May 18, 2010

Dr. Wade Richards, Manager of Operations and Engineering
NIST Center for Neutron Research
National Institute of Standards and Technology
U. S. Department of Commerce
100 Bureau Drive, Mail Stop 8561
Gaithersburg, MD 20899-8561

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-184/OL-10-02, NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY REACTOR

Dear Dr. Richards:

During the week of April 12, 2010, the NRC administered operator licensing examinations at your National Institute of Standards and Technology (NBSR) Reactor. The examinations were conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. Examination questions and preliminary findings were discussed with those members of your staff identified in the enclosed report at the conclusion of the examination.

In accordance with Title 10 of the Code of Federal Regulations Section 2.390, a copy of this letter and the enclosures will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html. The NRC is forwarding the individual grades to you in a separate letter which will not be released publicly. Should you have any questions concerning this examination, please contact Mr. Paul Doyle at (301) 415-1058 or via internet e-mail Paul.Doyle@nrc.gov.

Sincerely,

/RA/
Johnny H. Eads Jr., Chief
Research and Test Reactors Oversight Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Docket No. 50-184

Enclosures:
1. Initial Examination Report No. 50-184/OL-10-02
2. Written examination with facility comments incorporated

cc without enclosures:
Please see next page

May 18, 2010

Dr. Wade Richards, Manager of Operations and Engineering
NIST Center for Neutron Research
National Institute of Standards and Technology
U. S. Department of Commerce
100 Bureau Drive, Mail Stop 8561
Gaithersburg, MD 20899-8561

SUBJECT: INITIAL EXAMINATION REPORT NO. 50-184/OL-10-02, NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY REACTOR

Dear Dr. Richards:

During the week of April 12, 2010, the NRC administered operator licensing examinations at your National Institute of Standards and Technology (NBSR) Reactor. The examinations were conducted according to NUREG-1478, "Operator Licensing Examiner Standards for Research and Test Reactors," Revision 2. Examination questions and preliminary findings were discussed with those members of your staff identified in the enclosed report at the conclusion of the examination.

In accordance with Title 10 of the Code of Federal Regulations Section 2.390, a copy of this letter and the enclosures will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html. The NRC is forwarding the individual grades to you in a separate letter which will not be released publicly. Should you have any questions concerning this examination, please contact Mr. Paul Doyle at (301) 415-1058 or via internet e-mail Paul.Doyle@nrc.gov.

Sincerely,
/RA/
Johnny H. Eads Jr., Chief
Research and Test Reactors Oversight Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Docket No. 50-184
Enclosures: 1. Initial Examination Report No. 50-184/OL-10-02
2. Written examination with facility comments incorporated

cc without enclosures:
Please see next page

<u>DISTRIBUTION</u> w/ encls.:

PUBLIC	PROB r/f	RidsNRRDPRPRTA
RidsNRRDPRPRTB	Facility File (CRevelle) O-07 E-13	

ADAMS ACCESSION #: ML101380542 **TEMPLATE #:NRR-074**

OFFICE	PROB:E	N	PROB:CE	E	IOLB:LA	E	PROB:SC	
NAME	JNguyen:		PDoyle		CRevelle		JEads	
DATE	05/ 18 /2010		05/ 18 /2010		05/ 18 /2010		05/ 18 /2010	

C = COVER E = COVER & ENCLOSUREN = NO COPY

OFFICIAL RECORD COPY

cc:

Director, Department of State Planning
301 West Preston Street
Baltimore, MD 21201

Director, Air & Radiation Management Adm.
Maryland Dept of the Environment
1800 Washington Blvd., Suite 710
Baltimore, MD 21230

Director, Department of Natural Resources
Power Plant Siting Program
Energy and Coastal Zone Administration
Tawes State Office Building
Annapolis, MD 21401

President
Montgomery County Council
100 Maryland Avenue
Rockville, MD 20850

Test, Research, and Training
Reactor Newsletter
University of Florida
202 Nuclear Sciences Center
Gainesville, FL 32611

U. S. NUCLEAR REGULATORY COMMISSION
OPERATOR LICENSING INITIAL EXAMINATION REPORT

REPORT NO.: 50-184/OL-10-02

FACILITY DOCKET NO.: 50-184

FACILITY LICENSE NO.: TR-5

FACILITY: National Institute of Standards and Technology (NBSR) Reactor

EXAMINATION DATES: April 13 – 14, 2010

SUBMITTED BY: ____________________________ April 21, 2010
Paul V. Doyle Jr., Chief Examiner Date

SUMMARY:

On April 12, 2010, the NRC administered an NRC prepared written examination to two Senior Reactor Operator candidates at the National Institute of Technology (NBSR) Research Reactor. On April 12, 2010, the NRC administered NRC prepared operating tests to the same two candidates. Both candidates passed all portions of their respective examinations.

REPORT DETAILS

1. Examiners: Paul V. Doyle Jr., Chief Examiner, NRC
John T. Nguyen, NRC

2. Results:

	RO PASS/FAIL	SRO PASS/FAIL	TOTAL PASS/FAIL
Written	0/0	2/0	2/0
Operating Tests	0/0	2/0	2/0
Overall	0/0	2/0	2/0

3. Exit Meeting:

Participants:
Paul V. Doyle Jr., Chief Examiner, NRC[1,2]
Daniel E. Hughes, SRO, NIST[1]
John T. Nguyen, Examiner, NRC[2]
Warren J. Eresian, Trainer, NIST[1]
Someone x. Else, SRO, NIST[1]
Thomas J. Myers, Operations Chief, NIST[2]

[1] Persons attending Written Examination Meeting 04/12/2010
[2] Persons attending Final Exit Meeting 04/13/2010

Paul Doyle conducted an exit meeting to discuss facility comments on the written examination on April 12, 2010. All facility comments have been incorporated into the examination enclosed with this report.

