U.S. NUCLEAR REGULATORY COMMISSION
REGION I
REQUALIFICATION EVALUATION REPORT

Evaluation Report No. 50-166/87-02 (OL)

Facility Docket No. 50-166

Facility License No. R-70

Licensee: University of Maryland
College Park, Maryland 20742

Examination Date: March 29, 1987

Chief Examiner: D. Coe 5/29/87
D. Coe, Lead Reactor Engineer date

Reviewed By: RM Keller 6/4/87
R. Keller, Chief, Projects Section 1C date

Approved By: Samuel J Collins 6/4/87
S. J. Collins, Deputy Director date
Division of Reactor Projects

Summary: The NRC audited the facility licensee's administration of its 1987 requalification written examination to five out of six licensed operators. Twenty one percent of the examination was replaced with NRC questions, and all examinations were reviewed for adequate facility grading practices. All operators achieved a passing overall score and facility administration of this examination was determined to be satisfactory.

DETAILS

1. EXAMINATION RESULTS:

	RO Pass/Fail	SRO Pass/Fail	TOTAL Pass/Fail
Written Examination	0/0	5/0	5/0

Evaluation of Facility Written Examination: Satisfactory
Grading: Satisfactory

2. SCOPE

The facility prepared requalification written examination was reviewed by the NRC prior to its administration. The examination was administered to five senior operators. There are presently no licensed reactor operators at this facility. The NRC was present to monitor the proctoring methods used by the facility. Twenty one percent of the total examination value was replaced with NRC written questions to provide an independent check on examination validity. The NRC reviewed all facility graded examinations for adequate grading practices.

3. WRITTEN EXAMINATION

The facility written requalification examination consisted of a 100 point exam comprised of four equally weighted sections. Its format was identical to an NRC power reactor SRO written examination. The review determined that the facility examination was adequate to determine individual as well as generic knowledge deficiencies. However, three questions in Section 8, Administrative Procedures, Conditions, and Limitations were not operationally important and were replaced with NRC questions.

4. CONCLUSIONS:

This audit found that the facility properly wrote, administered, and graded a satisfactory requalification written examination for its licensed operators. Operator performance on NRC substituted questions was not significantly different than that on facility written questions, thus providing an independent check on the validity of the examination results. The facility commitment to continue to administer its requalification examinations on a proctored basis and in accordance with the NRC policy expressed in Generic Letter 83-17 is noted and will be subject to future inspection and audit. Since all operators fully passed the examination, it can be concluded that previous unproctored examinations did not adversely affect the overall knowledge level of the licensed operators.

Attachment: 1987 Written Requalification Examination and Answers

ATTACHMENT 1

Requalification Exam for 1987

Category V - Theory of Nuclear Reactor Operation

1. (3 pts) Using the six factor formula, describe the various processes which may happen to a neutron in one generation.

2. (See below)

3. (2 pts) Describe what happens and explain two reasons for the behavior when the source is withdrawn from the exactly critical condition at 10mW compared to 100kW.

4. (See below)

5. (2 pts) Explain how you could tell that you are exactly critical at 10mW compared to 100kW with the source inserted.

6. (2 pts) Descibe an experiment you could perform to measure the maximum shutdown Xe reactivity in the MUTR.

7. (3 pts) Assuming that the MUTR has a positive moderator temperature coefficient of reactivity, explain why the power level increases somewhat a few minutes after the primary pump is turned on at high power levels(e.g. 200kW).

8. (3 pts) Describe indications, if any, that may be observed on the control room instrumentation if the incore portion of the pneumatic tube broke while inserting a sample during high power operation.

9. (3 pts) State three reasons why the primary coolant water is kept as pure as it is.

10. (2 pts) State and explain the short term and long term indications you could detect due to a fuel rod rupture.

