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ENGELHARD INDUSTRIES, INC.
D. E. Makepeace Division

Review of Criticality Policies and Procedures
Summary of Manufacturing Operations

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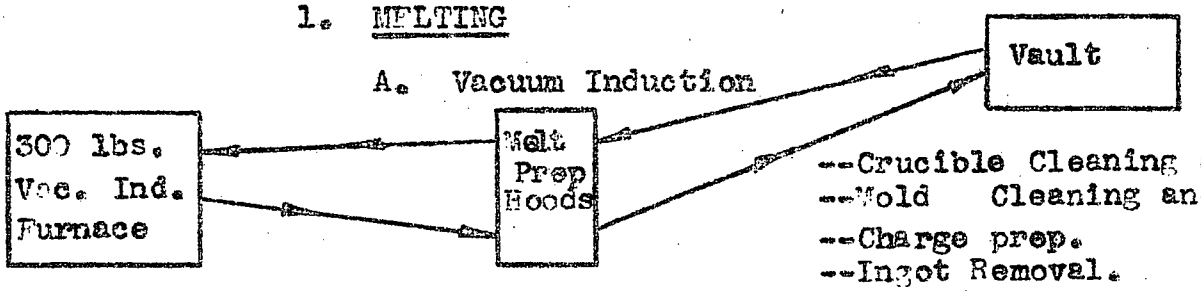
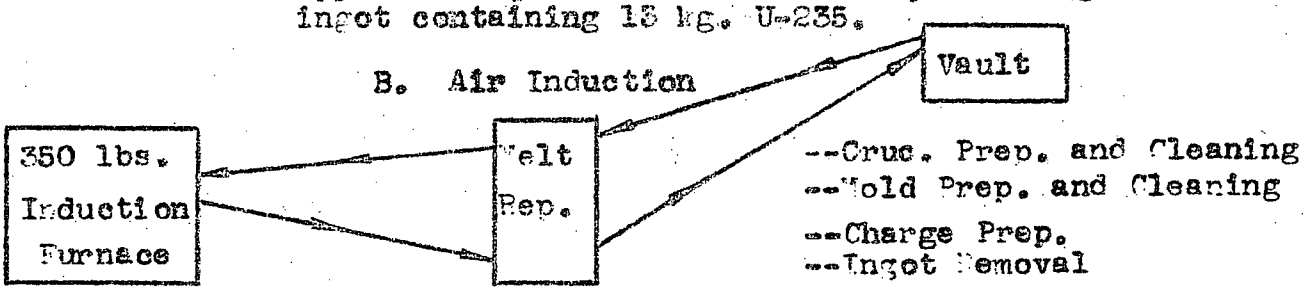
1. MELTING

A. Vacuum Induction



Fissionable material will enter the melting area as either virgin uranium (derbies, slugs, etc.) of various enrichment levels or of recycle alloy scrap in the form of turnings, solid pieces or compacted chips. Quantities will be restricted to safe levels as determined from the referenced literature and will vary with the particular enrichment, alloy and shape. Normally mass criteria are used in the establishment of critical quantities to be melted, occasionally, volume criteria are used in addition to mass. Ingots which are cast are usually in a cylindrical form and range from a 3" dia., 12" long U-Al ingot containing approx. 1 kg. U-235 to a 4" dia., 18" long U-Mo ingot containing 15 kg. U-235.

