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Subcontract NP-1

WANL-TME-646

Revision B

April 1967

Westinghouse Astronuclear Laboratory

WESTINGHOUSE ASTRONUCLEAR EXPERIMENTAL FACILITY NUCLEAR SAFETY MANUAL

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ABSTRACT

Presented herein are the rules and regulations by which the Westinghouse Astronuclear Experimental Facility (WANEF) will ensure that non-reactor fuel operations carried out at the facility will be nuclearly safe.

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I. Introduction

To maintain criticality control at WANEF during the performance of the various test programs to be conducted, two sets of controls have been formulated. The first set governs the methods to be employed in the actual performance of the test program and these are contained in the WANEF Operations Manual, WANL-TME-267. The second set governs the handling, storage, and processing of fuel at WANEF and are contained in this document. The controls, as contained in this document, will ensure safety from criticality hazards during handling operations by limiting the amounts of fuel in a particular area at one time, by limiting the areas where fuel may be handled, and by ensuring that all people handling fuel are thoroughly indoctrinated in the hazards involved in fuel handling.

The fuel limits have been established to limit storage arrays and the total elements, either full length or partial elements, allowed in a "criticality zone" at any time. The various areas where fuel may be stored or processed are clearly marked by signs indicating the limits and by "Crit-Zone" tape or other physical barriers which define the area.

The various criticality zones along with the limits and restrictions of each zone are listed in Section IX.

Detailed analyses of the criticality hazards calculations for the various storage arrays and fuel limits at WANEF are contained in the appendix which is a separate document.

No changes may be made to the procedure described by this document without the written approval of the Nuclear Safety Engineer and one permanent member of the Nuclear Safety Committee. They must examine the proposed changes and determine whether they fall within the intent of the document and satisfy the ground rules established in the Westinghouse Astronuclear Laboratory Criticality Hazards Control Guide, WANL-TME-185. If the changes fall within the intent of the document, the Nuclear Safety Engineer and one permanent member of the Nuclear Safety Committee will recommend approval in writing to

the line manager who originally approved the governing Nuclear Safety Manual with an information copy to the Nuclear Safety Committee. Proposed changes which do not fall within the intent of the document, or any change which they decide to so refer, will be referred to the Nuclear Safety Committee for consideration.

All approved changes will be incorporated into this document and a new revision number and date will be assigned to the document title page.

II. Conclusion

The directives presented herein have been established to ensure that a criticality hazard does not arise at WANEF by improper handling or storage of fuel at the facility during the course of the critical test programs. These rules and regulations, coupled with the procedures presented in the WANEF Operations Manual, WANL-TME-267, will ensure that nuclear safety is maintained at WANEF during all operations dealing with fuel.

III. Definitions

Listed below are a number of definitions which apply to WANEF.

1. Enriched Uranium: Uranium which is enriched in the U-235 isotope to 90% or greater.
2. Enriched Uranium Material: Any material containing enriched uranium. This includes fuel elements, partial elements, and scrap.
3. Non-Fuel Material: Any item that resembles a fuel element, but contains no enriched uranium.
4. Source and Special Nuclear Material (SS): Source Material is uranium or thorium. Special Nuclear Material is plutonium, U-233 and U-235 and materials artificially enriched in these fissile isotopes.
5. Criticality Zone: A well defined area where a specific operation is performed. The boundaries of a criticality zone are physically designated by yellow and black tape marked CRIT ZONE, and/or by physical boundaries such as fences, walls, and railings. A criticality zone is designated in each area where fissionable material is processed or stored and when used in conjunction with an appropriate "criticality limit" provides a method of administrative control.
6. Approved Containers: Approved, as used in this document, means that the referenced item has been reviewed and approved by the Nuclear Safety Engineer.
7. Accountability Personnel: An employee of WANEF who has been assigned responsibility for maintaining an accurate account for all S.S.-bearing materials at WANEF, and/or has been assigned specific responsibilities with respect to the control of S.S.-bearing materials in the various criticality zones.

