70-139
File 4.
(Trans. w/ltr. 9/25/59)

ENGELHARD INDUSTRIES, INC.

D. E. MAKE'EACE DIVISION

NUCLEAR MATERIALS DEPARTMENT

REVISION A

FEASIBILITY REPORT DEM-6

FABRICATION OF 164 ENRICHED (10%) FUEL PINS FOR THE SRE TEST PROGRAM

(E. F. F. B. R.)

Written by:
Norton Weiss
Criticality Officer

March 2, 1959
Revised September 4, 1959

Approved by:
C. H. Barney
Plant Manager

- DISTRIBUTION -

USAEC	Licensing Branch, Washington, D. C.
USAEC	Chicago Operations Office
USAEC	New York Operations Office
Mr. Richard Rateick	Power Reactor Development Corporation
Mr. W. C. Arnold	Power Reactor Development Corporation
Mr. Philip Thompson	Nuclear Metals, Inc.
Mr. John Siergiej	Nuclear Metals, Inc.
Mr. W. F. Mittendorf	Engelhard Industries, Inc. D. E. Makepeace Division
Mr. C. H. Barney	Engelhard Industries, Inc. D. E. Makepeace Division
Mr. C. A. Canham	Engelhard Industries, Inc. D. E. Makepeace Division
Mr. Norton Weiss	Engelhard Industries, Inc. D. E. Makepeace Division

Work to be Performed:

DEM in conjunction with Nuclear Metals, Inc. intends to fabricate and ship 164 prototype enriched fuel pins for the Sodium Reactor Experiment test program to Atomics International Inc., Canoga Park, California. These pins will be of the same type as those mentioned in our feasibility report DEM-5 previously submitted except that the U-235 enrichment will be 10% instead of 25%. Dimensions and alloy composition will be the same.

Material to be Supplied:

Uranium to be used for fabrication will be supplied by Mallinckrodt Chemical Co., St. Louis, Mo., in the form of biscuits $4\frac{1}{8}$" in dia. x $\frac{1}{4}$" - 3/4" thick. Each biscuit will weigh approx. 2.5 Kg. We estimate that a total of 55 Kg. 10% enriched uranium (5.5 Kg. U-235) will be required for the project.

Mallinckrodt will ship in 30" circular aluminum birdcages, a maximum of 4 biscuits (1 Kg. U-235) to a cage. Depending on the actual number of biscuits to be packed in a cage, we should receive from 5 to 7 birdcages of enriched material. It is anticipated that three shipments will be made by Mallinckrodt commencing on March 20.

Receiving and Storage:

Birdcages containing enriched material will be received at the DEM plant in Plainville, Mass. After removal from the truck, they will be transported to our enriched vault storage area. Our vault is constructed of 12" thick reinforced concrete and is 7' 11" wide x 13' 0" long x 7' 11" high with a Mosler combination safe door. The uranium will be stored in the original birdcages until ready for melting. Birdcages

are of such design that they may be stacked and still maintain a safe configuration to insure against the achievement of accidental criticality.

Each birdcage will be unbolted and the biscuits removed and weighed to verify the accuracy of the shipper's weights. The weighed biscuits will be replaced in the birdcage and sealed before the next one is opened. Storage and weighing will be under the supervision of the criticality officer or his representative. No one will be allowed in the storage area unless accompanied by one or the other.

Fabrication Procedures:

The fabrication of the 164 enriched pins is similar to that of the core assembly pins as discussed in our previously submitted feasibility report DEM-5. The following is an outline of the procedures to be followed:

A. Charge Preparation and Melting of U-Mo Ingot:

Enriched uranium biscuits will be issued for melting by the criticality officer. It is anticipated at this time that only one ingot will be melted. The ingot will be 4" in dia. x approx. 16" long. Total charge to be melted will be as follows:

Wt. Uranium (10% enr.) - 54 Kg. (5.4 Kg. U-235)

Wt. Moly. - 6 Kg.

Total - 60 Kg.

Uranium will be moved to the melting area under the supervision of the criticality officer in lots of 10 biscuits (2.5 Kg. U-235) on

a rolling cart and charged into the crucible. The moly. in the form of $\frac{1}{2}$" dia. rods, 3/8" long will be charged into the crucible at the same time.

