appropriate, have been or shall be in effect and followed for the following dismantling operations:

a) Removal of fuel elements and control rods from CAVALIER core. (using RSC approved CAV SOP 5.4 "Procedure for Unloading Core".)
b) Emergency conditions involving releases of radioactivity. (Such conditions are addressed by the Reactor Facility's NRC approved Emergency Plan and Implementing Procedures.)
c) Security controls. (The provisions in the NRC approved Security Plan shall be in effect and followed. The CAVALIER reactor room will be kept locked and the intrusion alarms activated as required.)
d) HP Controls. (Visitors will not be admitted to the CAVALIER control room when radiation and contamination exposures are considered to be likely. Reactor equipment will be removed from the CAVALIER room upon HP clearance. Staff will wear appropriate dosimetry when working and will observe the HP instructions for meeting frisking requirements.)
e) Removal of rod drives and core support structure.
f) CAVALIER tank draining and decontamination.

Substantive changes to procedures are made only with the approval of the Reactor Safety Committee. However, the reactor director may approve temporary deviations from procedures, with the proviso that their original intent is not changed. Such deviations shall be documented and subsequently reviewed by the RSC.

The radiation surveys required by the UVAR SOP's for the entire Reactor Facility will continue to be made prior to, during and following the CAVALIER dismantling. As stated in UVAR SOP 10.4.C: "Surveys shall be taken by the Reactor Health Physicist or his designee at predetermined locations outside the Facility to insure that radiation and/or contamination levels are monitored. Samples of air and water shall be collected and analyzed on a monthly basis. Radiation level surveys around the outside of the building shall be performed on a weekly basis."

The environmental monitoring program conducted at the Reactor Facility consists of the following:

a) Monthly Environmental Air Samples, taken at:
   1) The Reactor Facility rooftop.
   2) The Barrack's Road Shopping Center.
   3) University of Virginia's water filtration plant.

b) Monthly Water Samples, taken at:
   1) University of Virginia's water filtration plant.
   2) Creek adjacent to Barrack's Road Shopping Center, at two points downstream from the Reactor Facility liquid discharge point.
   3) Creek feeding the Reactor Facility pond, upstream from point of liquid discharge.

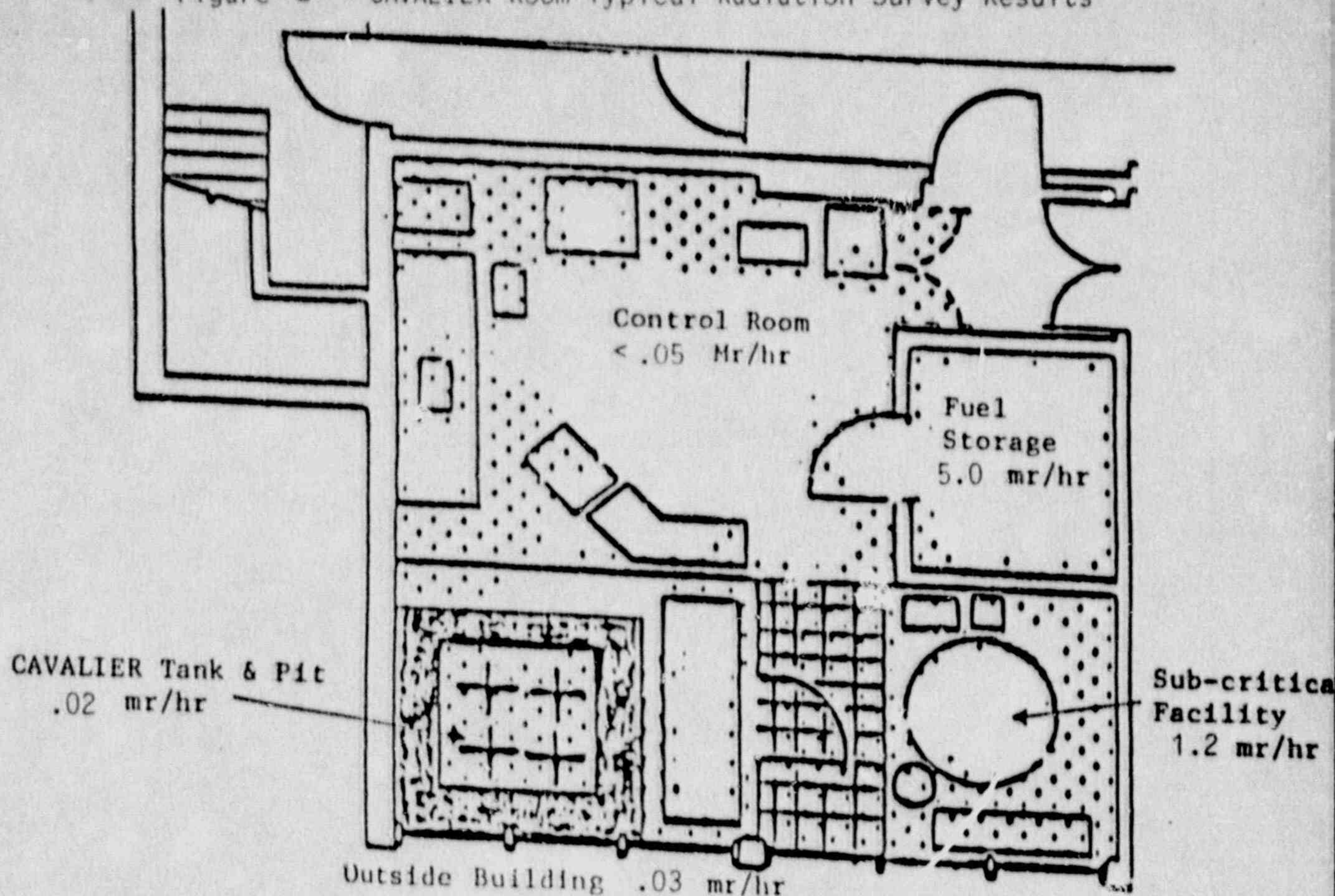
c) Quarterly Integrated TLD Environmental Gamma Measurements, at seven locations surrounding the Reactor Facility site.

Before the disassembly of non-fuel reactor components, a thorough radiation survey will be performed to determine the status of the CAVALIER pit and its immediate surroundings. This information may be used in estimating the radioactive waste inventory and in planning detailed activities of the dismantling program. This will also permit the estimation of occupational radiation dose during dismantling and the waste disposal requirements (see Figure 2, which depicts a survey taken in the CAVALIER room).

Substantial releases of radioactivity to the environment as a result of the CAVALIER dismantling are not expected. CAVALIER tank water, in the amount of 2450 gallons and at a concentration of 2.1(-08) uCi/ml, was released to the Reactor Facility's pond, as per procedures, on December 15, 1988. Removal of material from the CAVALIER tank will be done in a manner which prevents contamination of the work area and the Reactor Facility. Radwaste material will be properly disposed of, to avoid the creation of unposted radiation areas. Daily and other normal programmed facility radiation surveys will be performed to avoid such situations.

According to the new decommissioning rule, decommissioning activities do not include the removal and disposal of spent fuel because these are operational activities already covered by license and approved procedures. In fact, CAVALIER fuel elements have already been removed from the reactor core as per CAV SOP 5.4 "Procedure for Unloading Core".

Figure 2 CAVALIER Room Typical Radiation Survey Results



Instrument: BICRON (Micro-Analyst) Date Surveyed: June 19, 1989

A survey of the CAVALIER reactor tank was taken on June 13, 1989 to determine both dose rates and contamination levels. The results of this survey are as follows:

Highest dose rate found: 0.05 mR/hr on top of grid plate

Swipes (approximately 100 cm^2 each, net after background subtraction)
Each swipe was counted for 15 minutes and the two σ errors range from 20 to 40 percent.

#	Location	DPM / 100 cm^2
1	grid plate	17
2	grid plate	30
3	detector	12
4	wire mesh	0
5	tank wall	3
6	tank wall	4
7	tank floor	5
8	source tube	11
9	outside BF_3 tubes	32
10	tank drain	3

The CAVALIER HEU fuel elements are of the materials testing reactor type (MTR), consisting of 18 curved fuel plates containing nominally 195 grams of U-235 per standard element (Figure 3). The flat-plate elements are no longer used in the CAVALIER and were transferred to the UVAR in 1984 and after significant burnup had been achieved, they were shipped off-site as spent fuel. In the present curved-plate control elements, there are 9 fuel plates containing nominally 98 grams of U-235 per element. Partially loaded elements with some of the fuel plates removed and substituted with aluminum plates are also used. Finally, there is in use an "experimental" element from which individual fuel plates can be removed or inserted to provide shimming.

The CAVALIER HEU core, consisting of 16 CAVALIER fuel elements, comprising 2639 grams of U-235, have already been unloaded and transferred to the UVAR license R-66 (Figure 4). They will be used in that reactor until it is finally converted to LEU fuel, tentatively expected for late 1990. At that time, the former CAVALIER fuel elements will be shipped off-site. Those elements not yet in use in the UVAR are being stored in the Reactor Facility's fuel storage room. The fuel is considered to be "irradiated fuel", from the standpoint of having been in an operating reactor.

Radiologically speaking, there is very little difference between CAVALIER fuel and "fresh" fuel (which self irradiates!). Some of the curved plate elements from the CAVALIER were surveyed on 7-11-86 and it was determined that the highest dose rate from a typical element at one foot was about 2 mR/hr.

Disposal of spent fuel will, as always, be accomplished in accordance with the applicable NRC and DOT regulations. Also, because the fuel is owned by DOE, DOE will decide on its destination and disposition and pay for the transport. No graphite or other reflector elements were used in the CAVALIER core.