Paul Doyle and John Nguyen conducted the final exit meeting on April 13, 2010 where they thanked the facility for their support in the administration of the examinations, and discussed the one generic issued found on the operating tests: lack of familiarity with the requirements of 10 CFR 50.59.

U.S. Nuclear Regulatory Commission
Operator Licensing Examination
With Answer Key

National Institute of Standards And Technology

April 13, 2010

ENCLOSURE 2

QUESTION A.01 [1.0 point]

A reactor similar to the NBSR reactor was operated at full power for one week when a scram occurred. Twelve hours later, the reactor is brought critical and quickly raised to full power. Considering xenon effects only, to maintain a constant power level for the next few hours, control rods must be:

a. inserted

b. maintained at the present position

c. withdrawn

d. withdrawn, then inserted to the original position

QUESTION A.02 [1.0 point]

You enter the control room and note that **ALL** nuclear instrumentation show a **STEADY NEUTRON LEVEL**, and no rods are in motion. Which **ONE** of the following conditions **CANNOT** be true?

a. The reactor is critical.

b. The reactor is sub-critical.

c. The reactor is super-critical.

d. The neutron source has been removed from the core.

QUESTION A.03 [1.0 point]

Which ONE of the following is true concerning the differences between prompt and delayed neutrons?

a. Prompt neutrons account for less than one percent of the neutron population while delayed neutrons account for approximately ninety-nine percent of the neutron population

b. Prompt neutrons are released during fast fissions while delayed neutrons are released during thermal fissions

c. Prompt neutrons are released during the fission process while delayed neutrons are released during the decay process

d. Prompt neutrons are the dominating factor in determining the reactor period while delayed neutrons have little effect on the reactor period

QUESTION A.04 [1.0 point]

Which ONE of the following will be the resulting stable reactor period when a 0.00175 or 0.25$ reactivity insertion is made into an exactly critical reactor core? (Assume a β_{eff} of .0070 and a lambda of 0.1 sec^{-1})

a. 50 seconds

b. 38 seconds

c. 30 seconds

d. 18 seconds

QUESTION A.05 [1.0 point]
Reactor power doubles in 0.66 minutes (40 seconds). Which ONE of the following is the time required for power to increase from 10 watts to 800 watts? (Assume a positive step change in reactivity.)

a. 10.1 minutes

b. 6.4 minutes

c. 4.2 minutes

d. 2.8 minutes

QUESTION A.06 [1.0 point]
Which ONE of the following statements describes the difference between Differential and Integral (IRW) rod worth curves?

a. DRW relates the worth of the rod per increment of movement to rod position. IRW relates the total reactivity added by the rod to the rod position.

b. DRW relates the time rate of reactivity change to rod position. IRW relates the total reactivity in the core to the time rate of reactivity change.

c. IRW relates the worth of the rod per increment of movement to rod position. DRW relates the total reactivity added by the rod to the rod position.

d. IRW is the slope of the DRW at a given rod position.

QUESTION A.07 [2.0 points, ½ each]
Using the drawing of the Integral Rod Worth Curve provided, identify each of the following reactivity worths.

a. Total Rod Worth	1. B - A
b. Actual Shutdown Margin	2. C - A
c. Technical Specification Shutdown Margin Limit	3. C - B
d. Excess Reactivity	4. D - C
	5. E - C
	6. E - D
	7. E - A

QUESTION A.08 [1.0 point]
Given secondary flow through HE-1A & B is 9650gpm, HE-1A & 1B (Secondary Inlet Temperature) both read 80°F, HE-1A &1B secondary Outlet Temperature both read 91°F, and the Thermal Power constants for water is 147 watts/gpm-°F (H_2O), determine the current operating power.

a. 78%

b. 71%

c. 65%

d. 59%

QUESTION A.09 [2.0 points ⅓ each]
For the following terms (a through F) pick a definition (1 through 6) which most clearly describes the term.

a. Subcritical Multiplication	1. Substance used in a reactor to reduce the energy of neutrons to the energy at which there is a high probability of causing fissioning of the fuel.
b. Reactor Period	2. Different forms of the same chemical element which differ only by the number of neutrons in the nucleus.
c. Reactivity	3. The time required for neutron flux (power) to change by a factor of e (2.718).
d. Moderator	4. The multiplication of source neutrons resulting from reactivity addition.
e. Shutdown Margin	5. A measure of the deviation from critical.
f. Isotope	6. A measure of the reactivity which must be added to a shutdown reactor to make it just critical.

QUESTION A.10 [1.0 point]
K_{eff} is K_∞ times the

a. fast fission factor (ε)

b. reproduction factor (η)

c. total non-leakage factor ($\mathcal{L}_f \times \mathcal{L}_{th}$)

d. resonance escape probability (p)

QUESTION A.11 [1.0 point]
Which alteration or change to the core will most strongly affect the thermal utilization factor?

a. Build up of fission products in fuel.

b. Removal of a control rod.

c. Removal of moderator.

d. Addition of U-238

QUESTION A.12 [1.0 point]
Which one of the following describes the MAJOR contributor to the production and depletion of Xenon respectively in a STEADY-STATE OPERATING reactor?

