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Westinghouse Astronuclear Laboratory

EVALUATION OF PROTOTYPE FUEL ELEMENT HANDLING CONTAINER

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EVALUATION OF PROTOTYPE FUEL ELEMENT HANDLING CONTAINER

(Title Unclassified)

Prepared by:

S. Aducci
S. Aducci

L. G. Pilgrim
L. G. Pilgrim

D. Polinak
D. Polinak

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by H. F. C. TIC, date SEP 11 1973

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James L. Price 9/30/65
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Approved by:

J. P. Tully
J. P. Tully

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ABSTRACT

Damage to fuel elements during *in-process handling continues to be a significant problem. A substantial number of elements were rejected for use in the NRX-A4, because of in-process damage, with resultant loss in dollars and schedule time. This has been the case for all NRX reactors. Damage to coating, chipping of corners and chipping around flow holes have been the primary causes for rejection. Reactor tests have shown that the operating life of a reactor is adversely affected by imperfections in the niobium carbide coating on the fuel elements. The fuel elements will require a higher quality coating and thus a greater degree of protection to preserve this quality for future longer-life reactors.

Improvement in handling technique is imperative for effective resolution of this problem. In order to affect some improvement, a Fuel Element Handling Container was designed and several prototypes fabricated for tests and evaluation. This handling container is proposed as a replacement for the existing fuel element shipping container "suitcase" for use with the existing outer container "birdcage" during transportation and as a handling and storage tray for use during processing and assembly operations.

The prototype container was subjected to several tests including a shipping test, impact test and in-process handling test. The results of these tests and subsequent complete evaluation of the prototype container indicate that coating damage and chipping of elements can be substantially reduced with significant savings in time and costs.

* The term, "in-process handling", as used herein means all handling from initiation of manufacture to final assembly into the reactor.

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I INTRODUCTION

The need to define the causes of fuel element damage and to formulate corrective measures has been recognized since the fuel for the first NRX reactor was delivered. Considerable effort has been directed toward this objective. A survey of the complete fuel cycle, including in-process handling operations at WAFF and at WANL, was completed during 1964. Based on the results of this survey and upon subsequent studies and evaluation it was concluded that the damage to fuel elements could be effectively reduced by providing an improved handling container, whereby, the number of handling operations would be minimized and greater protection would be provided during the required operations.

A container was designed to meet these objectives. The upper and lower halves of this container can effectively serve as in-process handling trays. When assembled, the container can be used to ship fuel elements. This design is compatible with existing equipment and facilities, with some relatively minor exceptions.

Several prototype handling containers were fabricated for functional testing to determine the degree of fuel element protection provided, strength of the container, handling characteristics and adaptability to existing facilities and equipment.

This report defines the design characteristics of the prototype container; identifies the tests conducted thereon and presents conclusions and recommendations relative to its application.

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II DESCRIPTION OF PROTOTYPE FUEL ELEMENT HANDLING CONTAINER

The prototype fuel element handling container is shown in Figure 1. It consists of identical upper and lower sections each of which can be used as an in-process handling tray as shown in Figure 2.

The container sections are conveniently fastened together without the use of tools. The mating flanges are interlocked by means of four lock rods installed longitudinally at the corners (See Figure 3). Loose fasteners are eliminated. Each lock rod is stored in a longitudinal groove adjacent to the interlocking flange. A spring retainer secures each lock rod in either the closed or stored position. Figure 3 shows the lock rod secured by the spring retainer in the closed position.

The inside of the prototype container is completely lined with cellular rubber. Each fuel element is isolated from the metal surfaces of the container and from the other fuel elements for protection of the fragile niobium carbide coating (See Figure 4).

A polyethylene sleeve is placed on each end of a fuel element. The sleeve protects the fuel elements at the coated and uncoated ends against scratching, etc.; prevents plugging of the flow channels and orifices by foreign particles; and provides a tab at each end of the fuel element for convenient lowering and raising of the element in the tray. Figure 5 illustrates the use of the sleeve.

A handle is provided at each end of the upper and lower assemblies for handling of an opened or closed container. A gasket is used to seal the interlocking flanges of the upper and lower assemblies against the passage of contaminated dust.

The prototype fuel element handling container is similar to the "suitcase", in that it is an inner container for shipping elements within an outer container. The prototype container is not intended to meet the Atomic Energy Commission and Bureau of Explosives shipping requirements when used without an outer container.

Figure 1 Prototype Fuel Element Handling Container

Figure 2 Opened Prototype Container With Fuel Elements Installed

Figure 3 Lock Rod Installation and Removal

Figure 4 End View of Filled Lower Container Section

Figure 5 Operator Lifting Element by Sleeves

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III TEST DESCRIPTIONS AND RESULTS

The prototype container was subjected to several functional tests to evaluate fuel element protection, handling convenience and adaptability. These tests are described as follows:

1. Shipping Tests

Objective - To determine the adequacy of the prototype container to protect the coated fuel elements from the shock and vibration conditions normally encountered during transportation.