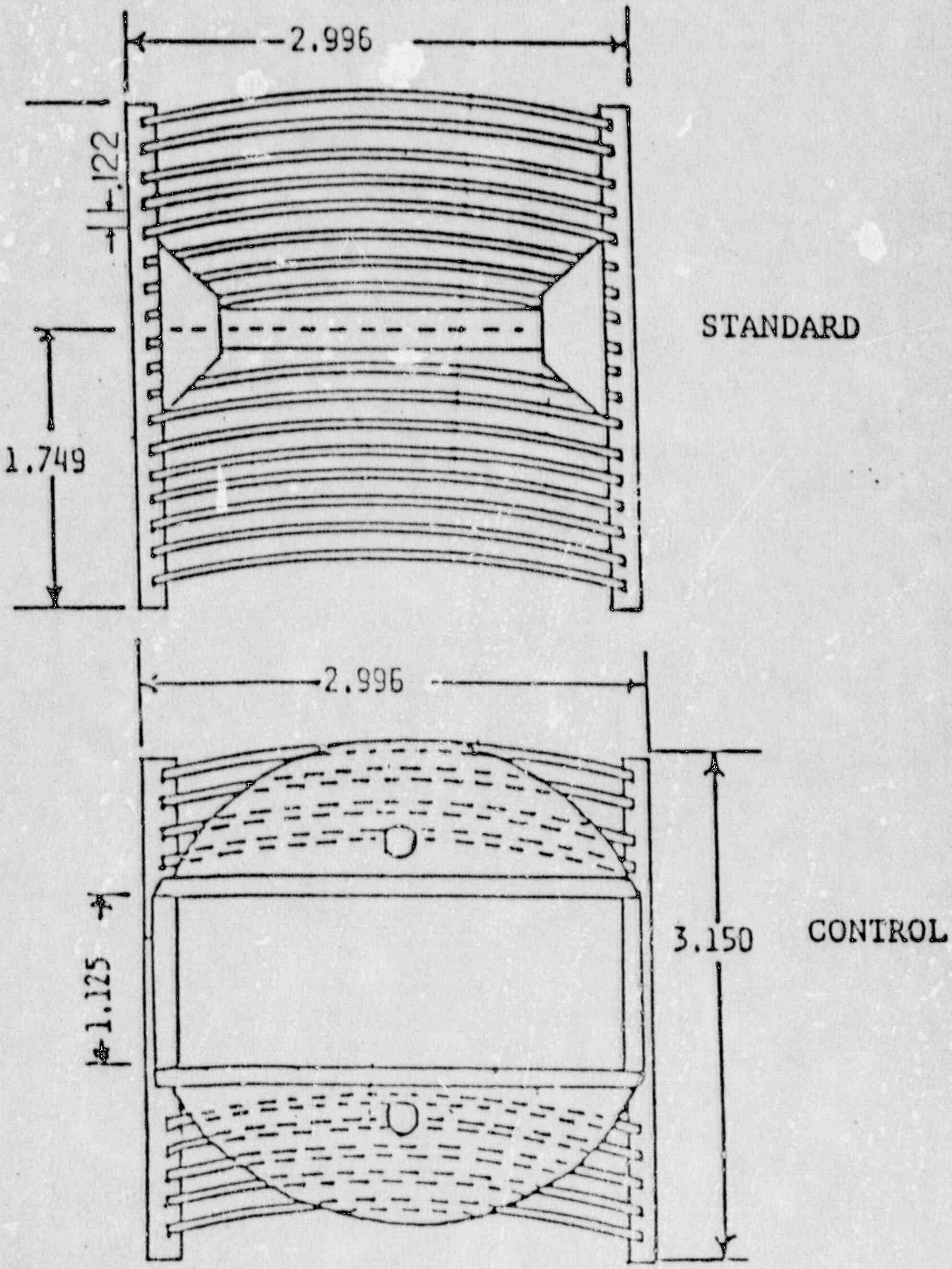
The CAVALIER's neutron source is a 1 Curie Pu-Be source. It will remain at the Reactor Facility under the University's By-product Materials License #45-0003426, and when not in use it will be stored in the source storage room.

The following reactor measuring channels are associated with the CAVALIER console:

a) Start-up Count Rate (2 BF_3 detectors)
b) Linear Power (Gamma-Ion Chamber)
c) Log N and Period (CIC)

Figure 3

FUEL ELEMENTS



CAVAL[illegible] REACTOR LOADING CHART

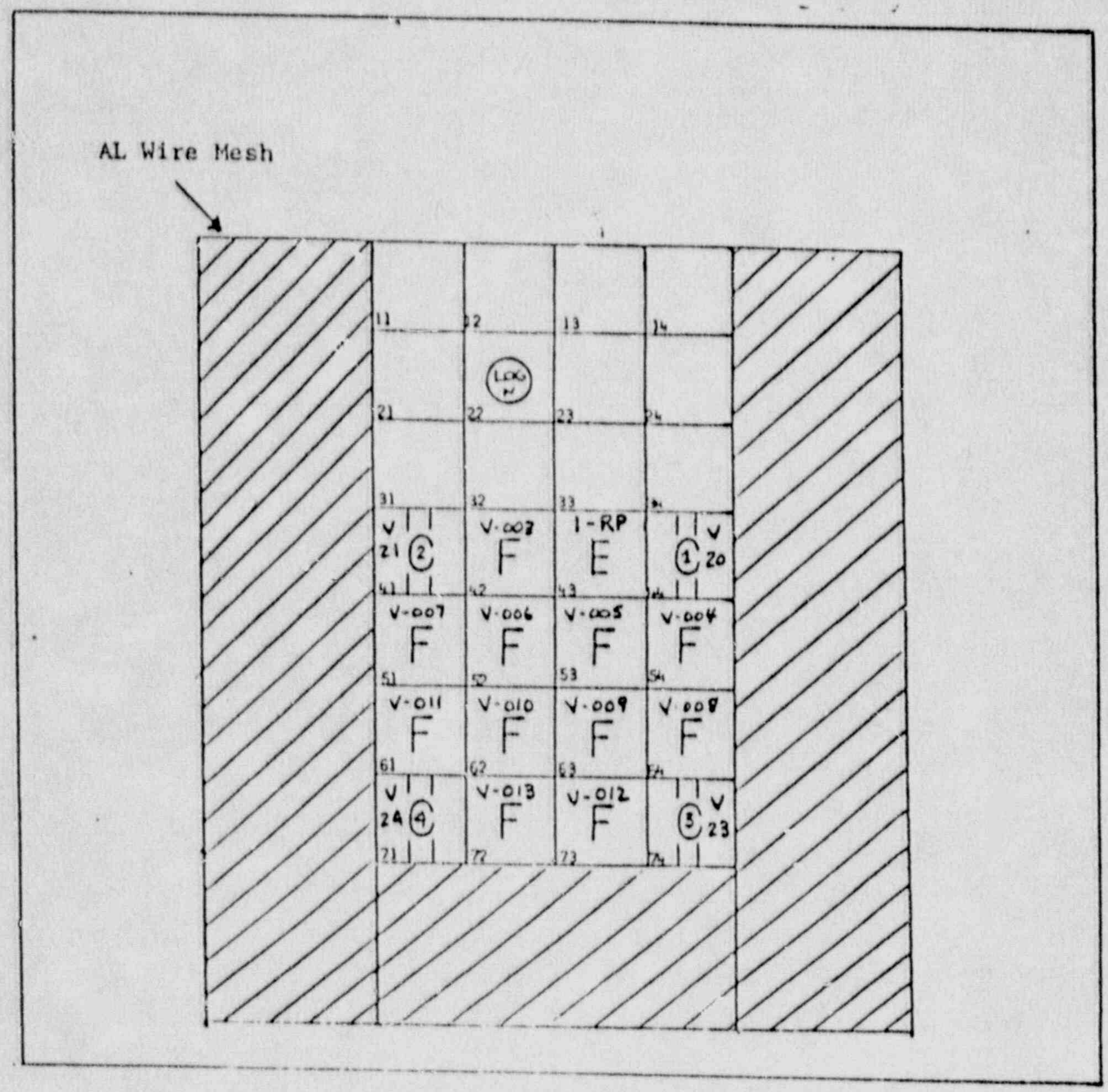
Loading No. CAV-6   Date April 2, 1985

Total Mass 2639 gram U-235

F - Normal Fuel Element
P - Partial Fuel Element
C - Control Rod Fuel Element
E - Removable Plate Fuel Element

Excess Reactivity 1.01% Δk/k

Shutdown Margin 1.47% Δk/k
Rod #4 Withdrawn



FUEL ELEMENT 1-RP HAS ONLY 10 FUEL PLATES

→ N

Figure 4 Typical CAVALIER Core Configuration

According to the decommissioning rule, decommissioning activities do not include the removal and disposal of nonradioactive structures and materials beyond that necessary to terminate the NRC license. However, the console components will be checked for contamination and the majority of these may go into storage or be used elsewhere at the Reactor Facility. If not needed, these components may also be properly disposed of as waste. Radioactive components may be kept under the UVAR R-66 license until disposed of as radioactive waste.

The former criticality monitoring system for the Reactor Facility's Fuel Storage Room was powered from the CAVALIER reactor console. To permit the de-energizing and dismantling of the console, a new independent criticality monitoring system was installed in parallel to the present system. Following an operational testing period and Reactor Safety Committee approval, the new system replaced the former system. This action clears the way for a complete disassembly and removal of the CAVALIER console.

The CAVALIER's aluminum grid plate was last surveyed on 6-19-89 and the dose rate on contact was found to be less than 1 mR/hr (Figure 2). The dimensions of the base plate are 36 in. by 36 in. by 1 in., and of the two center plates (with twenty-eight 3 in. holes) are 25 in. by 25 in. by 0.5 in., with a combined weight of about 150 lbs. Underwater cutting of core support structures is not anticipated. Bolted rather than welded construction techniques were used in assembling these structures. The CAVALIER grid plate and core support structures will be kept either in the UVAR pool, the source storage room or the hot cell, at the discretion of the licensee. Eventually they will be used or disposed of in an appropriate manner.

The four CAVALIER control rods are made from boron-stainless steel with an aluminum jacket and are the most radioactive components of the reactor. The dose rates measured on 5-4-84 were as follows:

ROD	CONTACT READING (mR/Hr)
1	200
2	350
3	400
4	1

It should be noted that the high values obtained for three of these rods is due to their use at one time in the UVAR, before their transfer to the CAVALIER.

The control rods were transferred to the Reactor Facility's source storage room following the final defuelling of that reactor. However, storage location and future use will be at the discretion of the licensee. Good HP practices will be observed in this undertaking. Use of one or more of these rods in the UVAR core at some future date is not precluded.

The aluminum tank in which the CAVALIER core sat measures 67 in. by 67 in. and is 11 feet deep, with a minimum thickness of 0.25 inches. Its total weight is about 1950 lbs. The tank volume is 2970 gallons, and it has been normally filled with 2900 gallons of reactor grade water. The tank was emptied following the removal of the CAVALIER fuel and rods as per SOP's. Decontamination of the tank walls will be accomplished by washing and wiping. If necessary, spray painting may be considered as a means of fixing contamination in place. The decontamination method to be ultimately used will be at the discretion of the licensee.

The CAVALIER tank will most likely remain in place following decommissioning, and may prove useful for other experimental uses involving radiation sources. However, the licensee reserves the option of later removing, disassembling and disposing of the tank under the UVAR license requirements.

The automatic reactivity insertion system (ARIS) tank held a solution of boric acid. This corrosive solution was discarded after CAVALIER defuelling. The ARIS tank is neither contaminated or activated and will be left in place or removed at the discretion of licensee.

The Reactor Facility's liquid waste tanks will remain in service for the UVAR. Liquid wastes from CAVALIER decommissioning can be placed in these waste tanks and disposed of as per UVAR SOP's.

The nature of operation of the CAVALIER was such that the likelihood of significant contamination or activation is extremely low. The CAVALIER was operated at powers below 100 W on an infrequent basis. A distance of about 2 feet separated the core and the tank wall. This distance will have served to prevent major activation of the tank and concrete biological shield. The reactor fuel has existed in a sealed form, and no fuel leaks were ever detected. The fuel did not receive sufficient exposure to accumulate a significant fission product inventory.