	Production	Depletion
a.	Radioactive decay of Iodine	Radioactive Decay
b.	Radioactive decay of Iodine	Neutron Absorption
c.	Directly from fission	Radioactive Decay
d.	Directly from fission	Neutron Absorption

QUESTION A.13 [1.0 point]
You perform two initial startups a day apart. Each of the startups has the same starting conditions. (E.g. core burnup, pool, fuel temperature and starting count rate are the same.) The only difference between the two startups is that during the **SECOND** startup you stop for 10 minutes to answer the phone. For the second startup compare the critical rod height and count rate to the first startup.

	Rod Height	Count Rate
a.	Higher	Same
b.	Lower	Same
c.	Same	Lower
d.	Same	Higher

QUESTION A.14 [1.0 point]
Which one of the following factors has the LEAST effect on K_{eff}?

a. Fuel burnup.

b. Increase in fuel temperature.

c. Increase in moderator temperature.

d. Xenon and samarium fission products.

QUESTION A.15 [1.0 point]
Which ONE of the following describes the response of the reactor to EQUAL amounts of reactivity insertion as the reactor approaches critical (K_{eff} =1.0)? The change in neutron population per reactivity insertion is …

a. smaller, and it requires a longer time to reach a new equilibrium count rate.

b. larger, and it requires a longer time to reach a new equilibrium count rate.

c. smaller, and it requires a shorter time to reach a new equilibrium count rate.

d. larger, and it takes an equal amount of time to reach a new equilibrium count rate.

QUESTION A.16 [1.0 point]
During a reactor startup, criticality occurred before the value calculated. Which ONE of the following reasons could be the cause?

a. Adding an experiment with positive reactivity.

b. Xe^{135} peaked.

c. Moderator temperature increased.

d. Power defect (Reactor power increasing).

QUESTION A.17 [1.0 point]
Which ONE of the following isotopes has the largest microscopic cross-section for absorption for thermal neutrons?

a. ${}_{5}B^{10}$

b. ${}_{54}Xe^{135}$

c. ${}_{62}Sm^{149}$

d. ${}_{92}U^{235}$

QUESTION A.18 [1.0 point]
During the neutron cycle from one generation to the next, several processes occur that may increase or decrease the available number of neutrons. Which ONE of the following factors describes an INCREASE in the number of neutrons during the cycle?

a. Thermal utilization factor.

b. Resonance escape probability.

c. Thermal non-leakage probability.

d. Fast fission factor.

QUESTION A.19 [1.0 point]
A reactor is slightly supercritical with the following values for each of the factors in the six-factor formula:

Fast fission factor =	1.03	Fast non-leakage probability =	0.84
Resonance escape probability =	0.96	Thermal non-leakage probability =	0.88
Thermal utilization factor =	0.70	Reproduction factor =	1.96

A control rod is inserted to bring the reactor back to critical. Assuming all other factors remain unchanged, the new value for the thermal utilization factor is:

a. 0.698

b. 0.702

c. 0.704

d. 0.708

QUESTION B.01 [1.0 point]

Which ONE of the following types of experiments shall **NOT** be irradiated at NBSR?

a. The experiment contains explosive materials.

b. The experiment contains corrosive materials.

c. The single experiment has a reactivity worth of – $ 0.80.

d. The sum of all experiments in the reactor and experimental facilities has a reactivity worth of -$2.65.

QUESTION B.02 [1.0 point, 0.25 each]

Match the type of radiation in column A with their quality factor in column B. Items in column B is to be used once, more than once or not at all.

	Column A	Column B
a.	Beta	1
b.	Gamma	5
c.	Alpha particles	10
d.	Neutrons of unknown energy	20

QUESTION B.03 [1.0 point]

A radioactive source reads 80 Rem/hr on contact. Four hours later, the same source reads 20 Rem/hr. How long is the time for the source to decay from a reading of 80 Rem/hr to 5 Rem/hr?

a. 6.0 hours.

b. 8.0 hours.

c. 9.0 hours.

d. 10.0 hours.

QUESTION B.04 [1.0 point]

Given that the following emergency conditions occur at the NBSR reactor facility:
(a) Earthquake occurs
(b) Particulate monitor alarms
(c) Radiological effluents at the nearest site boundary exceed 75 mRem TEDE accumulated in 24 hours.
Which ONE of the following is the appropriate Emergency Classification?

a. Notification of Unusual Event.

b. Alert.

c. Site Area Emergency.

d. General Emergency.

QUESTION B.05 [1.0 point]
A radioactive material is **DECAYING** at a rate of 20% per hour. Determine its half-life?

a. 1.5 hours.

b. 2.0 hours.

c. 3.0 hours.

d. 5.0 hours.

QUESTION B.06 [1.0 point]
During a reactor startup, the reactor operator calculates that the maximum excess reactivity for reference core conditions is 13% $\Delta\rho$. For this excess reactivity, which ONE of the following is the best action?

a. Continue to operate because the excess reactivity is within TS limit.

b. Increase power to 1 MW and verify the excess reactivity again.

c. Shutdown the reactor; immediately report the result to NRC due to excess being above TS limit.

d Continue operation, but immediately report the result to the supervisor since the excess reactivity is exceeding TS limit.

QUESTION B.07 [1.0 point]
An area in which radiation levels could result in an individual receiving a dose equivalent in excess of 20 mRem/hr can be considered as:

a. Radiation area.

b. Restricted Area.

c. High Radiation Area.

d. Very High Radiation Area.

QUESTION B.08 [1.0 point]
The parameters used to evaluate the NBSR Limiting Safety System Settings are:

a. reactor power level, coolant flow rate, and reactor outlet water temperature.

b. reactivity, reactor power level, and reactor outlet water temperature.

c. reactor power level, coolant flow rate, and water tank level.

d. reactor power level and coolant flow rate.