B. Air Induction



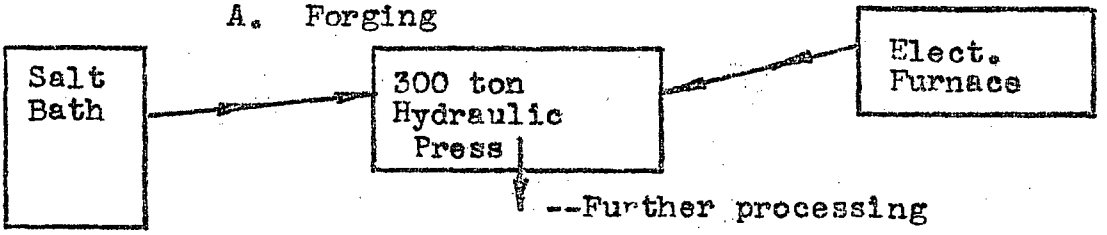
Air induction melting is done in the same area as vacuum melting, however, since both furnaces use the same power supply, only one may be in operation at any time. The same type of materials will be melted in the air furnace as in the vacuum furnace, all ingots being tilt poured as opposed to the vacuum furnace which can be either tilt or bottom poured. The same criteria as used above determine the maximum quantity of material to be melted at any particular time in the air furnace.

C. Vacuum Arc

Our equipment consists of an NRC consumable or non-consumable electrode Vacuum arc furnace with maximum ingot capacity of 4.8" dia. x 18" length. To date this furnace has been used only for development work not involving fissionable materials. However, in this furnace, the same criteria as used in the other melting processes would be used to determine maximum quantities.

2. FABRICATION

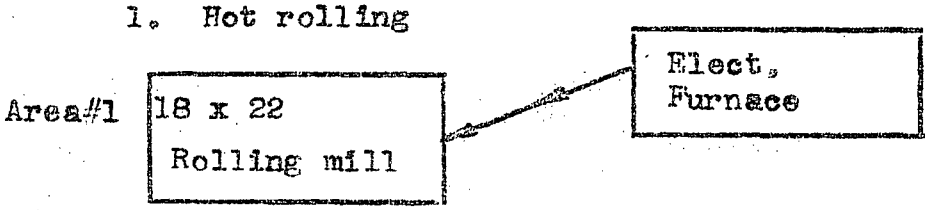
A. Forging



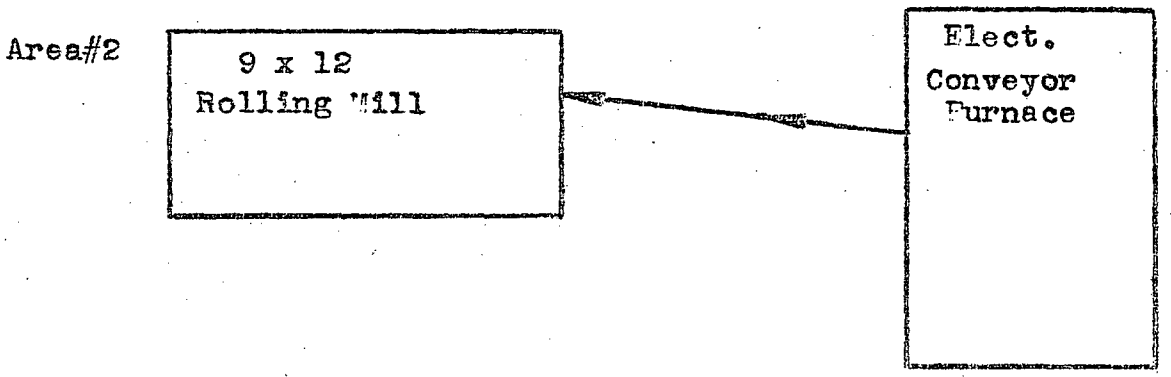
Forging is done on a 300 ton vertical hydraulic press. Material to be forged is usually pre-heated in either a salt bath or an electric furnace (see section under heating for details) adjoining the press. Forging temperature will vary from 1100°F-1260°F for uranium and its alloys. The entering material is normally in the form of a cylindrical ingot varying in size from 300 lbs., 7" dia. ingots of low enrichment (2%) to 10 lbs., 3" dia. ingots of higher enrichments. The forged product is usually in the shape of a slab suitable for rolling. Slab dimensions will range from 2" thick x 5" wide x 32" long to 1 1/4" thick x 3 3/8" wide x 18" long.

