

AFRRI 

**REACTOR OPERATOR
REQUALIFICATION
PROGRAM**

FOR

**AFRRI-TRIGA
REACTOR FACILITY**

DEFENSE NUCLEAR AGENCY
ARMED FORCES RADIOBIOLOGY RESEARCH INSTITUTE
BETHESDA, MARYLAND 20014

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AFRRI-TRIGA REACTOR FACILITY

Armed Forces Radiobiology Research Institute
Defense Nuclear Agency
National Naval Medical Center
Bethesda, Maryland 20014

I. PURPOSE.

This document sets forth the requirements for the Reactor Operator and Senior Operator Requalification Program for the Armed Forces Radiobiology Research Institute's TRIGA Reactor Facility in accordance with the Code of Federal Regulations (CFR), Title 10, Part 55, Section 55.33.

II. SCHEDULE.

The licensee will complete the requalification program every two years. The licensee will enter the requalification program on the date the Nuclear Regulatory Commission issues either a new license or a renewal of an existing license. The licensee will continue in the requalification program until either the expiration date of the current license or the date at which the current license is terminated. The licensee will perform duties at the reactor facility which includes the frequent operation and maintenance of the AFRRI reactor, this will insure familiarization and retraining on a continuous basis.

III. LECTURE.

The licensee shall participate in a preplanned lecture program. The lecture program will be designed to include refresher coverage of the following:

- A. Nuclear Theory.
- B. Radiation Control and Safety (10 CFR 20).
- C. Portions of 10 CFR 19, 50, 55, 70.
- D. Technical Specification and Reactor License.
- E. Reactor Operating Characteristics.
- F. Reactor Control and Safety Systems.
- G. Emergency Operating, Normal, and Abnormal Procedures.
- H. Changes, Modifications, or Malfunctions Occuring to Reactor Systems or Operational Procedures.
- I. Operational Characteristics, Use, and Storage Locations of Existing and New Radiation Safety Equipment.

(Individual study, training aids (audio-visual) or other forms of study may be employed, however they shall not be substitute for the lecture series.)

IV. ON-THE-JOB TRAINING.

Each licensed operator will manipulate the controls of the TRIGA reactor such that reactivity changes are made in performance of the following operations on at least 20 different occasions during the requalification period. Any combination of operations is acceptable, however, at least one from each category is required.

- A. Square wave or steady state operations.
- B. Pulsing operations.
- C. Excess reactivity measurements.

In addition each operator will perform the following reactor checkout operations on different (at least the number indicated) occasions during the requalification period.

- A. Daily startup checklist (10).
- B. Daily shutdown checklist (10).
- C. Weekly instrumentation checklist (2).

Each operator shall participate in the following facility activities at least once during the requalification period.

- A. Annual maintenance shutdown program.
- B. Control rod worth measurements.
- C. Fuel inspection.
- D. Fuel temperature measurement system calibration.

Each senior operator shall perform or directly supervise the performance of the above activities with the same frequency required of an operator.

V. EVALUATION.

The evaluation of the licensee's knowledge and performance of the requirements set forth in the requalification program will be accomplished by written examinations, a console performance examination, and an oral facility examination. The examinations will be administered by a Licensed Senior Operator at the facility. The written examinations for the reactor operator licensees will be prepared in accordance with 10 CFR 55.21 and for

the senior reactor operator licensees in accordance with 10 CFR 55.33. The console performance examination and the oral facility examination will be administered in accordance with 10 CFR 55, Appendix A. The licensee will be evaluated in accordance with the following specific requirements:

A. The licensee will complete a final written examination at the end of the two year requalification program.

B. The licensee will complete at least one annual written examination each year. Examination material will be taken from the general training requirements outline for operators and senior operators (see Inclosure 1).

C. The licensee will complete an annual console performance examination and an annual oral facility examination.

D. An annual evaluation will be prepared for each licensee, by the Senior Operator administering the evaluation and documented in a memorandum for record. The licensee will be assigned a rating of either SATISFACTORY or UNSATISFACTORY. In order to obtain a rating of SATISFACTORY, the licensee must attain a score of 70% on all examinations. If the licensee fails to obtain a rating of SATISFACTORY, the licensee will be removed from his licensed duties and enrolled in an accelerated, additional training program. The additional training will be given and a re-evaluation will be made and documented.