8. Facility: The building or buildings which make up the WANEF complex.
9. Identity: A serial number engraved on a component part or fuel element.
Each of these can be cross-referenced by appropriate accountability records.
10. Criticality Assembly: A physical arrangement of fissionable material which may, under credible circumstances, achieve an effective multiplication factor of 1 or greater.
11. Critical Experiment: A sequence of logically related reactor parameter measurements and reactivity determinations.

IV. Responsibilities

1. WANEF Scientist-in-Charge: The WANEF Scientist-in-Charge is responsible for the following:

- a. Assuring that all personnel working at WANEF are thoroughly indoctrinated in their specific assignments relative to nuclear safety and that they observe the fuel handling and storage rules set forth in this procedure.
- b. Assuring that all source and special nuclear materials and non-fuel materials are properly identified and that all paperwork accompanying such materials is kept up to date.
- c. Assuring, by periodic inspection, that the fuel handling and storage procedure is effective at the facility, and that all personnel are observing the rules set forth in the procedure.
- d. Assuring that, when an emergency condition arises at the facility, the proper action is taken in accordance with the Emergency Procedures set forth in the WANEF Operations Manual, WANL-TME-267.
- e. Referring all special situations not covered by this document and of a nature which modifies the rules set forth in the document to the Nuclear Safety Engineer.
- f. Understanding and abiding by the "Westinghouse Astronuclear Laboratory Criticality Hazards Control Guide", WANL-TME-185.

2. WANEF Operating Staff

All WANEF employees whose job assignment entails the handling, processing, or movement of S.S.-bearing materials in any way, shall:

- a. Have received as a minimum, the training established for a Fuel Handler in section 2.6.2 of the WANEF Operations Manual, WANL-TME-267.
- b. Have, as a minimum, the qualifications for Fuel Handler as established in section 2.5.3.1 of the WANEF Operations Manual.
- c. Observe all fuel handling and storage rules as outlined in this procedure or any addendum.
- d. Refer all questions or special situations not covered by this procedure to the WANEF Scientist-in-Charge.
- e. Ensure that his physical and mental condition does not impair his judgment or ability to effectively perform his duties concerning nuclear safety.

3. Accountability Personnel

Accountability personnel at WANEF shall perform the following duties:

- a. Move, direct, or control movement of special nuclear material between criticality zones at the facility.
- b. Obtain the required approvals and instructions as to quantity, time, and place of delivery prior to moving or directing the movement of special nuclear materials to another facility under the control of another individual.

- c. Receive, direct, or control receipt of special nuclear materials from another facility.
- d. Properly identify, package, or store material by approved techniques and in approved storage devices or areas.
- e. Refer all questions or special situations not covered by this procedure to the WANEF Scientist-in-Charge.
- f. Observe all fuel handling and storage rules as outlined in this procedure or any addendum.

4. Nuclear Safety Engineer

The Astronuclear Laboratory Nuclear Safety Engineer shall:

- a. Supply nuclear calculations for the facility.
- b. Ensure compliance with the Astronuclear Laboratory Criticality Hazards Guide, WANL-TME-185.
- c. Periodically inspect the facility to ensure compliance with the established procedures.

V. Fuel Handling Rules

1. Material Processing and Storage

a. Enriched Uranium Material

Enriched uranium material may be processed or stored only within a criticality zone and shall be limited in amount to that permitted by the appropriate criticality limits established for that zone.

b. Non-Fuel Material

Non-fuel material may be processed or stored in unlimited quantities within a criticality zone provided that no enriched uranium material is being processed or stored in that zone at the same time. In situations where enriched uranium material is present, the non-fuel material, which could be mistaken for enriched material, will be handled in accordance with the criticality limits established for that zone for enriched material.

c. Questionable Material Identification

When the identity of non-fueled material is questionable, that material will be considered as enriched uranium material and processed and stored as such until such time as its identity is established.

d. Criticality Limits

When more than one type of enriched uranium material with similar appearance is being processed at one time within a criticality zone, the material requiring application of the most restrictive criticality limit shall be the governing limit in that criticality zone.

e. Empty Containers

All approved containers for handling enriched uranium material, when empty, will be identified as "EMPTY" by an appropriate label or marking unless it is immediately obvious by visual inspection that the container is empty.

