U.C. IRVINE TRIGA REACTOR

Annual Report for Period

July 1st, 1977 to June 30th, 1978

Facility License: R-116

Prepared in accordance with Part 6.7f of the facility technical specifications.

by

Dr. G. E. Miller

Reactor Supervisor

I. Operations

Operation of the reactor has continued in support of the Department of Chemistry program in research and education in the use and application of radiochemical techniques and radioisotope utilization in chemical studies.

The reactor utilization has thus been entirely in the irradiation of samples of diverse origin except for some utilization in operator training. Samples have been analyzed from the fields of forensic science, art investigations, pollution investigations, pharmaceutical toxicology, chemical synthesis, enzyme studies, etc.

The reactor has continued to be utilized by a number of advanced laboratory courses in chemistry involving over 100 students at the undergraduate level in performing irradiation experiments, primarily of neutron activation analysis.

The graduate students and postdoctoral associates using the facility number approximately 18 and include students supported under IAEA programs from Nigeria, Malaysia, Iran, Israel and Chile.

The facility had five licensed senior operators during most of this period and two licensed operators as a result of license examinations conducted in November, 1977.

II. Data Tabulations

Table I.

No. of Experiment Approvals on File		14
No. of Experiments Performed (including repeats)		463
No. of samples irradiated		11,486
Energy generation, Mw hours		182.63
Total with 69 element core (to 3-26-74)	127.0	
Total with subsequent core (74-79 elements)	503.6	
Total energy generation since first criticality		630.6 MwH
Pulse operation (annual)		43
of which		27 > $2.00
Total pulses		584
Hours critical (annual)		818 hours
Total		3,251 hours
Operator training		119 hours
Inadvertent scrams:		55
Visitors		984
Max. dose recorded (all within dosimeter drift and reading reproducibility range)		1 mr
Visiting researchers (dosimeters)		201
Maximum dose recorded (dosimeter)		63 mr

Table II.

Reactor Status: 6-30-78

No. of fuel elements in core (incl. 2 fuel followers)		79
No. of fuel elements in storage (reactor tank)-used		28
No. of fuel elements unused - in closet (instrumented)		1
No. of graphite reflector elements in core		28
No. of experimental facilities in fuel element holes		4
No. of empty holes (water filled)		14
Core excess (cold, no Xenon)	\$2.40	

Control rod worths:

REG	\$4.26
SHIM	3.26
ATR	1.86
FTR	0.52
TOTAL	\$9.90

Maximum possible pulse insertion:	\$2.38	
Maximum peak power attained:		900 Mwatts
Maximum peak temperature observed (B-ring):		310°C

III. Inadvertent Scrams and Emergency Shutdowns

Table III.

Date	Time	Power Level	Type and Explanation
1977			
7/13	16:53	200w	Linear power scram - range switching error.
7/1	13:35	250kw	Unanticipated drop in power-electronic failure in console of +25 v power supply.
7/27	09:03	< 1.5w	Period scram - trainee operator error.
8/3	14:26	250kw	Building power failure caused scram.
8/17	09:41	< 3w	Period scram - trainee error.
9/7	13:43	< 150w	Period scram - trainee error.
9/22	14:08	< 500w	Period scram - trainee error.
9/22	12:36	5w	Linear power scram - trainee error.
9/22	15:12	< 500w	Linear power scram - trainee error.
9/22	16:57	< 1.5w	Period scram - trainee error.
9/22	17:12	< 1.5w	Period scram in auto-mode. FTR dropped. REG attempted to compensate.
9/22	17:33	< 1.5w	Period scram in auto-mode. FTR dropped. REG attempted to compensate.
9/22	18:19	< 0.5w	Period scram - operator error.
9/23	12:10	250kw	Linear scram - circuit switching transient.
9/28	10:16	< 1.5w	Momentary main power interruption.
9/28	16:19	5kw	Linear power scram - range switch switching transient.
10/3	11:52	< 1.5w	Period scram - trainee error.

Date	Time	Power Level	Type and Explanation
10/5	11:07	< 3w	Period scram - incorrect use of automatic servo mode at low power by trainee.
11/3	16:40	< 1kw	Linear power scram automatic servo unable to drive REG rod from full up position to compensate for power rise. Trainee use.
11/4	09:23	< 100w	Period scram - too large insertion (25 ¢) by trainee operator, too fast.
11/16	08:54	250kw	Power failure to building caused scram.
11/17	08:42	< 30w	Period scram - operator inattention.
12/2	09:16	250kw	Console power scram - clock fell on power switch.
11/17	19:58 20:11	250kw	Sudden drop of SHIM rod (two occurrences) ? low magnet power.
12/16	14:37	< 10w	Period scram - operator inattention.
12/20	10:45	250kw	Linear power scram caused by transient "glitch" on turning cooling pump off.
12/22	07:57	1.5w	Linear power scram - range switching electrical transient.
12/28	09:25	< 1w	Period scram. Operator inattention.
12/28	11:30	250kw	Seismic scram - no sign of seismic activity. Assume set too sensitive at start-up test.
12/29	08:41	< 3w	Period scram - Operator inattention.
12/29	11:50	250kw	Over tank area monitor alarmed. Meter indicated 0.1-0.2 mr/hr. Other meters at near zero. Facility evacuated. No sign of high radiation level. Electronic spike assumed to be cause. Reentry permitted. Instrument calibration, etc. O.K.
1978			
1/7	15:10	< 5w	Linear power scram. Operator range switching error.
1/11	09:52	250kw	Console power scram. Inadvertent short of temporary +25 volt power supply during tests on console.

Date	Time	Power Level	Type and Explanation
1/11	13:57	2.5kw	Linear power scram - operator range switching error.
1/11	20:04	0.0w (shutdown)	Laboratory area monitor alarm. Meter at 1-2 mr/hr. No high radiation revealed on survey re-entry permitted. Poss. voltage spike?
1/16	14:43	< 10w	Period scram. Operator inattention.
1/18	14:52	4kw	Period scram on lowering sample into c.t. for short irradiation. Lowering done too fast compared to usual, for central thimble.
2/3	15:20	250kw	Linear power scram - mode switch transient.
2/10	12:11	< 1w	Period scram - operator inattention.
2/14	08:32	< 100w	Period scram - operator inattention.
2/15	14:49	250kw	Seismic scram. No evidence of seismic activity - assumed to be too sensitively set after start-up test.
2/17	08:57	< 5w	Period scram - operator inattention.
2/22	08:25	< 1.5w	Seismic scram. Same as 2/15/78.
2/27	13:15	250kw	Linear power scram caused on lowering sample into central thimble. No %P scram.
3/8	08:30	250kw	Linear power scram - mode switch transient.
3/21	08:04	< 1w	Period scram - operator inattention.
4/13	12:03	250kw	Sudden drop in reactor power - SHIM rod dropped. No scram overall.
4/15	14:18	250kw	SHIM rod dropped again.
4/20	13:05	250kw	Building power transient caused scram.
4/21	14:09	250kw	Linear and period scram following +25 volt power supply failure coupled to overheating of cooling system pump contactor relay.
5/11	13:48	< 10w	Period scram - operator inattention.
5/18	15:36	250kw	SHIM rod dropped again.