A summary of any additional training given to a licensee will be prepared and documented in a memorandum for record.

E. If the annual evaluation indicates that the licensee can complete the requalification program within a shorter period of time, then the requalification program will be accelerated to meet the requirement.

VI. RECORDS.

An individual record file will be maintained for each licensee and the record file will contain the following information:

A. Current copy of either the licensee's reactor operator or senior reactor operator license.

B. Copies of all written examinations administered to the licensee, and the correct answers given to the licensee, during the requalification period.

C. The annual evaluations of the licensee documented in a memorandum for record.

D. The licensee's requalification program progress checklist.

E. The summary of additional training received by the licensee documented in a memorandum for record and any additional documentation

VII. IMPLEMENTATION.

This document describes the program to insure proper and timely training of AFRRI staff members licensed and assigned to operate the AFRRI reactor. This program will be detailed and implemented through internal AFRRI documents commencing on approval by the Nuclear Regulatory Commission.

TRAINING REQUIREMENTS FOR REACTOR OPERATOR AND SENIOR OPERATOR

SECTION A. Design and Construction

1. AFRRI Facility Description

- a. Be able to list the buildings that make up the AFRRI complex.
- b. Identify the major facilities located in these buildings.
- c. Describe the ventilation systems for the reactor building.
- d. Know the details of construction of the reactor building.
 - 1) Describe the features of the reactor room, such as penetration, confinement integrity, emergency isolation capability.
 - 2) Free volume requirements and implications.

2. Basic AFRRI-TRIGA Design Features

- a. Know what components comprise the reactor core.
- b. Know reactor power rating and what type measurements are made to denote reactor power.
- c. Describe the coolant and purification system.

3. Reactor Tank

- a. Describe the features of the reactor tank, such as shape and dimensions.
- b. Be able to identify all penetrations.

4. Shield Doors

- a. Know principle function of lead doors.
- b. Describe shield door features and measurements.
- c. Be able to sketch the Pb door bearings.
- d. Know purpose and limits of air line to door bearings.
- e. Know times involved to open and close Pb doors.
- f. Know interlock facilities associated with Pb doors.
- g. Know what maintenance is performed on Pb doors.

5. Reactor Carriage and Core Support Structure

- a. Know reactor carriage dimensions
- b. Be able to identify all components on carriage.
- c. Know driving mechanism of reactor carriage.
- d. Know travel speeds of driving mechanism; limits of travel; and travel time of reactor carriage.

(This enclosure is provided as an example of current training requirements and is subject to change).

- e. Know function of microswitches associated with the movement of reactor carriage.
 - f. Know what maintenance is performed on reactor carriage and core support structure.
 - g. Know core support dimensions, such as support structure adapter and shroud.
6. Reactor Core
- a. Know construction, dimensions and use of upper and lower grid plates.
 - b. Know how many elements go into the make-up of the AFRRI-TRIGA reactor core, how they are identified.
 - c. Know positioning of control rods.
 - d. Know where neutron source is located.
 - e. Know how coolant flows through core.
 - f. Know location of detectors.
7. Fuel Elements
- a. Know construction, make-up and dimensions of the fuel elements. Be able to draw cross section of each type.
 - b. Know what type and frequency of maintenance that is performed on fuel elements.
 - c. Know where thermocouple elements are located.
8. Control Rods and Guide Tubes
- a. Know details and dimension of standard control rods.
 - b. Know what type and frequency of maintenance is performed on standard control rods.
 - c. Know details and dimensions of transient rod.
 - d. Know what type and frequency of maintenance that is performed on transient rod.
 - e. Know the difference between the drive mechanism used on the two types of control rods.
 - f. Know the reactivity worth of each control rod; insertion rates.
 - g. Know dimensions and function of control rod guide tubes.
 - h. Know where control rod guide tubes are connected.
 - i. Know rod drop times, how measured, and frequency.

9. Neutron Source and Holder

- a. Know what type of source is used.
- b. Know the strength and reaction of source.
- c. Know dimensions of source capsule.
- d. Know why there is a source check in the reactor start-up checklist.
- e. Know dimensions and where the source guide tube is located and attached.

