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AEC Research and
Development Report
UC-81, Reactors - Power
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**specifications and
fabrication procedures for
type 3 neutron absorber sections**

Contract No. AT[30-1]-2639
with U. S. Atomic Energy Commission
New York Operations Office

ALCO PRODUCTS, INC.
NUCLEAR POWER ENGINEERING DEPARTMENT

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Development Report
UC-81, Reactors - Power
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**SPECIFICATIONS AND FABRICATION PROCEDURES
FOR TYPE 3 NEUTRON ABSORBER SECTIONS**

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Issued: April 25, 1962

Contract No. AT(30-1)-2639
with U. S. Atomic Energy Commission
New York Operations Office

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SPECIFICATIONS AND FABRICATION PROCEDURES
FOR
TYPE 3 NEUTRON ABSORBER SECTIONS

I. SCOPE

The specification contains material, process and product requirements to be met by the Fabricator. The ability to produce the required end product can only be demonstrated through destructive testing of qualification components manufactured under fabrication procedures identical to the procedures to be utilized in the production of the core loading components.

The following procedure describes in detail the process developed at Oak Ridge National Laboratory and further developed during commercial production for manufacturing this component. Differences in equipment and other factors existing at other plants may necessitate modifications of some of the procedures to arrive at the same result. For this reason, complete qualification of the Fabricator's process is required. This qualification of the Fabricator's process constitutes an integral part of this specification and the production of the desired component.

The control rod absorber section consists of four rectangular composite absorber plates joined by welding to form a rectangular parallelepiped. The composite plates consist of compacts of europium oxide in a stainless steel matrix that are clad with stainless steel by hot roll bonding.

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II. QUALITY ASSURANCE PROVISIONS

Quality control of the absorber section is primarily attained by rigid adherence to proven fabrication procedures. Thus, specifications for the absorber sections cannot be prepared along the lines normally used for industrial products, in which quality is assured by nondestructive inspection to industry-wide standards.

A. Qualification of Absorber Plate Fabrication

Qualification shall be performed by subjecting three sample plates to the tests outlined in 2-a through 2-h (Tests for Qualification) of this section. The Fabricator shall not proceed with fabrication of the absorber plates required in the end product until it has been demonstrated to the satisfaction of the Commission that requirements of section 2a - 2h (Tests for Qualification), described below, have been met.

1. Preparation of Qualification Samples

The three sample plates shall be prepared in conformance with the exact and complete fabrication procedure which is to be used in the manufacture of the absorber sections. Europium oxide, identical in every respect with the material to be used in the absorber sections, shall be used in the sample plates. The sample plates shall be subjected to the identical high-temperature treatment which will be encountered in the procedure for fabrication of the composite plate.

The chemical analysis of qualification plates shall be performed only by a laboratory which has satisfactorily demonstrated its ability to analyze, for europium in stainless steel dispersion type absorber plates. Choice of a laboratory for chemical analysis work shall be approved by the Commission.

2. Tests for Qualification

a. Visual Inspection - The three sample plates shall be inspected for over-all width, length, and thickness dimensions and shall be inspected for pitting, surface condition, and finish. The three sample plates shall meet all dimensional requirements and shall not exhibit any oxide indentations or pits in excess of 0.005 in. deep, scratches over 0.002 in. deep, blisters, scale, or dents.

b. Radiographic Examination - The three sample plates shall then be radiographed to delineate the europium oxide - bearing core area and voids or other internal defects. The radiographs shall be made using proper techniques with a fine-grained film such as Eastman "M" or equivalent. The radiographs shall be used as the basis of measuring core length, core width, and inactive edges and ends.

The samples shall meet all dimensional requirements and shall exhibit no evidence of voids or other internal defects.

c. Alpha Contamination Examination - The three sample absorber plates will be subjected to an alpha count to determine if any possible surface contamination exists. The plate shall be checked for alpha contamination by means of gas flow proportional counting or similar method. Alpha contamination equivalent to 0.5 micrograms of U-235 per square foot shall be the maximum allowable level of contamination. It is assumed that the one microgram of U-235 per square foot is equivalent to 150 disintegrations per minute per square foot of plate surface.

