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REQUIREMENTS FOR CAPSULE DISASSEMBLY AND POST-IRRADIATION ANALYSIS

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Fuel Irradiation Program
Series T-T
Phase II

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INTRODUCTION

The Westinghouse Post-Irradiation Facility (WPIF) will receive four irradiation capsules directly from the GETR. Each capsule will contain four pellets of irradiated fuel material. All capsules are to be disassembled within the hot cells and various analyses, tests, and metallographic examinations are to be performed upon the fuel. The work required is outlined below.

A. Capsule Disassembly

The recommended disassembly procedure is outlined in Appendix I.

B. Flux Wire Analysis

Each capsule has associated with it three cobalt-aluminum flux monitor wires. Each wire will be four inches long and its upper and lower ends suitably identified. The integrated neutron flux to which each wire has been exposed is to be determined at 0.50 inch intervals along the length of each individual wire. The analysis is to be performed on a total of 12 wires.

All pertinent data such as the chemical composition of the wires and duration of exposure will accompany the group of wires.

C. Dimensions

Radial and transverse dimensions will be recorded for each pellet. The recorded dimensions shall be the average of three trials and are as follows:

1) Pellet diameter - top
2) Pellet diameter - middle
3) Pellet diameter - bottom
4) Pellet length.

D. Photographs

Macroscopic photographs will be taken of each fuel pellet to indicate post-irradiation conditions of the sample.

E. Metallography

Metallographic examination is required to determine the condition of the fuel material. The techniques for metallographic examination of NERVA fuel material have been developed at WANL. It is suggested that the WANL metallographic section be consulted as to the suitable methods of mounting, polishing, and etching the fuel samples.

The requirements for the metallographic examination are outlined in Appendix III. Sixteen metallographic specimens are to be prepared. Numerous measurements and photomicrographs of each specimen will be necessary.

F. Compression Testing

The compressive strength on segments of each pellet is to be determined. Each sample to be tested will be cylindrical, 0.5" in diameter and 0.75" long, with both end faces parallel. Crush testing is to be performed on a total of 16 samples.

G. Hardness Testing

Diamond micro-hardness (DPH) measurements of selected areas of the metallographic samples will be made. The sample preparation and test procedures are outlined in Appendix IV.

Hardness measurements will be made on a total of sixteen of the metallographically mounted fuel samples.

H. Summary

The total number of samples needed for each specific operation or determination are summarized in Table I.

Table I - Summary of Required Post-Irradiation Operations or Determinations

Operation or Determination	Total Number of Samples
Capsule Disassembly	4
Pellet Dimensions	16
Flux Wire Analysis	12
Metallographic Examination	16
Compressive Test	16
Hardness Test	
a) fuel	16
b) controls	1

APPENDIX I

Capsule Disassembly

The following is the recommended procedure for capsule disassembly. An assembly drawing of the capsule (WANL drawing 576F385) accompanies this document.

1. Cut through the outer capsule at a point 0.25 inch from the top of the capsule. Discard the capsule top.

2. Cut through the four legs of the bottom spider, thus allowing the inner can to rotate freely.

3. Slip the inner capsule out of the outer capsule. Discard the outer capsule.

4. Three flux monitor wires are mounted on the outer surface of the inner capsule. Cut each flux wire at a point 1.5 inch from the bottom face of the inner capsule and then cut the wire at a point four inches from the first cut.

5. Mark the upper and lower ends of each flux monitor wire and place them in suitably marked containers.

6. Cut through the inner capsule at a point 0.25 inch from the top of the capsule. The cut should be made through all thermocouples.

7. Remove and discard the spring from the inner can.

8. Carefully remove the graphite sleeve from the inner capsule. Discard the capsule only if the flux wires fastened to the outside of the capsule were intact.

9. Gently break free one of the two cemented graphite rings restraining the fuel.

10. Carefully remove the fuel samples from the graphite sleeve. Each sample is to be identified as to its relative position within the capsule. The upper and lower ends of each sample are to be suitably marked.

11. Place the fuel pellets in suitably marked containers prior to sectioning. Sectioning requirements are outlined in Appendix II. It is imperative that all fuel pellets be stored at all times in a vacuum tight laboratory dessicator filled with a water absorbing chemical to prevent absorption of water into the fuel samples.

12. Remove the glued thermocouple assembly and place in a suitable glue solvent. Separate each thermocouple, visually examine, and place each thermocouple in an individual container listing capsule and thermocouple number on the outside. Containers must be at least six inches long by one inch diameter and will be supplied by WPIF.

13. Place all the graphite parts in a suitably marked container. Identify the upper and lower spacers and sleeve caps as to which end they came from.

14. Transfer the flux wires to the radio-chemical section.

15. Ship the following items to WANL:

a) all thermocouples

b) all graphite parts

c) the bottom segment of each fuel pellet, suitably identified.