10. N-16 Diffuser System

- a. Know the reason for N-16 Diffuser System and the principles of physics involved.
- b. Know the mechanical make-up of the diffuser system.
- c. Know rise time of N-16 bubbles, with and without diffuser.
- d. Know what maintenance is performed on diffuser system.

11. Experimental Facilities

- a. Be able to draw layout of experimental facilities; minimum shielding requirements around reactor tank.
- b. Know the procedures before entering each exposure room and what conditions must be satisfied before doors can be electrically opened.
- c. Know the duties of the reactor operator when experiments are loaded into rooms or other facilities.
- d. Know construction of each room, and shielding requirements.
- e. Know electrical outlets and penetrations in each room.
- f. Know functions of emergency stop in each room.
- g. Know maintenance requirements for each room and doors.
- h. Know the design features, operating characteristics, and hazards associated with the pneumatic tube system.
- i. Demonstrate your ability to operate the pneumatic tube system.
- j. Know location and procedure for in-core experiment tube (CET).

12. Auxiliary Handling Equipment and Tools

- a. Know the function of the various handling equipment and tools.
- b. Know what type of tool is used for the type of specific operation.

SECTION B. Control Console

1. Linear Power Channel

- a. Know location of detector, amplifier, signal switching relays and readouts.
- b. Know range of power level covered by this channel.
- c. Know what modes of operation for which this detector is used.
- d. Draw a block diagram of the system showing the detector, the power supplies, amplifiers, signal outputs and readout.
- e. Draw a fission detector, illustrating its operating principle.
- f. Know what information is provided by the linear power channel.
- g. Draw the mode diagram for the linear channel.
- h. Maintenance requirements.

2. Log Power Channel

- a. Know location of detector, amplifier, signal switching relays and readouts.
- b. Know what range of power this channel covers.
- c. Know what modes of operation for which detector is used.
- d. Draw a block diagram of the system showing the detector, the power supplies, and amplifier. Show signal outputs and readouts.
- e. Know what information is provided by the log channel.
- f. Draw the mode diagram for the log channel.
- g. Know what the period meter indicates and how the signal is developed.
- h. Maintenance requirements.

3. Control Rod Position Indication

- a. Standard Rod Position Indicators
 - 1) Range of indication.
 - 2) Type of detectors.
 - 3) Location of detectors.
 - 4) Location of readouts.
- b. Rod Indicator Lights and Microswitches
 - 1) Number of microswitches per rod.
 - 2) Purpose of microswitches.
 - 3) Meaning of control rod indicator lights under various conditions.

4. High Flux Safety Channels

- a. Know location of detectors, for each channel.
- b. Know power range for each channel.
- c. Explain difference between channel one and two.
- d. Draw a block diagram of each channel.
- e. Draw a diagram and explain the operation of each detector.
- f. Explain the SCRAM mechanics of each channel.
- g. Explain the functions of each channel in each mode.
- h. Know the channel maintenance requirements.
- i. List all SCRAM set points.

5. High Fuel Temp Safety Channels

- a. Know how many instrumented elements are required by R-84.
- b. Diagram a instrumented fuel element (label parts).
- c. Diagram the high fuel temp safety channels. Show all channel components and know their functions.
- d. Explain the importance of monitoring and protecting the fuel temperature.
- e. List and explain channel maintenance requirements.

6. Rod Control Switches

- a. Know how many and location of rod control switches for each rod.
- b. Know the name and describe the operation of each of these switches.
- c. Describe the indications observed at the control console that are provided by these switches.
- d. Explain the schematic of the standard control rod switches.

7. Gamma Chamber Channel

- a. Know location of detector, amplifier and readouts.
- b. Draw the gamma detector and explain its operation.
- c. Know what is the range of the gamma channel.
- d. Know what protection is provided by this channel.
- e. Describe the use of this channel in mode III.
- f. Know how the NVT circuit is calibrated.
- g. Explain how this channel is used in conjunction with the steady state safety channels.
- h. Explain the meaning of NVT.
- i. Required maintenance.