d. Homogeneity - Two of the three sample plates shall be examined for homogeneity. Five miniature samples of full-plate thickness, approximately one inch square, shall be extracted from each of the two plates on a diagonal between core corners and approximately equally spaced beginning 2 in. from core-end and 1/4 in. from core-edge interfaces. These samples shall be dissolved and chemically analyzed for total europium content, and the results expressed on a weight per cent basis. For each of the two plates, variation from location to location shall not exceed 5% of the average europium content.

e. Bond Integrity - Five transverse samples, equally spaced along the plate length, and three longitudinal samples from each end, equally spaced across the width, shall be removed from one of the three sample plates. After proper preparation and electrolytic etching with 5% chromic acid reagent, the samples shall show no evidence of lack of bond at the clad-frame interface or at the clad-core and frame core interfaces upon metallographic examination at 100 diameters.

f. Clad-Core-Clad Thickness - The five transverse samples used in "e" shall be measured to determine clad-core-clad thickness. As measured by a calibrated eye-piece, the thickness at all points shall fall within the specified thickness tolerances.

g. End Conditions - The six longitudinal samples used in "e" shall be examined metallographically. These samples shall show no evidence of the presence of core material in the inactive portions as dimensionally specified.

h. Fragmentation and Stringing - One longitudinal sample at least 1/2 in. long shall be taken from the core of two of the plates. When examined metallographically, none of these samples shall exhibit fragmentation and stringing greater than that illustrated in Figure 1. The europium oxide shall exhibit no evidence of reaction with matrix, clad, or frame material at magnifications up to 1500X.

B. Qualification of Procedures for Fabrication of Absorber Section

In addition to the qualification procedures for fabricating absorber plates, the Fabricator is required to qualify the operator and the procedure to be employed in welding the absorber sections. Qualification shall be performed by subjecting one assembled and welded solid stainless steel absorber section to the tests outlined in the following sections 2a and 2b. The Fabricator shall not proceed with fabrication of the absorber sections, required in the end product until it has been demonstrated to the satisfaction of the Commission that the requirements of Sections 2a and 2b (Tests for Qualification), described below, have been met.

1. Preparation of Qualification Sample

The simulated absorber section shall be prepared in conformance with the exact and complete assembly procedure which is to be used in the manufacture of the absorber sections. Solid stainless plates dimensionally identical to the production absorber plates shall be used in the qualification section.

2. Test for Qualification

a. Visual Inspection - The welded test section shall be inspected for over-all cross-sectional width and length dimensions and for weld integrity. The test section shall meet all dimensional requirements. The bead shall be continuous and limited to an area 0.050 to 0.200 in. wide measured from the outside edge of the absorber.

The finished test section must pass through a final test box with internal dimensions 2.650 x 2.650 x 26-1/16 in. without binding at any point.

ORNL Y-28331

Figure 1. Typical Microstructure of Fabricated Absorber Plate, containing 36 w/o Europium Oxide in Stainless Steel (as polished 250X)

b. Weld Integrity - Four transverse sections, equally spaced along the length of the finished test section shall be removed and examined metallographically for weld penetration. The weld bead shall be essentially flush with the plate surface. The average depth of penetration should be 0.025 in. and not less than 0.015 in. as measured from the plate surface by a filar micrometer eyepiece. The welds shall be essentially free of porosity, inclusions and tungsten particles.

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III. PROCESS AND MATERIAL SPECIFICATIONS

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In calculating the delta ferrite content from the Schaeffler Constitution Diagram, the following multiplying factors shall be used in computing the chromium and nickel equivalents for the production order: -

<u>Element</u>	<u>Factor</u>
Carbon	30
Manganese	1/2
Silicon	1-1/2
Chromium	1
Nickel	1
Cb + Ta	1/2
Nitrogen	30
Copper	2
Molybdenum	1

In the event that the chemistry of the heat is outside the range of the desired specification, but within the ASTM chemistry, and contains a delta ferrite content in the range of 2 to 10% as calculated from the Schaeffler Diagram, the heat will be acceptable.

In the event the chemistry is outside the desired specification limits, and below the lower limit of 2% delta ferrite, a weldability test shall be made without filler addition. Freedom from cracking shall consider the heat acceptable. The type and details of this welding test shall be as mutually agreed upon between the supplier and Alco Products, Inc. Material that is not weldable, as determined by this test, will not be acceptable.