Date	Time	Power Level	Type and Explanation
5/18	15:42	< 100w	Linear scram - operator range switching error.
5/18	16:24	250kw	SHIM rod dropped again.
5/18	16:42	250kw	SHIM rod dropped again.
5/19	14:50	250kw	SHIM rod drop.
5/19	15:01	250kw	SHIM rod drop. Operations suspended to work on SHIM magnet circuit.
5/23	13:20	250kw	Seismic scram. No sign of seismic activity. Assume too sensitive setting after start-up tests.
6/2	13:32	250kw	SHIM rod drop again.
6/2	14:02	< 300w	Period scram - operator inattention during restart to power.
6/2	15:39	250kw	Period scram - check being made in console of period scram Hg relay sticking.
6/2	18:09	250kw	SHIM rod drop again.
6/6	10:13	< 1w	Period scram - operator inattention.
6/6	12:27	< 300w	Linear power scram - trainee range switching error
6/8	08:57	< 100w	Period scram - operator inattention.
6/15	11:29	< 10kw	Linear power scram - operator range switching error.
6/20	11:06	< 1.5w	Linear power scram in automatic mode. No correct servo response.
6/21	08:17	250kw	Building power interruption caused scrams.
6/28	13:55	1.5w	Period scram caused by testing on period circuit in console.
6/30	12:45	250kw	Seismic scram. No sign of seismic activity. Too sensitive following rest after start-up test.
6/30	13:06	250kw	Linear power scram during rod banking movement. REG on servo could not adjust fast enough.

IV. Maintenance Operations

(1) Annual maintenance checks were made in January and all items including fuel rods, control rods, and detection systems were found to be in good order.

(2) Systems requiring maintenance other than routine were:

(a) Seismic trip - failed during daily test 8/10/77. Subject to brief report to NRC. Repaired and recalibrated the following day.

(b) Construction and use of a special rotating specimen rack filter system for use when samples cooled in dry ice are being irradiated was accomplished. This effectively reduces CAM recorded ^{128}I activity levels (see earlier reports) to below alarm levels. Personnel are still excluded from the room during such runs, but any activity is now effectively localized on filters and charcoal in a small drum.

(c) SHIM rod drive magnet. A continual problem has been the apart loss in power of the SHIM rod drive magnet such that jarring of the bridge system such as occurs during the firing of transient rods causes the SHIM rod to drop into core. Attempts to locate the cause seem to have eliminated everything but the magnet itself. Since this is an exceptionally expensive replacement, purchase of a new component has been delayed, pending exploration of all other alternatives.

(d) An evacuation of personnel was effected on 12/29/77 when the overtank area radiation alarm sounded. No other indication of any unusual radiation level was found and an electronic circuit "glitch" was blamed.

(e) +?5 volt power supply in console burned out on 1/10/78. This supplies voltage to much circuitry, but "shorts" out quite frequently when apparently "spiked" by current surges that occur when the reactor is scrammed. It seems

that it remained in the "shorted" condition once too often. A temporary 25 volt supply was used for three days while a new power supply was obtained. This latter was installed on 1/13/78.

(f) Pneumatic transfer system. Failure of a sample to return on 1/19/78 resulted in complete examination of the in-core terminus by X-ray. Following this the terminus was cut open so that the obviously broken up shock absorber component could be replaced. The system was rewelded, leak tested and placed back in service in core on 2/1/78.

Additional problems were noted with fracture of "rabbit" transfer capsules. These were of a new batch obtained from General Atomic. Discussions with the Company indicated that a new supplier and design were used. After several failures, this type were taken out of service and old ones and a second new batch used. There are still slightly greater frequency of fractures than with the earliest model, but so far no catastrophic failures. A closer watch is now kept on the frequency of use of each transfer capsule. Failures only occur in these at the cap threads so that the body usually does return to the unload port complete with sample. Thus no real safety considerations are involved, since the transfer capsule is never relied upon for encapsulation of samples.

(g) One component attached to the fixed area monitoring system to monitor samples being removed from the rotating specimen rack failed on 5/22/78. Several attempts to repair this unit by our electronics personnel have not been successful, perhaps partly as a direct GM tube replacement was not available. Efforts are still continuing, but the unit is still out of service. Local measurements of each sample as removed continue to be performed.

(h) The specimen removal tool ("fishing pole") electrical contact mechanism installed in the fishing reel had to be rebuilt as the circuit board and contacts had worn out. Some delays were encountered in manufacture of special parts but the unit was finally placed back in service 5/23/78.

(i) Problems were encountered with the scram reset mode in the period scram circuit. A mercury relay switch may have been the problem and was replaced.

(j) The REG rod position indicator potentiometer needed service on 6/28/78, as a worn spot at the zero position caused an open contact.

(k) The REG rod DOWN microswitch actuator lock screw was replaced on 6/30/78 to cure a problem of frequent slippage of this system out of adjustment.

V. Facility Changes and Special Experiments Approved

A monitoring system was installed to monitor all samples returning at the PT system load/unload terminus. This consists of a Technical Associates FSM-5 with ratemeter and alarm system coupled to a miniature G-M tube detector. Experiments are being conducted to establish the most appropriate alarm settings and calibration procedures. Meanwhile, the system serves as a warning device for unusually active samples and operators are instructed not to handle samples or items which trip the alarm (~200 mr/hr setting).

No other significant facility changes were made during this period and no special experiments were approved.

VI. Radioactive Effluent Release

(a) Gases. The sole direct release to the environs is ^{41}Ar produced during normal operations. The following releases are estimated based on measurements at points of origin within the facility and taking only dilution in the exhaust stream into account. Continuous measurements by means of an environmental dosimeter in the exhaust stack (see next section) confirm that the submersion dose to an individual at the exhaust stack would be less than detectable limits (?< 5 mr) above background over each quarterly period.

(1) Operation of the pneumatic transfer system (8/1/77-7/31/78):

Total (?50 kw) assumed)	13,880 minutes
Release rate	6×10^{-8} $\mu c/ml$
Flow rate (exhaust)	2×10^{6} ml/sec
Total rele[illegible]e:	1×10^{5} μC_i

(2) Release from pool surface:

Total operation (Mwh x 4)	731 hours
Release rate (assumed)	$< 1 \times 10^{-8}$ $\mu c_i/ml$
Flow rate (exhaust)	2×10^{6} ml/sec
Total release:	$< 5 \times 10^{4}$ μC_i

Total of (1) and (2): $< 1.5 \times 10^{5}$ μC_i

Concentration averaged over 12 months = $< 2.4 \times 10^{-9}$ $\mu C_i/ml$.

(b) Liquids and Solids. Liquid and solid wastes from utilization of by-product material are disposed through a University contractor.

The following quantities are logged for 7/77 - 6/78:

Solid waste: (a) 56 cubic feet low level activation products < 12 mC_i total.

(b) ~ 20 curies ^3H - spent targets from fast neutron accelerator tube in sealed tubes, mostly absorbed on Ti metal target (0.5 cuft).

Liquid waste: 11 gallons of aqueous solutions of mixed activation products estimated < 2 mC_i total. All above materials are mixed with other isotopes used under State of California Permit on Campus for final disposal.

Records of final disposal are maintained by UCI Environmental Health & Safety Office.

VII. Environmental Surveillance

Environmental Surveillance Packs containing $CaSO_4$: Dy thermoluminescent dosimeters from Radiation Detection Company, Sunnyvale, California, have been placed in locations around the Campus. Starting in July, 1977, two additional locations were included: one in the fume hood exhaust from the reactor facility laboratory and the other off campus in a home in the adjacent city of Irvine. This badge, in a wood framed home is intended to provide a true "low" background blank, although since all other dosimeters are in concrete buildings, their "background" will still be used for subtraction purposes, unless unusual readings are observed in which event the "control" will be useful.