8. Dual Pen Recorder
 - a. Know location of recorder.
 - b. Change recorder chart paper.
 - c. Describe what is on each pen of the recorder in each mode of operation.
 - d. Know what signals are displayed on the recorder in the various modes of operation.
 - e. Required maintenance.
9. Area Radiation Monitor System Annunciators
 - a. Know location of panel.
 - b. Know what indication is supplied by this panel.
 - c. Describe the meaning of each light on the panel and its origin.
 - d. Describe the action of the operator for each of the lights.
10. Servo Control System
 - a. Draw a block diagram of both servos showing the inputs and outputs.
 - b. Explain the operation of each servo.
 - c. Know the location of the servo components.
 - d. Know what modes in which the servos are used.
 - e. Know what rod(s) is (are) controlled by the servo, and when used.
 - f. Draw the mode diagrams in which each servo is operational.
 - g. Know what adjustments are required and when.
11. Operational Channel Calibrator
 - a. Describe the function of the calibrator.
 - b. Describe the signals generated for the various calibration positions.
 - c. Describe the operation of the calibration for the various ranges.
 - d. Know maintenance requirements.
12. Console Timer
 - a. Know when the timer is in the SCRAM circuit.
 - b. Know what happens when the timer SCRAM is turned on when the timer is running.
 - c. Know what happens when the tumblers are rotated if the timer scram is turned on.
 - d. Know what the timer does when a scram occurs if the timer scram is turned off/on.

- e. Know if the timer will run when magnet power is not available.
- f. Know if the timer forms a part of any interlock. Explain.

13. Core Dolly Position Indicator

- a. Type and location of readout.
- b. Type and location of detector.
- c. Normal readings vs. core dolly location.
- d. Equate between indicated dolly position and comparable dolly position as measured in feet or inches.
- e. Know what operates the core dolly position 1 and 3 lights.
- f. Know if these light actuators form a part of any interlock and/or control circuit. Explain.

14. Bulk, Inlet and Outlet Pool Temperature Indicators

- a. Describe the location of all detectors.
- b. Know the purpose of the temperature indicators.
- c. Describe the system (detector, amplifier and readouts).
- d. Give maintenance and calibration requirements.

15. NV and NVT Circuits

- a. Explain the meaning of NV and NVT.
- b. Know what kind of detector is used. Know what other types may be used.
- c. Know where this detector is located.
- d. Know how the NVT circuit operates.
- e. Know where the NV and NVT readouts are.
- f. Know the maintenance requirements.

16. Radiation Area Monitors (RAM's)

- a. Know what RAM detectors are located in the reactor room and in the prep area.
- b. Know what RAM's are required by license.
- c. Know what RAM's readouts are in the control room.
- d. Know the operator's action upon the receipt of any of these RAM alarms.
- e. Know what kind of detector the RAM's utilize.
- f. Know what kind of radiation they detect.

17. Required Instrumentation

- a. List the required instrumentation.
- b. Know the location of the required instrumentation readouts and detectors.
- c. Explain the purpose of each piece of required instrumentation.
- d. Know what kind, and location of, each alarm associated with all pieces of required instrumentation.
- e. Know each alarm setpoint and the determining factor(s) for its limit.
- f. Know the proper operator response to each of these alarms.

SECTION C. Carriage

1. PA5 Preamplifier

- a. Know the function of the PA5.
- b. Know where it is located.
- c. Explain how the PA5 operates.
- d. Know what precautions are taken before servicing the PA5.
- e. Know the maintenance requirements.

2. Power Monitoring Detectors

- a. Be thoroughly familiar with the theory of operation of the different types of detectors used in our reactor.
- b. Prepare diagrams of the internal structure of all of our detectors.
- c. Know the ranges and limitations of our detectors.
- d. Be familiar with the routine maintenance procedures.

3. Regulating Control Rod Drive

- a. Label parts and know location of reg rod drive.
- b. Know how the drive operates.
- c. Describe the function of all microswitches.
- d. Describe how the rod position is determined.
- e. Know the speed of travel and length of travel.

4. Standard Control Rod Drive Units

- a. Be familiar with the circuit diagram.
- b. Be able to label the callouts on the structural diagram.
- c. Know the design and operating characteristics of the drive units.