Description - Two tests were conducted as follows:

- A. Vibration Test - The loaded container was vibrated at frequencies of 2,4,6,7,8,9 and 10 cycles per second with the g level varied from .5 to 3.0 g, double amplitude for definite time intervals. Also, it was vibrated at fixed g levels from .5 to 3.0 g intervals with the frequency varying from 2 to 10 cycles per second.
- B. Road Test - The prototype container was installed in a truck mounted "birdcage". The container was transported over normal and irregular roads. Irregular road conditions included traveling through intersections, over bridges and railroad crossings and rough roads.

After completion of each of the above tests, the coated fuel elements were inspected for evidence

of damage.

Results - In the vibration test, the loaded prototype container was securely fastened at each end to a vibration apparatus as shown in Figure 6. Test data showed that 3.8 g, double amplitude, occurred at the outside center of the container in the vertical direction during an input of 3.0 g's at 10 cycles per second. The corresponding g at the outside center of the container in the horizontal direction was .22 g. After completion of the vibration test, the fuel element inspection revealed no evidence of damage to the fuel elements.

In the road test, the prototype container was transported over normal and irregular roads in a truck mounted "birdcage". (See Figure 7). After completion of the test, fuel element inspection revealed no damage to the coating or the fuel elements. The prototype container was not damaged by the vibration or road tests.

Conclusions - The objective of the test was satisfied. The prototype container is adequate to protect the coated fuel elements during transportation.

2. Impact Tests

Objective - To determine adequacy of the prototype container to:

- 1) Protect the coating and the fuel element from

Figure 6 Vibration Test Configuration

Figure 7 Road Test Configuration

inadvertent damage by shock loads incurred during in-process handling.

- 2) Withstand such shock loads without damage to the container.

For the purpose of this test, it is assumed that a shock load incurred during in-process handling will not exceed the equivalent of a six inch drop.

Description - An impact load equivalent to a six inch drop was imposed on a fully loaded container as follows:

Flat End Drops - The closed container was supported at each end six inches above an unyielding surface. The plane of the elements was in the horizontal position. One support was removed instantaneously allowing the lateral edge of the container to fall and strike the unyielding surface. The container and the elements were inspected for evidence of damage. This test was repeated for the opposite end of the prototype container.

Corner Drop - The closed container was supported at each end six inches above an unyielding surface. The plane of the elements was in the vertical position. The support under the end of the container at the coated end of the element was removed instantaneously allowing the corner to fall and strike the unyielding surface. The container and elements were inspected for evidence of damage.

Results - The impact tests were performed as described above. The test configurations for the flat end drop and the corner drop are shown in Figures 8 and 9 respectively. The inspections

Figure 8 Flat End Drop Test Configuration

Figure 9 Corner Drop Test Configuration

at the end of each drop revealed no evidence of damage to the coating, fuel elements, or the prototype container.

Conclusions - Shock loads such as those imposed by drops of six inches or equivalent impacts in the lateral direction will not damage the coating, fuel elements, or the prototype container. Thus, the container can be considered adequate to protect the fuel elements during rough handling, accidental bumps, etc.

3. In-Process Handling Test

Objective - To determine the suitability of the prototype container for use as an in-process handling tray.

Description - Six coated peripheral fuel elements were installed and removed from the prototype container. These elements were inspected and all visible defects were identified and recorded. This sequence of operations was performed by one operator wearing protective gloves using necessary precautions to prevent element damage. Each operation was timed to the nearest second with a stopwatch. The first operation included the installation of six fuel elements into a prototype container and closure of the container. The second operation included the removal of six elements from the prototype container. The container was closed at the start and end of each operation. This sequence was repeated three times. For more representative results, three different operators performed the test and the resulting times were averaged. At the conclusion of each sequence, the fuel elements were inspected

for evidence of damage.

Results - The in-process handling test was performed in the manner as described above. The inspections at the conclusion of each sequence revealed no evidence of damage to the coating or the fuel elements. The average results of operating time showed that 4 minutes were required to complete the installation of six elements in a prototype container and 3 minutes to remove six elements from a prototype container.