Inclusion Content:

The inclusion content of this material in the form of 1 in. thick sheet bar as determined by Method "B" set forth in ASTM E-45-51 shall be equal to or better than an inclusion rating of (12-5¹²). This rating as determined by method "B" shall be comparable to the following method "A" rating: -

<u>Inclusion Type</u>	<u>Thin Series</u>	<u>Heavy Series</u>
Type A (Sulfide)	2	1-1/2

- Title: - Cladding Material - Type 347 Low Cobalt, Low Tantalum Stainless Steel.
- Purpose: - This specification covers the material used for cladding, frames, combs, side plates and end fixtures.
- Material: - The surfaces shall be free of laps, seams, scabs, or other injurious defects. The material shall be sound and free of undue stringers, entrapped foreign materials, gases or items detrimental to the continuity and strength of the cladding.
- Chemistry: - This steel is AISI Type 347 having the chemistry limits set forth in ASTM A-240-58T except that the cobalt shall be 0.025 max and tantalum shall be 0.01 max.

Chemical Composition: - in weight percent

<u>Element</u>	<u>ASTM Specification</u>	<u>Desired Specification</u>
Carbon	0.08 max.	0.06 max.
Nickel	9.00 - 13.00	9.25 - 9.75
Chromium	17.00 - 19.00	18.00 - 18.75
Manganese	2.0 max.	1.00 - 1.50
Phosphorous	0.045 max.	0.030 max.
Sulfur	0.030 max.	0.030 max.
Silicon	1.0 max.	0.50 - 0.80
Columbium		
Tantalum	10 x C min; 1.10 max.	0.60 - 0.80
Cobalt	-	0.025 max.
Tantalum	-	0.01 max.
Nitrogen	0.05 max.	0.04 max.
Molybdenum	0.50 max.	0.20 max.
Copper	0.50 max.	0.20 max.

The material with the above composition limits will be used for inert gas shielded tungsten arc welding without filler metal. In addition to meeting the chemical restrictions set forth in this specification, the delta ferrite content of this material, as calculated from the Schaeffler Constitution Diagram shall be a minimum of 2% and a maximum of 10%.

<u>Inclusion Type</u>	<u>Thin Series</u>	<u>Heavy Series</u>
Type B (Alumina)	2-1/2	2
Type C (Silicate)	3	3-1/2
Type D (Globular Oxide)	3	2

The thickness of the inclusions found in 1 in. thick sheet bar shall not be any greater than that specified in the Inclusion Chart of ASTM E-45-51 specification.

Mechanical Properties: -

	<u>Tensile Strength</u>	<u>0.2% Offset Yield Strength</u>	<u>%Elong- ation in 2 In.</u>
Plate, Sheet and Strip	75, 000 psi	30, 000 psi	40%

Purchase Conditions: -

Cold rolled, annealed, and pickled sheared mill plate or sheet.

Certification: - Certification shall be furnished to the Fabricator or its authorized representative, that all materials used in the fabrication and furnishing of the fuel elements are in accordance with the requirement of these specifications.

NOTE: This material will be supplied by Alco Products to the Fabricator.

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- Material: - Europium Oxide Powder
- Purpose: - This specification describes the initial material and preparation of Europium oxide for use as a neutron absorber or flux suppressor.
- Process: - 1. Europium Oxide Preparation.

Europium oxide is prepared from europium oxalate by "calcining" at 950°C in air, resulting in a cubic crystal structure, or by "conditioning" at 1650°C in air, resulting in a monoclinic crystal structure. Each batch of oxide prepared by either of the above methods must be analyzed to determine that the material contains a minimum of 98% europium oxide. "Calcined" and "conditioned" europium oxide must not be mixed.

Because europium oxalate is extracted from monazite sands containing thorium, each batch must be tested for alpha activity. The thorium content will be determined by alpha activity measurements. Alpha activity shall not exceed 10 disintegrations per minute per milligram of sample above background. (This is equivalent to 5 counts per minute per milligram above background on a detector with a 50% alpha counting efficiency). The detector shall be an internal proportional counter and shall be calibrated with a known alpha source which has been previously standardized by the National Bureau of Standards. The sample shall not weigh more than 50 mg, and shall be distributed evenly on a 1 in. diameter stainless steel planchette.