- d. Know the relationship between the microswitches on the drive units and the indicator light combinations on the console.
- e. Know the purpose of the drive motor balance potentiometer.
- f. Know the drive speed and the associated maximum reactivity insertion rate.
- g. Be familiar with the routine maintenance procedures.

5. Transient Rod Drive Unit

- a. Be familiar with the circuit diagram.
- b. Be able to label the callouts on the structural diagram.
- c. Know the design and operating characteristics of the drive unit.
- d. Know the relationship between the microswitches on the drive unit and the indicator lights on the console.
- e. Be familiar with the electronic firing sequence for the rod.
- f. Know the manual drive speed and associated maximum reactivity insertion rate.
- g. Know the time required for the rod to each 100% withdrawal when fired with air.
- h. Be familiar with the routine maintenance procedures.

6. Core Dolly Drive System

- a. Be familiar with the circuit diagram.
- b. Know the design and operating characteristics of the system.
- c. Know the drive speeds associated with the carriage.
- d. Know the purposes of the microswitches mounted along the carriage rails.
- e. Be familiar with the routine maintenance procedures.

SECTION D. Auxiliary Systems

1. Transient Rod Air System

- a. Know major components and locations of each.
- b. Know proper system lineup and appropriate pressures.
- c. Be aware of maintenance procedures and be able to perform them.

2. Stack Particulate Monitor

- a. Know major components and their locations.
- b. Know what is monitored and where readouts are located.
- c. Know alarm points and what activity level they represent.

- d. Know type of detector and how it operates.
 - e. Know who is responsible for maintenance.
3. Stack Gas Monitor
- a. Know major components and their locations
 - b. Know what is and what can be detected and where readouts are located.
 - c. Know alarm points and what activity level they represent.
 - d. Know type of detector and how it operates.
 - e. Know propane system, how to line up properly and what alarms are associated with this system.
 - f. Know who is responsible for maintenance.
4. Water Monitor System
- a. Know major components and their locations.
 - b. Know types of detectors used in this system.
 - c. Know where readouts are for system and what alarm or maximum readings are allowed.
 - d. Know maintenance procedures.
5. Stack Effluent Velocity Readout
- a. Know type detector and how it operates, where it is located, and where the readout is located.
 - b. Know who is responsible for maintenance.
6. Reactor Coolant and Purification System
- a. Know all major components and their locations.
 - b. Be able to draw a detailed flow diagram of the system.
 - c. Know all limits of system with regard to monitoring systems.
 - d. Know ratings of all pumps, heat exchangers, etc.
 - e. Know types of filters used in purification system and when they are changed.
 - f. Know types of resin used in purification system.
 - g. Know function of holes in inlet and discharge lines to reactor tank.
 - h. Know operation of cooling tower fans.
 - i. Know how to vent the heat exchanger pump.
 - j. Know routine maintenance procedures and be able to perform them.

7. Reactor Facility Interlock System
 - a. Know location and function of each interlock microswitch or actuator button.
 - b. Be able to draw diagram of facility interlock system.
 - c. Know routine maintenance procedures and be able to perform them.

8. Water Distillation System
 - a. Know how system operates and be able to perform a startup and shutdown of system.
 - b. Know how to add clean make-up water to reactor tank.
 - c. Know what tests must be made before adding water to reactor tank from still and what the limits are for good water.
 - d. Know routine maintenance of system.
 - e. Know types of filters used in feedwater system, and their function.

9. Reactor Room Emergency Air System
 - a. Know major components and their locations.
 - b. Know how the dampers operate and from where control air is supplied.
 - c. Know how dampers can be closed and what indications are there when they are closed.
 - d. Know purpose of atmospheric relief valves.

10. Reactor Public Address System
 - a. Know location of microphones, speakers and amplifiers.
 - b. Know routine maintenance of this system.

11. Reactor Room Emergency Escape Doors
 - a. Know how to operate doors.
 - b. Know routine maintenance.

12. Exposure Room Plug Doors
 - a. Know proper operation of plug doors.
 - b. Know approximate weights and measurements of each door.,
 - c. Know why ER#1 plug door is larger than ER#2.
 - d. Know SOP for opening and closing each door, with regard to personnel required, radiation limits and safety requirements.
 - e. Know routine maintenance and be able to perform it.

