PROCESS AND CRITICALITY CONTROL PROCEDURES FOR WESTINGHOUSE TEST REACTOR FUEL ELEMENT FABRICATION

Standard Procedure
No. CR-17-D
Effective: January 1, 1959

GENERAL

This Standard Procedure has been prepared to establish process criticality control procedures for the fabrication of fuel elements for the Westinghouse Test Reactor. The fuel elements will be fabricated under contract to:

Westinghouse, Atomic Power Div.
Forest Hills
P. O. Box 355
Pittsburgh 30, Penna.

Purchase Order No. 54C-82575-M

Item I — A total of 588 tubes of aluminum-uranium alloy clad with aluminum. The tubes are of three sizes: 196 tubes 2.5 O.D. x 1/8 wall x 44" long; 196 tubes + 2" O.D. x 1/8" wall x 44" long and 196 tubes 1-5/8" O.D. x 1/8 wall x 44" long. The U-235 content varies with the tube diameter from 82.6 ± 0.6 gm. U-235 to 66.6 ± 0.6 gm. U-235 to 50.9 ± 0.5 gm. U-235. One tube of each size comprises a three tube fuel assembly, held assembled by an aluminum alloy "spider" at each end.

A. MELTING AND ALLOYING (VIRGIN METAL)

The amount of uranium with a U-235 enrichment of 93% which will be issued as a batch from the vault at any one time will not exceed 2.05 kgs. This uranium will be in the form of broken buttons. It will be alloyed with approximately 12 kgs. of 3A aluminum. This alloy will contain approximately 14.5% of total uranium by weight. This will result in U-235 maximum content per melt of 1.9 kgs. Later melts will utilize remeltable aluminum-uranium scrap as indicated in Section B.

1. Material flow to casting stage.

   a. Uranium buttons will be issued in a tote pan.(1)
   b. Metal will be melted, alloyed, and cast into ingots.
   c. Four cast ingots with "skull" from the melt will be returned to the vault for accountability check.

(1) All tote pans will bear a broad BLUE stripe--to identify all material for these fuel elements.

2. Technical Data for Criticality during Melting and Alloying.

   a. Crucible size 7 " OD x 6-1/8 " ID x 9-1/2 " deep.
   b. Maximum alloy melt crucible could contain is 22,000 grams with a total uranium content of 3.2 kgs. resulting in a maximum U-235 content of 2.97 kgs.
   c. Normal ingot size 1-1/4" x 6.3" x 7.5".
   d. Maximum total weight of ingot is approximately 3.5 kgs. resulting in a maximum U-235 content of 0.47 kgs. per ingot.

B. MELTING AND ALLOYING (REMELT MATERIALS)

For efficient utilization of materials it is required that uranium bearing trimmings, etc. be remelted.

1. A melt record card will be issued to the Vault Custodian indicating a nominal uranium content of each heat.

   a. A typical melt would consist of 1/67 kgs. of enriched uranium buttons, approximately 2.5 kgs. of U/Al scrap containing 0.36 kg. of enriched uranium plus proper amount of Al ingot to meet composition specifications.

2. Technical data and handling will be identical to Section A.

C. HOT ROLLING OF INGOT

1. Four ingots having a total weight of 14 kgs. will be issued in a tote pan.

   a. Pan will be conveyed to the Rolling Mill Area. (See Dwg. B523).
   b. Four ingots only will be hot rolled in a continuous sequence.
   c. Pan containing four strips will be conveyed to Niagara Shear (See Dwg. B523) for shearing and sampling for chemical analysis.
   d. Upon completion of hot rolling and shearing, the four strips will be returned to the vault in the tote pan for accountability check.

2. Technical Data

   a. A roller hearth, Globar type furnace will be used for heating ingots and rolled material. The furnace hearth is 18" wide x 16 feet long.
   b. The ingots or billets will be carried through the furnace on stainless steel trays.

   c. Final size of the hot-rolled material will be approximately 0.350"thick x 6.3" wide x 25" long.

d. Maximum weight of any strip is 3.5 kg. resulting in a maximum U-235 content of 0.47 kgs.