APPENDIX II

Fuel Sectioning Procedures

Each fuel pellet is to be suitably identified as to its relative position in the capsule (Pellet No. 1 bottom, No. 2 second from bottom, No. 3 third from bottom, and No. 4 top) and as to its orientation (top and bottom) section as follows:

1. Cut 1/4 inch slice from the bottom of each pellet. It is imperative in cutting that both flat end faces of the cut pieces be mutually parallel and also perpendicular to the cylinder axis. A suitable cutting rig will be supplied by WPIF (see Figure 1).
2. Cut the 1/4 inch slice into two equal halves as shown.
3. One of these halves is to be transferred to the metallographic section for mounting.
4. The other half is to be transferred intact to WANL.
5. The top 0.75 inch piece is to be compression tested.

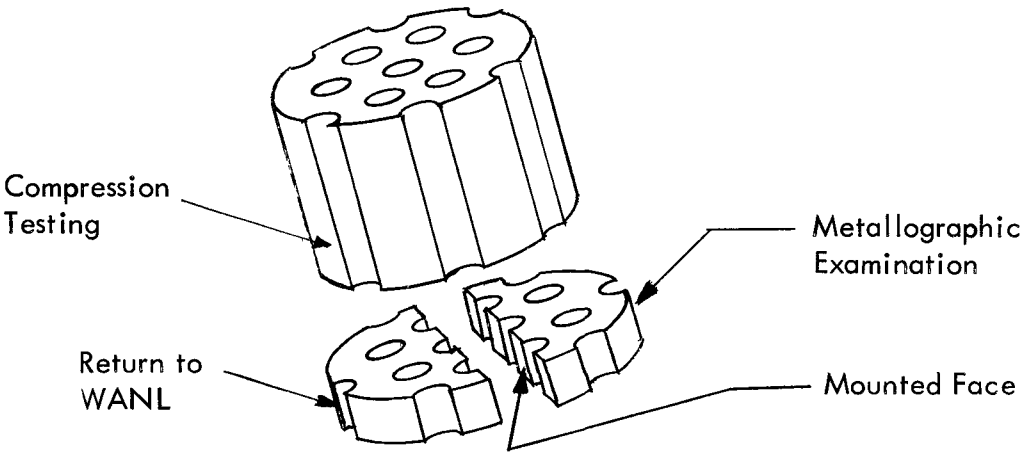

Figure 1

APPENDIX III

Requirements for Metallographic Examination

The metallography section will receive one specimen from each pellet. It is to be mounted so that the flat face showing axial view of three holes may be examined.

The samples are to be mounted in Hy-sol which will be supplied by WANL.

A 1/4 inch cylinder of metal is to be mounted adjacent to the fuel sample and polished with the fuel sample (see Appendix IV).

Each fuel specimen will receive extensive metallographic examination of liner, matrix material and fuel particles.

Numerous photomicrographs will be taken. Each specimen will also be hardness tested as outlined in Appendix IV.

APPENDIX IV

Requirements for Hardness Testing

Microhardness (DPH) measurements of selected areas of the fuel sample will be made after the metallographic analysis is completed.

The hardness of each of the following areas is to be determined.

1. Pyrocarbon fuel bead coating
2. Graphite matrix
3. Graphite matrix adjacent to pyrocarbon
4. Metal control mounted with each sample
5. UC_2 bead.

Due to resilience of the graphite matrix, it is necessary to cover each sample with a thin plastic film which will retain the impression of the diamond pyramid. Since film thickness and thickness variation will induce error into the hardness measurement, the following test preparation and operation will be adhered to:

A. Control Preparation and Calibration

1. A 1.0 inch diameter cylinder of some metal of known hardness will be mounted in Hy-sol and polished. This must be the same metal as that mounted with the fuel samples.

2. The DPH of this metal will be measured by at least ten trials over various portions of the surface. An average DPH will be computed and used as standard value for the test series. The weight used in the apparatus in all tests will be 10 grams.

3. The mounted metal sample will have a thin coating of 1 per cent Parlodian plastic applied evenly with cotton swab over the entire surface.

4. After the plastic has dried, DPH measurements will be taken in at least twelve different places over the surface to establish a typical range of surface film thickness variation, and the change in hardness effected by deposition of the plastic layer.

B. Fuel Sample Preparation and Measurement (see Figure 2)

1. All fuel samples will be covered with plastic in exactly the same manner as was the previous metal control sample.

2. Each fuel sample should be examined under microscope and a minimum of twenty pyrocarbon coated UC_2 beads selected for measurement on each sample. One selection criterion shall be that the bead be polished through to its geometric center, so that the maximum bead diameter is exposed at the polished surface. If measurements are taken at any other place on the pyrocarbon bead, considerable hardness variation will occur.