The long-lived radionuclides generally considered the most probable sources of contamination at research reactor facilities are Co-60, Ni-59, Zn-65 and Nb-94. They originate from the activation of reactor structural materials. Dose rates are largely determined by the amount and decay of Co-60. Assuming no decontamination, Co-60 decays to 10% of the shutdown value in about 17.5 years, and to 1% after 35 years. It should be noted however that the UVAR and CAVALIER reactor components contain aluminum 6061-T6 and 1100, not steel. This leads to short-lived Na-24 and Al-28 activation products and very small amounts of Zn-65.

The following components and hardware associated with the CAVALIER may be slightly contaminated:

a) Water pump and demineralizer system
b) Water drain lines
c) Concrete shield blocks
d) Tank water level indicator
e) Radiation detectors and chambers
f) Rod drive assemblies

Salvageable equipment and miscellaneous items from the CAVALIER "site" may be relocated to other onsite areas, or left in place as part of new experiments. All items from the site will be checked for contamination and carefully bagged before storage, if necessary. Decontamination will be attempted on items which are salvageable, while other items will be properly disposed of as LSA solid radwaste.

The decontamination requirements to be met are given in Regulatory Guide 1.86, Table 1 (see our Table 1). The methods chosen for decontamination shall be appropriate for the type of surface to be cleaned and the type of contamination present. It is anticipated that washing, scrubbing, or light abrasion of surfaces will be sufficient. Economic value will be a major consideration in initiating decontamination attempts.

On the basis of the past radiation health physics surveys of the CAVALIER room, there is good indication that radiation and contamination hazards in that room have been and are very low. The area that could be expected to be slightly contaminated is the area in the immediate vicinity of the CAVALIER tank within the confines of the CAVALIER cage. After removal of the reactor components and completion of the decontamination, it is expected that the radiation and contamination criteria presented in Section 2.0 of this plan can be met (Table 2).

Table 1 Release Criteria
(Reg. Guide 1.86)

ACCEPTABLE SURFACE CONTAMINATION LEVELS

NUCLIDE[a]	AVERAGE[b c]	MAXIMUM[b d]	REMOVABLE[b e]
U-nat, U-235, U-238, and associated decay products	5,000 dpm α/100 cm^2	15,000 dpm α/100 cm^2	1,000 dpm α/100 cm^2
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100 dpm/100 cm^2	300 dpm/100 cm^2	20 dpm/100 cm^2
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1000 dpm/100 cm^2	3000 dpm/100 cm^2	200 dpm/100 cm^2
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.	5000 dpm β-γ/100 cm^2	15,000 dpm β-γ/100 cm^2	1000 dpm β-γ/100 cm^2

[a] Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides should apply independently.

[b] As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[c] Measurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each such object.

[d] The maximum contamination level applies to an area of not more than 100 cm^2.

[e] The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.

Table 2 Acceptable Residual Contamination Levels

Summary of Calculated Example Acceptable Residual Radioactive Contamination Levels for the Reference Research and Test Reactors

	Time Exposure Begins (Years After Shutdown)[a]	Limiting Organ	Acceptable Residual Contamination Levels Corresponding to an Annual Dose of 10 mrem/yr: Surface Contamination ($\mu Ci/m^2$)	Soil Contamination: Mixed to 10 mm (pCi/g)	Soil Contamination: Mixed to 0.15 m (pCi/g)
Research Reactor Facility[b]	0	Total Body	0.066	--	--
	100	Lung	0.074	--	--
Research Reactor Site[c]	No reactor-produced site contamination is anticipated (see Section E.1.2.3 of Appendix E).				
Test Reactor Facility[b]	0	Bone	0.18	--	--
	100	Bone	0.22	--	--
Test Reactor Site	0	Bone	0.21	14	0.93
	100	Bone	0.11	7.4	0.49

(a) The time that continuous exposure begins.
(b) In the facility, a determination of acceptable surface contamination levels, based on the mixture of radionuclides, is assumed to be used to help determine the necessary decommissioning procedures.
(c) In any case, to do the final site certification survey before the license termination is approved, a confirmation of site-specific residual radioactive contamination levels would be required based on current acceptable measurement techniques, including the necessary documentation verifying the survey results.

Example Acceptable Residual Radioactive Contamination Levels Inside the Reference Research Reactor[a]

Time Exposure Begins (Years After Shutdown)[b]	Limiting Organ of Reference	Dominant Radionuclide Contributor To Dose	Acceptable Residual Contamination Levels ($\mu Ci/m^2$)
0	Total Body	^{60}Co	0.066
10	Lung	^{60}Co	0.041
30	Lung	^{60}Co	0.040
50	Lung	^{60}Co	0.052
100	Lung	^{60}Co	0.074

(a) Corresponding to an annual dose of 10 mrem/yr.
(b) The time that continuous exposure begins.

The terminal HP survey gamma radiation level survey, to be reported to the NRC in appropriate units, will be performed within the CAVALIER cage with a calibrated low-level reading instrument held at appropriate location at one meter above floor level. Within the CAVALIER tank and pit and in the immediate vicinity where the CAVALIER core was located, the instrument will be held at 1 centimeter from surfaces. The ceiling within the CAVALIER cage will also be surveyed. In general, the survey instrumentation to be used will have sufficient range, accuracy and sensitivity to determine that compliance with the criteria referenced in this plan and the Facility's SOP's are met. A release criterion of 10 uR/hr above natural background when measured at one meter from a surface will apply. Natural background levels will be established at on-site locations that have not been exposed to a neutron flux or contamination.

Contamination surveys will be performed on CAVALIER equipment removed from the CAVALIER room during the dismantling phase. The terminal contamination survey will cover the object left in place, for example, the interior of remaining CAVALIER tank piping, the tank and pit walls, and selected locations on other surfaces within the CAVALIER cage. The survey will consist of measurements of removable contamination. Small area smears (of approximately 100 cm^2) will be taken with dry filter paper disks, in accordance with standard industry practice, and counting the smear samples in a laboratory (gas proportional) low-background counter, for beta/alpha activity.

The release contamination criteria specified in Regulatory Guide 1.86's, June 1974, Table I will be used. Count rates obtained with the low-background counter will be converted into surface contamination levels for comparison with the limits, using internal HP procedures which call for counter calibration with NBS traceable beta and alpha sources. Smears taken will be identified and analyzed in accordance with HP procedures. Should contamination be found that is fixed and difficult to remove, attempts will be made to identify the nuclides involved by gamma spectroscopy, in our NAA lab supported with several germanium counters.

Radwaste generated during the dismantling will be tracked on the Reactor Facility's By-product Materials License, if justified. Preparation, packaging, storage and disposal of radwaste shall be in compliance with the license. Waste intended for disposal shall be sent to a licensed waste burial facility, in accordance with the applicable provisions of 10 CFR Parts 61 and 71, at a date convenient to the licensee.

The following CAVALIER records and logs shall be prepared and retained at the Reactor Facility until the termination of the NRC License R-123:

a) CAVALIER operational logbooks and documents (SAR, old and new Technical Specifications, old and new SOP's).
b) CAVALIER Decommissioning Plan and eventual QA/QC records associated with execution of the plan.
c) HP radiation surveys of the CAVALIER reactor room.
d) Radiation exposures records for personnel associated with the physical dismantling operations of the CAVALIER.
e) CAVALIER fuel inventory and transfer records.
f) Content and disposition of solid waste containers.
g) CAVALIER facility as-built drawings.
h) Records of inspection of physical barriers (same as Reactor Facility Security Plan inspection records).
i) Abnormal occurrences, such as spills.
j) Reactor Safety Committee meeting minutes

A summary of the CAVALIER decommissioning efforts and results will be documented in the appropriate Annual Report for the Reactor Facility that is sent to the NRC every year. Following this summary, it is not likely that mention of the CAVALIER will need to be made in future annual reports.

A NRC-314 form certifying the disposition of accumulated decommissioning wastes will be completed and submitted to the NRC.

The units for reporting radiation and radioactivity to the NRC shall be as follows:

Beta and/or Gamma radiation:	uRad/hr at 1 cm and 1 meter from surfaces
Radioactivity(alpha, etc.) :	dpm or uCi/100 sq.cm, removable and fixed, on surfaces; uCi/ml for liquids; pCi/g for solids.

The sequence of CAVALIER dismantling program steps and a probable schedule is provided below. The schedule assumes that the plan will be NRC approved by the indicated date. The schedule will slip by the number of months that the NRC approval is delayed. Dismantling operations will be conducted in accordance with the plan, CAVALIER SOP's and the procedures implementing the plan. The schedule is tentative and may have to be modified. However, best efforts will be made to maintain it.