2. Material Identification

All enriched uranium material, natural uranium material, and non-fuel material shall be identified at all times.

a. Enriched Uranium Material

All enriched uranium material shall be properly identified and when placed in storage or transfer containers, the containers will be marked to indicate that it contains enriched uranium material.

b. Non-Fuel Material

All non-fuel material will be properly identified by an appropriate serial number and when placed in storage or transfer containers, the containers will be identified "NON-FUEL" with appropriate labels or other markings.

c. Questionable Identification

When a question or doubt exists concerning material identification, the WANEF Scientist-in-Charge or the WANEF Accountability Clerk will be contacted for clarification.

3. Criticality Zones

a. Identification

All criticality zones are identified by CRIT-ZONE type and/or physical barriers (i.e., walls, rails, etc.) Exceptions may be taken to the identification of zones with

tape where a piece of equipment or a section of a piece of equipment is, in itself, a criticality zone. Such criticality zones may be identified by a sign on the piece of equipment.

Where walls serve as boundaries of criticality zones, a strip of CRIT-ZONE tape may be laid across the entrance or entrances of the walled area.

b. Establishment and Modification

The procedure described in the Introduction will be followed when criticality zones are established or modified.

c. Combustible Materials

Only those combustible materials that are absolutely necessary for processing or experimental purposes shall be allowed in any criticality zone.

d. Hydrogenous Materials and Reflective Components

Only those hydrogenous materials (including water) and reflective components, specified for use in conjunction with an experimental program, will be permitted in any criticality zone. Containers (other than approved containers) that could accidentally be filled with water will not be permitted in criticality zones. Note that, when a reactor is present in the test cell, special procedures apply to the use of liquids (section 6.1 of the Operations Manual).

4. Enriched Uranium Material Storage

a. Storage Requirements

All enriched uranium materials not in use in the reactor or in other processes relating to reactor operation will be stored in an approved container in approved storage arrays.

b. Containers

All containers for the storage of enriched uranium materials at WANEF must be approved following the procedure described in the Introduction prior to use. The storage containers approved for use in the WANEF Fuel Storage Vault are shown in figures 1 and 2.

c. Vacuum Cleaners

All vacuum cleaners used in areas where enriched uranium materials are stored or processed must be approved following the procedure described in the Introduction prior to use. The approved type cleaner is shown in figure 3.

5. Enriched Uranium Material Transfer

a. All containers used for transferring enriched uranium materials from one CRIT-ZONE to another must be approved following the procedure described in the Introduction.

b. The transfer of a single cluster or a single element between CRIT-ZONES is permitted.

c. Fuel will not be allowed in areas other than criticality zones except for continuous transport between criticality zones.

Figure 1. Fuel Storage Containers

Figure 2. Fuel Storage Container - Single Cluster

Not To Scale

Figure 3. Criticality-Safe Vacuum Cleaner

VI. Fuel Handling Procedures

1. Personnel required in fuel handling operations will be cognizant of radiation hazards associated with the fuel and at all times when fuel is being handled or processed standard radiation monitoring equipment shall be employed.
2. All new fuel received at WANEF will be subjected to appropriate contamination tests when received and at any time when contamination is suspected to exist.
3. All irradiated fuel will be subjected to the precautions of a "High Radiation Area," (as defined in the Waltz Mill Site Health Physics Manual, WCAP-2304), until downgraded by appropriate checks.
4. All persons handling fuel or in areas where fuel is present will be required to perform appropriate contamination checks of their person upon leaving the area.
5. All areas where fuel is stored or being used will be locked or equipped with an alarm when not attended.
6. Only those personnel authorized by the Scientist-in-Charge may enter the fuel areas and manipulate fuel.
7. In all instances when fuel elements or clusters are being assembled, disassembled, loaded or unloaded from their storage or transfer containers, precautions will be taken to prevent the spread of contamination.
8. All fuel material being transferred must be in an approved storage or transfer container, an aluminum tube or a plastic bag.
9. The fuel assembly room ventilation system must be functioning properly prior to commencing any fuel operations in the room.

10. During all cutting, grinding, or other operations where graphite dust may be produced, the personnel in the areas shall have glasses, respirators, and/or other protective clothing as specified by the Health Physics Engineer. In addition, an approved "criticality safe" vacuum system must be available for operation in the area.