13. Reactor Room Hoist

- a. Know rating of hoist.
- b. Know who is authorized to operate hoist.
- c. Know dangers involved with operation of hoist and safety requirement.
- d. Know purpose of flashing red light in reactor room.

14. Radioactive Waste Disposal System

- a. Know number of collection tanks and how they are identified, what their capacities are, and when they are drained.
- b. Know color coding of drains in AFRRI.
- c. Know locations of all drains in the reactor complex and what type drain they are.
- d. Know limits on waste disposal to sewage.

15. Electric Distribution System

- a. Know type distribution system and be able to draw simple one line diagram of feeders up to motor control center in reactor room.
- b. Know what each of two transformers feeds.
- c. Know what happens when one feeder is lost.
- d. Know main breakers on motor control center #1. Know where starter panels are located for core dolly drive motor, lead shield door drive motor, exposure room plug door drive motors and know their voltages.

SECTION E. CALIBRATION PROCEDURES

1. Detector Calibration

- a. Be familiar with the detector calibration procedure, the restrictions thereto, and the possible consequences.
- b. Demonstrate your ability to carry out all detector calibrations.

2. Thermal Power Calibration

- a. Be familiar with the thermal power calibration procedure.
- b. Be familiar with the procedures used to set up the auxiliary equipment necessary to support and monitor the thermal power calibration.

- c. Demonstrate your ability to perform a thermal power calibration.
- d. Know the importance of "ambient temperature" to the proper accomplishment of a thermal power calibration.

3. Tank Constant Calibration

- a. Be familiar with the tank constant calibration procedure.
- b. Know the safety hazards and precautions associated with the tank heater.
- c. Be familiar with the procedures used to set up the auxiliary equipment necessary to support and monitor the tank constant calibration.
- d. Know the importance of "ambient temperature" to the proper accomplishment of a tank constant calibration.
- e. Demonstrate your ability to perform a tank constant calibration.

4. Control Rod Calibration

- a. Be familiar with the control rod calibration procedures.
- b. Know the effects of various rod configurations to the calibration of a particular control rod.
- c. Know why the control rod curves vary with reactor position in the tank.
- d. Know the importance of performing control rod calibrations the same way each time.
- e. Demonstrate your ability to set up and operate the Data Acquisition System during a control rod calibration.
- f. Demonstrate your ability to perform a control rod calibration at the reactor console.

5. Reflector Coefficient Calibration

- a. Be familiar with the reflector coefficient calibration procedure.
- b. Demonstrate your ability to perform a reflector coefficient calibration.

6. Power Coefficient Calibration

- a. Be familiar with the power coefficient calibration procedure.
- b. Demonstrate your ability to perform a power coefficient calibration.

7. Pulse Parameter Calibration
 - a. Be familiar with the pulse parameter calibration procedure.
 - b. Know the values of the parameters associated with various pulse sizes.
 - c. Demonstrate your ability to perform the pulse parameter calibrations.
8. Fuel Element and Control Rod Measurement
 - a. Be thoroughly familiar with the procedures, hazards, and precautions associated with this operations.
 - b. Know the facility license, and department directive requirements pertaining to this operation.
 - c. Demonstrate your ability to perform all aspects of this operation.
9. Control Rod Drop Tests
 - a. Be familiar with the control rod drop test procedures.
 - b. Know the importance of conducting these tests after control rod maintenance has been completed, prior to any reactor operation.
 - c. Demonstrate your ability to set up and perform the control rod drop tests.

SECTION F. OPERATIONS

1. Steady State Operation
 - a. Demonstrate your ability to efficiently perform steady state exposure operations.
 - b. Demonstrate your ability to approach a designated power level on a fast period.
2. Square Wave Operation
 - a. Demonstrate your ability to efficiently perform square wave exposure operations.
3. Pulse Operation
 - a. Demonstrate your ability to efficiently perform pulsing exposure operations.
4. K Excess Measurement
 - a. Know the purpose of measuring K excess.