The melting crucible will be $\frac{1}{2}$" thick graphite, 8" in dia. and 12$\frac{1}{2}$" high. The mold will be 1" thick graphite, 4" in dia. and 16" high. Melting will be done in a hooded Kinney vacuum induction furnace. The rubber hoses which control the flow of water through the cooling coils of the furnace will be uncoupled before charging to prevent accidental flooding of the crucible. After charging has been completed, they will be re-fastened.

When the charge has been melted, it will be bottom poured into the mold and allowed to cool for a minimum of two hours.

B. Removal of Ingot from Mold and Crucible from Furnace:

After the ingot has cooled for a sufficient length of time, the mold container will be dropped and the mold removed from the furnace. The mold will be capped with a tared cover and weighed. It will then be sent to a hood for removal of the ingot from the mold. After the ingot has been removed, it will be vacuumed to remove loose oxide and wiped with a damp cloth. The ingot will then be steel stamped for identification and placed in a birdcage container of the type shown in our drawing number 1033-2 previously submitted.

The crucible will be removed from the furnace, covered, and weighed to determine the weight of oxide and skull. All personnel working inside the furnace will be required to wear respirators. After weighing, the crucible will be moved to a hood where the skull

will be mechanically removed and placed in a tared, covered 5 gal. steel bucket.

Both mold and crucible will be wiped thoroughly with damp cloths before being removed from the hood.

C. Pickling Enriched U-Mo Ingot:

The ingot in the birdcage will be moved to the enriched pickling area under the direction of the criticality representative. It will be pickled in hydrochloric acid and scrubbed with a steel brush while in the tank to remove oxide. After pickling and scrubbing, the ingot will be rinsed in water, and dried with clean rags. The ingot will then be reweighed and sent to the canning area in the birdcage. Pickle solutions will be retained in polyethylene screw cap containers for eventual disposition.

D. Canning, Welding, and Evacuation of Ingot:

The ingot will be removed from the birdcage and inserted into a cleaned copper can on a roller table. Extrusion components (nose plug, cut-off slug, end caps, evacuation tube) will be inserted into the can and heli-arc welded. The canned billet will be evacuated to one micron and leak tested. If no leaks are apparent, the evacuation tube will be sealed, and the canned billet placed in the birdcage for shipment to NMI.

E. Shipment of Canned Billet to NMI for Primary Extrusion:

The birdcage will be sealed and inspected by the criticality officer before being released for shipment. Transportation will be via DEM truck. The loading and securing of the birdcage in the truck will be directed by the criticality officer before shipment may be

made. The driver will be briefed on possible hazards before being allowed to proceed with the shipment.

F. Receipt of Copper Clad Secondary Billet from NMI:

The copper clad extruded billet (1.525" dia. x approx. 9 ft. long(will be received from NMI in an angle iron exclusion frame. A drawing of the exclusion frame to be used (#1033-3 and 4) has been previously submitted. It will be moved to the in-process storage area until such time as it may be required for production. When needed, the billet will be released for production by the criticality representative.

G. Removal of Steel Cladding from Extruded Secondary Billets:

One rod will be transported to a hood which has been set aside for the purpose of removing the steel cladding from the extruded rod. The rod will be clamped in a vise and the cladding mechanically stripped with a hammer and chisel. When completely stripped of cladding, the rod will be weighed and then transported to the pickling area.

The rod will be pickled in a 1:2 nitric acid solution to complete the removal of all cladding material. When removal is complete, the rod will be placed in a rinse tank and rinsed thoroughly with cold tap water. After rinsing, the rod will be removed and dried. It will then be weighed and sent to the hacksaw when authorized by the criticality officer.

Pickle solutions will be sampled and transferred to polyethylene containers whenever 50 grams U-235 is in solution as calculated from before and after weighings. Polyethylene containers will be stored in the enriched scrap area until analytical results have been received. The containers may then be combined in a 30 or 55 gal. polyethylene lined drum as long as the total U-235 content per drum is less than 100 grams.

H. Sawing Extruded Secondary Billet:

The pickled billet will be moved to the mechanical hacksaw where it will be sawed into pieces approx. 4" long. Approx. 25 slugs will be cut from one billet. Each slug will be wiped clean with TCE, steel stamped for identification, and placed in a tote tray capable of holding 15 slugs (3.0 Kg. U-235). Two such tote trays will be required per billet.

Saw chips will be stored in one gal. covered steel pails, a max. of 3.9 Kg. alloy (350 gm. U-235) per container. We anticipate generating only approx. 1.5 Kg. alloy (.135 Kg. U-235) in the form of saw chips and thus will require only one pail to hold the total amount of saw chips generated. The pail containing saw chips will be sealed and sent to the enriched scrap storage area at 12" edge-edge distance from similar containers.