The alpha activity limits should be low enough to allow careful out-of-glove box handling. It is recommended however, that sufficient air samples be taken under local operating conditions by the Fabricator's Health Physics personnel to insure against unsafe airborne contamination.

2. High Firing

The "calcined" or "conditioned" europium oxide is high fired to convert to the monoclinic phase and to remove excess oxygen, to insure the europium oxide is stoichiometric (Eu_2O_3).

The following high firing method is suggested as a suitable procedure known to be satisfactory.

The "calcined" or "conditioned" powder is pressed into small cylindrical pellets to facilitate handling. Approximately 35 gm of the material is pressed into an individual pellet. The measured amount of oxide is poured into the cavity of a double acting, 0.8 in. diam. powder metallurgy die, leveled, and pressed into pellet form by applying a pressure of about 33 tons per square inch. The resulting pellets are of sufficient strength for handling and have dimensions 0.8 in. diameter by 0.8 in. length.

Approximately 10 pellets weighing a total of between 300 - 350 gm comprise the firing batch size. The individual pellets are placed in a tungsten crucible approximately 2 x 2 x 7 in. in size which is constructed by edge welding 1/8 in. sheet stock. The loaded tungsten crucible is inserted in a reactor grade graphite crucible mounted in the center of an induction coil. Amorphous thermatomic carbon powder is packed between the reactor grade graphite crucible and the outer quartz furnace tube to serve as an insulator. A reactor grade graphite block with an attached off-gassing stem is placed over the reactor grade graphite crucible to prevent the thermatomic graphite from contaminating the europium oxide pellets. The remainder of the quartz tube is filled with amorphous thermatomic carbon powder and is capped with a gas-tight, brass end plug. A hydrogen gas stem is attached to the lid to permit passage of hydrogen to the pellets during the firing operation. The exit hydrogen gas escapes through the stem attached to the top of the graphite crucible. The pellet firing is carried out at 1700°C for a period of three hours. The atmosphere is dried hydrogen gas with a dew-point of at least -60°F. The power is varied initially to control the rate of temperature rise in the furnace; a rate of 300°C/hr is average. Temperature measurements are made on the surface of the pellets by sighting an optical pyrometer through the off-gassing stem. Upon completion of the firing, the power is shut off and the furnace is air-cooled to approximately 150°C, at which time it is disassembled and the fired pellets removed.

3. Crushing

The fired pellets are crushed to -325 mesh size by a method which will not produce excessive fines, using a series of intermediate screening operations. Initially one-third of the fired batch size is crushed using only impact-type strokes. Circular grinding motions have been found to produce considerable fines in the crushed oxide. After the pellets have been initially broken down, the product is placed in a series of vibrating screens which separate out the +100, -100, -270, and -325 mesh fractions. Each fraction is then recrushed until the entire material is of a -325 mesh size. The various sizing separations are necessary to minimize presence of fines. The final product from each batch is examined macroscopically to insure that the particles are irregular and not rounded. A representative sample of each batch of hi-fired oxide is analyzed by wet chemistry to determine that the europium content is 85 wt. % minimum.

4. Test of High Fired Europium Oxide

A specimen from each fired batch of europium oxide shall be tested for weight change by firing in a dry hydrogen (dew-point at least -60°F) atmosphere for $1\text{-}1/2$ hr at $2250 \pm 25^{\circ}\text{F}$. The specimen shall be cold pressed in a $1/4$ in. die at a pressure at least 30 tsi before firing. The pellet is fired on a molybdenum lined type 316 stainless steel boat in a leak tight muffle. The specimen shall weigh 1.5 ± 0.05 gm before firing. After firing, the specimen shall not show weight gain or loss in excess of 0.008 gm.

5. Handling

After high firing the europium oxide must be handled and stored under conditions which preclude the pickup of moisture.