2. Your reactor is subcritical and K_{eff} is 0.95. Your start-up channel reads 20 CPS

a) When the count rate has increased to 40 CPS, what is the new K_{eff}? (Show all work) (2)

b) Would the reactor be subcritical, critical, or supercritical if enough reactivity was added to double the count rate again? (Show all work) (1.0)

4. Would the control rod's or shim rod's worth vary:

a) If another rod is placed adjacent to it. Briefly explain. (1.0)

b) If the moderator temperature increases? Briefly explain. (1.0)

Category VI - Reactor Facility Design, Control and Instrumentation

1. (2 pts) Describe and explain any differences you would see in the response of the CIC when going to low power operation following a scram for a long period (several hours) of operation at 200kW under two different conditions on the compensating voltage:
a. Undercompensated
b. Overcompensated

2. (2 pts) What setpoint setting would you adjust the fuel temperature so that it would scram at about the same power level as safety channels I & II. Would this violate the Tech Specs? Why?

3. (3 pts) From the attached drawing of the instrumentation, give labels to the numbers 1->6.

4. (3 pts) From the attached drawing of the MUT[illegible] configuration, give labels to the numbers 1->6.

5. (4 pts) List the construction design features which are implemented to minimize the release of radioactive material to the environment.

6. (4 pts) List , describe , and give the reasons for the sequencing of the up, down, contact, and mag on lights if you when button pushed drop the Reg. Rod from full out. Assume operating in the steady state mode.

7. (4 pts) Lable all the major actions on the attached chart recording , such as startup checks, red and blue pens, scrams, source removal, estimated power levels, etc.

8. (3 pts) Calculate the positive reactivity which is maintained by the automatic control system when going from 100mW to 200kW.

Category VII - Procedures - Normal, Abnormal, Emergency and Radiological Control

1. (4 pts) What conditions must be met prior to any fuel movement? How often must the fuel be inspected? What constitutes a damaged element?

2. (see below)

3. (4 pts) List the indications of a leak in the tube side of the first heat exchanger. What actions would you take if you discovered it while operating at 200 kW with the cooling system on. primary & secondary on.

4. (3 pts) List three types of Emergency Plan emergencies and give one example of each.

5. (3 pts) List the people who must be present during the removal of an experiment in the through tube. What precautions are to be observed?

6. (3 pts) Provide the following in accordance with 10 CFR 20 for radiation workers per quarter.
   a. maximum permissable dose to the whole body
   b. maximum permissable dose to the hands
   c. maximum permissable dose to the skin

7. (4 pts) A radioisotope is known to emit a single 2 MeV gamma ray for each disintegration. An unshielded sample of the radioisotope is observed to cause a radiation level of 0.5 rad/hr at a distance of 1 ft.
   a. How many Curies of the radioisotope is present?
   b. What is the radiation dose rate at 4 feet?
   What thickness of shielding will be required to reduce the radiation level from the sample to 50 mrem/hr at one foot? Assume a half value thickness of 1 cm.

8. The following measurements are made from a beta-gamma point source.

   2r/hr at six inches (1)

   0.5 mr/hr at ten feet (1)

   What are the relative fractions of betas and gammas emitted? (state assumptions and show calculations).

2. You are in charge of loading one of several experiments into the reactor

   a) What is the maximum allowable worth of this experiment? (1)

   b) How do you insure that the experiment is within the limits of part a)? (1)

Category VIII - Administrative Procedures, Conditions, and Limitations

1. (4 pts) Suppose an experimenter proposed to undertake a prompt jump experiment by removing a rabbit containing cadmium at low power critical conditions. What steps must be undertaken before this experiment could be undertaken?

2. (3 pts) Upon proceeding to 200kW, you notice that the CIC pen on the chart is not operating properly. What course of action would you take? Then suppose instead you notice that the fuel temperature indicator is not operating correctly. What course of action would you take?

3. (3 pts) During reactor operation, how many people must be present in the control room and what must their qualifications be? In the Chemical & Nuclear Engineering Building and their qualifications?

4. List the two Technical Specifications requirements that assure safe storage of your fuel when it is not in the core. (2)

5. (3 pts) During reactor operations, an experiment fails and releases substantial amounts of radioactive material into the reactor building. The evacuation alarm is sounded. What specific actions and responsibilities do you have as an SRO in this situation?