Locations:

1. Window of reactor room (inside facility).
2. Between reactor laboratories and radiochemical lab, in hall.
3. Loading dock, adjacent to west wall of reactor facility.
4. Classroom 152, over reactor facility.
5. In roof exhaust air flow from reactor room.
6. Steinhaus Hall (Bio. Sci.) building: 4th floor.
7. Library Building, 5th floor.
8. Computer Science Building, 4th floor.
9. Fume Hood Exhaust, Roof Level, from reactor lab.
10. 17941 Spicewood Way, Irvine (Control).

Table IV shows the data received from RDC measurements.

Table IV

ENVIRONMENTAL THERMOLUMINESCENT DOSIMETER REPORT

1977-78

Average Exposures in mr

Location	Quarter 1 4/77-6/77	Quarter 2 7/77-9/77	Quarter 3 10/77-12/77	Quarter 4 1/78-3/78	Total	Total less "BACKGROUND" (130 mr)
1	58	64	62	72	256	126
2	61	59	72	48	240	110
3	60	74	51	46	231	101
4	31	31	34	27	123	0
5	27	28	-	30	(85) (3 quarters)	0
6	32	35	38	31	141†	(0)
7	33	35	39	35	142†	(0)
8	25	28	25	29	107†	(0)
9*	-	35	39	36	110 (3 quarters)	0
10*	-	25	22	30	77 (3 quarters)	0

* Addition locations added 7/1/77.

† Average of these used for background.

<u>Summary</u>: All levels are background within experimental variation with the exception of locations 1, 2 and 3. The dose received at these locations is accumulated as a result of the Cesium Gamma Irradiator "normal" background, the use of the 14 MeV neutron generator (N-16 activity in the cooling water), by-product (samples from experiments) storage and, probably least, from direct reactor operations. The highest annual personnel exposure indicated would be 0.13 rem. Since areas 1 and 2 are partly controlled - the building is locked at night and on Sundays, the maximum possible exposure is only 0.10 rem in location 3.

VIII. Radiation Exposure Records

In order to coordinate with proposed rulings requiring annual submission of personnel dosimetry studies on a Calendar year basis, the results presented in this report are those for Calendar year 1977. Thus they include six months of data already reported in last year's annual report. This overlap will not be repeated hereafter.

During the earlier report, the high dose to one individual as a result of an incident were fully discussed. The annual doses recorded are presented in Table V.

Almost all of these exposures have been acquired as a result of handling of isotopes in experiments subsequent to reactor irradiation (i.e., handling of by-product material). Most are not unreasonable in view of the large number of experiments performed by these individuals. These personnel have been informed of their continued exposure and encouraged to attempt to minimize future exposures. In some cases, such exposure has occurred outside the confines of the reactor facility in State of California licensed areas. All personnel monitoring results are combined, however, in a single badge or ring measurement, as to personnel "UCI activities." About one-half of the personnel monitored also carried neutron film. No non-zero exposures were reported for neutrons (or have ever been reported for this facility).

59 of the personnel reported were undergraduate students in a class in Radioisotope Techniques. These students perform several experiments within the reactor facility as well as others, some using reactor by-product materials in a laboratory elsewhere. No non-zero readings were reported for this group.

Table V

Personnel Dose Summary - 1/1/77 - 12/31/77, in mrem

Whole Body

Individuals	Pen	Non-Pen	Finger Ring
1	355	0	1830
1	150	470	( )*†
1	95	70	120
1	35	0	0
1	20	170	1120
2	20	0	0
1	15	0	0
1	0	190	80
1	0	0	360
1	0	0	210
1	0	0	90
1	0	0	60
1	0	0	50
82	0	0	-*

*not monitored

†estimated 30 Rem (4/13/77) - see prior report

Contamination surveys consisting of wipe tests and G-M counter surveys show significant removable contamination in isotope handling areas. Further spread has not been encountered. Such contamination is of a short half-life variety and decreases markedly if sample handling has not recently occurred. Independent surveys performed by the E, H & S office have confirmed these conclusions.

Radiation level measurements performed with the reactor at full power remain completely consistent with those obtained when the facility was first surveyed.

A complete neutron and gamma survey was conducted by the Campus E, H & S office on 9/9/77 using a 1 x 1 NaI detector for gamma and a Ludlum 10" sphere 42-4 system for neutrons. The results were as follows (reactor at 250 kw):

	Reactor Bridge	Classroom Over (max rdg)
Neutrons:	3×10^{-3} mrem/hr	Background ($< 7 \times 10^{-5}$ mrem/hr)
Gamma (integ): (via ion chamber comparison)	1.1 mr/hr	.03 mr/hr

U.C. Irvine
Department of Chemistry
Nuclear Reactor Facility

Report: Reactor Core Unload, Removal of Objects, Reload to Criticality, Excess Addition and Calibrations

Period Covered: October 22nd - November 10th, 1978

Report Date: December 1st, 1978

References: Incident Reports for 8/8/78 and 9/28/78
- Proposed Installation of Temporary Fuel Storage Racks to Permit Core Unload (10/11/78)
- Evaluation of Proposed Storage Rack Installation (10/15/78)
- Procedure for Unloading Core Components and Retrieval of Dropped Items (10/11/78)

Since attempts to remove the finger ring and pen dropped into the region below the core had failed, a procedure was initiated to unload the core. On 10/22/78 two storage racks built from "Dexion" aluminum alloy using stainless steel nuts and bolts were installed in the tank. Slight modification to the length was needed as the tank walls were found to bulge more than anticipated. The racks were finally lowered securely onto the floor of the tank and fastened by bolts to the top of the tank. A wooden ladder placed across the open end of the pool formed a rest platform for personnel loading the rack. The six B ring elements were removed to one of the former storage racks at the pool side. The C ring elements followed by all D and E ring and 9 from the F ring filled the new large rack (59 elements in a linear array). The following day, the remaining F ring elements were removed to the smaller new rack (10 elements) and 2 were placed in remaining vacant positions in old racks. All graphite ("dummy") elements were cool enough (20 mr/hr surface maximum) that they were completely removed from the tank and placed in plastic bags in one of the "fuel element storage pits" in the room. The REG and SHIM control rods were removed from core to storage rack positions in the old racks. At no time during these operations were any significant radiation levels experienced by any of the operational monitors nor on any of the personnel dosimeters placed around the top level of the tank.

On October 24th, the ATR rod and drive was dismantled and the rod tied securely at the side of the tank. It was then observed that the dosimeter ring could just be observed on the support ring below the lower grid plate now that better illumination could be obtained in the empty core area. Thus it was decided to forego removal of the FTR drive system and attempt removal of the items with no further dismantling of core structure especially as it had been ascertained some days before that the grid plate bolts on our model core could not even be accessed without removal of the rotary specimen rack - a considerably complicated chore.

In addition, attempts were made to grasp the pen which could be "poked" out into view from its location just beneath the lower grid plate. The latter attempts resulted in disintegration of the pen which had apparently become quite brittle. The pen "filler" however was not so brittle and this was maneuvered out into view beneath the core and retrieved with a "grabber" tool. This section, including the metal end, was removed intact, complete with ink filling, and had almost no radiation level.

The following two days were spent using various "prods" in attempting to dislodge the remaining objects into view. In addition, three of the adapters used to plug large holes in the bottom grid plate were removed to give better access to the safety plate. Radiation level on contact for these aluminum cylinders was only 20-30 mr/hr maximum. Finally, by using the cooling system operation, most of the plastic parts of the pen were swept out of the core area to the bottom of the tank and swirled to the end away from the core. On October 30th, a long aluminum tube hooked to the compressed air line was used to blow down into the lower region of the core. After several goes at this, the finger ring was finally seen to have been dislodged from the core region and was visible on the bottom of the tank. On removal, the measured radiation level on contact was 0.5 mr/hr.