Figure 2. Furnace Assembly for High Firing Europium Oxide Pellets

- Material: - Absorber and Suppressor Matrix Powder
- Purpose: - This specification covers the requirements for elemental stainless steel powder for use in flux suppressor absorber plate matrices and in absorber plate matrix diffusion barrier foils.
- Process: - The matrix material and diffusion barrier foil material shall be prepared from elemental iron, chromium and nickel powders in the weight ratio of 71, 18 and 11, respectively. The particle size of all materials is -325 mesh. The iron powder should be hydrogen annealed electrolytic iron with a minimum iron content of 99.0 wt %. The nickel powder shall be prepared by the carbonyl process and the chromium powder may be produced either electrolytically or by lithium reduction. The maximum content of impurities for each powder is as follows:

	<u>Fe</u>	<u>Ni</u>	<u>Cr</u>
Si	0.03 wt %	0.03 wt %	0.03 wt%
O ₂	0.30	0.20	0.10
C	0.02	0.10	0.02
Co	0.02	0.02	0.02

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- Title: - Weighing of Absorber Core Component Powders
- Purpose: - This specification covers weighing of component powders for absorber plate cores.
- Process: - The absorber plate core consists of three compacts or sub-cores stacked on top of each other. The component powders for each sub-core are separately weighed and then combined in a single blending jar or container. A wide mouth pyrex glass jar has been found to be satisfactory. With the exception of possible losses during subsequent pressing and sintering operations, this method offers accurate accounting and reproducibility of the critical ingredient, europium oxide, in each absorber sub-core and ultimately in each absorber core within the limits of the accuracy of the weighing balance. Europium oxide is the first material loaded into the blending jar and is followed by the constituents of the elemental stainless steel powder, namely electrolytic iron, nickel, and chromium. Since the absorber section contains no contaminated or active materials, handling of all powders can be done in a conventional manner. The individual weighing procedures are as follows:

a. Weighing of europium oxide

The neutron poison, europium oxide, in the sub-core is weighed to an accuracy of at least $\pm 0.03\%$ on a Grammatic balance or equivalent of 200 gm capacity. A sheet of glazed paper with glazed side up and of known weight is placed on the pan. The europium oxide is added to the paper and is accurately weighed after which it is poured into the jar.

A camel's hair brush is used to brush any remaining particles of europium oxide into the jar. The jar is immediately capped.

b. Weighing of the elemental stainless steel powder

The elemental stainless steel constituents, electrolytic iron, nickel, and chromium are weighed in exactly the same manner

as the europium oxide with the exception that a triple-beam balance is used. The individual powders are weighed to a tolerance of $\pm 0.01\%$. After each weighing the individual powder is transferred to a blending jar containing the previously weighed europium oxide. The jar is immediately recapped. The procedure is repeated for the two remaining constituents.

These operations are repeated until the lot of jars has been processed. After final weighing and capping, the joint between the cap and the jar is sealed with masking tape and each jar identified by europium oxide batch number.

- Title: - Blending of Absorber Core Component Powders
- Purpose: - This specification covers the blending of the absorber plate sub-core component powders to obtain a homogeneous mixture of matrix and absorber material.
- Process: - Two types of blenders have been successfully used. The first is a modified U. S. Stoneware Company Double Cone Blender Model 733. The double cone blender is modified by replacing the cones with a pair of two-quart steel cans mounted with the vertical axis of the cans at a 30° angle with the vertical. The second is a standard ball mill roller drive on which is placed a two-quart can mounted within a circular band or pipe about 12 in. in diameter. The two-quart can is mounted with its vertical axis at an angle of 30° from the vertical, giving the same blending action as the modified cone blender. The cans are rotated at about 80 revolutions per minute.

The blending jars containing the europium oxide and matrix materials are placed into the two-quart cans, with adequate packing to prevent breakage and to keep the jars in a vertical position in relationship to the vertical axis of the cans, and are blended 3 hours. The blended powders are then ready for the first pressing operation. The identity of the contents of the blended absorber cores must be maintained at all times.

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- Title: - Initial Compacting of Absorber Core Powders
- Purpose: - This specification covers the initial pressing of absorber sub-core matrix and absorber powders into a "green" compact.
- Process: - The initial operation in shaping the blended powders into a compact suitable for absorber plate billet is to cold press into a "green" compact. A press of 150 ton minimum capacity and with a hydraulic control system to permit variable movement of the ram is employed for compaction. On the top of the lower ram is fastened a large platen onto which is placed the powder metallurgy die set. The die set consists of a female die which is spring mounted, a die punch and filler block. The bottom of the die punch compacts the bottom ram, while the top of the filler block inserted into the die cavity after the powder, contacts the upper ram.