6. In accordance with your Technical Specifications, name four types of "Reportable Occurrences." (2)

7. Title 10, Part 55, Operators Licenses, defines an operator as any individual who manipulates a control of a reactor

   a) Define "control" (1.5)

   b) When can an unlicensed operator manipulate a control? (2)

8. Describe immediate actions required by procedures which must be performed upon learning that a group of students are marching to the Reactor Facility to attempt a sit-in. (2.5)

9. According to your Technical Specifications, the rate of reactivity insertion by control rod motion can not be greater than $0.30 per second. Briefly explain why. (2)

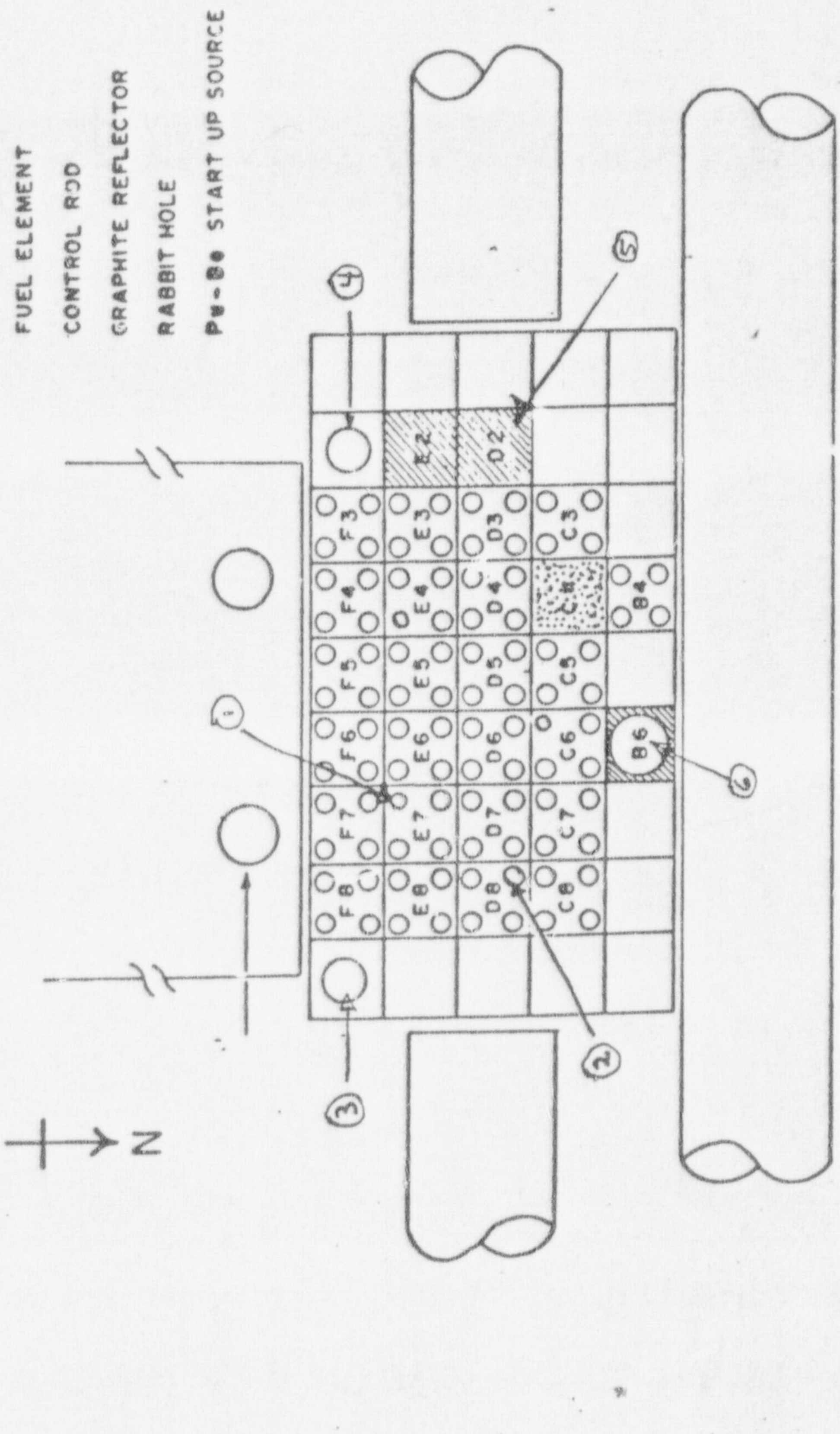


Figure 4.1 MUTR core configuration

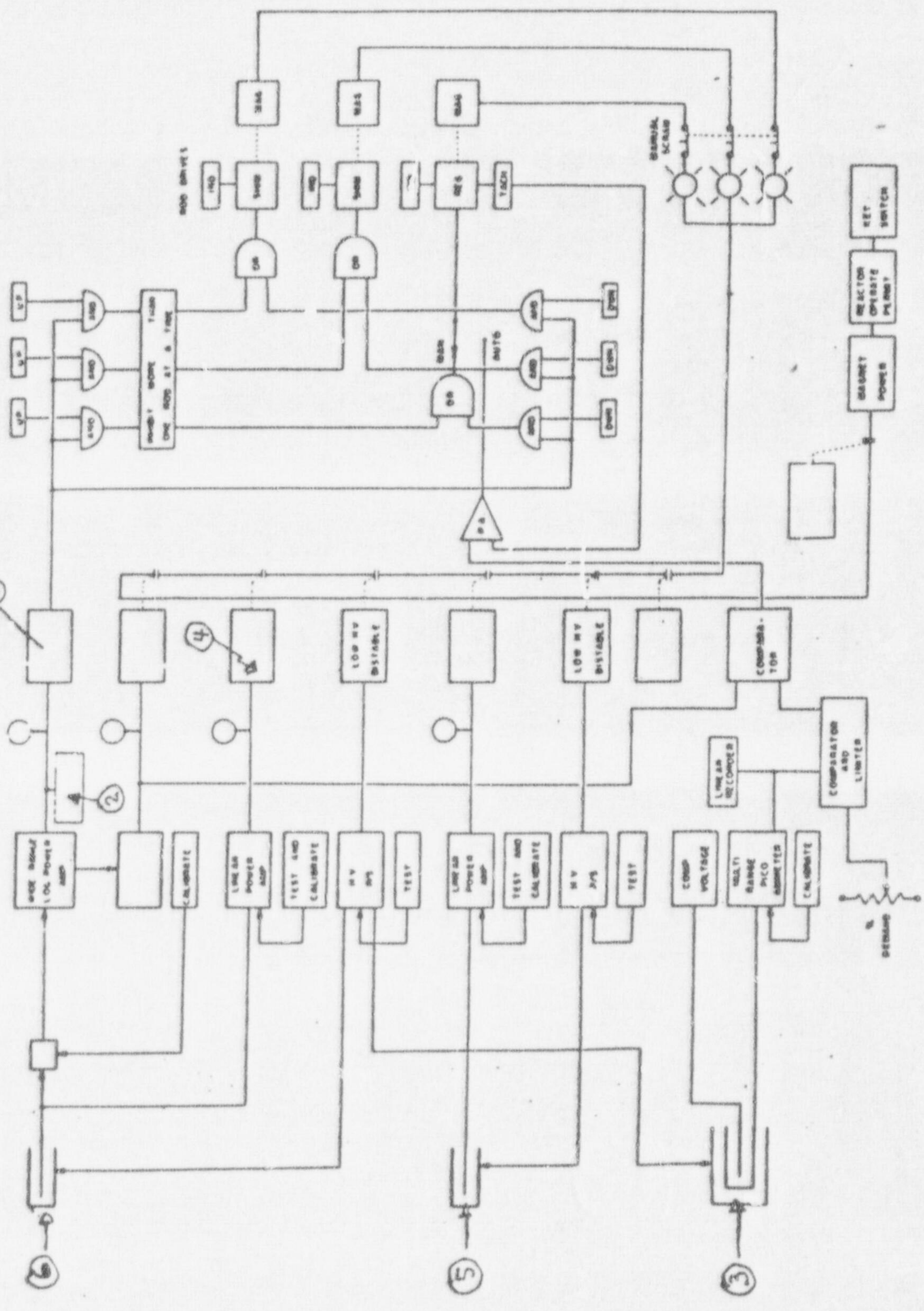
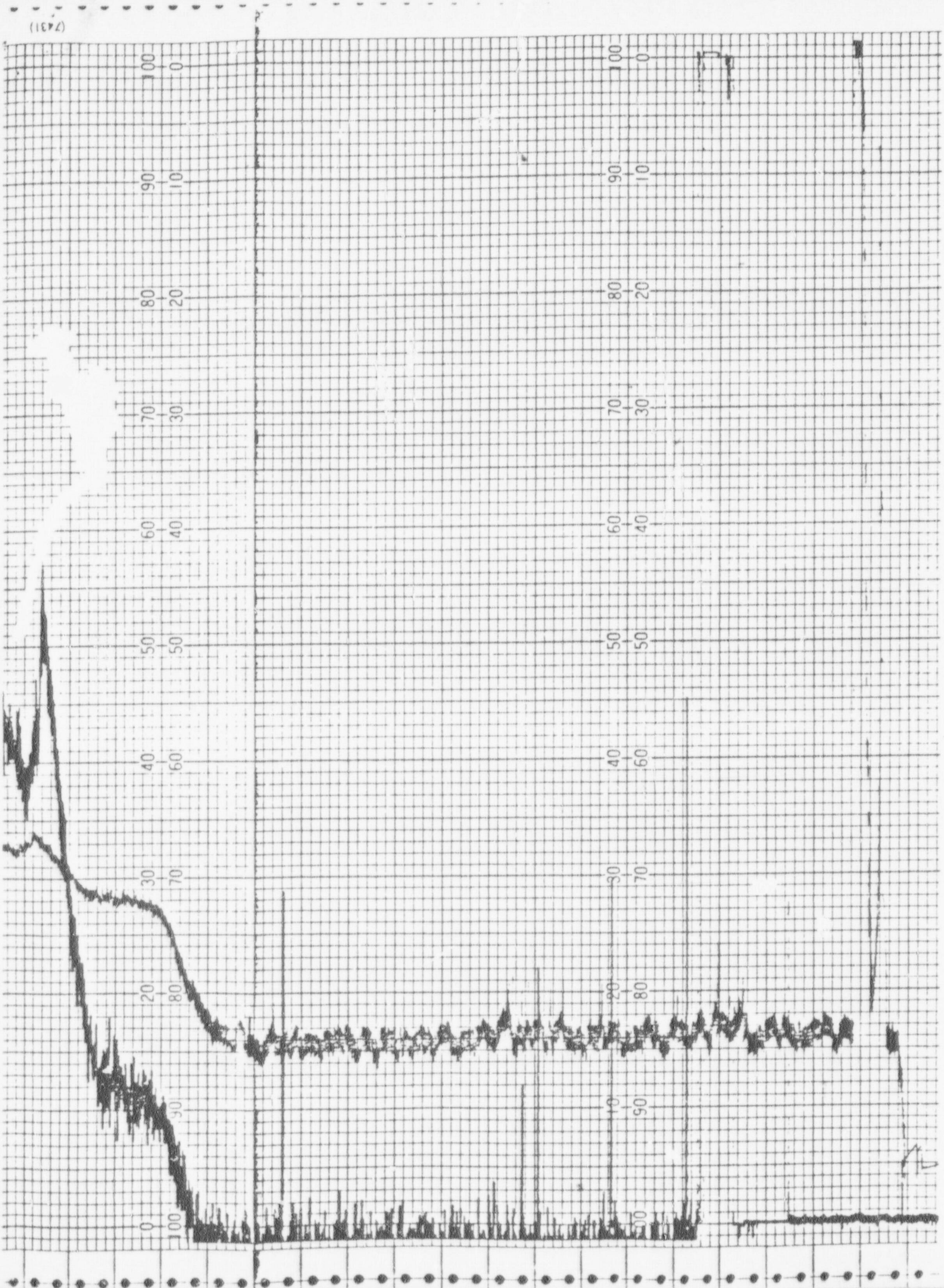