Conclusions - The prototype container is suitable for use as an in-process handling tray since the fuel elements were installed and removed many times without damage. No handling problems were encountered. As an indication of the handling convenience, the operating times are compared with the corresponding times for the "suitcase" operations in the following tabulation:

OPERATION	TIME	
	1 "Suitcase" Container (19 fuel elements involved)	3 Prototype Containers (18 fuel elements involved)
Installation of Fuel Elements into Container	46 Minutes	12 Minutes
Removal of Fuel Elements from Container	28 Minutes	9 Minutes

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IV FUNCTIONAL AND DESIGN FEATURES

Some of the functional and design features of the prototype fuel element handling container with respect to protection of fuel elements, shipping, in-process handling convenience, shock and vibration isolation of the fuel elements and adaptability are:

1. Some auxiliary equipment is eliminated since the upper and lower sections are used as in-process handling trays or vault storage trays. For example, the fuel element transfer trays as shown in Figure 10 can be eliminated.
2. Cellular rubber completely isolates the fuel elements from each other and the metal parts of the container. This is an improvement over the existing "suitcase" since the probability of inadvertent scraping on exposed metal surfaces and coating damage is decreased.
3. Partial elements are shipped in the container without the use of spacers or additional items.
4. Handling time and number of operations are minimized and procedures are simplified, thus the probability of damage to the coated fuel elements is reduced. For example, the transfer of the fuel elements from the shipping container to the in-process handling equipment can be eliminated since the prototype fuel element handling container can be used as an in-process handling tray.

Figure 10 Fuel Element Transfer Tray

5. Handling time is reduced by approximately two-thirds as indicated in Section III. Thus, a significant time savings is realized during many in-process operations. For example, transfer of elements between sites requires verification of element serial numbers with the transfer papers which necessitates opening of the suitcases and tubes. Also, the element serial numbers are again verified against IBM records during inventory of elements in the vaults.
6. Accountability checks of fuel elements transferred between areas are conveniently accomplished without handling of the elements since the handling containers can be easily opened and serial numbers are readily visible for verification with transfer papers (See Figure 11). This is an improvement over the "suitcase" where the elements must be partially removed from the tubes for serial number identification.
7. Fuel elements are located without disassembly of the container since the element serial numbers can be conveniently placed on the ends of the handling container with expendable dymo-tape (See Figure 4). As a comparison, the "suitcase" must be opened and up to 19 fuel elements must be partially withdrawn since the serial numbers are marked on the side of the tube.
8. There are few separate parts of a container assembly. A shipment of 6 elements in one container assembly requires the following parts:

Figure 11 Fuel Element Serial Number Location

<u>Item</u>	<u>Quantity</u>
Container Sections	2
Lock Rods	4
Polyethylene Sleeves	12

Storage holes are provided at each end of the upper and lower container sections to store the lock rods during the use of the container as an in-process handling tray. The spring retainers secure the lock rods in the stored as well as the closed position. The expendable polyethylene sleeves are the only loose parts since the lock rods are secured in the storage holes during the use of the container as an in-process handling tray. In comparison, the "suitcase" consists of approximately 130 loose parts such as fasteners, rubber bands, tubes, inserts and plugs. The "suitcase" and aluminum tube assemblies are illustrated in Figures 12 and 13.

9. The loaded prototype container weighs 23 pounds compared to 65 pounds for the loaded "suitcase". Thus, the prototype container can be more easily and safely handled especially when lifting containers into high storage ports in the vaults. The prototype container can conveniently be handled as an in-process tray since the upper and lower sections weigh just seven pounds each.
10. The entire interior of the prototype container is easily accessible for monitoring contamination levels. It is more difficult to check the contamination level inside the small

Figure 12 Suitcase Container

Figure 13 Aluminum Tube Assembly

one inch diameter aluminum tubes of the "suitcase". Also, less frequent decontamination of the prototype container will be required since the probability of element scraping is less than with the close fitting aluminum tubes.

11. The fuel elements are securely positioned in the container sections and will resist dislodging when the opened container is tilted laterally up to 60 degrees (See Figure 14). This is an improvement over the existing method since the aluminum tubes can be dislodged in a partially loaded "suitcase" or the aluminum tubes can inadvertently roll off a work table.
12. The existing storage vaults at WANEF and the Reactor Assembly Area at WANL and the truck mounted "birdcage" will accommodate the prototype container with the use of adapters. For example, Figure 7 shows the "birdcage" adapted to accommodate two prototype containers in each port.

Figure 14 Prototype Container Tilted 60°

V CONCLUSIONS AND RECOMMENDATIONS

The functional tests described and the evaluation presented herein are based on a prototype fuel element handling container.

It is concluded that a container of this design is basically sound and trouble free and can provide greater protection to the niobium carbide coated fuel elements during in-process handling and shipping operations. Damage to fuel element coating and chipping of elements can be substantially reduced with resultant savings in costs and improvement in reactor schedules.

It is recommended that further consideration be given to incorporation of fuel element handling containers of this type into the system at WANL and associated facilities.