- b. Know what differences will be reflected in K excess when measuring it in various positions in the tank.
 - c. Demonstrate your ability to perform a K excess measurement.
5. Criticality Achievement
- a. Demonstrate your ability to achieve criticality from a shutdown condition.
 - b. Know the significance of all points of the power level recorder traces during startup and shutdown.
6. Reactivity Insertion vs Period
- a. Demonstrate your ability to approach power on a predetermined period using the in-hour curve.
7. Loading and Unloading Experiment
- a. Know the procedures, hazards, license requirements, additional equipment needed, detector placement considerations, and manpower requirements necessary for the proper performance of core loading and unloading experiments.
8. a. Demonstrate your ability to perform a startup checklist properly.
b. Know why each item is listed on the checklist.
9. Startup/Shutdown Checklist
- a. Demonstrate your ability to perform a startup/shutdown checklist properly.
 - b. Know why each item is listed on the startup/shutdown checklist.

SECTION G. ADMINISTRATIVE PROCEDURES

1. RSD Instruction 5-1
- a. Know the organizational relationship of the positions relevant to the reactor.
 - b. State duties and qualifications for facility personnel.
2. RSD Instruction 5-2
- a. Know the operating limits for the reactor.
 - b. Know the administrative limits and controls on reactor operation.
 - c. Define the different types of reactor experiments.

- d. Know what approvals are required for the different experiments.
 - e. Explain the purpose and how we accomplish core criticality monitoring.
3. RSD Instruction 5-3
- a. Know the purpose for emergency procedures.
 - b. Know the entire information contained in Table I.
 - c. Know the action to take resulting from any alarm on Table I. Define the three action levels available to the operations staff.
 - d. Know actions required in the event of a fire alarm.
 - e. Be aware of other events that may require action by staff members.
4. RSD Instruction 5-4
- a. Define major and minor modifications.
 - b. Be aware of duties required by staff positions with regard to the maintenance program.
 - c. Know the different types of maintenance required by the reactor and related systems.
 - d. Know what logs are required, where they are kept, who makes entries and who reviews the logs.
 - e. Know requirements for core maintenance work.
5. RSD Instruction 5
- a. Know who grants permission for hoist operation.
 - b. List requirements for use of hoist.
 - c. Know hoist limits.
6. RSD Instruction 6
- a. Know the purpose for maintaining a training and requalification program for the reactor staff.
 - b. Know how often operators must be relicensed.
7. RSD Instruction 7
- a. Know location and describe the rabbit and CET system.
 - b. Know the duties of an operator directing or operating each of the above.

8. RSD Instruction 8

- a. Know the general theory behind the core loading and unloading procedures.
- b. Know the personnel requirements for loading and unloading the core.
- c. Know what instrumentation is required.

9. Title 10-CFR-20

- a. Know definitions of:
 - 1) Airborne radioactive material.
 - 2) Byproduct material.
 - 3) Licensed material.
 - 4) Occupational dose.
 - 5) Radiation.
 - 6) Restricted area (and radiation limits).
 - 7) Source material.
 - 8) Special nuclear material.
 - 9) Unrestricted area (and radiation limits).
 - 10) Rad, Rem.
 - 11) RBE of γ , n, p, X.
 - 12) Curie, micro curie (μCi).
 - 13) Radiation area.
 - 14) High radiation area.
- b. Know neutron dose flux equivalents for thermal and 1 MeV neutrons.
- c. Know restrictions for exposure to individuals in:
 - 1) Unrestricted areas.
 - 2) Restricted areas.
- d. Know provisions to receive 3 Rem per quarter.
- e. Know and sketch the radiation symbol.
- f. Know requirements for:
 - 1) Release of contaminated waste into sewage system.
 - 2) Release of Argon-41 into the atmosphere.
- g. Know requirements for immediate and 24 hour notice to AEC for incidents.
- h. Know how to use App. B.