Table 3

PROPOSED CAVALIER DISMANTLING SCHEDULE

```
                                    1990        |1991
                         J F M A M J J A S O N D|J F

NRC Dis. Plan Review         .......
Order to Decommission                .
Procedure Preparation                 ...
Personnel Training                      .
Comprehensive Rad. Survey               .
Defuelling & Transfer (completed)
Control Rod Storage (completed)
Tank-water Drainage (completed)
Core Structure Removal                   ..
Tank Decontamination                      .
General Cleanup                             .
Console Deconfiguration                    .
Final Decontamination                       .
Storage of Items                          .....
HP Normal Surveys      ........................
HP Final Survey                               .
Packaging LSA Wastes                    .    .
Shipment of LSA Waste          N
Shipment of CAV/UVAR Fuel      N
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N = Date not foreseen

2.3 Decommissioning Organization and Responsibilities

The Reactor Facility is an integral part of the School of Engineering and Applied Science of the University of Virginia. The present organizational structure of the Reactor Facility is shown in Figure 5. It is noted that this structure will be slightly changed upon NRC approval of recent UVAR Technical Specification changes requested by the licensee for the conversion to LEU.

The present Chairman of the Department of Nuclear Engineering and Engineering Physics has overall responsibility for management of the Reactor Facility (Level 1). The chairman is a professor in the Department of Nuclear Engineering and Engineering Physics and has a doctorate degree in physics.

The Reactor Facility Director is responsibility for the overall facility operation (Level 2). He has a doctorate degree in nuclear engineering and is an assistant professor in the department. The Director is responsible for overall planning and for providing direction to the reactor supervisors. He is responsible for developing the plan and overall supervision of the decommissioning operations.

Below the Reactor Director (at Level 3) are the Reactor Supervisors (responsible for reactor operation, maintaining facility records & budgets, quality assurance, training, facility security, etc.). They have eleven and twenty-two years of experience at this facility, respectively. Their degrees are in nuclear engineering and physics. During the active phase of the decommissioning they will have day-to-day oversight and will manage the dismantling group. The reactor supervisors shall be responsible for the safe dismantling of the CAVALIER, assuring that operations are conducted in a safe manner, within the limits prescribed by the facility license, federal regulations, the Facility's QA/QC Plan and the requirements of the decommissioning plan. They shall be advised by the reactor director on compliance matters and by the reactor health physicist on radiological requirements.

In the event that problems are encountered with the execution of the decommissioning plan, the reactor supervisors will communicate these to the reactor director. Significant occurrences shall be reported to the Reactor Safety Committee, stating the causes and corrective actions taken or proposed. Reports to the NRC of abnormal occurrences shall be made as defined and prescribed in the CAVALIER SOP's, which will continue to apply until the successful termination of the decommissioning activities.

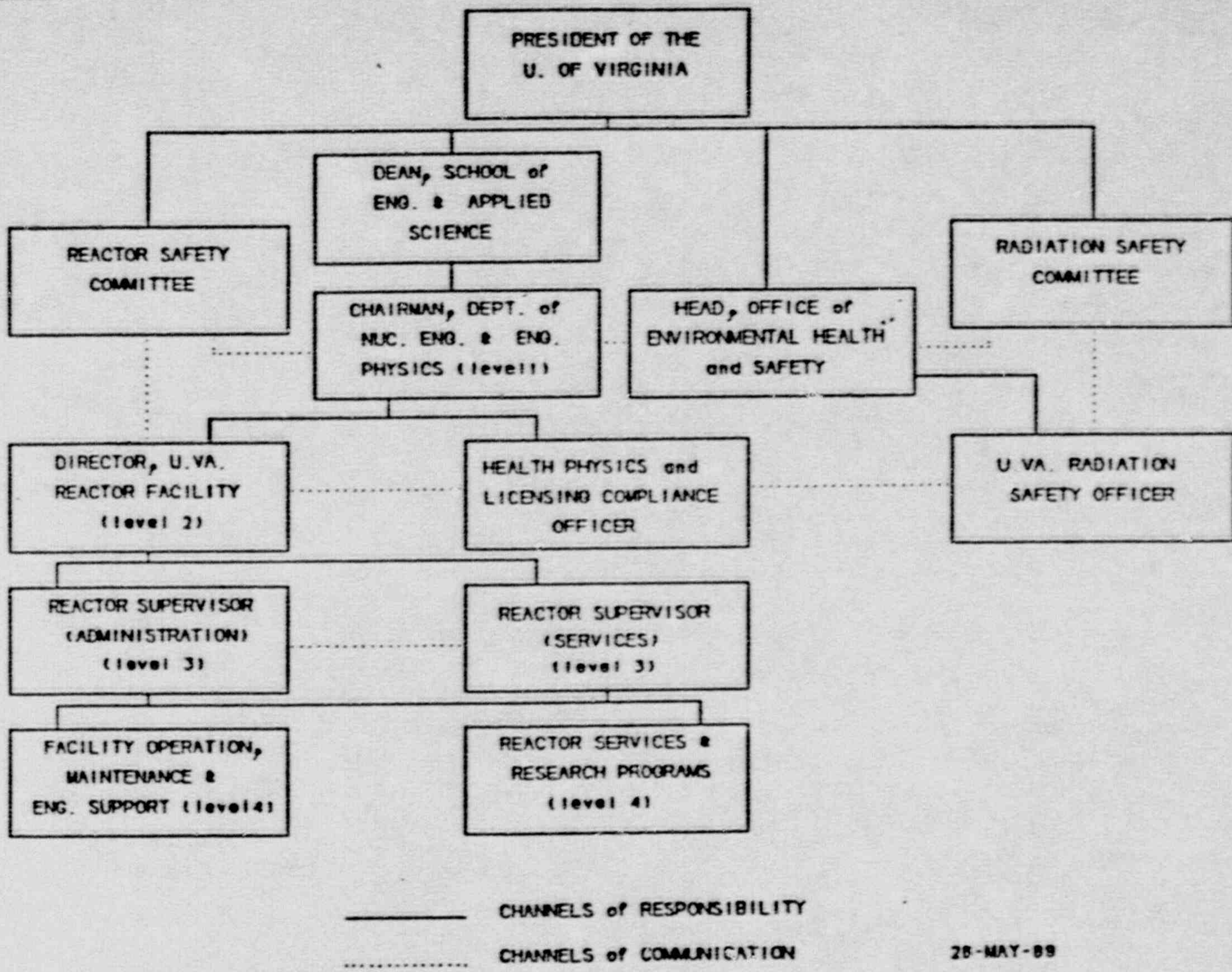

Figure 5 Organizational Structure of U.Va. Reactor Facility

The reactor staff (Levels 4 and 5) is usually composed of NRC licensed senior reactor operators and reactor operators, reactor operator trainees, and electronic and machining technical support staff. Many individuals on staff hold college degrees. Staff members will be responsible for carrying out specific dismantling tasks, in accordance with the NRC approved decommissioning plan, SOP's, licenses, methods and supervisor instructions.

Reactor health physicists (HP's), who are organizationally independent of the Reactor Facility operations group (Levels 2 and higher), are responsible for radiological safety at the Reactor Facility. During the dismantling process, the HP's will provide surveillance in accordance with the Facility procedures, and strive to minimize the radiation exposures incurred, in conformity with the ALARA concept. Other services to be provided by the HP's coverage include: survey meter calibrations, performance of radiological surveys and control-zone posting, personnel dosimetry, protective clothing and respiratory protective device services, facility and equipment decontamination, handling of contaminated injuries, maintenance of radiation exposure records, liquid effluent and gaseous effluent monitoring and control.

The HP responsibilities that are typically applicable to decommissioning activities include:

a) Performing or supervising performance of area radiation, contamination and air surveys by technicians.
b) Administering the respiratory and bio-assay programs.
c) Supervising the shipping and receiving of radioactive material.
d) Supervising personnel, equipment, and facility decontamination and waste disposal.
e) Conducting HP and Radiation Safety training of Reactor Staff.
f) Generation and maintenance of HP required records.
g) Providing for personnel radiation monitoring.

The line organization described above will be responsible for the dismantling of the CAVALIER. Personnel experienced in reactor operations and in radioactive material handling will perform the actual dismantling operation. This group will include the reactor health physicist, reactor supervisors, several senior reactor operators, reactor operators, reactor operator trainees, and technical support staff. The licensee reserves the right to make substitution of members of its staff and to assign these to dismantling activities, notwithstanding the detailed and personal descriptions given above, in case more positions are created, or personnel resignations occur in the future.

Operations review and audit functions are and will be performed by the Reactor Safety Committee (RSC) which is composed of seven members. One of the members of this committee is from outside of the Department of Nuclear Engineering, while another is the University of Virginia's Radiation Safety Officer. To assure that the decommissioning will be accomplished safely, the dismantling plan and eventual implementing procedures will have been reviewed by the RSC.

2.4 Training Program

Personnel performing dismantling tasks shall do so under the direction of the Reactor Supervisors who are licensed Senior Reactor Operators (SRO's). Both supervisors are qualified users of radioactive material, and are authorized to handle radioactive materials without supervision and to direct the handling of radioactive material by personnel designated as restricted users. They are also familiar with standard health physics procedures, use of counters and detectors, facility documents and plans, standard operating procedures and federal regulations.

Personnel assigned to the dismantling crew shall belong to the reactor staff. They will have had training in HP procedures at least to the extent necessary to qualify them as restricted users of radioactive materials. The staff currently trains and the NRC licenses our operators on both the CAVALIER and UVAR reactors. Requalification lectures given by the staff presently cover both CAVALIER and UVAR related topics. With the CAVALIER decommissioned, licensing and requalification on the CAVALIER will be no longer required.

2.5 Contractor Assistance

The decommissioning activities do not involve major construction or demolition aspects. The disposal of systems normally associated with larger research reactors, such as activated/contaminated beam tubes, rabbit systems, thermal column, primary system piping, resin demineralizer system, heat exchanger system, radwaste storage room &/or tank, cooling tower, graphite reflector elements, emergency discharge basin, hot cells and laboratory hoods, will not be necessary in the CAVALIER decommissioning, because they do not exist. Explosive techniques, or remote cutting apparatus will not be needed. Soil decontamination will not need to be performed. Therefore, the decommissioning will be accomplished by the existing in-house reactor staff and outside specialty contractors will not be needed or used. Documentation, dismantlement operations, decontamination work, and surveys can and will be performed by the Reactor Facility staff.

3. PROTECTION OF OCCUPATIONAL AND PUBLIC HEALTH AND SAFETY

3.1 Facility Radiological Status

The Reactor Facility houses both the UVAR and CAVALIER reactors, as well as the Department of Nuclear Engineering, with its offices for faculty, students and staff, as well as laboratories, machine and electrical/electronic shops, and a classroom (Figure 6). The Facility is sited approximately 2000 feet west of the city limits of Charlottesville, in Albermarle County, Virginia, at latitude 38°2' 30'' N, longitude 78°31' W, and at an elevation of 700 feet. To the north, east and south of the site, no closer than 2000 feet, there are city residential districts. Approximately 3/4 mile west over a nearby ridge, there are thinly populated suburban developments (Figure 7). The only highway access to the Facility is by way of Old Reservoir Road. A map of the University of Virginia "Grounds" is included as Figure 8.

The Reactor Facility also lies next to an abandoned reservoir within the ridge between Mt. Jefferson and Lewis Mountain, some two miles from the downtown business district of the City of Charlottesville. The reservoir is formed in a draw which begins at the top of the ridge, collecting water over a watershed area of about 10^5 square feet. The Reactor Facility is on a side of this draw, approximately 50 feet above the water level of the reservoir.

The maximum CAVALIER reactor power level was set in the Technical Specifications at 100 watts, but the actual administrative set-points were set at more conservative values. Over the past 10 years the operation has been at a maximum power of about 60 watts. With a water level above the core of approximately 8 feet, measured dose rates have been obtained at the top of the tank of about 4 mR/hr, and of less than 1 mR/hr in the general control room area.

The CAVALIER was defuelled for the last time on March 8, 1988 and the tank was recently drained. The tank and interior components were checked for signs of corrosion, but none were found. The CAVALIER fuel elements are presently maintained under the UVAR license, and some of these elements are being used in the UVAR core. (Note: Defuelling is a normal operation carried out under approved Standard Operating Procedures (SOP's) and is not an operation dependent on the decommissioning plan.)

Between October 1974 and April 1984, the CAVALIER has been operated for 3347 W-hours on its original flat-plate MTR-type fuel. Since April 1984 it has been operated for 230 W-hours on curved-plate fuel. The flat-plate fuel elements were transferred and used in the UVAR beginning in May 1984. These same elements had nearly reached the end of their usefulness and were shipped in the early fall of 1987 to the Savannah River Plant for reprocessing.

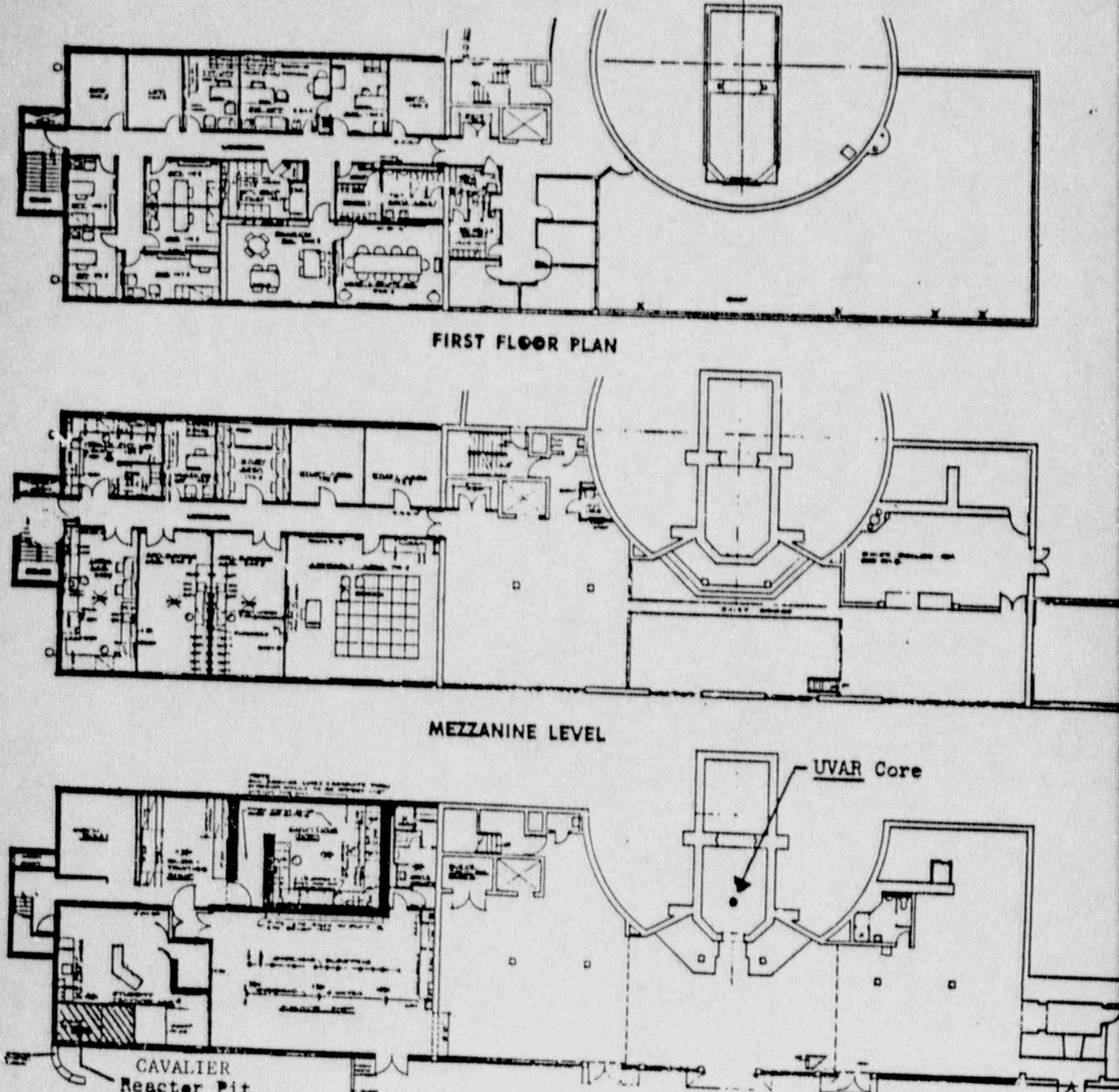

Figure 6 UVA Reactor Facility Building Lay-out.

Figure 7

Aerial View of Reactor Facility Site

Figure 8

UNIVERSITY OF VIRGINIA GROUNDS

The purity of the CAVALIER water was maintained by either a water change (using purified water from the UVAR pool) or by running a small filtration system. Because of this, the integrity of the CAVALIER fuel and other components has been maintained throughout its operating history. No radwaste effluent releases from the CAVALIER to the environment above regulatory limits were ever made. On several occasions, the CAVALIER was defuelled without incident as per CAV SOP's, and the fuel elements temporarily stored in the Reactor Facility's fuel storage room.