Reassembly of the core structure was commenced 10/31/78 by first replacing adapters in the bottom grid plate at positions A1, D10 and E16 and replacing the central thimble and the ATR. On 11/1/78, the two fuel follower control rods were reinstalled and graphite dummy elements began to be replaced. This operation was continued on 11/2/78.

On 11/3/78, control rod reassembly was completed and rods checked out for drop times, the pneumatic terminus was reinstalled and the neutron source replaced. Prior to formal reloading the core contained two fuel follower control rods, two transient rods, one instrumented fuel element and 34 graphite elements.

At about 14:00, critical loading was commenced with a scaler being used on the count rate channel and a Keithley microammeter to monitor the log chamber readings. Instrumentation was confirmed to be monitoring neutrons. The estimated k_{eff} from the scaler counts (3, 2 min. counts, averaged) for each loading step were as followed:

Step	# Elements Added	Total # Present	Co/C	Predicted Critical (# elements)
1	24	27	0.88	60
2	12	39	0.82	70
3	6	45	0.73	100
4	6	51	0.67	
5	6	57	0.49	73
6	5	62	0.27	68
7	3	65	0.20	68
8	1	66	0.11	68
9	1	67	0.07	69
10	1	68	0.03	69
11	1	69	(35.0 sec period)	crit'.

Assuming old rod worths when last shutdown, shutdown margin of reactor is $8.00 at this point. Loading completed at 01:06 a.m. on 11/4/78.

On 11/7/78 a remeasurement gave k_{eff} of 1.0013 (by period).

On 11/8/78, 8 additional elements were added to core yielding a core excess based on period measurement summations of $2.94. Rod calibration measurements were completed on 11/9/78 with the following results:

		At previous operation
REG	$4.48	$3.75
SHIM	$2.70	$2.84
ATR	$1.93	$1.96
FTR	$0.55	$0.61
Total	$9.66	$9.16

These values are commensurate with the changes made in the loading pattern which placed more graphite adjacent to the REG rod side of core and included a Cd lined fast pneumatic terminus adjacent to the REG rod. This latter was not reinstalled at this time in core.

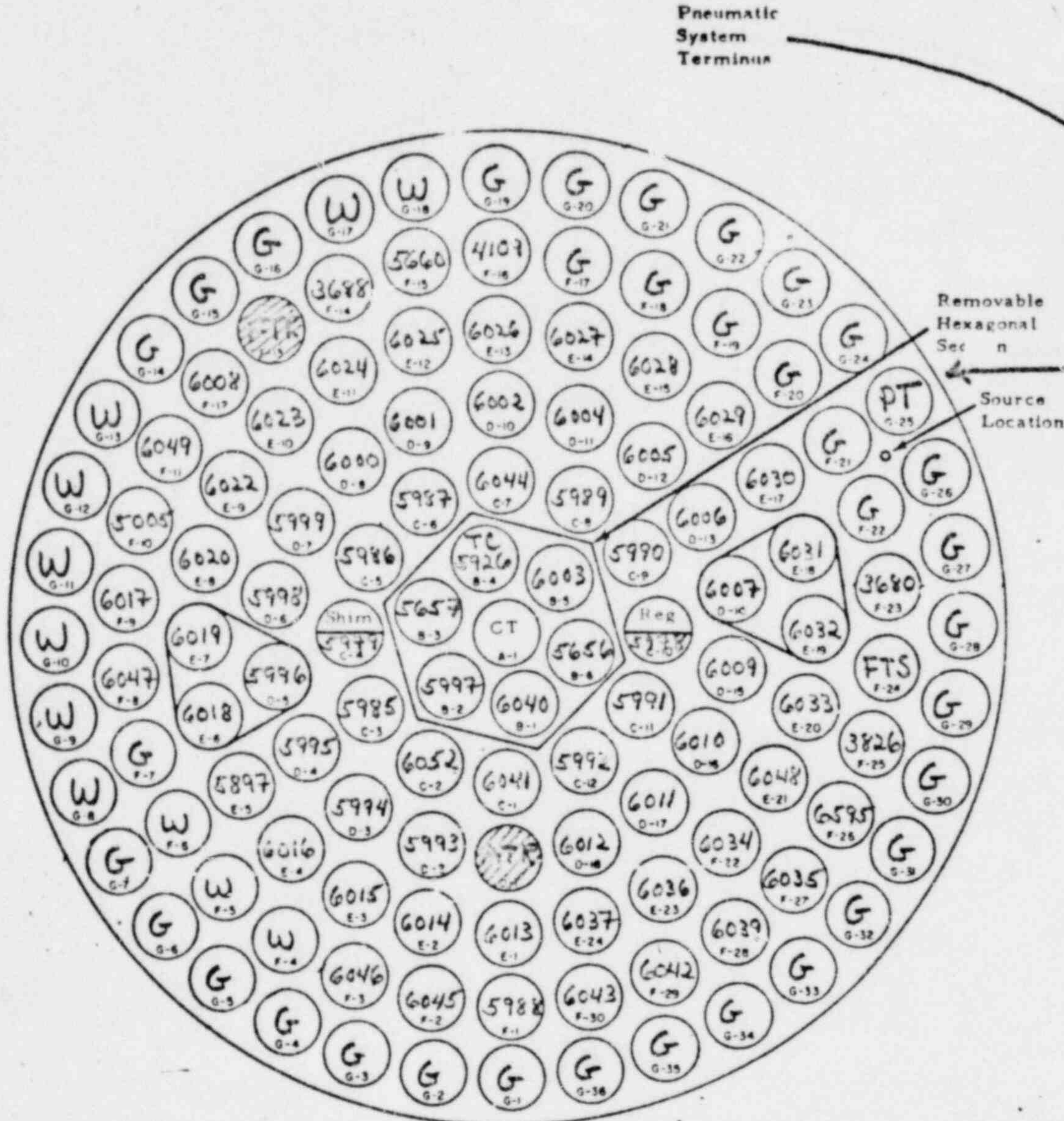
Power calibrations were performed on 11/10/78, and a value of 206.6 kw obtained for an indicated power of 200 kw. Chamber position adjustment was made to correct this small discrepancy.

A loading diagram of the revised core is attached. All parameters in the reactor are in satisfactory agreement with those measured in earlier arrangements and in the initial core loaded in 1969. The differences are mainly that burn up increased the critical loading from 60 to 69 elements even though 12 additional positions are filled with graphite. This time, all holes on the open side of the core have been filled in the hope that this will lessen the chance of dropped objects entering the core region.

Routine operation of the reactor was resumed on 11/14/78 following shutdown since 9/28/78.

The only "incident" during all the handling was the dropping of one graphite element while removing it from a storage pit. The soft aluminum pin bent slightly to one side as a result of this. This was straightened sufficiently with gentle hammering using a lead brick as an anvil and deburred slightly with a file. Close inspection indicated that no obvious damage to any welds could be seen, and the element was retained in service. Because of their much lighter weight, the graphite elements do not lock so securely into the fuel handling tool as do the fuel elements and are more easily "let go."