B. Rolling

1. Hot rolling

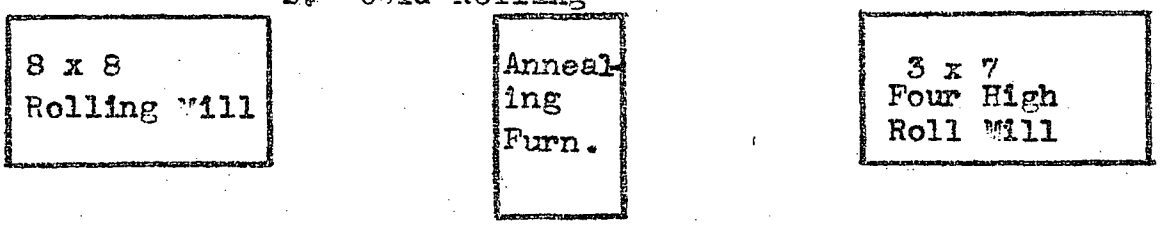


Two areas have been set aside for hot rolling of special Nuclear material. Each consists of a rolling mill and a furnace. Material to be hot rolled is normally in the form of slabs which are broken down on our 18 x 22 mill and further reduced on our 9 x 12 mill. Hot rolling consists of alternately heating and rolling the material until a desired thickness is obtained. As the piece elongates during rolling it is sometime necessary that it be sheared in order to fit into the furnace. Minimum thickness of material which has been hot rolled is usually .100" while the maximum length reaches approx. 6 ft. Average lot sizes contain approx. 3 kg. U-235 for intermediate and low enrichments and lesser quantities for the higher enrichments.



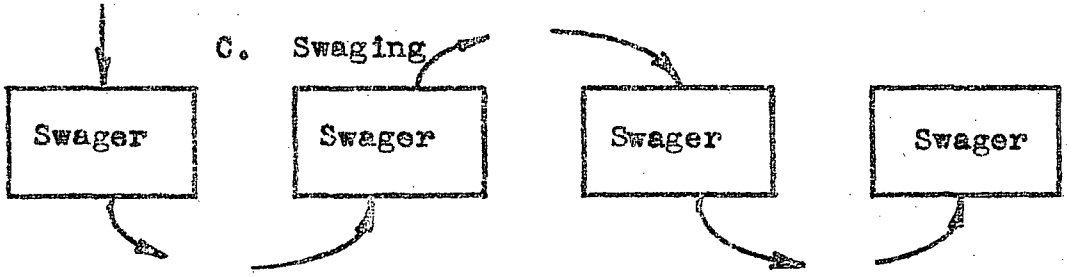
2. Cold Rolling

Area#1



Cold rolling is usually a finishing process to roll material to a very small tolerance. The procedure is to roll a certain reduction, anneal the rolled stock and roll to finish size. We normally use either of our two cold rolling mills depending on the desired thickness of our finished product. The four high mill is used for rolling foil to very low thickness and produces material which is coiled. The 8 x 8 mill is used for slightly heavier material and produces product in the form of strip or plate which is not coiled. The same average lot sizes are used as in the hot rolling operations.

C. Swaging



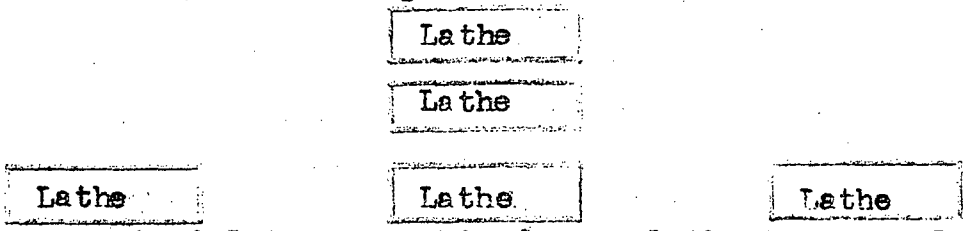
Material to be swaged is in the form of rods which are fully clad, usually with zirconium. The rods are reduced in diameter through a series of dies to the final desired size. After final swaging, the rods are sometimes quite long (25-30 ft.) and are usually cut to a smaller size. Lot sizes will average 5 kg. U-235 for material of intermediate enrichment.