During the operation history of the CAVALIER there were no contamination events, i.e., spills, radioactive leaks penetrating concrete or soil, and airborne radioactivity contaminating ventilation duct-work, piping, etc. The radiation dose rates above the reactor, with the CAVALIER shutdown, are less than 0.5 mR/hr. In a corner of the CAVALIER room there is a subcritical natural uranium assembly not associated with the CAVALIER, used in laboratory submultiplication experiments, which will remain in place for the near future. This facility produces the highest dose rate in the room when the reactor is shutdown, ranging from 0.5 mR/hr to about 1.5 mR/hr.

There are no known areas of substantial activation or contamination of the concrete biological shield in the CAVALIER pit. Low activation levels derive from the fact that the concrete wall is about 2 feet distant from the nearest core face, and the CAVALIER has been operated at low powers. A special survey of the CAVALIER empty tank was made on March 9, 1989, with calibrated and tested RM-14 and pancake probe, and an Eberline ESP-1 survey meter. The most radioactive component after the control rods is, as expected, the reactor grid plate, which measured about 80 uR/hr gamma radiation at about one centimeter from the surface with the ESP-1. Background levels taken elsewhere in the Reactor Facility with this meter at 1 meter from surfaces were about 10 uR/hr. The maximum pancake probe readings on direct contact with the surfaces were about 250 cpm on the grid plate, and 150 cpm on tank walls and floor in the CAVALIER pit. The tank wall levels readings corresponded to background level readings taken with this meter at other locations of the Reactor Facility.

3.2 Radiation Protection

The decommissioning plan is an aid in minimizing worker exposure. Occupational doses will be kept ALARA by:

(1) performing radiation surveys to identify radiation areas,
(2) minimizing the exposure of personnel to radiation exposure by limiting the time spent in high radiation areas, by using remote devices, and by using shielding,
(3) promptly decontaminating any areas accidentally contaminated during the course of operations,
(4) careful accounting of the radiation doses as they are being incurred, to take corrective action as necessary,
(5) the wearing of throwaway garments where called for, and
(6) body frisking upon leaving the work area, as necessary. It is noted that the Reactor Facility has a record of very low occupational exposures of its personnel.

Exposure to radiation and contamination will be controlled by the Reactor Health Physicist and HP Technicians. Radiation exposure pathways normally considered for airborne releases are (1) direct external exposures, (2) inhalation, and (3) ingestion of food products. The primary hypothetical sources of radioactive effluent from routine dismantling are radioactive liquid aerosols produced during localized chemical decontamination, vaporized radioactive metal released during equipment or piping removal, and radioactive concrete dust resulting from concrete removal.

It is noted again that the decommissioning of the CAVALIER will not involve the disposal of systems normally associated with larger research reactors, such as activated/contaminated beam tubes, rabbit systems, thermal column, primary system piping, resin demineralizer system, heat exchanger system, radwaste storage room &/or tank, waste evaporator, cooling tower, reactor bridge, emergency retention basin, hot cells, laboratory hoods and exhaust stack. Demolition of concrete structures, or soil removal, are not planned, and the contamination levels are minute at any rate. Therefore, it appears highly unlikely that the dismantling crew will be subject to these sources and pathways, specially when common sense health physics practices are followed.

It is very difficult to estimate the occupational dose resulting from the dismantling of a small training reactor. The occupational estimate of 18 man-rem for the decontamination of a research reactor is made in NUREG/CR-1756 pg. 12-1. It is not unreasonable to estimate that for a training reactor such as the CAVALIER, subject to the considerations previously stated, the dose may well be lower by a factor of 1000 or more, considering also that the CAVALIER dismantling involves mostly defuelling (already completed without incident) and very little decontamination work.

The occupational exposure expected to be associated with decommissioning of the CAVALIER is dependent principally on the method adopted for unloading the core, the radiation levels presented by the fuel elements and control rods. The structures of the CAVALIER have been constructed from highly purified aluminum, hence low amounts of long-lived activation products are expected. Data has been presented elsewhere on these radiation levels, and it indicates that with prudent work habits the exposure to be incurred will be well within regulatory limits. When possible, tools will be used to maintain the radioactive items at a distance. Time analysis and shielding considerations can also be brought to bear. The reactor HP will provide guidance on maintaining exposures as low as reasonably achievable (ALARA).

Due to the low power of operation of the CAVALIER, the use of aluminum structures, and the excellent history of fuel element integrity, the internal surface contamination of the tank is very low. At present, no radiation levels or radioactivity above normal background levels are detected on reactor console components or on the floor surfaces of the CAVALIER room (Figure 2).

The following radioprotection requirements will be met during dismantling:

a) Maintain exposures of personnel ALARA.
b) Prevent personnel contamination.
c) Prevent contamination of other areas of the Facility.
d) Prevent airborne contamination and monitor for same.
e) Provide adequate protective clothing.
f) Provide adequate personnel dosimetry.
g) Perform detailed surveys as work progresses.
h) Train and advise personnel involved in the dismantlement, as necessary.
i) Legally dispose of and ship (if necessary) radioactive waste.

In the development of procedures and methods, the following should be considered (if necessary):

a) Activity concentration of CAVALIER pool water.
b) Induced activity of reactor components.
c) Contamination levels of reactor components.
d) Area radiation levels.
e) Removal of start-up source.
f) Movement of fuel.
g) Potential for airborne contamination.
h) Generation of radioactive waste.

3.3 Radioactive Waste Management

The CAVALIER's HEU fuel elements are of exactly the same type as those presently used in the UVAR. Due to the infrequent and short periods of CAVALIER reactor operation and the low powers achieved, the elements are not very radioactive (maximum dose rate of about 2 mR/hr at 1 foot). Therefore, an easy, quick physical in-house transfer of CAVALIER fuel to the Fuel Storage Room or the UVAR pool, and inventory transfer to the UVAR license was possible. The UVAR license's fuel limit is such that all CAVALIER fuel could be transferred to it.

It should be noted that the Reactor Facility no longer stores fresh HEU fuel within the secure fuel storage room on its premises. However, "used" HEU reactor fuel elements of low activity may be stored there safely and legally. It is intended that the CAVALIER fuel elements be used in the UVAR until it's conversion to LEU, and that they be eventually shipped off-site as spent fuel. The spent fuel shipments costs will be covered by the DOE sponsored LEU conversion program for the UVAR.

The residual radioactive items associated with the CAVALIER may be kept temporarily in the UVAR pool, or in waste drums stored in the unused hot cell, or in other areas and conditions at the discretion of the licensee, until a sufficient number of drums have gathered to warrant shipment for burial as low specific activity solid radwaste.

Airborne radioactive release due to CAVALIER dismantling can be predicted to range from non-existent to negligible amounts. The dismantling of the CAVALIER will be done in a closed room, which does not have a stack to the exterior environment. No credible mechanisms for airborne release outside of the Reactor Facility are foreseen as a result of the benign techniques to be employed.

The amounts of solid low-specific-activity (LSA) radwaste that are anticipated to be generated are small, certainly no more than several barrels. This waste eventually will be sent off-site for legal disposal in a licensed burial ground, probably at Barnwell, South Carolina. The principal environmental impact of solid waste disposal is the land area that must be committed to this activity. Shipping of these wastes may also involve a very low dose to the drivers and possibly to persons along the transportation route. Clearly, the environmental impact of this aspect of the CAVALIER decommissioning will be minuscule.

The water contained in the CAVALIER tank has a volume of about 11,000 liters. It originally was obtained from the UVAR, and has very low activity. Following CAVALIER core defuelling it was disposed of in conformity with the Reactor Facility's procedures with negligible environmental impact.

Soil contamination outside of the Reactor Facility is also not expected. Soil or concrete removal operations will not take place. Other forms of solid waste will leave the facility sealed in appropriate packages for burial at a licensed waste facility.

3.4 Accident Analysis

In the event that problems are encountered with the execution of the decommissioning plan, the reactor supervisors will communicate these to the reactor director. Significant occurrences shall be reported to the Reactor Safety Committee, stating the causes and corrective actions taken or proposed. Reports to the NRC of abnormal occurrences shall be made as defined and prescribed in the CAVALIER SOP's, which will continue to apply until the successful termination of the decommissioning activities.

Possible (but highly improbable) occupational, public, and transportation safety impacts from dismantling the CAVALIER are summarized in this section. These safety impacts include (1) radiation doses and industrial accidents involving the reactor staff members involved in the CAVALIER dismantling, (2) radiation doses to the public from routine or accidental atmospheric releases of radioactivity during the dismantling, (3) radiation doses to transportation workers and the public during shipment of radioactive material from the Reactor Facility site.

The public impact from an atmospheric release of radioactive materials during the dismantling of the CAVALIER is considered next. Radiation exposure pathways for postulated atmospheric releases are (1) direct external exposures, (2) inhalation, and (3) ingestion of food products. The primary sources of radioactive effluent resulting from a routine reactor dismantling would be radioactive liquid aerosols produced during localized chemical decontamination, vaporized radioactive metal released during equipment or piping removal, and radioactive concrete dust lifting during concrete removal.

It has been noted several times before that the dismantling of the CAVALIER will not involve the disposal of systems normally associated with larger research reactors, such as activated/contaminated beam tubes, rabbit systems, thermal column, primary system piping, resin demineralizer system, heat exchanger system, reactor bridge, radwaste storage room &/or tank, waste evaporator, graphite elements, cooling tower, emergency drainage basin, hot cells, laboratory hoods, and exhaust stack. Demolition of concrete structures, or soil removal, are not planned, and at any rate, the contamination levels associated with the CAVALIER are minute. Therefore, it appears highly unlikely that the public will be subjected to the afore mentioned sources and pathways as a result of CAVALIER dismantling. Finally, as all dismantling work will be done in a closed building, off-site releases of radioactive materials is a relatively straightforward process to prevent or control. The CAVALIER room does not have a stack or a direct ventilation system discharging to the outside environment.

It is hypothetically possible that the general public could receive some very small exposure as a result of the shipment of spent reactor fuel. In the case of the CAVALIER decommissioning, the spent fuel will not be immediately shipped. Most likely, all or fractions of the former CAVALIER fuel will be used in the higher powered UVAR. Therefore, when it is shipped, the fuel's impact on the public will depend on its irradiation history in the UVAR. Hence, no impact on the health and safety of the public is expected as a result of the decommissioning of the CAVALIER.