Final Core Loading NOV 10 1978



Experimental facilities	3
Control Rods	2
Fuel follower control rods	2
Fuel Elements	75
Graphite dummies	34
Water holes	11

⊖ CONTROL ROD AND FUELED FOLL WER

(TR) TRANSIENT ROD

(CT) CENTRAL THIMBLE

(G) GRAPHITE DUMMY

MIII-18E-IRV

CORE LOADING DIAGRAM

(PT) PNEUMATIC TERMINUS

TRANSIENT RODS

(W) EMPTY POSITION

(TC) THERMOCOUPLE

Department of Chemistry
University of California, Irvine
Nuclear Reactor Facility

10/11/78
G. E. Miller

Proposed Installation of Temporary Fuel Storage Racks to Permit Core Unload so that "foreign" objects can be removed from below core.

Purpose

The additional fuel storage racks are intended to provide locations within the reactor pool so that all fuel elements may be removed from the core. Additional devices not containing fuel and graphite reflector elements will also be removed so that the core grid plates (upper and lower) can be unbolted and removed. This will then permit direct access to the shield region below the core so that objects dropped into that area can be removed. Specifically a pen and a finger dosimeter ring are known to have dropped into this area.

Design (See diagrams attached)

A rack will be constructed from angle aluminum alloy to hold 59 elements in a straight line configuration, two inches between centers. The rack will be bolted to vertical angle sections which in turn will be bolted through holes in the top support rim of the tank, via short sections of angle. This rim was installed for attachment of devices and runs completely around the pool. The rack will extend across the 10 foot width of the tank. The lower portion of the rack will have locating holes for the individual elements - 1 5/8 diameter holes at the top and 5/8 inch diameter holes at the base. The base portion will consist of two pieces of angle bolted with a plate containing the 5/8 inch diameter holes to form an inverted channel which will rest on the bottom of the tank. No vertical weight will actually be supported by the sections attached at the tank rim. A horizontal section of angle will be bolted perpendicularly to the base of the rack at its center in order to provide additional support against tipping.

A small additional rack will be similarly constructed to contain 10 elements and this will be installed at the very end of the tank where it will be at least 4 1/2 feet away from the larger rack.

Elements will be placed in the racks using the standard element handling tool. In position in the rack the base of the element will be located only 1/8 to 1/4

inch above the bottom of the tank. Any conceivable slippage or falling of an element would thus involve only a very short vertical distance.

Design Bases

The criterion established within the facility license for fuel storage are contained within the Technical Specifications, Section 5.3, reproduced in entirety below:

5.3 Fuel Storage

Applicability

This specification applies to the storage of reactor fuel at times when it is not in the reactor core.

Objective

The objective is to assure that fuel which is being stored will not become supercritical and will not reach unsafe temperatures.

Specifications

a. All fuel elements shall be stored in a geometrical array where the k_{eff} is less than 0.8 for all conditions of moderation.

b. Irradiated fuel elements and fueled devices shall be stored in an array which will permit sufficient natural convection cooling by water or air such that the fuel element or fueled device temperature will not exceed $800^{\circ}C$.

Bases

New fuel is stored in their shipping containers. Hot fuel is stored in pits described in the submittal to the AEC dated June 5, 1969. These pits are designed to hold 19 elements, an amount which cannot form a critical array. Very hot fuel is stored in racks in the main tank where cooling water is provided.

The two safety criteria established are those of (1) criticality considerations and (2) of cooling provision. It may be assumed that these criteria should

also be met in the event of a credible incident such as an earthquake, and that these criteria provide acceptable margins of safety, therefore, for both normal and accident situations.

(1) Provision against accident criticality is made by requiring that the effective multiplication factor be less than 0.8.

Assessment of the value for k_{eff} for configurations of TRIGA fuel elements is complicated by the extremely heterogeneous nature of these elements. Calculations were performed at General Atomic in 1966 using a computer code GAZE, in which a homogeneous model representing an infinite plane 1.47 inches thick containing 42.3% water (corresponding to fuel elements placed on a 2 inch centered separation in an infinite row). The homogeneous material was assumed to contain the correct amounts of uranium (235 and 238), hydrogen, zirconium and stainless steel in addition to the water. The assumption of an homogeneous system is certainly conservative as lumping the fuel, as in a real element, causes some self shielding. This effect may be partly offset - but not completely so - by a small reduction in the effective U 238 resonance integral.

The assumptions made apply to the type of fuel used at UCI. The calculations yielded a value for $k_{eff} = 0.51$ for a plane array, 1 element thick, of an infinite number of elements. A similar calculation was also performed assuming that two such arrays were placed side by side as if two racks were placed adjacent to each other. In this case, $k_{eff} = 0.72$ was obtained.

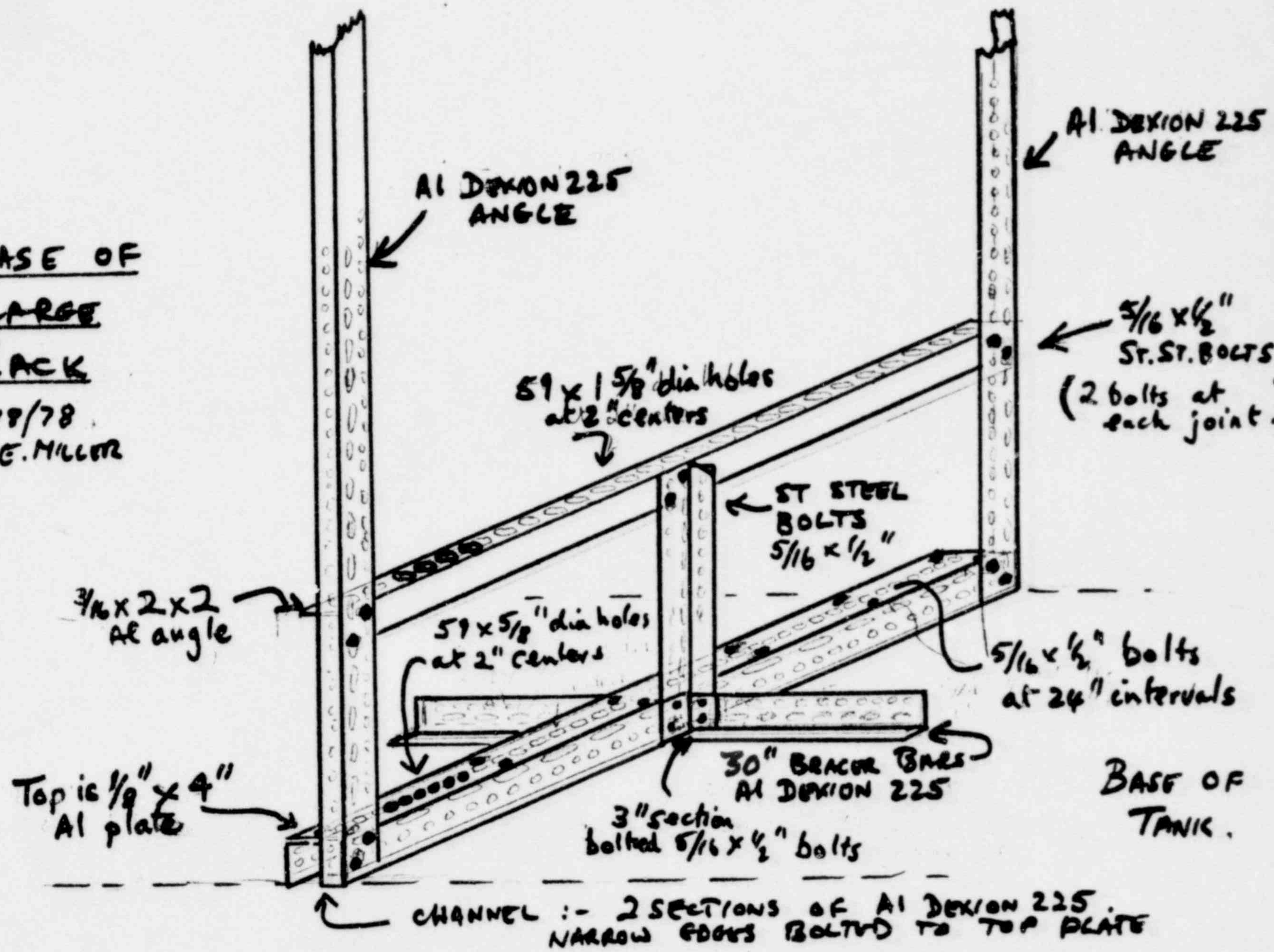
Allowing for the conservative nature of the assumptions and also that elements were assumed to be new with a full content (40 grams) of U-235 (ours have between 36-39) and no poison build-up, gives confidence that these particular arrays would both meet the < 0.8 criterion for k_{eff} required by Section 5.3.