10. Title 10-CFR-50
 - a. Know definitions of:
 - 1) Utilization facility.
 - 2) Nuclear reactor.
 - 3) Controls.
 - b. Show a general knowledge of conditions of licenses.
 - c. Know what is required to make a change to any part of the reactor system which is part of the license.
11. Title 10-CFR-55
 - a. Know definitions of:
 - 1) Operator.
 - 2) Senior operator.
 - b. Show a general knowledge of requirements for and restrictions on license.
12. Title 10-CFR-70
 - a. Know definition of:
 - 1) Sealed source.
 - b. Know requirements on possession in excess of 500 g of contained U²³⁵.
 - c. Know what system at AFRRI-TRIGA meets this requirement.
13. AFRRI-TRIGA Facility License R-84
 - a. Through review of basic licenses and all amendments show a basic knowledge of the history of AFRRI-TRIGA.
 - b. Know the limit on:
 - 1) Contained uranium-235.
 - 2) Startup source.
 - 3) Separation of byproducts.
 - c. Know the license maximum steady state power level.
 - d. Know what records are required to be maintained by the license and amendments.
 - e. Know when the license expires.
 - f. Know definition of:
 - 1) Reactor shutdown.
 - 2) Reactor secured.

- 3) Reactor operation.
 - 4) Modes of operation.
 - 5) Cold critical.
 - 6) Operable.
 - 7) Experiment.
 - 8) Exposure facilities.
- g. Know how the reactor building meets the requirements of the Technical Specification.
 - h. Know how the TRIGA fuel element composition and geometry meet the requirements of the license.
 - i. Know how stored fuel elements are monitored.
 - j. Know the basic safety parameters.
 - k. Know how these parameters are implemented at AFRRI.
 - l. Know requirements for reactor control, and how implemented.
 - m. Know requirements for nuclear instrumentation, and how implemented.
 - n. Know all safety interlocks.
 - o. Know required facility interlocks and how implemented.
 - p. Know required maintenance tests and intervals.
 - q. Know required calibrations and how conducted.
 - r. Know requirements for an experiment, and how AFRRI insures compliance.
 - s. Know your responsibility (as an operator) to insure that the requirements for an experiment have been met.
 - t. Know the limit for absolute reactivity worths of experiments.
 - u. Show a general knowledge of the Environmental Monitoring Program which meets Technical Specification requirements.
 - v. Show a working knowledge of required procedures and where to find the written procedures.
 - w. Know required minimum safety scrams.

SECTION H. REACTOR THEORY

1. Nuclear Physics Review
 - a. Nuclear Particles

- 1) Be able to define and classify nuclear particles, i.e., protons, electrons, neutrons.
 - 2) Be able to discuss and calculate binding energies.
- b. Cross Sections
- 1) Define and distinguish between the various cross sections of absorption, total, scattering, fission.
 - 2) Calculate attenuation of direct beams of radiation, both $\gamma + \eta$.
- c. Neutron and gamma flux
- 1) Define and discuss significance of flux, population.
 - 2) Differentiate between flux and interaction.
2. Reactor Physics
- a. Fission
- 1) Discuss parameters of fission: ν , η , energy release, energy distribution, fission particles, γ rays, neutrons.
 - 2) Know significance of ν for each type of fuel.
- b. Multiplication Constant
- 1) Give definition of M.
 - 2) Discuss 4 and 6 factor formulae.
 - 3) Discuss neutron economy.
 - 4) Discuss delayed neutrons.
 - 5) Discuss k_{inf} .
 - 6) Discuss k_{eff} .
 - 7) Discuss subcritical, critical, and supercritical reactors.
- c. Neutrons from fission
- 1) Prompt and delayed neutron characteristics of lifetime, energy, origin.
 - 2) Importance in reactor control of delayed β n^1 .
- d. Reactor period
- 1) Define.
 - 2) Calculations from power response data.
 - 3) Differentiate between period and power level.

e. Reactor kinetics

- 1) Know the in-hour equation.
- 2) Know what for the in-hour equation is used.
- 3) Parameters that effect kinetics, e.g., α_t (temp coeff), α_d (volume coeff), doppler effect.
- 4) Effect of each delayed neutron group on asymptotic periods, \pm .

3. Reactor Engineering

a. Moderation

- 1) Definition.
- 2) Characteristics of high and low Z elements.

b. Reflection

- 1) Definition.
- 2) Characteristics of high and low Z elements.

c. Control rods

- 1) Worth as function of ϕ and \bar{r} .
- 2) Rod shadowing.

d. Neutron source

- 1) Importance of (function in reactor).
- 2) Characteristics of various types.