On a more general note, the radiation doses to the public from research reactor spent fuel shipments are recognized as very low. This is a reflection of the relatively small amounts of radioactivity produced in research reactors, as compared to power reactors. In conclusion, no public impact from the CAVALIER facility is believed to be possible during and following the dismantling of the CAVALIER, completion of the fuel disposal, and termination of the operating license.

The CAVALIER reactor has been permanently defuelled according the existing CAV SOP 5.4. CAVALIER fuel not already in use in the UVAR is being stored temporarily in the Reactor Facility's fuel storage room, in racks designed to prevent a criticality event. These racks have been used to store fresh CAVALIER and UVAR fuel in the past. As a result of the CAVALIER final defuelling, nuclear criticality safety is no longer a consideration under the decommissioning plan.

At the time of CAVALIER final defuelling, the neutron start-up source was removed and properly stored, to prevent staff exposure.

Industrial Safety

Industrial type accidents are no more likely to occur during the CAVALIER decommissioning operations than routine plant operations. Procedures are followed and the personnel receive training as a means to prevent accidents. It is felt that continuing proper management and safety practices can minimize the occurrence of such accidents.

Explosive techniques, or remote cutting apparatus will not be used in the dismantling. Soil removal or decontamination will not be performed. Gases, vapors, fumes, dusts and mist are not expected to be generated in appreciable quantities, and therefore a toxic or radioactive atmosphere that requires the wearing of breathing air supply equipment will not likely exist. It is anticipated that the requirements of 29 CFR 1910 "Occupational Safety and Health Standards" can be satisfied through the use of standard operating procedures.

Environmental Impact Statement

Title 10, CFR 51 pertains to licensing and regulatory policy and procedures for environmental protection. Section 51.5(b)(7) provides guidance for determining if an environmental impact statement (EIS) is needed for decommissioning a nuclear facility. The licensee believes that an environmental impact statement is not required for the CAVALIER decommissioning by 10 CFR 51.20(b)(5), for it is a small research/training reactor. A consideration of potential hazards, to lead to a conclusion that no significant hazards exist associated with the CAVALIER decommissioning, may use criteria contained in 10 CFR 50.92, 51.20(b)(5), 51.23, and 51.32. Consultation of 10 CFR 51.23 indicates that a generic finding of no significant impact arising from the temporary storage of on-site spent fuel after cessation of reactor operation can be made by the NRC.

It is pointed out that the decommissioning request does not involve a significant increase in the amount or extent of effluent or radiation emitted. Also clearly not involved are (1) a significant increase in the probability or consequences of an accident previously evaluated, (2) the possibility for the creation of a new or different kind of accident from any accident previously evaluated; or (3) a significant reduction in a margin of safety. The provisions of 10 CFR 50.59 will continue to apply to the licensee during the decommissioning phase.

In conclusion, the licensee believes that the present decommissioning plan describes the proposed actions in sufficient detail to permit the NRC to reach the finding (by 10 CFR 51.32) that no significant impact will result from the CAVALIER dismantling and decommissioning.

4. PROPOSED FINAL RADIATION SURVEY PLAN

In sections 30.4, 40.4, 50.2, 70.4, and 72.3 of 10 CFR, the term "decommissioning" is defined as "the removal (of a facility) safely from service and reduction of the residual activity to a level that permits release of the property for unrestricted use and termination of license". Unrestricted use refers to the fact that, from a radiological standpoint, no hazard exist at the site and the site can be considered an unrestricted area. This concept is in accordance with 10 CFR 20.3, which defines an "unrestricted area" as being "any area access to which is not controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials and any area used for residential quarters." In the case of the CAVALIER, its "site" is defined as the reactor pit and surrounding area within the CAVALIER cage.

Acceptable levels of residual radioactivity for unrestricted use of property were not addressed in the final rule on decommissioning of nuclear facilities. It appears that Federal guidelines will eventually be issued by the EPA rather than by the NRC. In the interim, as a result of a review of dismantling plans for other nuclear research facilities, the following levels of radiation appear acceptable to the NRC for the release of such facilities to unrestricted use:

a) Surface Contamination

Maximum permissible levels are taken from Table 1 of Reg. Guide 1.86, and are presented in the plan's Table 1. It is noted that this Reg. Guide pertains specifically to power reactors, and therefore only those parts that appear applicable to non-power reactors are used for guidance in the development of this plan.

An ANSI standard that may also provides some guidance is ANSI N13.12 "Control of Radioactive Surface Contamination of Material, Equipment, and Facilities to be Released for Uncontrolled Use".

b) Other than surface contamination

Isotopes such as Co-60, Eu-152, and Cs-137 may exist in concrete, components, structures, etc... The radiation level from these isotopes at a distance of one meter from the surface should be less than 5 uR/hr above natural background (as measured at a comparable uncontaminated structure or exterior soil surface), or 10 mrem/yr above background, considering reasonable proximity and occupancy (from NRC Div. of Lic.'s "Guidance and Discussion of Requirements for an Application to Terminate a Non-Power Reactor Facility Operating License").

From NUREG/CR-1756, pg. 6-7, the following is quoted: "a residual radioactivity level for permitting release of a nuclear facility for unrestricted use should be consistent with ALARA. Guidance in establishing such a level is best expressed in terms of a value which bounds the dose for the majority of nuclear facilities. This value is determined to be 10 mrem/yr whole-body dose equivalent..." NUREG/CR-1756 contains tables on page 2-12 and page 9-10 depicting acceptable residual radioactive contamination levels inside a reference research reactor. These tables are reproduced in our Table 1.

It is the intention of the University of Virginia Reactor Facility staff to make reasonable efforts to decontaminate the CAVALIER reactor pit, following reactor dismantling, to meet the levels for the terminal HP survey required for license termination. However, the area presently occupied by the CAVALIER will not be released for unrestricted access. Therefore, the radiation dose standards to be applied within the Reactor Facility, and specifically the CAVALIER room following CAVALIER operating license termination, will be for individuals in restricted areas (10 CFR 20.101).

The purpose of the terminal post-dismantling radiation and contamination surveys is to provide assurance that the CAVALIER site meets the prescribed radioactivity levels that permit its safe and legal use following decommissioning. In the case of the CAVALIER site, the area is ultimately destined for further restricted use within the Reactor Facility building that also houses the UVAR. Hence, the requirement that this site meet the release criteria necessary for operating license termination should be restricted to a one-time affair.

5. UPDATED COST ESTIMATE FOR DECOMMISSIONING METHOD CHOSEN AND PLAN FOR ASSURING AVAILABILITY OF FUNDS FOR COMPLETION OF DECOMMISSIONING

In general, decommissioning costs are strongly dependent on the power level and operation history of the reactor, which determines the degree of concrete contamination, the amounts of activated core support materials, soil contamination, etc.. The cost categories identified for estimating the dismantling charges for the CAVALIER are, in order of approximately decreasing amounts, as follows:

a) Staff labor
b) Disposal of spent fuel
c) Disposal of radioactive waste materials
d) Miscellaneous tools, equipment and supplies
e) Nuclear insurance
f) Specialty contractors

It is noted that the decommissioning of the CAVALIER will <u>not</u> involve demolition and/or disposal of systems normally associated with larger research reactors, such as activated and/or contaminated beam tubes, rabbit systems, thermal column, primary system piping, resin demineralizer system, heat exchanger system, radwaste storage room &/or tank, cooling tower, graphite reflector elements, emergency discharge basin, hot cells and laboratory hoods. Hence, the decommissioning will be accomplished by the existing in-house reactor staff. Outside specialty contractors will not be needed or used.

The labor cost associated with the preparation of documentation, dismantlement operations, decontamination work, and surveys can and will be borne by the operating budget for the Reactor Facility. For a "ball park" estimate of the dismantling cost, one might cite the $10,000 cost for the dismantling of Oregon State University's AGN-201 reactor (NUREG/CR-1756, pg 5-7). The University of Virginia labor costs are expected to be on the order of $50,000. This will be the single largest cost item associated with the dismantling.

The CAVALIER's HEU fuel elements are of exactly the same type as those presently used in the UVAR. Due to infrequent and short periods of CAVALIER reactor operation and the low powers achieved, the elements are not very radioactive (maximum dose rate of about 2 mR/hr at 1 foot). Therefore, an easy, quick physical in-house transfer of CAVALIER fuel to the Fuel Storage Room or the UVAR pool, and inventory transfer to the UVAR license was already possible. The UVAR license's fuel limit is such that all CAVALIER fuel could be transferred to it.

It should be noted that the Reactor Facility no longer has the practice of storing fresh HEU fuel within the secure fuel storage room on its premises. However, used HEU reactor fuel elements of low activity may be stored there safely and legally. It is intended that the CAVALIER fuel elements be used in the UVAR until it's conversion to LEU, and that they be eventually shipped off-site as spent fuel. The spent fuel shipments costs will be covered by the DOE sponsored LEU conversion program for the UVAR.

The residual radioactive items associated with the CAVALIER may be kept temporarily in the UVAR pool, or in waste drums stored in the unused hot cell, or in other areas and conditions at the discretion of the licensee, until a sufficient number of drums have gathered to warrant shipment for burial as low specific activity solid radwaste. These shipments would be paid for out of the operating budget for the Reactor Facility.

The CAVALIER was assembled by the reactor staff, and some of the original constructors are still employed at the Reactor Facility. This qualifies them well for the CAVALIER disassembly. It is believed that all necessary tools and supplies already exist on site for the CAVALIER dismantlement. Arc cutting and welding devices, although available, will not be employed. Many structural supports have been bolted together and arc cutting will not be needed.

Miscellaneous supplies for the CAVALIER decommissioning may possibly include HEPA air filters, anticontaminant clothing, cleaning and contamination control supplies (chemical agents, sweeping compounds, rags, mops, and plastic bags and sheeting), expandable handtools, and decontamination chemicals, as well as office supplies. For the most part, these supplies are routinely available at the Reactor Facility and are purchased through the operating budget.

The yearly NRC indemnity fees for research reactors are relatively low, on the order of $100. The fee to be charged by the NRC for dismantling licensing services and for amending the license is delineated in 10 CFR Part 170, Table J.1-10 in Appendix J. However, such fees are waived for research reactors.

It is anticipated that the nuclear insurance fee paid by the Facility will be reduced as a result of the CAVALIER shut-down and decommissioning. The insurance company (ANI) has already been contacted in this regard.