3. Location of DPH measurement on or near each bead shall be:

   a) in pyrocarbon coating
   b) in the adjacent graphite matrix
   c) diametrically opposite measurement "a" in the pyrocarbon coating (see Figure 3)
   d) in the graphite matrix adjacent to measurement "c"
   e) in the center of the UC_2 bead.

4. A total of 20 beads (minimum) per fuel sample will be measured.

5. Hardness measurements will be made at twenty scattered positions in the graphite matrix away from the vicinity of any pyrocarbon coatings.

6. Four measurements of the 1/4 inch metal control (mounted beside the fuel sample) shall be taken and averaged to obtain a correction for plastic layer thickness.

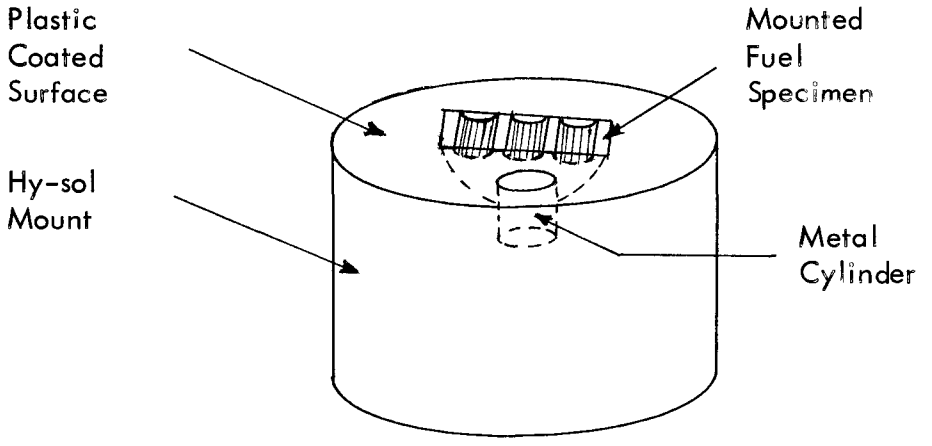

Figure 2
Mounted Fuel Specimen

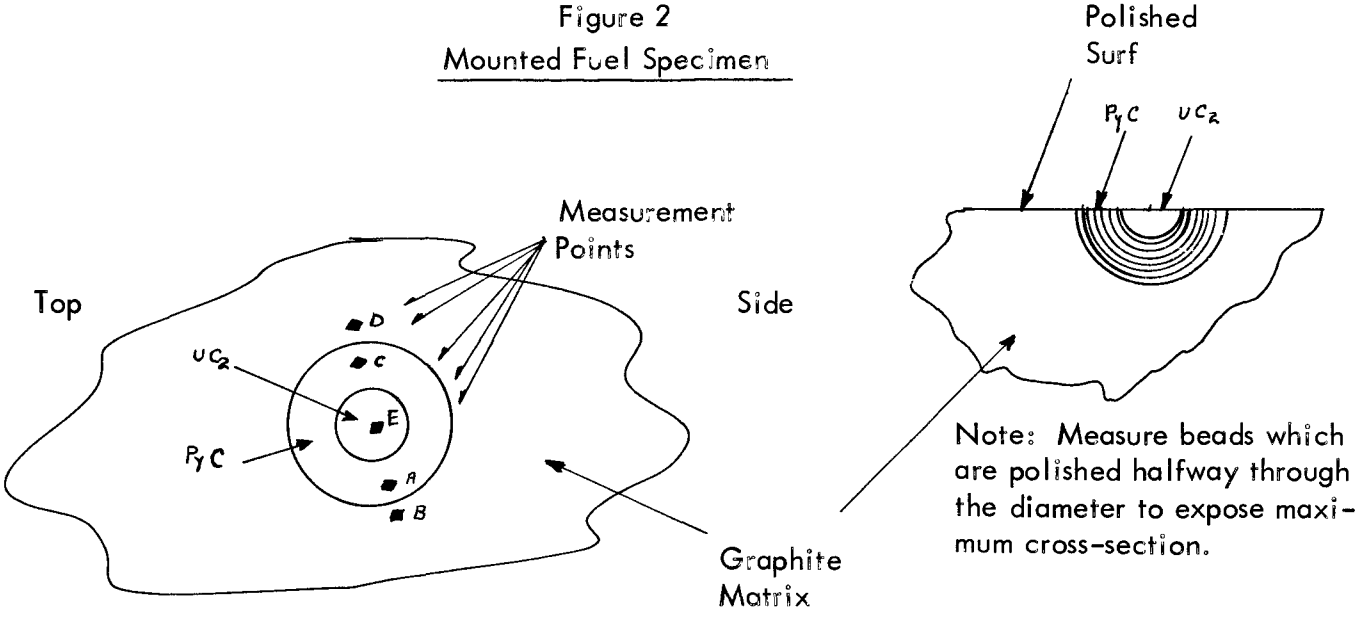

Figure 3
Measurement Points on Each Fuel Bead