QUESTION B.09 [1.0 point]
Minor modifications to the original procedures which do not effect reactor safety or change their original intent may be made by…

a. the Reactor Operator on his/her own and such changes shall be documented and reported within the next working day to the Senior Reactor Operator.

b. the Senior Reactor Operator on his/her own and such changes shall be documented and reported within the next working day to the Chief, Reactor Operations and Engineering.

c. the Reactor Supervisor and such changes shall be documented and reported within the next working day to the Reactor Director.

d. the Reactor Supervisor and such changes shall be documented and reported within the next working day to the Chief, Reactor Operations and Engineering.

QUESTION B.10 [1.0 point]
A two curie source, with a 1.8 Mev gamma, is to be stored in the reactor building. How far from the source should a HIGH RADIATION AREA sign be posted?

a. 4 feet.

b. 15 feet.

c. 22 feet.

d. 66 feet.

QUESTION B.11 [1.0 point]
Select the list that gives the order of types of radiation from the **LEAST** penetrating to the **MOST** penetrating (i.e. travels the further in air).

a. neutron, gamma, beta, alpha.

b. alpha, beta, neutron, gamma.

c. beta, alpha, gamma, neutron.

d. alpha, neutron, beta, gamma.

QUESTION B.12 [1.0 point] **Question does not specify whether permission from emergency director has been granted therefore either a or d could be correct.**
If an emergency situation requires personnel to search for and remove injured person(s), a planned emergency exposure to the whole body could be allowed up to ____ to save a life.

a. 25 rem

b. 50 rem

c. 75 rem

d. 100 rem

QUESTION B.13 [1.0 point]
You've detected a stuck regulating rod. Which ONE of the following is your immediate action(s) according to Annunciator Instruction 0.3?

a. Attempt to drive the regulating rod in until power decreases by 2%.

b. Drive all shim arms in verifying the stuck regulating rod fails to move.

c. Scram the reactor, noting the position of the stuck rod.

d. Control reactor power using the shim arms.

QUESTION B.14 [1.0 point]
Two point sources have the same curie strength. Source A's gammas have an energy of 1 Mev, whereas Source B's gammas have an energy of 2 Mev. You obtain readings from the same GM tube and Ion Chamber at 10 feet from each source. Concerning the four readings, which ONE of the following statements is correct?

a. The reading from Source B is twice that of Source A for both meters.

b. The reading from Source B is twice that of Source A for the Ion chamber but the same for the GM tube.

c. The reading from Source B is half that of Source A for the GM tube, but the same for the Ion Chamber.

d. The readings from both sources are the same for both meters.

QUESTION B.15 [1.0 point]
Which ONE of the following is the ***LOWEST*** level of NIST management who may authorize reactor startup following a scram, where the cause of the scram remains unknown?

a. Reactor Operator

b. Senior Reactor Operator

c. Reactor Supervisor

d. Deputy Chief Engineer

QUESTION B.16 [2.0 points 0.5 each] Question deleted (Old question, no longer applicable).
~~Match the actions in column A with the nuclear instrumentation readings in column B. (Note items from column b may be used more than once or not at all.)~~

~~Column A~~	~~Column B~~
~~a. Bypass NC-3/4 period automatic functions~~	~~1. NC-3/4 at 2 × 10~~$^{-10}$ ~~amps~~
~~b. Switch Scram Logic Selector to 2 of 3~~	~~2. NC-6/7/8 on scale~~
~~c. Secure HV to NC-1/2~~	~~3. NC-6/7/8 > 10%~~
~~d. Power Range Scram Setpoint to 125%~~	~~4. NC-6/7/8 > 20%~~

QUESTION B.17 [2.0 points, ½ each]

Match the NBSR Requalification Plan requirements in Column A for an actively licensed operator with the correct time period from Column B. Column B answers may be used once, more than once, or not at all.

	Column A	Column B
a.	License Expiration	1 year
b.	Medical Examination	2 years
c.	Requalification Written Examination	3 years
d.	Requalification Operating Test	6 years

QUESTION B.18 [1.0 point]

In accordance with 10 CFR 20, the "Annual Limit on Intake (ALI)" refers to:

a. the amount of radioactive material taken into the body by inhalation or ingestion in one (1) year which would result in a committed effective dose equivalent of five (5) rems.

b. the dose equivalent to organs that will be received from an intake of radioactive material by an individual during the 50-year period following the intake.

c. limits on the release of effluents to an unrestricted environment.

d. the concentration of a given radionuclide in air which, if breathed for a working year of 2000 hours, would result in a committed effective dose equivalent of five (5) rems.

QUESTION C.01 [2.0 points, 0.25 each]
Match the input signals listed in column A with their respective responses listed in column B. (Items in column B is to be used more than once or not at all.)

Column A	Column B
a. NC-3 Channel = 9-sec period.	1. Indication only.
b. 14" inlet flow (FRC-3) = 5200 gpm.	2. Indication and rod prohibit.
c. 145" - reactor D_2O level low.	3. Indication and rod run down.
d. Delta T (TIA-40B) = 22 °F.	4. Indication and minor scram.
e. Cold source hydrogen pressure = 5 psid	5. Indication and major scram.
f. Reactor outlet temperature (TRC-2) = 120 °F	
g. Irradiated air monitor (RD3-4) = 60K cpm.	
h. Reactor period (NC-2) = 1 cps, Log and Linear Channel = 100 kW	

QUESTION C.02 [1.0 point]
Which ONE of the following is capable of causing automatic reactor isolation?

a. Area Radiation Monitor at the reactor top goes off

b. Loss of primary coolant flow initiates.

c. Stack Gas Monitor goes off.

d. Tritium Monitor goes off.