11. In all instances when fuel elements or clusters are being loaded or unloaded from transfer or storage containers in the test cell, an approved "criticality safe" vacuum system must be available.

12. Two persons authorized and instructed by the Scientist-in-Charge must be present when fuel elements are being handled, assembled, or disassembled in the fuel storage and/or fuel assembly areas.

VII. Vacuum Cleaner Handling Procedures

a. At all times when a "criticality safe vacuum cleaner" is being employed in an operation where fuel is present, consideration must be given to the amount of material in the vacuum cleaner when observing criticality limits.

b. Each time a "criticality safe vacuum cleaner" is used, the particulate collection bottle will be checked to ensure that the collected scrap material does not exceed the RED line mark on the bottle (350 gms.).

c. Whenever a collection bottle is changed the contents of the bottle will be packaged and sent to the Astrofuel Facility for processing.

VIII. Fuel Accountability

Fuel accountability at WANEF shall be in accordance with the guidelines set forth in the WANL S.S. Accountability Procedures Manual, WANL-IL-009. This manual describes the various forms used to ensure proper accounting for all fuel material at the various WANL facilities.

Each new fuel element and/or cluster which is received at WANEF will have an accountability record made out for it when received. This record will indicate the element or cluster serial number, its type, its loading, and the storage or reactor position into which it was placed. All subsequent movements of the element or cluster will be recorded.

IX. WANEF Criticality Limits

Each area where fuel is processed or stored at WANEF has been defined as a criticality zone and appropriate limits established for each. The various criticality zones are shown in figure 4 and the limits for each zone are listed below.

1. Fuel Storage Vault (CRIT-ZONE 1)

a. Storage Containers

- Limit:
1. Maximum of 21 equivalent elements per container.
 2. Maximum of two storage containers out of racks and in vault at one time. Containers must be attended when not in racks.
 3. Front cover plates must be removed from storage containers during storage in racks.

b. Fuel Clusters

- Limit:
1. No fuel clusters are allowed out of storage containers while in the vault.

c. Enriched Material (U-235)

- Limit:
1. Maximum amount of enriched material in the form of uranium-bearing wires permitted in the vault is limited to an amount which contains 350 grams of enriched uranium (U-235).

d. Fuel Element

- Limit:
1. No fuel elements are allowed out of storage containers while in the vault.

2. Fuel Assembly Room and Counting Room (excluding the sink)
(CRIT-ZONES 2 and 4)

One of the following limits apply:

a. Storage Containers

Limit: 1. Maximum of one fully loaded storage container.
(21 elements in container)

b. Fuel Clusters

Limit: 1. Maximum of three fuel clusters not in storage containers.
(Total of 21 fuel elements)

c. Fuel Clusters plus Enriched Material (U-235)

Limit: 1. Maximum of two fuel clusters plus an amount of partial
elements and/or uranium-bearing wire which contain 350
grams of enriched uranium (U-235). See Note (1).

d. Fuel Elements

Limit: 1. Maximum of 14 full length fuel elements which are not
in containers.

e. Fuel Elements plus Enriched Material (U-235)

Limit: 1. Maximum of 12 full length fuel elements plus an amount of
partial elements or uranium-bearing wires which contain
350 grams of enriched uranium (U-235). See Note (1).

NOTE (1): Approximately three full length elements or 450 full length wires are equivalent to 350 grams of enriched uranium.

NOTE (2): No fuel allowed in counting room sink.

3. Test Cell - Main Area (exclusive of reactors) (CRIT-ZONE 3)

One of the following limits apply:

a. Storage Containers

- Limit:
1. Maximum of one fully loaded storage container.
(21 elements in container)
 2. Maximum of two fully loaded vendor shipping containers.
They may not be in the reactor stand area of the test cell.

b. Fuel Clusters

- Limit:
1. Maximum of three fuel clusters not in storage containers.
(Total of 21 fuel elements)

c. Fuel Clusters plus Enriched Material (U-235)

- Limit:
1. Maximum of two fuel clusters plus an amount of partial elements and/or uranium-bearing wire which contain 350 grams of enriched uranium (U-235). See Note (1).

d. Fuel Elements

- Limit:
1. Maximum of 14 full length fuel elements which are not in containers.

e. Fuel Elements plus Enriched Material (U-235)

- Limit:
1. Maximum of 12 full length fuel elements which are not in containers or storage rack plus an amount of partial elements or uranium-bearing wires which contain 350 grams of enriched uranium (U-235). See Note (1).