Figure 7.1 Block diagram of instrumentation


(7431)
100 0
90 10
80 20
70 30
60 40
50 50
40 60
30 70
20 80
10 90
0 100

100 0
90 10
80 20
70 30
60 40
50 50
40 60
30 70
20 80
10 90
0 100

Answers to 1987 Requalification Exam

V.1. Six factor formula k=epsilon*p*eta*f*$P_f P_t$

epsilon=fast fission factor
p=resonance escape probability
eta=neutron replication constant
f=thermal utilization
Pf=fast non-leakage probility

P_t =thermal non-leakage probability

~~V.2. M1/M2=(1-k2)/(1-k1)=1/3=(1-k2)/.04=>k2=0.987~~

V.3. The two parts are
1. Drop due to removal of neutrons
2. Drop due to insertion of negative reactivity since the source is made of Pu-239 and is worth about +4 cents
@10mW both effects are comparable but @100kW only the reactivity effect is around. @10mW the reactor will continue with a long negative period to almost zero power, but at 100kW, the reactor power level will level off at a slightly lower power due to the fuel temperature feedback effects.

~~V.4. Worth is dependent on the square of the thermal neutron flux which changes with location.~~

V.5. @ 10mW the power level would be increasing in a linear manner, but would appear to be constant 100kW.

V.6. First measure the critical rod position at low power. Next, operate at max power for several days. Go to low power and measure the critical rod position over about 15 hours. Max Xe should occur at about 12 hours. Max reactivity measured as the difference in critical rod position before and after high power.

V.7. Turning on the primary cooling pump increases water flow through the core which increases the heat transfer coefficient, which lowers the fuel temperature which causes an increase in power level. The fuel effect is larger than the moderator effect.

V.8. Power level would flucuate more due to the void coefficient of reactivity, bridge monitor may increase due to Ar-41 level increase,...

V.9. 1. Reduce activation products
2. Easier to detect leaking fuel rods
3. Less corrosion
4. Clearer water to the the core for inspection

V.10. Short term:
1. Increase in bridge and exhaust monitor levels
2. Visual inspection
3. Increase in conductivity

Long term:

1. Increase in gross beta/gamma activity in pool water measurement

2. Increase in gamma spectrum activity in pool water measurement

VI.1. a. undercompensated

CIC would be reading higher than the actual power since it is falsely including some gammas. It would indicate a constant power due to the fission product gammas until the actual neutron signal became large enough to overide the false gamma signal. This could occur at a power level of several watts or even higher.

b. overcompensated

Just the oposite of a. CIC reading lower than actual power since it is subtracting gammas from the neutron signal. It would indicate a negative power up to several watts or even higher.

VI.2. Set point of about 200 deg Cent on the fuel would scram the reactor at about 300kW=120% licensed power.
This wouldn't violate the Tech Specs because it says that the fuel temperature setpoint shall be<= 400 degrees Cent.

VI.3. 1=source count rate relay
2=chart recorder
3=CIC
4=Safety I 120% relay
5=Ionization chamber
6=Fission chamber

VI.4. 1=shim 2
2=instrumented fuel rod
3=fission chamber
4=B-10 lined ionization chamber
5=graphite reflector
6=neutron source

VI.5. 1. fuel=UZrH
2. ss clad
3. automatic exhaust fan turn off
4. all 9 scram point settings
5. etc.

VI.6. 1.mag current light off because switch interrupt, contact light off when rod is in because opposite conditions on carriage down and rod drown switches, up light off due to CRDM starting to be driven down.

2. mag current back on when drop rod button released.

3. down light on and contact on when CRDM has driven all the way down.

VI.7. ......

VI.8. rho$=1/(1+lambda*T)=1/(1+0.12*15)=.36$

VII.1. Conditions:

a. SRO on bridge
b. Reactor shutdown with control rods inserted
c. RO or SRO in control room
~~d. Fuel movement recorded in log book~~

Inspected once every two years. Bowing >1/8", length>1/4"

~~VII.2. 1. alpha~~
~~2. neutrons~~
~~3. beta~~
~~4. gamma~~

VII.3. The pool water level would increase and overflow into the sump tank. Also the conductivity would increase. If it was important to remain at power, I would turn off the primary pump, valve off the city water to HX1 and sewer valve to HX1. Leave HX2 on. Could operate in this condition for several hours but then would have to shutdown.

VII.4. 1. personnel emergency=class 0 being cut on a piece of radioactive material

2. unusual event=class 1 = sustained fire with a minor explosion in the reactor bldg.

3. alert=class 2 = severe fuel damage with clad failure following an earthquake or explosion in reactor bldg.

VII.5. SRO or RO and appropriate number of assistants. Precautions:gloves, face mask, radiation monitors, rope off area, monitor for radiation levels,....