QUESTION C.03 [1.0 point]
Which ONE of the following best describes the 42 volts DC power distribution connected to the safety instrumentation system?

a. There is only one DC power supply connected to the safety instrumentation system. If a loss of power supply occurs, relays will initiate a reactor scram.

b. There are two DC power supplies connected in parallel to the safety instrumentation system. If a loss of both supplies occurs, relays will initiate a reactor scram.

c. There are two DC power supplies connected in series to the safety instrumentation system. If one of the supplies loses its power, the relays will initiate a reactor scram.

d. There are two DC power supplies connected in parallel to the safety instrumentation system. If a loss of both supplies occurs, relays will initiate a reactor rundown.

QUESTION C.04 [1.0 point]

Which ONE of the following represents the normal flow rate of the ENTIRE primary coolant system at 20 MW power?

a. 2300 gpm.

b. 6700 gpm.

c. 9000 gpm.

d. 12000 gpm.

QUESTION C.05 [1.0 point]

To isolate the electrical distribution to the emergency cooling sump pump, the NBSR staff can turn off the breakers located at…..

a. Motor Control Center -1 (MCCA-1).

b. Motor Control Center -2 (MCCA-2).

c. Motor Control Center -4 (MCCA-4).

d. Motor Control Center -5 (MCCA-5).

QUESTION C.06 [1.0 point]

It is uncertain whether 0.30$ insertion is great enough to cause the power deviation limit to be exceeded. Therefore this question is deleted from the examination.

~~The reactor is operating in automatic mode where the Shim arms are at 28° positions and the Reg rod is at 21 inches. A rabbit with sample worth of $0.30 is quickly inserted to the reactor core. Which ONE of the following is a result with respect to this insertion?~~

~~a. The reactor power will increase and scram.~~

~~b. The Reactor power will increase and remain in automatic.~~

~~c. The reactor will go out of automatic because the power deviation limit is exceeded.~~

~~d. The reactor will go out of automatic because the upper Reg rod limit is reached.~~

QUESTION C.07 [2.0 points, 0.25 each]
Match each monitor and instrument (channel) listed in column A with a specific purpose in column B. Items in column B are to be used only once.

Column A	Column B
a. Intermediate Range Channel.	1. Monitor radiation level in the reactor top.
b. Power Range Channel.	2. Detect radioisotopes released due to fuel failure.
c. Source Range Channel.	3. Provide input for ECP calculation.
d. Portable monitor.	4. Survey of laboratory.
e. Gaseous Product Monitor	5. Monitor neutron level during the reactor startup.
f. Area radiation monitor.	6. Provide a period scram.
g. Core Temperature.	7. Provide a high power level scram.
h. Linear Power Channel.	8. Permit reactor power to be automatically controlled.

QUESTION C.08 [1.0 point]
Which ONE of the following describes the operation of the ventilation dampers?

a. Air open, air close.

b. Air open, gravity close.

c. Motor-operated (open and close).

d. Spring open, air close.

QUESTION C.09 [1.0 point]
Which ONE of the following is the MAXIMUM capacity of the hold up tanks for radioactive liquid waste?

a. 5,000 gallons (five tanks with 1,000 gallons capacity each).

b. 10,000 gallons (two tanks with 5,000 gallons capacity each).

c. 15,000 gallons (three tanks with 5,000 gallons capacity each).

d. 25,000 gallons (five tanks with 5,000 gallons capacity each).

QUESTION C.10 [1.0 point]
A neutron flux will activate isotopes in air. This is the reason that CO_2 gas is used to drive the rabbit into and out of the core. The primary isotope we worry about in irradiating air is …

a. N^{16} (O^{16} (n,p) N^{16}).

b. Kr^{80} (Kr^{79} (n, γ) kr^{80}).

c. Ar^{41} (Ar^{40} (n, γ) Ar^{41}).

d. H^2 (H^1 (n, γ) H^2).

QUESTION C.11 [1.0 point]

The Process Instrumentation Safety system is required to be operable during startup and operations. If one channel is suspected of being faulty, the Process Test Switches, A and B, should be replaced in the 2 of 2 position and checked for the trip. Which ONE of the following is the MAXIMUM time period allowed the reactor operation in this mode?

a. 4 hours.

b. 8 hours.

c. 16 hours.

d. 24 hours.

QUESTION C.12 [1.0 point, 0.25 each]

Match the Thermal Column Tank (TCT) setpoints listed in column A with their respective responses listed in column B. (Items in column B is to be used more than once or not at all.)

Column A	Column B
a. TCT low flow at 3 gpm.	1. Alarm only.
b. TCT abnormal level at 49”	2. Alarm and rod prohibit.
c. Surge Tank high level at 30° F	3. Alarm and rod run down.
d. Surge Tank low level at 5”	4. Alarm and scram.

QUESTION C.13 [1.0 point]

Which ONE of the following is the correct statement regarding the materials used to construct the Shim arms at NBSR?

a. The SHIM arms are <u>cadmium</u> poison clad in <u>aluminum</u>. The hollow interior is filled with <u>helium</u>.

b. The SHIM arms are <u>boron carbide</u> poison clad in <u>aluminum</u>. The hollow interior is filled with <u>helium</u>.

c. The SHIM arms are <u>cadmium</u> poison clad in <u>stainless steel</u>. The hollow interior is filled with <u>helium</u>.

d. The SHIM arms are <u>cadmium</u> poison clad in <u>stainless steel</u>. The hollow interior is filled with $\underline{CO_2}$.