D. FINAL COLD ROLLING

Four hot-rolled strips from the previous operation will be issued from the vault in a tote pan which will be conveyed to the Rolling Mill Area. (See Dwg. B523).

1. Following the reduction to finish thickness, the material will be returned to the vault for accountability check.

2. Technical Data.

Cold-rolled strip will be approximately 0.318" thick x 6.3" wide x 28" long.

Maximum weight of the strip and U-235 content will be the same as indicated in Item C above.

E. SHEARING FILLERS

Four cold-rolled strips from the previous operation (Sec. D) will be issued from the vault in a tote pan and conveyed to the Niagara Shear and Punch Press Area (See Dwg. B523) for shearing.

1. Technical Data:

Since the WTR fuel tube assembly is composed of three concentric fuel tubes, the filler size will vary in relation to the tube diameter. Therefore, from this point in the process the fillers will be segregated by filler size. As far as is possible a given heat will be used for one filler size.

a. Fillers will be rough sheared to one of the three dimensions given below:

	Thick	Width	Length
Type W 2-1/2" Dia. Tube Fillers	0.318	x 7.4	x 6.35
Type M 2-1/16" Dia. Tube Fillers	0.318	x 6.0	x 6.35
Type S 1-5/8" Dia. Tube Fillers	0.318	x 4.7	x 6.35

b. Maximum fuel filler per ingot is as follows:

Maximum

Type W - 3 fuel fillers
Type M - 4 fuel fillers
Type S - 5 fuel fillers

Approximately 4 times these quantities can be obtained from a given heat or melt.

c. The approximate total weight and U-235 of each filler is tabulated below:

	Total Weight	U-235 Content
Type W	607 grams	83 grams
Type M	500 grams	67.5 grams
Type S	375 grams	51.2 grams

F. MACHINING OF FILLERS

1. Following rough shearing, the fillers will be milled in groups of 12 to the following approximate sizes, weights and U-235 content:

	Thick	Width	Length		Total Wgt.	U-235
Type W	0.318"	x 7.35"	x 6.30"	-	595 grams	82 grs.
Type M	0.318"	x 5.95"	x 6.30"	-	490 grams	67 grs.
Type S	0.318"	x 4.65"	x 6.30"	-	373 grams	50.5 grs.

2. Milling will be performed in a tank which will contain the chips produced during this operation. A jet of water directed at the cutting tool will provide the necessary cooling and lubrication. This water will be supplied from a pump with a one gallon reservoir. The milling chips will be removed from the tank after each batch of filler blanks has been completed. These chips will be placed in special chip containers which consist of a one-quart can positioned in the center of a 12" diameter 3-1/2 gallon bucket. The chips from a maximum of 10 stacks is the limit to be placed in any one chip container. This would be a maximum of 1000 grams of alloy with a U-235 content of 135 grams.

3. The chip containers will be taken to the vault where the Vault Custodian will weigh the chips, store the one-quart containers in racks designed to hold the one-quart cans in vertical arrays on 24-inch centers.

4. Filler Weighing and Inspection of Fuel Loading.

a. Lots consisting of not more than 12 "W" fillers, 15 "M" fillers or 20 "S" fillers containing a maximum of 1805 grams of U-235 will be issued from the vault. Fillers will be weighed and inspected.

b. Acceptable fillers returned to vault for accounting check.

c. Rejected fillers will be returned to the vault for accountability and storage for remelting.

G. SUBSEQUENT OPERATIONS

1. In the subsequent operations a maximum of 12 "W" fillers, 15 "M" fillers or 20 "S" fillers or the equivalent in clad plates containing these fillers will be handled in one batch at any one work area. The U-235 mass per batch will not exceed 1005 grams.

These operations include:

Roll cladding
Fluoroscopy for Radiography
Tube Forming
Brazing
Inspection

2. One tube of each of the three sizes will be mechanically assembled into the finished fuel element. During and after assembly, the three-tube fuel element will be handled in batches of no more than six assemblies. The U-235 mass per batch will not exceed 1212 grams.