VII.6. a. 1.25 rem
b. 18.75 rem
c. 7.5 rem

VII.7. $D=6CE/d^2$
a. 41.7 mCi
b. 31 mrad/hr
c. 3.3 cm

VIII.1. 1. approval by RSC and RD because a special experiment
2. fill out irradiation forms

VIII.2. a. Would not have to shutdown the reactor. Would try to fix the CIC pen & recorder

b. Scram the reactor. This would be a reportable occurrence and would have to take the appropriate actions

VIII.3. In cotrol room= licensed RO or SRO. In bldg. another person that has some knowledge of reactor operations.
If RO in control room then SRO must be on call.

~~VIII.4. a. one requal cycle=2 yrs.~~
~~b. >=5 yrs~~
~~c. >=1 yr~~

d. >= 5 yr
e. lifetime of facility

VIII.5. secure reactor, secure ventillation, take log book and radiation monitor, check to see if averyone evacuated, prevent re-entry into reactor room, notify RD and RSO, assist in emergency

~~VIII.6. Not transferable, Only for facility on the license, only on controls specified in license, subject to NRC rules~~

~~VIII.7. Only SRO=a,c,d~~
~~RO & SRO = b,e,f~~

V. 2.

a) $\frac{C.R._2}{C.R._1} = \frac{1 - K_{eff1}}{1 - K_{eff2}} = 2 = \frac{1 - .95}{1 - K_{eff2}}$; $K_{eff2} = .975$

b) $\frac{1 - K_{eff2}}{1 - K_{eff3}} = 2 = \frac{1 - .975}{1 - K_{eff3}}$; $K_{eff3} = .9825$

Therefore the reactor is still subcritical.

4.

a) Yes, placing a second rod adjacent to a first will depress the flux in that area and decrease the worth of the first rod. This is known as rod "shadowing."

b) The rod worth will increase as temperature increases. This is because the neutron diffusion length increases as temperature increases, allowing the control rod to see more neutrons.

VII 8. Assume β will not travel 10 ft in air therefore the 0.5 mr is all gamma's

$$\text{dose at 6 inches (0.5 ft)} = \frac{R_1 D_1^2}{D_2^2} = \frac{0.5\ (10)^2}{(0.5)^2} = \frac{50}{.25} = 200 \text{ mr/hr}$$

at 6 inches $\gamma = 200$ mr/hr $\beta = 2000-200 = 1800$ mr/hr

$$\therefore\ \beta/\gamma \text{ ratio} = \frac{1800}{200} = 9$$

VII 2. a) $1.00 reactivity (Tech. Spec. pg. 13)

b) Go critical without experiment, insert Reg. Rod. Add experiment, go critical on Reg. Rod. Find ρ worth from difference in Reg. Rod positions.

VIII 4. Ref. Tech. Specs, pg 19

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 design values.

6. (Ref. Tech. Specs., p. 3) (Any four)

Reportable ~~Abnormal~~ Occurrence - An reportable ~~abnormal~~ occurrence is any of the following which occurs during reactor operation:

a) Operation with any safety system setting less conservative than specified by the Limiting Safety System Settings

b) Operation in violation of a Limiting Condition for Operation

c) Malfunction of a required reactor or experiment safety system component which could render or threaten to render the system incapable of performing its intended safety function

d) Any unanticipated or uncontrolled change in reactivity greater than \$1.00

e) An observed inadequacy in the implementation of either administrative or procedural controls, such that the inadequacy could have caused the existence or development of a condition which could result in operation of the reactor outside the specified safety limits

f) Release of fission products from a fuel element

7. a) Control means apparatus and mechanisms the manipulation of which directly affect the reactivity or power level of the reactor

b) Any individual may manipulate the controls of a facility as a part of his training to qualify for an operator license under the direction and in the presence of a licensed operator or senior operator, or as part of his training as a student in a nuclear engineering course under the direction and in the presence of a licensed operator or senior operator.

8. Ref. - EP 405, pg. 1

a) Notify the Division of Public Safety Office

b) Notify the Reactor Director

c) Notify the Radiation Safety Office

d) Secure all doors to reactor building and containment area

e) Activate the intrusion alarm system

9. Ref. Tech. Spec., pg. 8

Assures that power increases caused by rod motion will be terminated by the reactor safety system before the fuel temperature safety limit is exceeded