I. Machining Slugs:

Slugs will be machined on a lathe to 4.163" in length and 1.443" diameter. Slug ends will be shaped to a convex at the rear end and a concave at the front end. A water soluble wax will be used as the cutting lubricant on a hooded lathe.

Turnings will be placed in one gal. covered steel pails, a max. of 3.9 Kg. alloy (350 gm. U-235) per pail. Pails will then be sent to the enriched scrap storage area to be stored on 15" centers when filled to max. allowable capacity.

When machined, the slugs will be replaced in the tote tray and sent to the cleaning area under the direction of the criticality representative.

J. Cleaned Machined Slugs:

The slugs will be detergent cleaned in batches of 5 slugs (900 gm. U-235) each. After cleaning, the slugs will be weighed on a metrogram balance to 0.1 gram and replaced in the tote tray. The tote tray will then be moved to the canning area under the direction of the criticality representative.

K. Canning, Welding, and Evacuation of Slugs:

Each slug will be canned according to the following procedure:

Copper-nickel extrusion components will be placed on either end of the slug and a zirconium sleeve fitted over the assembly. A steel can containing an end cap will then be placed over the entire assembly and heli-arc welded in a fixture. The canned billet will then be checked for leakage on a helium mass spectrometer leak tester.

When the billet is free of leakage, it will be attached to a vacuum pump by means of an evacuation tube and evacuated for 30 - 45 minutes. Near the end of the period, the billet and evacuation tube

will be heated to 800°F with a torch. The evacuation tube will then be welded shut to seal off the billet. The sealed billets will be placed in the birdcage for shipment to NMI. A maximum of 15 canned billets (3.0 Kg. U-235) will be placed in one birdcage.

L. Shipment of Canned Slugs to NMI:

The birdcages containing the canned slugs will be bolted securely and inspected by the criticality officer before shipment may be made. Slugs will be packed end to end in a covered steel tray which is bolted to a piece of channel iron. A drawing of the container (#1033-3 and 4) has been previously submitted with our feasibility report DEM-5. The containers will be fastened in the truck securely to prevent accidental movement in transit.

M. Receipt of Coextruded Rods from NMI:

Coextruded rods .310" in dia. x approx. 9 ft. long will be received from NMI in the same birdcage in which the slugs were transported. Each birdcage will thus contain a maximum of 15 rods (3.0 Kg. U-235). The rods will be laid in the steel tray in two parallel layers of 8 and 7 rods respectively.

Upon receipt at DEM, the birdcages will be moved to the in-process storage area until ready for processing. They will then be issued one container at a time by the criticality representative.

N. Cropping and Pickling of Coextruded Rods

A lot of 15 coextruded rods will have the ends cropped on an alligator shear. The cropped ends will then be painted with two coats of Unichrome #324 stop off laquer to prevent the exposed uranium from being attacked by acid. The rods will then be weighed and rough pickled to remove the majority of the steel cladding. End croppings will be cut into 1½" lengths and sorted into four categories:

1. Pieces containing U-Mo only.
2. Pieces containing U-Mo with Zr cladding.
3. Pieces having some Cu-Ni on the surface.
4. Pieces containing primarily Cu-Ni.

Categories 1 and 2 will be placed in one gal. steel pails (max. .35 Kg U-235 each) and sent to the scrap storage area. Category 3 will be pickled to remove Cu-Ni and then sent to the scrap storage area for storage prior to recycle melting. A max. quantity of .35 Kg. U-235 will be adhered to in pickling cropped ends. Category 4 material will be placed in metal containers for storage.

A maximum of 7 rods (1.1 Kg. U-235) will be placed in a pickle tank which contains a 1" overflow leading to a 5" ID polyethylene container to assure an "always safe" solution height. The rough pickle solution is 1:2 nitric acid. The rods will be pickled for 15 minutes, rinsed in cold water, and wiped dry. They will be weighed prior to finish pickling. Rough pickle solutions will be sampled and changed after every 25 rods. The solutions will be placed in polyethylene carboys for temporary storage.

The rods will undergo a finish pickle to remove small spots of steel which may remain after the rough pickle. The finish pickle solution is dilute (1:9) sulfuric acid. A maximum of 7 rods (1.1 Kg. U-235) will be allowed in the tank at any one time. After the steel is completely removed, the rods will be rinsed and wiped dry. The pickled rods will then be weighed before proceeding to the next operation.