An additional margin of safety is provided by the large separation proposed between the new (temporary) racks and the previously existing racks - at the opposite end of the pool. Not only are they separated by the longitudinal distance in the pool but the previous racks are at a height of some 12 feet off the bottom of the tank.

(2) Cooling. Elements in such racks are clearly as well cooled as when sitting in the core structure. Adequate cooling is assured.

BASE OF LARGE RACK

10/18/78
G.E. MILLER



10/15/78

Reactor Operations Committee, Nuclear Reactor Facility

University of California Irvine

Evaluation of Proposed Storage Rack Installation for Fuel Unload to Enable Core Dismantling. A Change in the Facility Authorized under Section 50.59 of 10 CFR.

According to Section 6.2 of the Technical Specifications for the U.C. Irvine Nuclear Reactor Facility, the Reactor Operations Committee has the responsibility to:

6.2.b.2. Review and approval of all proposed changes to the facility, procedures and Technical Specifications.

3. Determination of whether a proposed change, test, or experiment would constitute an unreviewed safety question or a change in the Technical Specifications.

The following evaluation is made to fulfill these responsibilities for the proposal dated 10/11/78 by Reactor Supervisor, G. E. Miller, for installation of additional fuel storage racks sufficient to hold all the core elements so that the core may be dismantled to enable items dropped below the core on 8/8/78 and 9/28/78 to be retrieved.

Safety concerns are as follows:

(1) Criticality considerations: Is the proposal adequate to assure that the margin of safety provided in the Technical Specifications, section 5.3, regarding fuel storage, is not reduced?

The proposal indicates that the fixed arrangement provided will maintain a k_{eff} of 0.51 or less. Since only one element will be handled at a time, the placement of this element in any location adjacent to the array cannot increase k_{eff} to anywhere near 0.8, the safety margin limit. The calculational estimates appear entirely reasonable in the light of experience with geometry of critical TRIGA cores. No one rack, maximum 59, will contain enough elements which placed in a core array arrangement, complete with graphite reflector elements and with no burn-up or poison allowance, would achieve criticality since 60 elements

were required for initial reactor criticality. Seven additional elements were needed at that time to raise k_{eff} to 1.020. Transient supercritical conditions of $k_{eff} = 1.021$ were shown to be perfectly safe (SAR Sections 7.2 and 8.5) for this type of fuel.

It is concluded that from criticality considerations no unreviewed safety question exists, nor is a change in Technical Specifications required by this proposal.

(2) Fuel element cooling. Is the proposal adequate to ensure that sufficient cooling is provided for irradiated fuel elements so that excessive cladding temperatures are not attained as a result of fission product heating?

A specific design basis is not provided in the fuel storage section of the Technical Specifications, which simply requires "adequate" cooling. In the SAR and in other sections of the Technical Specifications, it is indicated that 900-1,000°C may be considered the Safety Limit and that temperatures below 800°C would provide an adequate margin of safety. Elements are clearly maintained well below this temperature at their current core locations. Movement to the proposed racks clearly permits even better access for cooling water at the same temperature (that of the pool).

Adequate element cooling is assured so that no unreviewed safety question exists, nor is a change in Technical Specifications required.

(3) Mechanical Security of Elements. Is the proposal adequate to assure full mechanical support for the fuel elements at all times, even in the event of a calamity such as an earthquake?

No basis for this requirement can be found in the SAR or in the Technical Specifications. The present racks used at the facility since 1969 for storage of used fuel were of "standard" General Atomic Company design and were thus assumed to provide adequate mechanical support. In comparison to those racks, the proposal, which allows for the same fuel element array configuration, appears to offer additional mechanical benefits, primarily because the proposed racks are entirely supported by the base of the reactor tank so that the support braces are not required to be under vertical tension. In addition, other than tilting over completely, the elements, in the unlikely event of a rack break, essentially have

nowhere to fall, since they are located immediately above the floor of the tank. The pre-existing racks are at heights of about 12 feet above the tank floor. It appears that the proposed fastening and bracing of the new racks against tilt will be sufficient to prevent any such occurrence even in the event of a major seismic shake.

It is concluded that the proposal provides mechanical support for the temporarily stored fuel which is superior to that provided in pre-existing storage racks and comparable in stability to location of the elements within the core grid plates.

Thus it is also concluded that no unreviewed safety question is raised by the proposal in this regard, nor is a change in Technical Specifications required.

(4) Release of Fission Products from a Damaged Element. Is the proposal adequate to assure that the probability of release of fission product materials from damaged elements is not increased and that the hazard from such release, if it did occur, would not be enhanced?

Neither the SAR, nor the Technical Specifications specifically address the question of the relation between handling fuel elements and the probability of release of fission products as a result of cladding damage. However, the Technical Specifications, in requiring annual fuel measurement and inspection require that individual elements be handled on a frequent basis. A special tool was provided by the reactor manufacturer for this purpose. Thus it may be supposed that at facilities such as this, the handling of fuel elements, one at a time, may be considered "routine." The Reactor Supervisor proposes that all elements handled be passed through the normal annual inspection process before being placed back in core upon completion of the strip-down. This, together with the continual operation of all monitoring equipment within the facility, as required by the Tech. Specs., would seem to provide adequate assurance of the discovery of any damage.

Only one fuel element will be handled at one time since only one handling tool exists at the facility. Thus the section of the SAR (Section 8.7) which examined the consequences of release of fission products from a B-ring element

stripped of its cladding following an infinitely long irradiation are directly applicable here. In this it was shown that an individual could remain in the reactor room for about 25 minutes before exceeding a dose of 100 mr. Even in the incredible event that the pool water were not present, the 300 rad thyroid dose limit would only be reached following an 11 minute exposure. These calculations made the conservative assumptions of immediate release and mixing, and no exhaust flow or dilution. They were also made for the hottest fuel element under long term irradiation conditions.

These considerations indicate that, although not pleasant or desireable, the consequences of complete release from a bare TRIGA fuel meat are not unmanageable. The likelihood of such an event as a result of the current proposal is concluded to be no greater than that from other "routine" fuel handling operations at this, and other, facilities. In addition, the consequences of mechanical damage to an element cladding are clearly within those discussed by the referenced section of the SAR.

Thus it is concluded that no unreviewed safety question exists with regard to possible release of radioactive fission products from a fuel element damaged during this procedure, nor is a change in Technical Specification involved.

Approval

The Reactor Operations Committee, acting under the authority indicated within the Technical Specifications for the U.C. Irvine Reactor Facility, and acting on behalf of the licensee as indicated in 10 CFR 50.59, thus approves the proposal to install storage facilities for fuel elements within the reactor pool, and removal of the core elements thereto with the following provisos:

(a) The Committee shall be kept informed frequently as to progress in the various stages of this procedure.