D. Drawing

Tube drawing is done on our drawboard as a part of certain fabrication techniques. Material which is drawn is usually in the form of fully clad alloy tubes. The procedure involves drawing each tube over a series of plugs which are successively smaller until the final desired size is reached. A wax type lubricant is ordinarily used. Average lot sizes are on the order of 2 kg. U-235.

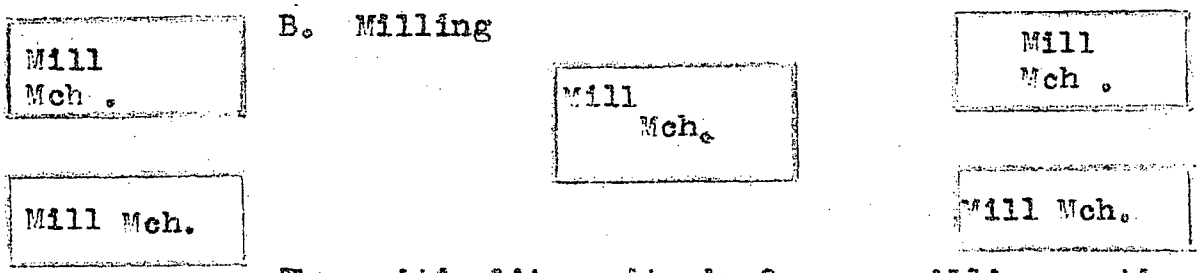
3. CUTTING

A. Lathe Turning



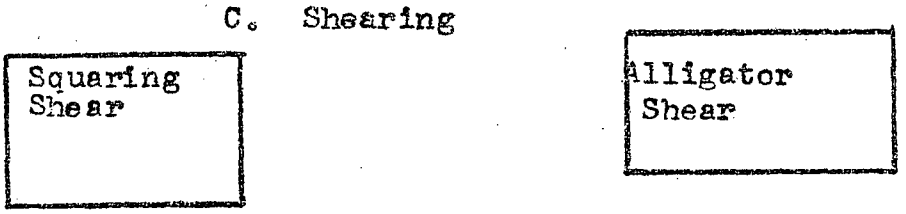
Material to be machined on a lathe is normally in the form of cast ingots, tubes, or slugs. The operation usually involves the removal of material from the diameters and possibly the shaping of the ends. The lathe turnings which are generated are retained in 1 gal. pails under fuel oil, a max. of 350 gms. U-235 per pail. The scrap container travels with the machined stock to the weigh station to determine the extent of the machining losses. The scrap is thensent to the storage area while the material proceeds to the next operation. Lot sizes will vary from 1-5 kg. U-235 for high and intermediate enrichments with higher quantities for lower enrichments.

B. Milling



The criticality criteria for our milling section are essentially the same as for our lathes. Most of our milling procedures involve the removal of surface defects from forged slabs to provide a better rolling surface. The chips which are generated are stored in one gal. pails under fuel oil, a max. of 350 gms. U-235 per pail. When the maximum amount per pail is reached, the pail is sent to the storage area.

C. Shearing



Our shearing equipment consists of a 6 ft. squaring shear and an alligator shear. The squaring shear is used mainly to cut sheet or plate to finish dimensions while the alligator shear is used to cut scrap into small pieces for remelting. The lot size of material to be sheared usually varies from 2-5 kg. U-235. Small pieces which are cut for remelting are placed in steel pails for storage until required for processing.