Finish pickle solutions will be sampled and changed whenever a quantity of 25 grams of U-235 has gone into solution as computed from weight loss data. Solutions will be transferred to polyethylene carboys for temporary storage. When analytical results are received, solutions may be combined in 30 or 55 gal. polyethylene lined drums as long as the maximum quantity per drum does not exceed 100 grams U-235.

O. Swaging, Cutting, and Pointing Pickled Rods:

Each rod will be removed from the birdcage and swaged on a four-die swaging machine to .158" dia. At this point, the rods will be approx. 26 ft. long. When all the rods have been swaged to finish dia., they will be moved on a rolling table to the parting machine. Each rod will be inserted into the dies and cut to 30.5" lengths. As the pin blanks are cut, they will be placed in trays capable of holding 10 pins each (drawing #1033-5) in the order of cutting. The metal cabinet which holds the trays has a capacity of 150 pins (2.0 Kg. U-235).

Scrap ends will be placed in covered steel pails, max. 3.9 Kg. (350 gm. U-235) per pail. Pails when full will be sent to the enriched storage area to be stored on 15" centers.

Each pin blank will be measured to 1/64" and then weighed to

0.1 gm. Weights and measurements will be recorded by pin numbers. The pins in the cabinet will then be returned to the swaging area where both ends of each pin will be pointed to a 30° angle. Pins will be replaced in the proper tray after pointing. Pointed ends of pins will be inspected to assure that specifications have been met. When all pins have been pointed, the metal cabinet will be moved to the cleaning area under the direction of the criticality representative.

P. Cleaning Pins after Pointing:

Pointed pins will be cleaned by a detergent in max. lots of 25 pins (335 gm. U-235). When each lot of pins has been cleaned, it will be placed in a graphite annealing fixture capable of holding 165 pins (2.21 Kg. U-235). This fixture has been previously described in our feasibility report DEM-5 in NMI drawing 3902. When all the pins have been cleaned and placed in the fixture, it will be moved to the vacuum annealing area under the direction of the criticality representative.

Q. Vacuum Annealing of Pins:

The fixture containing the pins will be placed in the vacuum annealing furnace which will be heated to 800°C. The furnace will be held at temperature for one hour and then cooled to 375°C to room temperature. When room temperature has been reached, the retort and fixture will be removed from the furnace. The pins will be removed

from the fixture and placed in trays in the original metal cabinet. The metal cabinet will then be moved to the testing area.

R. Dye Penetrant Inspection of Pins:

Pins will be inspected for surface defects with a dye penetrant test in max. lots of 25 (335 gm. U-235). Rejected pins will be cut to 6" - 7" in length and placed in one gal. covered steel pails (max. 350 gm. U-235 each pail). Acceptable pins will be vapor degreased and replaced in the original tray of the metal cabinet. When all pins have been tested and cleaned, the cabinet will be moved to the swaging area.

S. Swaging End Caps onto Pins:

Zirconium end caps will be swaged onto the ends of each pin. The pins will then be replaced in the proper tray. After all pins have been swaged, the metal cabinet will be moved by the criticality representative to the inspection area.

T. Inspection of Finished Pins:

Pins will be inspected in lots of 10 (134 gm. U-235) for straightness, diameter, and surface. No more than ten pins will be allowed on any one inspection bench. Acceptable pins will be wrapped and heat sealed in polyethylene and replaced in the metal cabinet. Rejected pins will be cut to 6 - 7" lengths and placed in steel covered pails, a max. of 3.5 Kg. (350 gm. U-235) per pail. Pails will be stored in the enriched scrap area on 15" centers.

U. Packing and Shipment of Finished Pins:

The 164 pins will be separated into 4 lots of 41 pins each. Each lot will be placed in a 1½" ID hard rubber tube which has been split in half. The two halves of the tube will be banded together with tape and rubber plugs inserted into each end. The four hard rubber tubes will be banded together and inserted into a steel pipe which will be capped at both ends. The pipe will be 3½" ID with a 3/16" wall. The pipe is suspended in a welded angle iron framework covered with expanded metal. A drawing of the shipping container (#1038) is enclosed.

Shipment will be made via Railway Express, Protective Signature Service, Armed Surveillance to:

James M. Young
Atomics International Division
8900 Desota Avenue
Canoga Park, California