QUESTION C.14 [1.0 point]

According to the NBSR differential worth curve, which ONE of the following ranges provides the HIGHEST worth for the Shim arms?

a. 4°- 8°

b. 10°- 14°

c. 18°- 22°

d. 30°- 34°

QUESTION C.15 [1.0 point]
Which ONE of the following is the main function of the demineralizer in the primary purification system?

a. Remove insoluble impurity to maintain low conductivity in the tank water.

b. Reduce N-16 formation, thus reduce the dose rate at the reactor tank.

c. Absorb thermal neutrons, thus increase life of the reactor tank.

d. Absorb tritium, thus maintain purity of the tank water.

QUESTION C.16 [1.0 point]
The main function of the bismuth sheet placed in the Thermal Column is to:

a. thermalize fast neutrons.

b. reduce gamma ray of the fission fragments.

c. absorb kinetic energy of the fission fragments.

d. serve as a moderator and reflector for the Thermal Column.

QUESTION C.17 [1.0 point]
During reactor operation, a truck door open alarm will …

a. have no effect on the operation of the reactor.

b. prevent withdrawal of control arms.

c. cause a reactor scram.

d. cause a rod run in.

QUESTION C.18 [1.0 point] **This question is identical to question C.13, and has been deleted from the examination.**

~~Which ONE of the following is the correct statement regarding the materials used to construct the Shim arms at NBSR?~~

~~a. The SHIM arms are cadmium poison clad in aluminum. The hollow interior is filled with helium.~~

~~b. The SHIM arms are boron carbide poison clad in aluminum. The hollow interior is filled with helium.~~

~~c. The SHIM arms are cadmium poison clad in stainless steel. The hollow interior is filled with helium.~~

~~d. The SHIM arms are cadmium poison clad in stainless steel. The hollow interior is filled with CO_2.~~

A.01 a
REF: Ref 1, Volume

A.02 c
REF: Ref 1, Volume Standard NRC Question[1]

A.03 c
REF: Ref 1, Volume

A.04 c $T = (\beta_{eff} - \rho)/(\rho\ \lambda)$ $T = (.0070 - .00175)/.1 \times .00175$ T = 30 seconds
REF: Ref 1, Volume

A.05 c
REF: $P_f = P_0 e^{t/\tau} \Rightarrow \tau = (\ln P_f/P_0) \times t \Rightarrow \tau = 0.66\ \text{min}/\ln 2 = 0.952$ $t = \ln(800/10) \times 0.952 = 4.17$ min

A.6 a
REF: Ref 1, Volume

A.07 a, 7; b, 2; c, ~~6~~ 1; d, 5 Correct typographical error
REF: Standard NRC Question

A.08 a Also: 9650gpm × 11°F × 142 watt/gpm°F = 15.6×10^6 watts; $15.6 \times 10^6 \div 20.0 \times 10^6 = 0.78 = 78\%$
REF: Ref 1, Volume NRC Exam administered 02/1991

A.09 a, 4; b, 3; c, 5; d, 1; e, 6; f, 2
REF: Ref 1, Volume

A.10 c
REF: Standard NRC question

A.11 b
REF: Ref 1, Volume

A.12 b.
REF: Burn, R., *Introduction to Nuclear Reactor Operations*, © 1988, §§ 8.1 —8.4, pp. 8-3 — 8-14.

A.13 d Same rod height (core burnup and temperatures are the same. Higher count rate due to increased subcritical multiplication
REF: Ref 1, Volume

A.14 a
REF: Ref 1, Volume

A.15 b
REF: Ref 1, Volume

A.16 a.
REF:

A.17 b.
REF: Ref 1, Volume

A. 18 d Exam 2, Exam 3
REF: Ref 1, Volume

A.19 a $1.03 \times 0.96 \times X \times 0.84 \times 0.88 \times 196 = 1.000$ $X = 1/(1.03 \times 0.96 \times 0.84 \times 0.88 \times 1.96) = 0.698$
REF: Exam 3 Ref 1, Volume

REF 1 = Ref 1 Volume I and II.

B.01 c
REF: TS 3.8

B.02 a, 1 b, 1 c, 20 d, 10
REF: 10 CFR 20

B.03 b
REF: $DR = DR_{\circ} * e^{-\lambda t}$ 20 rem/hr = 80 rem/hr* $e^{-\lambda(4hr)}$ Ln(20/80) = -λ*4 --> λ=0.347;
solve for t: Ln(5/80)=-0.347 *t → t=8 hours

B.04 b
REF: EP 5.0, Emergency Action Levels

B.05 c
REF: $DR = DR_{\circ} * e^{-\lambda t}$ 20% is decayed, so 80% is still there 80% =100%* $e^{-\lambda(1hr)}$
Ln(80/100) = -λ*1 -->λ=0.223 t1/2=Ln(2)/ λ -->.693/.223 t=3.1 hours

B.06 a
REF: TS 3.1.2(1)

B.07 a
REF: 10 CFR 20

B.08 a
REF: TS 2.2

B.09 d
REF: TS 6.4

B.10 b
REF: 6CEN = R/hr @ 1 ft. -> 6 x 2 x 1.8 x 1 = 21.6 R/hr at 1ft. $I_0 D_0^2 = I * D^2$
21.6 R/hr*1 ft = 0.1 R/hr *D ^{2} D= √(21.6/0.1) = 14.7 ft.

B.11 b
REF: NRC standard question

B.12 a or d, 2nd correct answer added per facility comment.
REF: EP 7.6, Protective Action Exposure

B.13 d
REF: Annunciator Instruction 0.3.