D. Sawing

Sawing is done on either of two mechanical hacksaws. Material to be sawed is usually in the form of ingots to be cropped or rod to be cut into smaller length pieces. A water soluble wax is ordinarily used as lubricant in all cutting operations. In addition to saw chips, scrap is produced in the form of end croppings. Saw chips are retained in pails under # 2 fuel oil, max. 350 gm. U-235 per pail. End croppings are also stored in pails.

4. HEATING

A. Vacuum Annealing

Special Nuclear material is annealed in a Westinghouse vertical pit furnace with a 14" diameter by 10 ft. long retort. The material is usually suspended from fixtures inside the retort while being annealed. Annealing temp ratures range from 800°C to 1025°C. While being annealed, the material is usually in the form of plates, rods, or cast ingots.

Lot sizes of material to be annealed will vary with the shape and enrichment of the stock but will usually range from 3-8 kg. U-235.

B. Electric Furnaces

Electric furnaces are normally used in conjunction with a hot rolling mill or the forge press. The material is heated to a desired temperature and either rolled or forged. The lot sizes will be limited usually by the sizes of the furnace rather than by criticality criteria. Furnace sizes are:

1. 18" x 12" x 36' to 1700°F

2. 32" x 24" x 60" to 1700°F

3. 12" x 8" x 12" to 1600°F

Average lot sizes are on the order of 2 kg. U-235.

C. Salt Bath

The salt bath is used to pre-heat material which is to be forged. Its dimensions are : 6" x 12" x 5' with a max. temp. of 1700°F. The usual bath composition is a mixture of lithium and potassium carbonates. The limiting mass of U-235 which is normally applicable to this operation is 2 kg.

Periodic cleaning of the salt bath assures removal of any uranium-containing sludge which might be entrapped at the bottom.

5. CLEANING

A. Pickling

Special Nuclear material is immersed in various acid mixtures for different periods of time in order to remove surface contaminants. The acids normally used are nitric, sulfuric, hydrochloric, and hydrofluoric. Material is usually in the shape of either plate, rod, or ingot.

Pickling is done in an enclosed area containing 12 foot PVC acid tanks and rinse tanks. Solutions are maintained under strict controls to prevent a possible accumulation of enriched material in the tank. Whenever a pre-determined maximum limit has gone into solution as calculated from before and after weighings of the material, the solution is sampled and transfered to a storage container. The maximum limit normally allowed to accumulate in the tanks is 50 grams U-235.

B. Vapor Blast

Vapor blasting is done only on material of low enrichment. Its purpose is to remove heavy scale or oxide from forged or rolled material by blasting with a mixture of grit and water. A maximum number of pieces is established from before and after weighings to limit the amount of U-235 removed. After this amount has been processed, the machine is thoroughly cleaned and the water reservoir containing the slurry transfered to a storage container. The normal maximum used for U-235 in solutions is 350 grams.

C. Detergent Cleaning

In addition to pickling and vapor blasting, special nuclear material is often cleaned with hot detergent. Normally, the material is immersed in a detergent tank, scrubbed with nylon brushes, and wiped dry. Since no material goes into solution, there is no problem of U-235 accumulation. The amount of material in the tankat one time is, however, limited usually to a maximum of 1 kg. U-235.

6. JOINING

A. Welding and Brazing

Our welding operations usually involve the canning of an ingot or billet which is to be extruded. The canning components are assembled over the billet and heliarc welded after which they are evacuated and sealed off. No welding is done on the bare uranium. Normal lot sizes of material to be canned and welded will vary from 2-5 kg. U-235.

Brazing operations would normally be limited to the same maximum quantities as welding.

7. NON-DESTRUCTIVE TESTING

A. X-ray and Fluoroscope

Our X-ray equipment consists of a 250 KV Westinghouse unit which is used for detecting sub-surface defects and also for locating core sections in fully clad material. The material which is x-rayed is usually in the form of tube, plate, or rod. Lot sizes average 2-5 kg. U-235.