State government research reactor licensees are permitted by the new decommissioning rule to meet the decommissioning funding requirements through the submittal of a statement of intent that the state will be the guarantor of decommissioning funds. Such a statement for the CAVALIER decommissioning is in attachment.

6. TECHNICAL SPECIFICATIONS IN PLACE DURING DECOMMISSIONING

The federal regulation that outlines the information and procedures necessary for the termination of an operating license appears is 10 CFR 50.82. The application for termination of license is submitted at the time of initiation of decommissioning. Decommissioning is carried out under an amended license in accordance with the terms of a decommissioning order. The license is terminated only after the NRC is satisfied that decommissioning has been properly completed. Normally, an amended Part 50 license authorizing "possession-only" will be issued prior to the decommissioning order, to confirm the nonoperating status of the reactor and to reduce some surveillance requirements which are important only for operation.

The NRC is expected to follow its customary procedures, set out in 10 CFR Part 2 of the NRC Rules of Practice, in amending Part 50 licenses to implement the decommissioning process. The licensee's authority to possess radioactive materials under Parts 30, 40, and/or 70, as appropriate, continues to be incorporated in the modified license, as it was during operation. Subsequent amendments are issued as appropriate.

Following the adoption of the new rule on decommissioning, the term "decommissioning order" is used by the NRC in lieu of the term "dismantling order" because the overall approach to decommissioning must now be approved shortly after operation ceases, rather than an amended "possession-only" Part 50 license being issued without plans for ultimate disposition.

The NRC acknowledges that a licensee may proceed with some activities such decontamination, minor component disassembly, and shipment and storage of spent fuel if these activities are permitted by the operating license and/or 10 CFR 50.59.

Following the decommissioning of the CAVALIER, the CAVALIER SAR will no longer be applicable. Decommissioning of the CAVALIER will be deemed to have been completed once the terminal HP survey results have been found to be acceptable by the NRC.

The Technical Specifications are part of the operating license and are meant to assure the safe operation of the reactor. They will be in effect during the decommissioning phase, and amended by the NRC as necessary. After the CAVALIER has been decommissioned, the Technical Specifications for License R-123 will no longer be applicable.

The Emergency Plan for the Reactor Facility has been "bounded" by the requirements imposed by the higher power UVAR, and was formulated for the Reactor Facility as a whole. Therefore, no changes to the plan are foreseen other than dropping all sections or references to the CAVALIER at the next opportune review date for the Emergency Plan following CAVALIER decommissioning.

7. QUALITY ASSURANCE PROVISIONS IN PLACE DURING DECOMMISSIONING

The procedures that will be used in the CAVALIER decommissioning operations are meant to ensure that a criticality accident is made impossible, that special precautions are taken to isolate radioactive materials and avoid contamination, that releases of radioactivity from the CAVALIER facility are prevented or minimized, that the Reactor Facility's QA/QC Program is followed, that members of the public are not overexposed and that personnel exposures are kept to a minimum (ALARA concept). A copy of the QA/QC Program can be found in the Appendices.

Much like the Emergency Plan, the QA/QC plan has been applied to reactor related activities taking place within the entire Reactor Facility, and has been "bounded" by the requirements imposed by the UVAR. The plan does not mention the CAVALIER by name, and changes to it due to the CAVALIER will not be necessary.

8. PHYSICAL SECURITY PLAN PROVISIONS IN PLACE DURING DECOMMISSIONING

The Physical Security Plan for the Reactor Facility will be followed prior to, during and following the CAVALIER dismantling. That means that existing doors, fences, intrusion alarms, and reactor staff will be continue to be employed. The integrity of the physical barriers is checked daily and inspected weekly.

Administrative procedures for the notification and reporting of abnormal occurrences such as the entrance of an unauthorized person or persons into the Reactor Facility and a significant change in the radiation or contamination levels in the Facility or the offsite environment, are presently in effect and will continue to exist throughout the period of validity of the NRC operating license for the UVAR. This period clearly extends through and beyond the period for the CAVALIER decommissioning. These procedures cover the manner in which authorized access into and movement within the Reactor Facility is granted and monitored.

Changes to the Physical Security and Safeguards Plan must be protected from public disclosure in accordance with 10 CFR 73.21 or 10 CFR 2.790, and sent under separate cover. The licensee has not identified major plan alterations, due in great part to the fact that the CAVALIER and the UVAR share the same building, protected areas, etc.. and because the UVAR will remain operational.

APPENDIX

A. Letter of Intent
(regarding the availability of decommissioning funding)

B. QA/QC Program

APPENDIX A

STATEMENT OF INTENT

BY THE UNIVERSITY OF VIRGINIA

REGARDING DECOMMISSIONING FUNDING

FOR THE CAVALIER REACTOR
(NRC Docket 50-396, License No. R-123)

February 1990

A. Background

New NRC Decommissioning Regulations

On June 27, 1989, the NRC issued its final regulations on decommissioning of nuclear facilities (53 FR 24018). NRC's requirements for the decommissioning of reactors are contained in some detail in sections 50.33, 50.75 and 50.82 of the NRC regulations. The regulations address requirements for decommissioning planning, decommissioning alternatives and timing, environmental review requirements and financial assurance by a licensee for future availability of decommissioning funds. Not resolved by the new rule were issues related to levels of residual radioactivity acceptable for the release to unrestricted use of property where licensed activities had been conducted. While awaiting the establishment of final residual radioactivity limits, the NRC is developing interim guidance in this area.

NRC's decommissioning regulations apply to the reactor site, buildings, their contents and radioactively contaminated equipment. They do not apply to the removal and disposal of spent fuel which is considered an operational activity. The regulations also do not apply to the removal of non-radioactive structures or materials which the licensee may opt to make to prepare the building for new use.

As regards planning for decommissioning during a facility's lifetime, the rule requires the submittal of a preliminary decommissioning plan five years prior to shutdown, containing a decommissioning cost estimate and an up-to-date assessment of major technical factors that could affect decommissioning planning. No later than one year prior to the expiration of the facility's operating license, or two years after actual shutdown, the licensee is required to prepare a proposed decommissioning plan that will form the detailed basis for performing decommissioning tasks.

Research and test reactor licensees are required to submit to the NRC a decommissioning report by July 26, 1990, which contains a cost estimate for the decommissioning of their facilities, with an indication of the method that will be used to provide funds for decommissioning, and a description of the means of periodically adjusting the cost estimate and associated funding level over the life of the facility. The methodology and level of detail of the cost estimate should be based on the Battelle-Pacific Northwest Laboratories (PNL) report prepared for the NRC, Technology, Safety and Costs of Decommissioning Reference Nuclear Research and Test Reactors, Vols. 1, 2 and Addendum (NUREG/CR-1756, February 1982 and July 1983). The licensee should adjust the PNL study costs to include those principal factors specific to its facility.

Financial assurance issues were evaluated by the NRC in three reports, only one of which applies to research reactors: NUREG-0584 ("Assuring the Availability of Funds for Decommissioning Nuclear Facilities", Revision 3, R. Wood: March 1983. Funding assurance is important to the NRC as a means to reduce the likelihood of a situation where lack of funds could threaten public health and safety. The NRC believes that funding assurance is necessary for a variety of reasons unique to the decommissioning process.

Guidance to explain in greater detail the financial requirements in the regulations is available in the draft Regulatory Guide, "Assuring the Availability of Funds for Decommissioning Nuclear Reactors" (Task DG-1003). The guide recommends formats and wording for the financial assurance instruments allowed by the decommissioning rule. However, a licensee is free to use alternatives not described in the guidance that it believes would comply with the regulations. The NRC has indicated that research and test reactor licensees which are part of federal, state, or local governments may provide financial assurance by submitting a statement of intent containing a cost estimate for decommissioning and indicating that the necessary funds will be obtained following the licensee's decision to shut down the reactor.

Research and test reactor licensees must periodically adjust the decommissioning cost estimates for their facilities to take account of inflation. The Consumer Price Index published by the Bureau of Labor Statistics, U.S. Department of Labor may be used for this. The inflation adjustments should be made annually, although the adjustments do not have to reported to the NRC. The licensees are, however, required to keep records of these and other decommissioning activities available for NRC inspection as required under 10 CFR 50.75(g)(3).

B. STATEMENT OF INTENT

The decommissioning plan for the CAVALIER reactor which accompanies this statement describes the estimated funding requirements. The CAVALIER decommissioning costs will be kept very low due to its unique character. It is a low power reactor located in the same building as the more powerful UVAR, and many of the usual site disassembly measures will not be necessary or can be postponed until the time of the UVAR decommissioning. Therefore, the CAVALIER decommissioning costs can and will be funded from the Reactor Facility's operating budget. It is noted that the University of Virginia is a state institution.

T.G. Williamson 2/27/90

Dr. Thomas G. Williamson
Chairman of the Dept. of
Nuclear Engineering and
Engineering Physics

Sworn to and subscribed before me this 27th
day of February, 1990
Witness my [illegible]
Delores E. Van Notary Public
My Commission Expires 2/28/93

APPENDIX B

QA/QC PROGRAM FOR THE U.VA. REACTOR FACILITY

(Revision completed December 1987)

Approved by Reactor Safety Committee 12-9-87

REACTOR FACILITY
DEPARTMENT OF NUCLEAR ENGINEERING AND ENGINEERING PHYSICS
SCHOOL OF ENGINEERING AND APPLIED SCIENCES
UNIVERSITY OF VIRGINIA
CHARLOTTESVILLE, VIRGINIA
22901

Foreword

The Quality Assurance/Quality Control (QA/QC) Program for the U.VA. Reactor Facility is based on recommendations contained in the ANS-15.8/ANSI N402-1976 Standard entitled "Quality Assurance Program Requirements for Research Reactors", and on guidance given in U.S. Reg. Guide 2.5 (Oct. 1977). The QA/QC program is established to comply with the non-power reactor applicable requirements of 10 CFR 50.34 and 10 CFR 71 (specifically Subpart H). It is noted that QA/QC provisions contained in Appendix B to 10 CFR 50 are applicable to nuclear power plants.

The wording used, in the present August 1987 revision, to describe the program scope, organization and requirements has been reduced to a minimum, with the specific requirements listed in the referenced QA/QC checklists. The revised QA/QC program is submitted to the U.S. NRC for approval in accordance with 10 CFR 71.12 (B), following its review and approval by the U.VA. Reactor Safety Committee (RSC).

