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Astronuclear Laboratory

Pittsburgh 36, Pennsylvania

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WESTINGHOUSE ASTRONUCLEAR

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WANEF TRAINING PROGRAM

MASTER

(Title Unclassified)

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ABSTRACT

A training program leading to the appointment of an initial operating staff for the Westinghouse Astronuclear Experimental Facility (WANEF) of the NERVA Program has been prepared, approved and executed. Subsequent training for facility personnel will follow explicitly the established procedures of WANL-TME-287, WANEF Operations Manual.

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I. Introduction

In conformance with the request of the WANL Nuclear Safety Committee, the appointed WANEF Operator's Qualification Subcommittee has reviewed the proposed qualification program at WANEF. The review included the approval of the presented training material, time and sequence of presentation and final approval of examination results. The program was conducted as required by WANL-TNR-099, "WANEF Safety Report," and as directed by AEC Manual 8401, "Safety of AEC-Owned Reactors," and Subcontract No. NP-1, Amendment No. 1, Supplemental Agreement No. 2.

II. Conclusion

As a result of the reviews discussed in the introduction, it is concluded that the execution of the WANEF Training Program as discussed in the following pages and as guided by the requirements of WANL-TME-267, "WANEF Operations Manual," will lead to the appointment of competent critical facility reactor operators. This competency will ensure safety and efficiency in the performance of the proposed tests at WANEF.

III. Discussion

The personnel responsibilities of the WANEF Operating Staff have been discussed in detail in Section 2-6, Chapter 2, of WANL-TME-267. The detail covers position description, position qualifications and training. As indicated under the training subsection, a formal sequence and demonstration of competence is required for each progressive step of staff responsibility. The formal sequence is presented as Appendix A, "WANEF Initial Training Program," of this report and the demonstration of competence is tested by Appendix B, "WANEF Operator's Examination." When staff personnel have successfully completed the requirements of the attachments, they will be appointed to the appropriate operating staff positions by the Scientist-in-Charge as dictated by the programmatic needs and individual technical and personality traits. At all times the requirements of WANL-TME-267 will be specifically followed with the following exception. Paragraph 2.6.3.3.1 of WANL-TME-267 identifies qualification items as ten approaches to critical and thirty hours of critical operation for a Reactor Operator and an Experimentalist. Since it will be impossible for staff members to meet this requirement prior to initial criticality of the facility, the subcommittee has specifically waived this requirement. Justification for this waiver is based on the fact that all appointments to the initial operating staff will be made from personnel who have previously been a qualified reactor operator at either a licensed or contract facility. Furthermore, item II-H of Appendix A serves in part the intention of this qualification.

APPENDIX A

WANEF INITIAL TRAINING PROGRAMI. Personality Trait Examination

Executed, graded and evaluated by Dr. Ayers, Consulting Psychologist, Westinghouse Electric Corp., Gateway Center. Coordinated by A. Cervi, Subcommittee Member.

II. Technical Training Program

Executed as indicated.

Coordinated by E. J. Ney, Supervisor, WANEF Critical Test Operations.

A. Nuclear Physics by Dr. A. Rothman, Advisory Scientist - 9 hrs.

B. Health Physics by J. Zuzik, Supervisor, WANL Health Physics; T. Merrick, Waltz Mill Site Health Physicist; and M. Cox, LASL Trained Health Physicist - 9 hrs.

C. NERVA Nuclear Design by Dr. D. McCutchan, Supervisor, Reactor Analysis, Nuclear Design - 3 hrs.

D. Instrumentation by J. Beene, WANEF Staff - 9 hrs.

E. Operating Procedures by E. J. Ney, Supervisor, Critical Test Operations - 9 hrs.

F. Criticality Procedures by E. Hemmerle, Supervisor, Safeguards Engineering Dept. - 3 hrs.

G. Emergency Procedures by Dr. W. P. Kovacik, WANEF Staff - 2 hrs.

H. Los Alamos Scientific Laboratory, N-2 Division participation in NERVA experiments

III. Written Operator's Examination (Appendix B) by J. Roll, Supervisor, Flight Safety Laboratory

To be prepared from items IIA through IIG, above, in addition to material from the following documents:

- A. WANL-TNR-099 - WANEF Safety Report
- B. WANL-TME-267 - WANEF Operations Manual
- C. WANL-TME-355 - WANEF Pre-Assembly Experimental Plan
- D. WANL-TME-383 - WANEF Operating Limits
- E. WCAP-2304 - Waltz Mill Site Health Physics Manual
- F. Dr. Rothman's notes
- G. WANL-TME-185 - Criticality Hazards Control Guide

IV. Oral examination and walk-thru by Nuclear Safety Subcommittee for WANEF Operator's Qualification to cover all facility checkouts in addition to selected areas of III, above.