B. Ultra-sonic testing

Another method of locating internal flaws is by the use of ultra-sonic techniques. Each piece is immersed in the medium, usually water, and scanned by a crystal. No more than one piece is in the medium at any time. Flaws are picked up on an oscilloscope which is mounted on the unit. A lot size will average 2-5 kg. U-235 with individual pieces containing less than 100 gms. U-235.

C. Dye Penetrant

To determine the presence or absence of minute surface defects a dye penetrant test is used. The material is dipped in a tank containing a dye solution, sprayed with a developer, rinsed with water, and hot air dryed. An average lot size would be 500 gms. U-235.

PRINCIPLES AND POLICIES FOR MAINTAINING NUCLEAR SAFETY

Nuclear Safety is the responsibility of the Criticality Control officer and his staff. In order to assure complete safety in inter-plant processing, strict control is exercised over all movement of fissionable material. Every movement must be cleared in advance with the Criticality Control monitor. He has the authority to stop immediately any operation or handling procedure which he feels may be potentially dangerous.

Prior to the beginning of work on any project involving fissionable material, the criticaltiy control officer will contact representatives from Production, Engineering, and Accountability to work out acceptable procedures for handling and processing. These procedures are then incorporated into a feasibility report which is submitted for AEC approval. When this approval is received, the material is released for processing. It is the responsibility of the supervisory personnel to see that the limits established in the feasibility report are adhered to in production. At the same time the Criticality control staff monitors all operations to assure that this is being done.

In addition to the physical controls used to prevent the accumulation of a potential critical mass, administrative controls are also used. All process sheets issued to the production floor pertaining to work with special nuclear material must first be approved by the criticality officer. This assures that instructions to supervisory and floor personnel are in accordance with the acceptable limits as set forth in the feasibility report.

In addition, the Criticality control staff works very closely with both Production control and Accountability. A copy of the route card which accompanies the material as it travels through production is submitted to the Criticality officer before it enters the shop. Any discrepancies in the sequence of operation which conflict with the feasibility report or standard safety procedures will be noted and resolved before any actual movement or handling takes place. No material is moved or processed without a route card and proper clearance from the Criticality control section. Red route cards are used to distinguish enriched material.

Shipments of enriched material are scheduled by Production Control after prior approval from both Criticality Control and Accountability. This insures the proper packing of the material and the issuance of the correct forms for shipment. No enriched material is packed without the direct supervision of Criticality control.

Receipt of special nuclear material is handled under the supervision of Criticality control after being informed of receipt by Accountability. The maintenance of the storage vaults and areas in a safe condition is a direct responsibility of Criticality control. No material is received in or issued out without the prior knowledge and approval of Criticality and Accountability.

The operation of greatest hazard insofar as accidental criticality is concerned, is the pickling of special nuclear material. In this area a rigid administrative control is applied over the entire operation from the makeup of the pickle solutions to the disposal of the used acids. Every piece of material which is pickled is weighed both before and after the operation to determine the quantity which remains in solution. This weight difference is assumed to be all uranium or the particular alloy which is being pickled in computing U-235 weight in solution. When a pre-determined limiting amount of U-235 has gone into solution as calculated from weight loss data, the solution is sampled and transfered to a polyethylene carboy for storage. When analytical results are received, carboys may be combined in one 30 or 55 gal. polyethylene lined drum as long as the amount of U-235 in the drum totals less than 500 grams.

In certain instances pickle tanks have been equipped with 1" overflows leading to a 5" I.D. always safe container. This limits the height of the solution to where it approaches an infinite slab or always safe condition. This cannot always be done, however, due to the size of the material being pickled.

REFERENCES: LA-2063, Nuclear Safety Guide, Callihan
LA-1623, Safety Tests for Melting and Casting, Oralloy, Hart
LA-1958, Critical Masses of Fissionable Metals as Basic Nuclear Safety Data, Paxton and Graves.