B.14 b
REF: Standard NRC question

B.15 b
REF: O.I. 1.1B (Checklist B) step I.B.

~~B.16 a, 2; b, 3; c, 1; d, 3~~ **Question deleted (Old question, no longer applicable).**
~~REF: O.I. 1.1 § III Notes after steps 9 and 13, also step 11.~~

B.17 a, 6(4); b, 2(2); c, ~~1~~ 2(2); d, 2 1(1) Correct Typographic error.
REF: NIST Requalification Plan ……

B.18 d
REF:

C.01 a, 3; b, ~~4~~ 1; c, 3; d, 4; e, 3; f, 1; g, 5; h,1 (due to NC-1 and NC-2 bypassed) Answer to part 'b' changed due to facility comment.
REF: TS 3.2.2, SOP O.I.1.1, and NBSR Reactor Operations Training Guide, Section 6.2

C.02 c
REF SOP O.I. 1.1

C.03 b
REF: NBSR Reactor Operations Training Guide, Section 6.3.1, Power Supplies

C.04 c
REF: NBSR Reactor Operations Training Guide, Section 2.0, Primary Coolant System

C.05 d
REF: NBSR Reactor Operations Training Guide, Section 5.4, Electrical Loads

~~C.06 c~~ Question Deleted. It is uncertain whether 0.30$ insertion is great enough to cause the power deviation limit to be exceeded. Therefore this question is deleted from the examination.
~~REF: SOP O.I.1.1, Section L, Auto Flux Control Channel.~~

C.07 a, 6; b, 7; c, 5; d, 4; e, 2; f, 1; g, 3; h, 8
REF: TS 3.2.2 and NBSR Reactor Operations Training Guide

C.08 b
REF: Answer received from the NBSR staff on March 24,2010

C.09 b
REF: NBSR Reactor Operations Training Guide, Section 4.12.3

C.10 c
REF NRC Standard Question

C.11 b
REF: SOP O.I. 5.7.I.B, Limitations and Precaustions

C.12 a, 3; b, 1; c, 1; d, 3
REF: SOP O.I.3.8.IV, Instrumentation and Alarms

C.13 a
REF: TS 2.2

C.14 b
REF: NBSR differential worth curve.

C.15 a
REF: NRC Standard Question

C.16 b
REF: General knowledge for Thermal Column design

C.17 a
REF: Answer received from the NBSR staff on March 24, 2010

~~C.18 a~~ Question Deleted. This question is identical to question C.13
~~REF: NBSR Reactor Operations Training Guide, Section 1.3~~

U. S. NUCLEAR REGULATORY COMMISSION
NON-POWER INITIAL REACTOR LICENSE EXAMINATION

FACILITY: National Institute of Standards and Technology

REACTOR TYPE: Heavy Water cooled and moderated Tank

DATE ADMINISTERED: 04/ /2010

CANDIDATE:

INSTRUCTIONS TO CANDIDATE:
Answers are to be written on the answer sheet provided. Attach the answer sheets to the examination. Points for each question are indicated in brackets for each question. A 70% in each section is required to pass the examination. Examinations will be picked up three (3) hours after the examination starts.

% of Category Value	% of Total	Candidates Score	Category Value	Category
20.00	33.3	______	____	A. Reactor Theory, Thermodynamics and Facility Operating Characteristics
20.00	33.3	______	____	B. Normal and Emergency Operating Procedures and Radiological Controls
20.00	33.3	______	____	C. Facility and Radiation Monitoring Systems
40.00	______	____%		TOTALS FINAL GRADE

All work done on this examination is my own. I have neither given nor received aid.

____
Candidate's Signature

NRC RULES AND GUIDELINES FOR LICENSE EXAMINATIONS

During the administration of this examination the following rules apply:

1. Cheating on the examination means an automatic denial of your application and could result in more severe penalties.

2. After the examination has been completed, you must sign the statement on the cover sheet indicating that the work is your own and you have neither received nor given assistance in completing the examination. This must be done after you complete the examination.

3. Restroom trips are to be limited and only one candidate at a time may leave. You must avoid all contacts with anyone outside the examination room to avoid even the appearance or possibility of cheating.

4. Use black ink or dark pencil only to facilitate legible reproductions.

5. Print your name in the blank provided in the upper right-hand corner of the examination cover sheet and each answer sheet.

6. Mark your answers on the answer sheet provided. USE ONLY THE PAPER PROVIDED AND DO NOT WRITE ON THE BACK SIDE OF THE PAGE.

7. The point value for each question is indicated in [brackets] after the question.

8. If the intent of a question is unclear, ask questions of the examiner only.

9. When turning in your examination, assemble the completed examination with examination questions, examination aids and answer sheets. In addition turn in all scrap paper.

10. Ensure all information you wish to have evaluated as part of your answer is on your answer sheet. Scrap paper will be disposed of immediately following the examination.

11. To pass the examination you must achieve a grade of 70 percent or greater in each category.

12. There is a time limit of three (3) hours for completion of the examination.

13. When you have completed and turned in you examination, leave the examination area. If you are observed in this area while the examination is still in progress, your license may be denied or revoked.