As described in Section A, the QA/QC program applies mostly to reactor safety-related items. There are compelling reasons for limiting QA/QC programs at research reactors to reactor safety-related items and shipments of radioactive materials. It should be recognized that "non-power" research reactors lack many of the power reactor operational characteristics. For example, one of the most important distinctions that can be made between power and non-power reactors is with respect to the operating power level (approximately 3000 MW_{th} vs. 0 to 10 MW_{th}). The thousand-fold lower power level of a research reactor results in greater safety, since cooling of a research reactor after a "scram" is not a problem. The potential for personnel exposure at non-power reactors is much lower too, as observed when a comparison of annual dose exposure data is made. These and other differences justify the reduction in the complexity of QA/QC programs at no-power reactors.

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A. QA/QC Program Philosophy

Quality Control is exercised primarily through good engineering. This is assisted by the use of checklists developed by experimenters (defined below under QA/QC Organizatinal Structure), and reactor or health physics staff, which are then reviewed and approved by the Reactor Safety Committee (RSC). The checklists may be based on:

1) Federal Regulatory Requirements
2) Reactcr Technical Specifications and Standard Operating Procedures
3) Applicable provisions of the U.VA. Radiation Safety Guide.

The Quality Assurance Program is effected by completing and keeping on file QA/QC program applicable checklists used, as necessary, by experimenters, reactor and health physics staff.

B. QA/QC Program Scope

The U.VA. Reactor Facility QA/QC Program only applies to:

1) Replacement of, and modifications to reactor safety related systems made subsequent to the date of the original QA/QC program.

   Reactor safety related systems are those that are associated with reactor control and protection. Safety related systems (1) prevent reactor accidents which could cause undue risk to the health and safety of the public, or (2) control and mitigate the consequences of reactor accidents. The following are examples of reactor systems which are safety related:

   a) Reactor Fuel Elements
   b) Reactor Control Rods and Drives
   c) Reactor Automatic Control System
   d) Reactor Instrumentation
   e) Reactor Cooling System
   f) Reactor Radiation Monitoring System.

2) Design, construction, installation and operation of in-pool experimental reactor irradiation facilities.

3) Design, construction, installation and operation of experimental facilities using a radiation beam emanating from the UVAR.

4) Quality-affecting activities related to shipments of radioactive materials.

Reactor maintenance, surveillance, system calibration and Technical Specification requirements are presently adequately addressed by the UVAR and CAVALIER reactors' Standard Operating Procedures (SOP's), methods and checklists. The SOP's may contain elements of quality assurance and control, however, these elements are not addressed by this QA/QC Program, in order to avoid unnecessary duplication, and to conform to the restricted scope indicated above.

Quality assurance documentation is not required to be on file for as-built existing reactor and associated facilities predating the implementation of the original QA/QC program.

C. QA/QC Organizational Structure

The present U.VA. Reactor Facility organization chart is shown in Fig. 1. Updates of this chart will be kept on file at the Reactor Facility, separately from the QA/QC Program. In addition to the personnel listed in the organizational chart, there are users of the reactor who are called "experimenters". Experimenters may include reactor staff, faculty or students. For the purpose of the QA/QC plan, experimenters are individuals who perform experiments that interact with the reactor system.

The requirements for the allocation of QA/QC responsibilities are given in 10 CFR 71.103. The responsibilities for the execution of the QA/QC Program are as follows:

1. Experimenters, Reactor & HP Staff Members
   * Develop system or experiment designs.
   * Perform safety or experiment reviews.
   * Prepare procedures, methods & checklists.
   * Submit designs, reviews, procedures, methods and checklists to the Reactor Director and Reactor HP for review. When necessary, the above are referred to the RSC for further study and approval.
   * Purchase and inspect construction materials.
   * Assemble or build systems or experimental facilities.
   * Install, test and operate systems or experimental facilities.
   * Prepare radioactive materials for shipment.
   * Fill out QA/QC checklists for the above and submit these for approval and filing.

2. Reactor Administrator

* Provides for QA/QC indoctrination and training of reactor staff.
* Independently reviews staff document packages to be submitted to Reactor Director for review and approval.
* Has overall authority and responsibility for the implementation of the QA/QC program.
* Maintains the QA/QC files.

3. Reactor Director

* Establishes Facility's QA/QC policies, goals and objectives.
* Assures implementation of the recommendations contained in the RSC audits of the QA/QC Program.
* Reviews designs, reviews, procedures, methods and checklists. When necessary, refers these to the RSC for further study and approval.

4. Reactor Safety Committee

* Reviews Reactor Facility's QA/QC goals, objectives and policies.
* Approves QA/QC Program and changes thereto.
* Reviews documentation packages consisting of, for example: experiment designs; safety analyses; construction, installation and test plans; operating procedures and checklists.
* Audits the QA/QC Program on a biannual basis to assess its implementation, effectiveness and scope. This is to assure compliance with the 10 CFR 71.137 requirement of management independent periodic licensee review.

D. Safety Analyses

Written safety analyses may be developed by experimenters, reactor staff, or health physics personnel, or combinations thereof. These analyses have as a principal objective the evaluation of the reactor and radiological safety significance associated with proposed changes to reactor safety-related systems, or the introduction into use of new reactor irradiation facilities. As necessary, probabilities and/or consequences of reactor accidents may be considered in the detailed analyses, as related to safety margins and Technical Specifications.

Generally, the individual(s) initiating a reactor safety analysis will have it checked by other experts or reactor staff members. The analysis should then be further reviewed by either, or both, the Reactor Administrator and the Reactor Supervisor. As related to the scope of the QA/QC program, radiological safety analyses will be reviewed by both the Reactor Health Physicist and the Reactor Director.

All analyses, together with other pertinent documentation such as drawings, material specifications, inspection procedures, calibration procedures, test plans, calculations, references to standards, etc.., as appropriate, will normally be assembled into a document package for submittal to the Reactor Director. The Reactor Director will determine whether sufficient documentation is being presented and whether the experiment or system change involves an unreviewed reactor safety question.

The Reactor Director may approve an experiment or system change, or refer the matter to the Reactor Safety Committee, depending on his evaluation of the safety significance. The RSC may, at its discretion, request that more documentation be presented; for procedures, methods, and QA/QC checklists to be developed; and for a radiological safety analysis to be made in addition to the reactor safety analysis, before granting its approval for the proposal. Where deemed appropriate by the RSC, the experimental facilities will be subjected to operational tests prior to introduction into regular service.

Materials to be used in the construction of reactor associated experiments, or in the modification of existing reactor safety-related systems, should be chosen and checked for suitability and compatibility.

Failures, malfunctions or serious deficiencies of reactor safety related items, or reactor associated experiments, will be brought to the attention of the Reactor Director and the RSC. Corrective actions will be taken or initiated by the Reactor Director (or his substitute), as appropriate.

E. QA/QC Checklists

QA/QC checklists, addressing the scope indicated in Section A of the QA/QC Plan, are prepared by the experimenter(s) in collaboration with/or by the reactor and/or the health physics staff, and approved by the Reactor Safety Committee for routine use. Where pertinent, acceptance criteria should be indicated on the checklists. It is through the use of these checklists that the key operational aspects of the QA/QC program are carried out.

When appropiate, QA/QC checklists similar to the following examples will be completed:

1) Facility Design, Construction or Modification Evaluation Form (designed to meet 10 CFR 50.59 requirements)
2) DOT/49 CFR Quality Assurance Checklist for Fissile Radioactive Material Shipments
3) "GE CASK 700" Spent-fuel Shipping Procedure Checklist
4) Radioactive Material Shipment Quality Assurance Checklist
5) LSA "Class A" Packaging Quality Assurance Checklist

The above typical checklists used in the implementation of the QA/QC program are indicated as examples in the appendices to this document. Additional checklists may be developed, to specifically meet special circumstances. Changes to existing checklists, or additional checklists, are not to be considered to be changes to the RSC and NRC approved QA/QC Program. Copies of new or revised checklists will be sent to the RSC for review and approval, but will not be sent to the NRC. Following approval by the Reactor Safety Committee, QA/QC checklists will be appended to this program.

After QA/QC checklists are completed, they should be routed to the Reactor Director for review, as indicated, and for filing by the Reactor Administrator. Normally, the QA/QC checklists will be filed with the records on each facility and experiment, as applicable (see section on QA/QC Records).

F. QA/QC Training and Indoctrination

The Reactor Administrator will be the individual overall responsible for the training of reactor staff members in quality control and assurance matters. Typically, training will be accomplished by junior staff getting hands-on directions from senior staff on why, when and how to fill out QA/QC checklists, and by their participation in safety reviews and analyses. The QA/QC program will also be a topic addressed in the reactor operator requalification lecture series. The Reactor Administrator will assist experimenters at the Reactor Facility with QA/QC matters. QA/QC topics may be discussed at yearly orientation meetings for new Reactor Facility personnel.

G. Audits of QA/QC Program

The Reactor Safety Committee will conduct audits of the Reactor Facility's QA/QC Program (10 CFR 71.137) on a biannual frequency, to determine its effectiveness, status and adequacy. The audit report will be reviewed by the Reactor Director, who will be responsible for having the RSC recommendations implemented.

H. QA/QC Records

Documentation pertaining to the QA/QC Program will be kept by the Reactor Administrator (10 CFR 71.135, & 72.80). Document packages reviewed and approved by the Reactor Safety Committee should be kept in the RSC files. Complementary records may be kept by the Reactor Administrator and/or the Reactor Health Physicist, when necessary, in separate files. Such records should contain, as reasonable, fuel and radioactive material shipping records, inspection and test results, material quality reviews, special procedures, engineering analyses and checklists. The retention period for QA/QC files should be for the lifetime of the system described. Radioactive material shipping documents should be kept by the Health Physicist and copies of these may also be kept by the Reactor Administrator, for a minimum period of two years after the date of shipment.

Quality assurance documentation is not required to be on file for existing as-built facilities which predate the implementation of the original QA/QC program.