V. Medical examination by Dr. A. A. Spritzer, Medical Director, Westinghouse Astronuclear Laboratory, to be in accordance with Atomic Energy Commission Form #396, Certification of Medical Examination for Facility Operator's License.

APPENDIX B

WESTINGHOUSE ASTRONUCLEAR
EXPERIMENTAL FACILITY
OPERATIONS EXAMINATION

December 9, 1963

by

E. J. Ney

Supervisor

Critical Test Operations

Examinee Name _____ Date _____

Grader Name _____ Date _____

Score _____

WANEF OPERATIONS EXAMINATION

December 9, 1963

A. Theory

1. Define "delayed neutrons."
2. Define "prompt neutrons."
3. Define reactivity.
4. Define dollar.
5. Define K excess.
6. Define stable reactor period.
7. Define delayed neutron fraction.
8. Define four factor formula.
9. Define subcritical multiplication.
10. Define fission fragment.
11. Define an inhour.
12. What is the average energy of delayed neutrons?
13. What is the average energy for prompt neutrons?
14. Why is the delayed neutron fraction larger in a finite reactor than in an infinite medium?
15. On the average, how many neutrons are produced when a U-235 nucleus undergoes fission?
 - a. 2.5_____
 - b. 1.0_____
 - c. 2.0_____

16. The neutron age is related to
- a. The length of time required for a neutron to cause fission. _____
 - b. The distance a thermal neutron travels before it is absorbed. _____
 - c. The distance a neutron travels before it becomes thermalized. _____
17. Delayed neutrons are generally more effective in a reactor than prompt neutrons because
- a. They are produced at a lower energy _____
 - b. They are less likely to leak out of the core _____
 - c. The neutron age is smaller _____
 - d. All of the above _____
18. The length of time between fission and formation of a delayed neutron depends on
- a. The mean life of the precursor _____
 - b. The neutron age _____
 - c. The energy of the neutron causing fission _____
 - d. None of the above _____
19. For a particular core, it is found that $\bar{\beta}/\beta = 1.10$. What is the effective delayed neutron fraction?
- a. .00704 _____
 - b. .0064 _____
 - c. .070 _____
20. A core with all rods inserted has a shutdown reactivity of .05. It is found that raising two rods to half height changes the shutdown reactivity by .01. With the two rods at half height, what is the

subcritical multiplication?

a. 0.96

b. 20

c. 0.04

d. 25

21. The mean life of the longest-lived delayed neutron precursor is approximately

a. 10^{-5} sec

b. 0.1 sec

c. 8 sec

d. 80 sec

22. The purpose of the reflector is to

a. prevent some neutrons from escaping.

b. provide cooling for the core.

c. slow down the neutrons before they escape.

23. The amount of energy released per fission is approximately

a. 20 mev

b. 200 mev

c. 2000 mev

24. The time for a neutron produced by fission to be slowed down and then produce another fission is the order of

a. 1 sec

b. 10^{-5} sec

c. 10^{-8} sec

25. A reactor is said to be delayed critical when the reactivity (k_{eff}) is equal to
- a. 1.0 _____
 - b. 1.025 _____
 - c. 1.0075 _____
26. When a reactor is just prompt critical then
- a. the production of delayed neutrons has ceased. _____
 - b. the reactor would be critical if no delayed neutrons existed. _____
 - c. the reactor becomes an atomic bomb. _____
27. The total fraction of delayed neutrons from thermal neutron induced fission in U-235 is about
- a. .0064 _____
 - b. .002 _____
 - c. .064 _____
28. The energy of thermal neutrons at room temperature is approximately
- a. 5.0 ev _____
 - b. 0.63 ev _____
 - c. 0.025 ev _____
29. Most of the energy obtained from the fission process comes from
- a. gamma radiation _____
 - b. energy dissipated by the neutrons _____
 - c. energy dissipated by the fission fragments _____