EQUATION SHEET

$$\dot{Q} = \dot{m} c_p \Delta T = \dot{m} \Delta H = UA \Delta T$$

$$P_{\max} = \frac{(\rho - \beta)^2}{2\alpha(k)\ell}$$

$$\ell^* = 1 \times 10^{-4} \text{ seconds}$$

$$\lambda_{eff} = 0.1 \text{ seconds}^{-1}$$

$$SCR = \frac{S}{-\rho} \approx \frac{S}{1 - K_{eff}}$$

$$CR_1(1 - K_{eff_1}) = CR_2(1 - K_{eff_2})$$

$$CR_1(-\rho_1) = CR_2(-\rho_2)$$

$$SUR = 26.06\left[\frac{\lambda_{eff}\,\rho}{\beta - \rho}\right]$$

$$M = \frac{1 - K_{eff_0}}{1 - K_{eff_1}}$$

$$M = \frac{1}{1 - K_{eff}} = \frac{CR_1}{CR_2}$$

$$P = P_0\, 10^{SUR(t)}$$

$$P = P_0\, e^{\frac{t}{\tau}}$$

$$P = \frac{\beta(1 - \rho)}{\beta - \rho} P_0$$

$$SDM = \frac{(1 - K_{eff})}{K_{eff}}$$

$$\tau = \frac{\ell^*}{\rho - \overline{\beta}}$$

$$\tau = \frac{\ell^*}{\rho} + \left[\frac{\overline{\beta} - \rho}{\lambda_{eff}\,\rho}\right]$$

$$\Delta\rho = \frac{K_{eff_2} - K_{eff_1}}{k_{eff_1} \times K_{eff_2}}$$

$$T_{‰} = \frac{0.693}{\lambda}$$

$$\rho = \frac{(K_{eff} - 1)}{K_{eff}}$$

$$DR = DR_0\, e^{-\lambda t}$$

$$DR = \frac{6CiE(n)}{R^2}$$

$$DR_1 d_1^{\,2} = DR_2 d_2^{\,2}$$

DR – Rem, Ci – curies, E – Mev, R – feet

$$\frac{(\rho_2 - \beta)^2}{Peak_2} = \frac{(\rho_1 - \beta)^2}{Peak_1}$$

1 Curie = 3.7 x 10^{10} dis/sec

1 kg = 2.21 lbm

1 Horsepower = 2.54 x 10^3 BTU/hr

1 Mw = 3.41 x 10^6 BTU/hr

1 BTU = 778 ft-lbf

°F = 9/5 °C + 32

1 gal (H_2O) ≈ 8 lbm

°C = 5/9 (°F - 32)

c_P = 1.0 BTU/hr/lbm/°F

c_p = 1 cal/sec/gm/°C

A.01 a b c d ___

A.02 a b c d ___

A.03 a b c d ___

A.04 a b c d ___

A.05 a b c d ___

A.05 a b c d ___

A.06 a b c d ___

A.07a 1 2 3 4 5 6 7 ___

A.07b 1 2 3 4 5 6 7 ___

A.07c 1 2 3 4 5 6 7 ___

A.07d 1 2 3 4 5 6 7 ___

A.08 a b c d ___

A.09a 1 2 3 4 5 6 ___

A.09b 1 2 3 4 5 6 ___

A.09c 1 2 3 4 5 6 ___

A.09d 1 2 3 4 5 6 ___

A.09e 1 2 3 4 5 6 ___

A.09f 1 2 3 4 5 6 ___

A.10 a b c d ___

A.11 a b c d ___

A.12 a b c d ___

A.13 a b c d ___

A.14 a b c d ___

A.15 a b c d ___

A.16 a b c d ___

A.17 a b c d ___

A.18 a b c d ___

A.19 a b c d ___

B.01 a b c d ___

B.02a 1 5 10 20 ___

B.02b 1 5 10 20 ___

B.02c 1 5 10 20 ___

B.02d 1 5 10 20 ___

B.03 a b c d ___

B.04 a b c d ___

B.05 a b c d ___

B.06 a b c d ___

B.07 a b c d ___

B.08 a b c d ___

B.09 a b c d ___

B.10 a b c d ___

B.11 a b c d ___

B.12 a b c d ___

B.13 a b c d ___

B.14 a b c d ___

B.15 a b c d ___

B.16a 1 2 3 4 ___

B.16b 1 2 3 4 ___

B.16c 1 2 3 4 ___

B.16d 1 2 3 4 ___

B.17a 1 2 3 4 ___

B.17b 1 2 3 4 ___

B.17c 1 2 3 4 ___

B.17d 1 2 3 4 ___

B.18 a b c d ___

C.01a 1 2 3 4 5 ___

C.01b 1 2 3 4 5 ___

C.01c 1 2 3 4 5 ___

C.01d 1 2 3 4 5 ___

C.01e 1 2 3 4 5 ___

C.01f 1 2 3 4 5 ___

C.01g 1 2 3 4 5 ___

C.01h 1 2 3 4 5 ___

C.02 a b c d ___

C.03 a b c d ___

C.04 a b c d ___

C.05 a b c d ___

C.06 a b c d ___

C.07a 1 2 3 4 5 6 7 8 ___

C.07b 1 2 3 4 5 6 7 8 ___

C.07c 1 2 3 4 5 6 7 8 ___

C.07d 1 2 3 4 5 6 7 8 ___

C.07e 1 2 3 4 5 6 7 8 ___

C.07f 1 2 3 4 5 6 7 8 ___

C.07g 1 2 3 4 5 6 7 8 ___

C.07h 1 2 3 4 5 6 7 8 ___

C.08 a b c d ___

C.09 a b c d ___

C.10 a b c d ___

C.11 a b c d ___

C.12a 1 2 3 4 ___

C.12b 1 2 3 4 ___

C.12c 1 2 3 4 ___

C.12d 1 2 3 4 ___

C.13 a b c d ___

C.14 a b c d ___

C.15 a b c d ___

C.16 a b c d ___

C.17 a b c d ___

C.18 a b c d ___