(b) The transferral of fu[illegible] or any other portion of the core component removal or reinstallation shall be halted at any time that any unexpected event occurs, or any unusual radiation monitoring response is obtained. Such event shall be reported as soon as possible to members of the Committee and concurrence of a majority of the Committee shall be obtained before further operations are conducted.

(c) Authorization is hereby provided ONLY for a one time utilization of the additional storage racks. Any further use of these racks for storage of any fuel elements subsequent to this particular operation is expressly prohibited without Committee approval.

Approval Signatures.

Approval is indicated of the Evaluation of Proposed Storage Rack Installation for Fuel Unload to Enable Core Dismantling. A Change in the Facility Authorized under Title 10 CFR, Section 50.59.

Document Dated October 13th, 1978.

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E.K.C. Lee , Chair (Date)

F. S. Rowland Oct. 15, 1978

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Original signed by Full Committee

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Restrictions noted and accepted:

______________________ ______________

G.E.Miller, Reactor Supervisor (Date)

______________________ ______________

P. Jerabek, Assistant Reactor Supervisor

Procedure for Unloading of Core Components and Retrieval of Dropped Items.

1. Basis

The complete core contents need to be unloaded so that the upper and lower reactor grid plates can be removed to permit direct access below the core.

2. General Requirements

a. Instrumentation. As required by the facility license, console instrumentation, area monitoring systems and the continuous air monitor must be operational for all work involving core components. Thus, a START-UP checklist MUST be performed, each day, to assure this.

b. Console Operator. An Operator in Charge must be logged in at the log book. This operator will observe console instrumentation at all times that work on the core is in progress. Each and every item moved in the core area must be entered in the reactor log at the time that the move is made. The entry shall indicate the time, the object, the original location and the final location. Any unexpected event, or observed peculiarity about any item shall also be logged.

c. Fuel element records. Every time a fuel element is moved, its serial number and initial and final location must be recorded in the reactor log. In addition, its new location must immediately be entered on the Fuel Record Sheet for that element and the tag corresponding to that element must be moved to record the final location.

d. Personnel. Only personnel authorized to do so may handle items or enter records. A list of authorized personnel will be prepared by the Assistant Reactor Supervisor, reviewed by the Reactor Supervisor and submitted to the ROC for review. All personnel within the facility shall be wearing monitoring devices. Personnel working handling objects within the pool shall wear lab coats or coveralls

and shall be surveyed for loose objects before entering within the guard rail. Other personnel may not enter within the guard rail and, at the discretion of the Reactor Supervisor or his superiors may be excluded from the reactor room completely.

Operations shall not be commenced until adequate personnel are present. Minimum personnel shall comprise at least one licensed operator within the control room (as indicated above), one licensed operator and at least one other authorized individual in the reactor room.

e. Radiation Safety. In addition to the personnel monitors required above and the fixed facility monitors, also required, the following monitoring arrangements shall be made at all times that work on the core is in progress:

1) One monitor with an audible indication of dose rate (either PRM or Geiger type) shall be in operation on the reactor bridge immediately above the core.

2) The "over-tank" area radiation monitor readout shall be set to alarm at 5 mr/hr instead of the normal 10 mr/hr.

3) Personnel dosimeters with read-out shall be read every hour and the indicated reading recorded. If possible, such devices shall be worn by all those working directly above the pool.

4) A Cutie-Pie or Ju[illegible] monitor which has been recently calibrated shall be available within the reactor room. All items removed from the pool shall be monitored with such a device and the reading recorded in the radiation log book.

5) ALL PERSONNEL SHALL EVACUATE IMMEDIATELY FROM THE REACTOR ROOM IF ABNORMAL OR UNEXPECTED RADIATION LEVELS ARE INDICATED BY ANY DEVICE.

f. Avoidance of Contamination

1) No items shall be placed in the pool until they have been suitably cleaned. For metal items (with the exception of the fuel element handling tool) this shall include the use of a degreasing solvent followed by distilled water. Handling of such items shall be done entirely using gloves.

2) Items removed from the pool shall, where possible be placed into plastic bags while still over the pool water to avoid dripping. If this is not feasible, the items shall be placed on absorbent materials on the floor of the reactor room. Special areas of the room shall be marked off for this purpose. Any such items which are not to be reused shall be carefully monitored for contamination prior to storage.

3) All personnel shall check for shoe and hand contamination using a suitable low-level geiger monitor prior to exiting the reactor room.

3. Order of Strip-down.

The following order of removal and storage of major core components shall be followed as far as possible. Minor modifications to this order may be made by the Reactor Supervisor as the work proceeds. Major changes must be reported to the Reactor Operations Committee prior to performance of the operations.

a. In examination and attempts to remove the offending items to this point the following systems have already been removed:

   1) Pneumatic Transfer System Terminus.
   2) Fast pneumatic system terminus - regular.
   3) Fast pneumatic transfer system terminus - Cd lined.
   4) Six "B" ring elements to "regular" storage positions: II, JJ, KK, LL MM and NN.
   5) Central Thimble assembly.

   Each of these devices has been securely fastened at the side of the tank away from further operation areas.

b. Remaining items to be removed in the order indicated and to the indicated locations.

Items to be removed from reactor core:

1. Graphite dummy elements from G-ring. Individually to be removed from the pool and collected, five elements to a plastic sack within the fuel storage pits. Radiation levels must be monitored at all times.

2. Remove fuel elements,one at a time, commencing with the C ring to the large rack, loading the latter from one end with consecutive elements removed, to avoid position confusion.

   Fuel inventory sheets and a tag board will be updated with each transfer.

   When 59 elements have been removed, continue by filling the 10 element rack at the pool far end.

3. Remove REG rod drive mechanism and then the rod itself. This unit to be stored in the 'old' rack on the tank south wall.

4. Remove SHIM rod drive mechanism and then rod itself. The rod to be placed in the 'old' storage rack on the tank south wall.

   Both the drive mechanisms to be carefully placed in the back counting room bench so as to avoid accidental damage.

5. Remove ATR drive mechanism by usual procedure. Remove this mechanism from above the bridge to the back laboratory for storage. The control rod then will be removed from core and fastened at the tank side.

6. Remove FTR cylinder mechanism. Remove FTR support shroud system and rod, intact. This system shall be removed from the pool - CARE with dripping water! - and laid on the floor to the south of the reactor tank on absorbent paper for subsequent inspection before reinsertion. Monitor radiation levels.

7. Remove control rod guide tubes by unscrewing carefully with hook tool. Each one to be identified carefully immediately after removal and stored as appropriate to radiation level.

8. Using the screw onthe pole without the hook, remove the fuel element adapters from below positions D-10, D-8, and D-3.

9. Considerable visual access should now be available to the

region below the core.

AT THIS POINT, FURTHER DISMANTLING WILL CEASE.

An attempt will be made using a water pipe flow to dislodge the known objects from their 'flange' positions down into the below core area. If this is successful they should be able to be seen through the grid plates. If so, an attempt will be made to retrieve them using the previously constructed 'grabber tool'. A report on the success or failure of this attempt will be made to all concerned.

A decision as to whether to proceed to remove the rotating specimen rack and the grid plates themselves can then be made at that time.

The visibility attainable with this much unloaded is shown by the photographs attached which were taken of our core before installation of any fuel elements, adapters or control rod guide tubes.