30. The reactor neutron source (e.g., Po-Be) is needed to
- a. achieve criticality _____
 - b. observe approach to critical _____
 - c. take data _____
31. The minimum critical mass of U-235 is about
- a. 800 gms _____
 - b. 5 kg _____
 - c. 10 kg _____

B. Health Physics

1. What is the maximum permissible radiation exposure to the whole body per quarter? Give example when this dose may be increased and under what conditions.
2. What is the permissible weekly dose at the Waltz Mill Site? State who may authorize an increase in this figure and under what conditions.
3. Describe a contamination area, radiation area, high radiation area, airborne radioactivity area and radioactive materials area.
4. State what the Westinghouse policy is concerning the transportation of radioactive materials in private cars.
5. List the various types of radiation detection equipment in use at WANEF. Besides portable equipment include the radiation monitoring system and for what purpose is its intended use.
6. Indicate what action you would take if a radiation monitor alarmed in your area.

7. What is the purpose of a continuous air monitor and what action would you take when an alarm condition is observed?
8. What action would you take if you observed personnel contamination during a personnel survey?
9. State how you would remove protective clothing when leaving a contaminated area.
10. What action would you take first, upon receipt of any radioactive contamination or accountable material at WANEF?
11. A lethal radiation dose is about
- a. 500 r _____
 - b. 10,000 mr _____
 - c. 750 mr _____
12. In whole body external radiation exposure, the most dangerous is
- a. alpha _____
 - b. beta _____
 - c. gamma _____
13. In internal radiation exposure, the most dangerous is
- a. alpha _____
 - b. beta _____
 - c. gamma _____
14. Specific Activity which is a measure of the total radioactivity of an isotope per gram of the radioactive isotope is a function of the radioactive half-life.

True _____

False _____

15. Protective clothing is not required in a lab or room where the loose removable beta contamination level smears less than 125 disintegrations per minute per square foot.

True _____

False _____

16. The self-reading dosimeter can be used both as dose rate measuring device and an integral or cumulative dose measuring device.

True _____

False _____

17. If the dose rate at 2 feet from a point source of radiation is 125 R/hr, the dose rate at 10 feet from the source is:

a. 250 mr/hr _____

b. 500 mr/hr _____

c. 5000 mr/hr _____

d. 25,000 mr/hr _____

e. None of these _____

18. Which of the following survey meters is the proper radiation detection instrument to use to measure the test cell radiation level when entering after a flux plot to remove irradiated test specimens?

a. Cutie pie (Beta-Gamma ion chamber type survey meter) _____

b. Thermal Neutron Survey Meter _____

c. PAC-3G - Alpha Survey Meter _____

d. Fast Neutron Survey Meter _____

19. The Laboratory radiation exposure limits to critical organs is
- a. 100 mrem/week _____
 - b. 300 mrem/week _____
 - c. 1,250 mrem/quarter _____
 - d. 5,000 mrem/quarter _____

C. Instrumentation

1. What is the facility maximum allowable scram time in the Operating Limits?
2. What is the actual approximate scram time?
3. List the scram time components and their approximate values.
4. What is the facility maximum allowable reactivity insertion?
5. What is the actual approximate reactivity insertion for the PAX?
6. Does the red cell veto light in the Test Cell mean operations cannot be conducted?
7. Does the absence of the green, yellow or red startup channel lights in the Test Cell indicate a safe condition?
8. Under emergency conditions, how would you start up the reactor single-handedly?
9. List the design areas and facility rules that would prevent an unauthorized startup.