H. ALLOY RECOVERY FROM CLAD ASSEMBLIES

1. For efficient utilization of uranium it may be necessary to strip the cladding from rejected clad plates, tubes or completed assemblies prior to remelting these materials. The decladding process is carried out by immersing the clad component in a strong caustic solution which dissolves the aluminum cladding. The component is then given a brief dip in a dilute hydrofluoric acid solution to remove any residual caustic and brighten the etched surface. The extent of the etching is controlled by the time in bath required to remove a specific thickness of cladding, by thickness measurements and by visual observation since the appearance of the core alloy is easily discernable.

2. Clad plates or tubes to be decladded will be grouped into batches containing less than 200 grams of U-235 per batch.

Only one batch at a time is placed in any one etch tank or rinse tank. Tank dimensions are approximately 4" wide x 6" high and 36" to 60" in length.

3. The number of pieces which are processed through all tanks over a specific period is selected to control the U-235 pickup in all solutions to less than 100 grams.

This number is determined for the various types of components by calculating the number of pieces which, if over-etched into fuel alloy by 0.002 of an inch, would result in the removal of 100 grams of uranium.

4. The spent etching solution and rinse water are combined in a 30-gallon drum after the specified number of components have been processed. The contents of the drum are sampled and analyzed for uranium content.

5. Since uranium is insoluble in strong caustic, the contents of the containers are allowed to settle and the supernatent liquid syphoned off into a hold tank. The contents of the hold tank are analyzed for residual radioactivity and discharged into the sanitary sewer with appropriate dilution in accordance with limits of Part 20, Title 10, Code of Federal Regulations.

6. The sludge which remains is combined in 30-gallon drums as far as possible, based on the analytical results, so that the limit of 100 g. of U-235 per drum is not exceeded.

I. REMELTABLE MATERIAL CONTROL

1. All remelt material will be in alloyed form obtained from rejected ingots or strip, shearing scrap, rejected fuel fillers and clad plates or tubes.

2. Ingots, strip, shearing scrap and rejected fuel fillers will be stored in the original tote for each melt. The mass limit for remeltable scrap in this form is 14,000 grams of alloy containing a maximum of 1990 grams of U-235.

3. Rejected clad plates, tubes or completed assemblies will be stored in lots equivalent to six completed fuel assemblies with a U-235 limit of 1220 grams per lot.

4. Tote pans and lots of scrap plates, tubes or elements will be stored in the vault in racks on 19" centers.

J. SCRAP CONTROL

1. Unusable scrap such as skulls and dross will be stored in the original tote pan with the remeltable scrap for a particular heat where it remains until packaged for final disposition.

2. Scrap chips produced in the fuel filler milling operation will be weighed by the Vault Custodian (See F-3) and repackaged into one quart cans containing 2500 grams of alloy with a maximum of 340 grams of U-235 per can. These cans will be stored in vertical arrays in special racks on 24- inch centers until placed in shipping containers for final disposition.

3. All solid alloy scrap and remelt material is stored dry unless otherwise indicated.

4. Scrap analytical solutions are placed in polyethylene carboys. The U-235 mass limit in any one carboy is 100 g. Each addition to the carboy is recorded on an attached tag and a total shown. The carboy is sealed when the 100 g. limit is reached.

5. Liquid sludge produced in the decladding operation is handled as described in par. H.

K. SHIPPING

1. Tubular Fuel Elements.

The specific shipping procedure for the finished tubular fuel elements has not as yet been established.

2. Scrap Material.

Scrap materials will be shipped in accordance with ICC and AEC Regulations.

Packaging will be according to the following:

Description	Physical Condition	U-235 Mass	Type of Container
Alloy	Solid masses	$\leq$ 4 kg.	Standard 20" birdcage
Alloy	Chips, misc. metal pieces-dry	$<$ 2 kg.	Standard 20" birdcage or spec. scrap container*
Analytical sol'ns.	Dilute sol'ns.	$<$100 g.	30-gal. drum
Decladding sludge		$<$100 g.	30-gal. drum
Residues	Misc.	$<$100 g.	30-gal. drum

*The special scrap container will consist of a 55-gallon drum having a 5-inch diameter or less tube firmly positioned on the central axis.

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