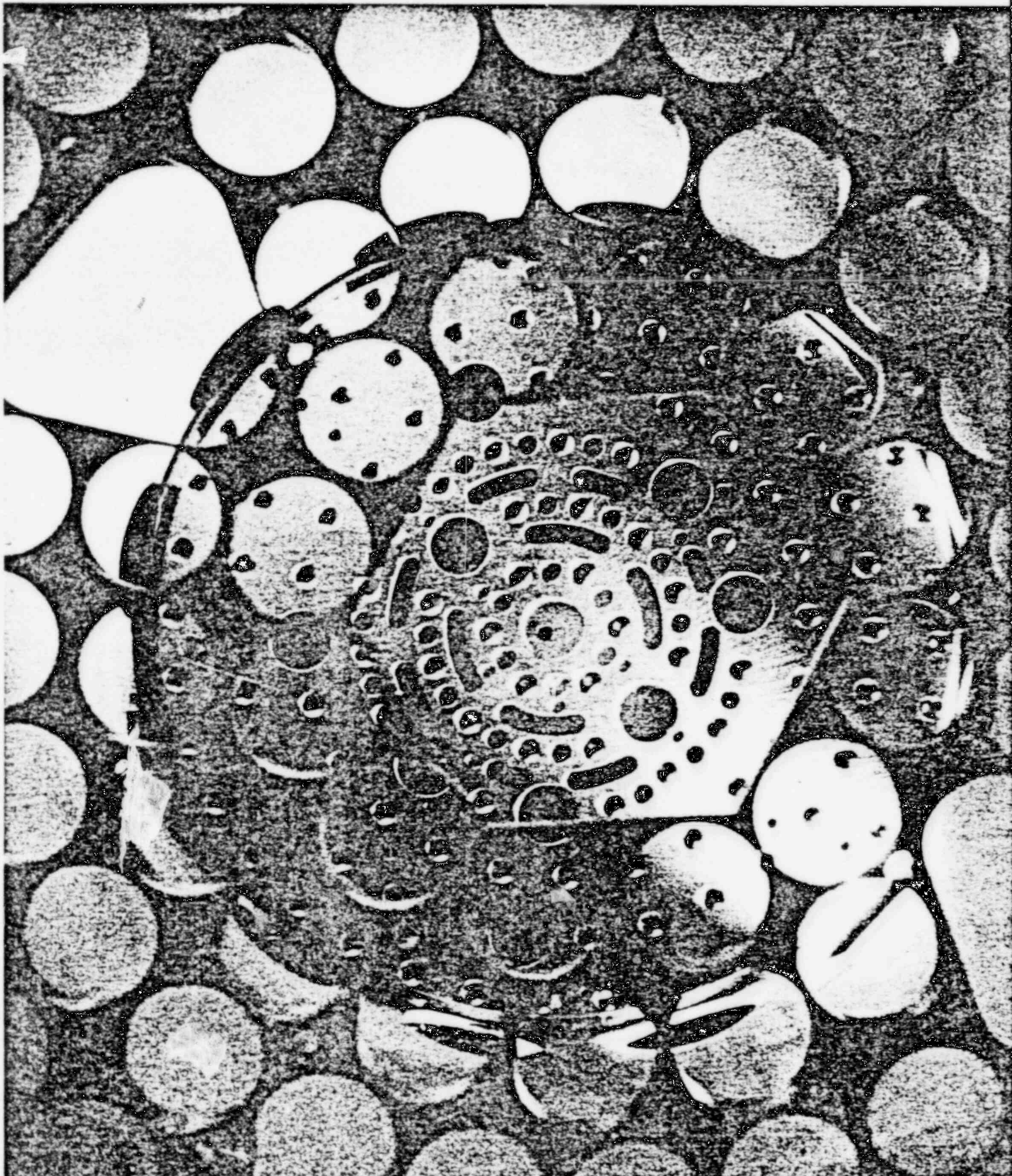

Fig. 5-12a

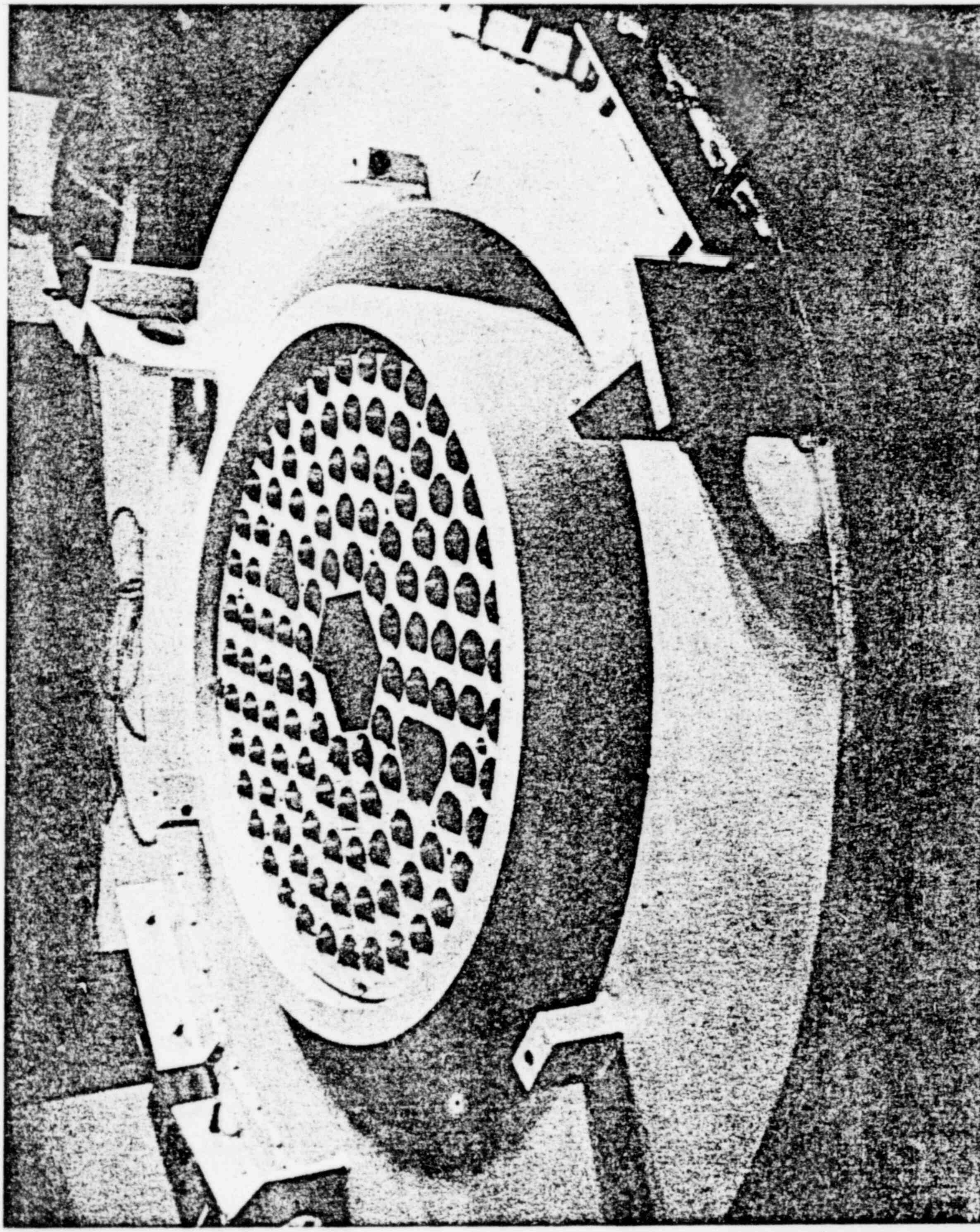

Fig. 5-12b