10. What would you do if in preparing for a startup, with source in and all drums at zero, and the instrumentation suddenly indicated a 10-second period on all channels?
11. What would you do if on an approach to a relatively high power level by a period for a flux plot, all instruments level off at the desired power with no insertion of the control drums?
12. What is the facility maximum power level?
13. Why was this value selected?
14. Can a PAX reactor, which has an individual drum worth of 1 cent per degree at a delayed critical drum bank of 40 degrees, be operated within the minimum shutdown reactivity of the Operating Limits?
15. List the means by which more than one drum is prevented from moving while in bypass.
16. Will the loss of voltage to the startup channel scram the reactor? Why?
17. Describe the airborne monitor alarm conditions.
18. Is the response time for the log n amplifier better at high levels or low levels?
19. If at startup the background reading of the ion chambers is at least 10^{-11} without the reactor source in place, it is not necessary to use the reactor source.

True _____

False _____

20. Minimum number of level safety channels required is _____.
21. Minimum number of period safety channels required for startup is _____.
22. Minimum number of period channels required after startup is _____.
23. Number of level channels recorders required on which source multiplication can be seen is _____.
24. Number of gamma safety channels required is _____.
25. Suppose a reactor is just critical, that is, $\rho = 0$. A positive reactivity of 10×10^{-4} is introduced by withdrawing the control rods. The resulting period would be approximately
- a. 5 sec _____
 - b. 50 sec _____
26. The reactor is on a positive period of 50 sec. The neutron level will increase by a factor of 20 every
- a. 50 sec _____
 - b. 100 sec _____
 - c. 150 sec _____
 - d. 200 sec _____
27. Plastic is sometimes placed around a neutron chamber because
- a. it results in a better multiplication approach curve. _____
 - b. it produces a higher source reading during operation. _____
 - c. it produces a higher source reading during control rod withdrawal. _____

28. If the neutron source strength were increased in a slightly subcritical reactor
- a. the reactor may become critical. _____
 - b. the reactor power level will increase. _____
 - c. there will be no change in power level. _____
29. The power level of a reactor is 1 watt. A control rod is withdrawn and the power level raised to 10 watts. The critical bank height for the reactor when at 10 watts is
- a. less than at 1 watt. _____
 - b. greater than at 1 watt _____
 - c. same as at 1 watt. _____
30. When making inverse multiplication measurements, the counters should be
- a. as far from the core as possible. _____
 - b. as close to the neutron source as possible. _____
 - c. neither one of the above. _____
31. The purpose of a reactor precritical checkout is to make sure the operator is familiar with the various controls.
- True _____
- False _____
32. If only two level trip channels operate satisfactorily during checkout, the inoperative level channels should be reported in the deficiency log and operations should continue.
- True _____
- False _____

33. If an over-compensated ion chamber is placed in a radiation field consisting of neutrons and gamma rays the output current, compared to that from a properly compensated chamber, will be
- a. higher _____
 - b. lower _____
 - c. same _____
34. An ideal location for the PoBe reactor source is halfway between the ion chamber and the fuel so that both receive equal amounts of source neutrons.
- True _____
- False _____
35. If the fuel is placed between the PoBe reactor source and the ion chamber, the chamber current output will be almost directly proportional to the fuel subcritical multiplication.
- True _____
- False _____
36. The location of a counter with respect to the core, source, and control rods affects the shape of the inverse multiplication curve on an approach to critical.
- True _____
- False _____
37. If you are measuring a period using a stopwatch, the period can be read off the stopwatch if the stopwatch is running between
- a. neutron levels of 1×10^{-11} to 2.72×10^{-11} _____
 - b. 35 to 50 _____
 - c. 10.5 to 98.6 _____

38. During a period the rate of rise is called
- a. exponential _____
 - b. linear _____
 - c. quadratic _____
39. What three alarms are provided to the guard house?
40. How are they shown in the Control Room?
41. What is the meter range of the log n amplifier? Of the linear n?
Of the source range?
42. What is the flux up bypass setting on the log n recorder?

D. Operations

Standards

1. What are the minimum personnel requirements for reactor operation?
2. What is the maximum number of people in the Control Room during operations?
3. What is the minimum personnel requirements for fuel element changes to the critical assembly?
4. Why is there a maximum number of people allowed on the test stand with a fully loaded PAX?
5. Can the WANEF secretary demand that the critical assembly be shut down and must it, according to rule, be shut down?
6. Can the Manager, Reactor Analysis, operate the console?