4. Test Cell - Shelf (CRIT-ZONE 5)

a. Storage Rack

Limit: 1. No loose fuel elements in tubes (all elements must be clustered).

2. Solid FCX cluster plates must face out.

One of the following limits also apply:

b. Storage Containers

Limit: 1. Maximum of one fully loaded storage container (21 elements in container)

2. Maximum of one fully loaded vendor shipping container.

c. Fuel Clusters

Limit: 1. Maximum of three fuel clusters not in storage containers or storage rack. (Total of 21 fuel elements)

d. Fuel Clusters plus Enriched Material (U-235)

Limit: 1. Maximum of two fuel clusters plus an amount of partial elements and/or uranium-bearing wire which contain 350 grams of enriched uranium (U-235). See Note (1).

e. Fuel Elements

Limit: 1. Maximum of 14 full length fuel elements which are not in containers or storage rack.

f. Fuel Elements plus Enriched Material (U-235)

Limit: 1. Maximum of 12 full length fuel elements which are not in containers or storage rack plus an amount of partial elements or uranium-bearing wires which contain 350 grams of enriched uranium (U-235). See Note (1).

5. Fume Hood (CRIT-ZONE 6)

a. Fuel Elements plus Enriched Material (U-235)

Limit: 1. Maximum of 12 full length fuel elements plus an amount of partial elements or uranium-bearing wires which contain 350 grams of enriched uranium (U-235).
See Note (1).

Figure 4. Criticality Zones

X. Approved Fuel Storage Arrays

1. Fuel Storage Vault

The walls of the fuel storage vault are of standard concrete block construction, 8 inches thick and covered with fireproof paint. Overhead construction utilizes metal deck giving an overall height of 9 feet 2 inches. The floor is 4-inch thick concrete covered with asphalt tile. The door, a Mosler steel vault type, the exhaust system penetrations, and the fuel transfer passage into the fuel assembly room are the only openings in the vault.

The fuel storage racks consist of steel Unistrut construction bolted into place and spot welded to insure additional mechanical stability. Steel shelving plate, 1/8 inch thick, 30% perforated, is bolted to the Unistrut framework to provide the necessary fuel element storage space. Solid aluminum plates are used to prevent storage in a 12-inch zone between shelves. Each shelf will accommodate a single row of fuel containers. Each fuel container in a row is isolated from its neighbor by a .030-inch cadmium partition which is a permanent component of the storage rack structure. This design has a load safety factor greater than 10. The fuel storage racks are painted with fireproof paint.

Figure 5 shows a layout of the fuel storage racks in the vault with fuel storage containers in place. The maximum storage capacity of the vault is 180 of these containers, each containing a maximum of 21 fueled elements. A detailed criticality analysis is reported in Appendix A.

2. Test Cell Fuel Storage Racks

Two fuel storage racks are located on the shelf at the north end of the test cell. Each storage rack consists of an 8 x 56 array of 60" cluster storage tubes made of 2-7/8" O.D., 0.083" wall, aluminum. No poly tube liners are utilized. The rows have a one-foot center-to-center separation while the tubes are close-packed in the horizontal direction. The tubes are tack welded to front and rear horizontal angle (3 x 2 x 1/4"

Figure 5. Vault Fuel Storage Array

aluminum) which are bolted to 1-5/8" Unistrut vertical members. The vertical members are located every 2 feet. In order to facilitate drainage, the storage tubes are slightly inclined (the front horizontal supports are 1" higher than the rear ones).

The overall size of each fuel rack is about 7-1/2' x 16'. The racks, which are bolted to the cell wall and the shelf floor, have a minimum safety factor of 20 when each is completely filled with 448 clusters. The arrangement of the two racks can be seen in figure 6. The criticality analysis for the storage racks is contained in Appendix B.

Figure 6. WANEF Test Cell