7. What are the minimum personnel requirements for fuel handling in the fuel storage vault?
8. What intentional action would be the easiest accomplished to create a nuclear excursion at WANEF and what rule prevents this action?
9. What are the alarm settings for the five console gamma instruments and what is the basis for the selected setting?
10. What is the "neutron-source-out-of-storage indicator" for the test cell?
11. What are the locations of the general alarm buttons?
12. Where can the general alarm be turned off?
13. What systems have emergency power supplies?
14. How can an "inverted reactivity effect" be encountered on PAX? On FCX?
15. Why are cores that can be made critical with one drum not allowed to be operated in that mode?
16. Criticality must be attained by the motion of control rods rather than by other means.

True _____

False _____
17. Critical facilities have many possible ways of being modified, thereby requiring a checkout before each operation.

True _____

False _____

18. During reactor operations, the operator does not question any instructions given him by the Experimentalist-in-Charge, but promptly proceeds to carry them out.

True _____

False _____

19. During reactor operations the operator is responsible for chronologically recording in the operator's log every step taken and every adjustment made by him.

True _____

False _____

20. If a rod is surrounded by other rods its worth compared to an isolated rod's worth is likely to be

a. higher. _____

b. lower. _____

c. about the same. _____

21. Shutdown reactivity measurements by rod drop are subject to some error because

a. the rods do not drop fast enough. _____

b. the flux shape changes after the rods are dropped. _____

c. the delayed neutrons are not in equilibrium. _____

22. For a nuclear incident in the test cell, the general alarm is set off automatically.

True _____

False _____

23. For a nuclear incident in the vault, the evacuation alarm is set off automatically.

True _____

False _____

Procedures

1. Why was a master bypass installed for use during checkouts rather than use individual bypasses?
2. Is the dome removed during the daily checkout?
3. What is the position of the cell veto during daily checkout?
4. Who is authorized to conduct a daily checkout?
5. What is the function of the pre-startup checkout?
6. What is the shortest allowable operational period?
7. Why is the approach to critical for normal operations conducted under the full bank method rather than taking each drum sequentially to the full out position?
8. After critical operations, what are the four important operations to be conducted in the test cell?
9. List five of the nine basic rules for manual reactivity changes?
10. What is the maximum allowable reactivity change without an intermittent critical check?

11. What is the first action item for a person in the area of an area evacuation alarm?
12. What is the first action item for a person in WANEF test cell when the Building Alarm sounds?
13. List the five site emergency signals.
14. What would be your first action for a large uncontrollable fire in the WANEF control room?
15. What is the combination to the lock on the front gate?
16. What is the health physics office telephone number?
17. What would you do for an uncontrollable fire on the core truck, parked in the WANEF test cell, with a fully assembled reactor, in an opened shipping container with no fire extinguisher but the WREC fire hose available?
18. Why is it important that all WANEF abnormalities be immediately reported to the Scientist-in-Charge?
19. How many grams of U-235 are there in a high loaded PAX fuel element?
20. How many PAX fuel elements can be made critical flooded and reflected with water?
21. How many elements can be made critical with no flooding and no reflection?
22. What is the approximate reactivity worth in dollars for a six inch thick, 30 inch diameter piece of polyethylene on the exhaust end of the PAX?

23. What is the maximum number of fuel elements allowed in the Fuel Assembly Room and the Counting Room?
24. Can fuel clusters be removed from the storage containers in the fuel storage vault?
25. What is the minimum amount of water poured into the exhaust end of the core that could override the \$2.8 minimum shutdown?
26. What is the minimum critical mass of a sphere of pulverized PAX fuel that could be made critical with a full reflector?
27. List the approximate reactivity worth in cents per kilogram for the following materials in the PAX: Uranium, carbon, hydrogen, and steel.
28. Calculate the approximate reactivity worth of a poisoned (24 wires) and shimmed (TaC) cluster.
29. What is the keff for a PAX that is \$4 shutdown and suddenly becomes fully reflected with polyethylene on the top, bottom and completely around the reflector.
30. What is the approximate reactivity worth of the following full length items in the dry PAX core: TaC shim, B_4C poison wire, carbon shim and polyethylene pencil (.100 inches diameter by 50 inches long and density equal .93 grams per cc).
31. What four ways can the TaC shims be distinguished from the carbon shims?

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