A solution of 10 wt % C. P. stearic acid - 90 wt % carbon tetrachloride, which serves as a die lubricant for each die charge, is applied with a 1/4-in. camel's hair brush around the top of the die cavity and the lower sides of the filler block. The die face is occasionally lubricated when the pressed core adheres to it. The blended powder is poured into the die cavity. The jar is brushed thoroughly to ensure complete transfer of all powders. Once the core material has been loaded into the cavity, it is leveled with the straight edge of a scoopula. The filler block is inserted into the die and the powders are pressed at 10 tsi pressure (approximately 45-tons total load) for 15 seconds to a thickness of approximately 0.404 inch. The filler block is removed and the "green" compact is ejected with the hand lever. Extreme care must be exercised in removing the "green" compact to avoid breakage since the compact is of low strength. The pressed compact is immediately placed on the sintering boat to minimize handling.

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- Title: - Absorber Compact Sintering and Resintering
- Purpose: - This specification covers the sintering and resintering of absorber sub-core components.
- Process: - A. Initial Sintering of "Green" Compacts

The sintering operation is carried out in a 20-kw molybdenum-wound sintering furnace or equivalent, equipped with a 3 in. diameter Inconel muffle. Thirty-six inches of the muffle extends beyond the furnace and acts as a cooling chamber. The sintering temperature is 2250°F. Uniformity of temperature along the length of the sintering boat is maintained at $\pm 25^\circ\text{F}$. Dry hydrogen is used as atmosphere in the muffle, with a dew-point of at least -60°F, as measured by an Alnor Dewpointer or equivalent at the gas inlet. A sufficient flow rate is maintained to prevent oxidation during heating and to promote reduction of the metal powder oxides.

The sintering boat which contains the pressed "green" compacts is constructed of type 316 stainless steel formed into the shape of an "H". The crossbar between the two vertical sides is 2-1/2 in. wide x 14 in. long, and is located approximately 1/2 in. above the bottom of the legs.

Prior to positioning five "green" compacts end to end along the length of the boat, a molybdenum-foil liner is inserted to prevent the sub-cores from contacting the stainless steel. This liner has 1/16 in. diameter molybdenum wire spacers welded along its length upon which the five compacts rest. This spacer wire is used to permit access of hydrogen gas to all surfaces of the compacts.

The sintering boat containing the five compacts is inserted in the furnace at 2250°F and the system is purged with hydrogen. The compacts remain in the hot zone for 1-1/4 hours. The boat is moved to the cooling chamber, allowed to cool to 450°F under the hydrogen atmosphere removed from the muffle, and air-cooled to room temperature. Again, in an effort to minimize handling cores are not removed from the boat until re-inserted into the pressing die for additional compaction.

B. Resintering of Compacts

The repressed compacts are resintered in the furnace described in section A under dry hydrogen for 1-1/4 hours at 2250°F and cooled in the cold leg of the muffle to 450°F. This second sintering promotes densification and alloying of the elemental powders.

- Title: - Preparation of Foils
- Purpose: - This specification covers the preparation of diffusion barrier stainless steel foil for separating the absorber compacts from the cladding materials and to promote bonding between the absorber sub-compacts.
- Process: - Foils are prepared by combining the elemental powders in the proportion of 71 wt % iron, 18 wt % chromium and 11 wt % nickel. The powders are blended for 3 hours in an oblique blender; cold pressed at 31 tsi; sintered in a dry hydrogen atmosphere for 1 hour, and coined at 31 tsi. The coined stainless steel is cold rolled to a thickness of 0.005 inch $\pm$ 0.0005 inch with the necessary intermediate annealing operations to minimize edge cracking. Light reductions coupled with cross rolling yield the most satisfactory material.

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Title: - Repressing and Coining of Sintered Absorber Sub-cores

Purpose: - This specification covers the repressing of sintered absorber sub-cores to improve densification. Also, this specification covers coining of the sub-cores after the resintering operation to increase density and establish dimensions.

Process: A. Repressing the Sintered Compacts

The compacts, after the initial sintering, are repressed in the powder metallurgy die set. The shrinkage encountered during sintering permits reinsertion of the compact into the same die cavity. After careful insertion, the sintered compacts are pressed at a pressure of 31 tsi (approximately 150 ton load) for 15 seconds. The repressed compacts are ejected from the die and are repositioned on the sintering boat.

B. Coining of Sintered Compacts

The shrinkage encountered during the second sintering operation permits re-insertion of the compact into the original die cavity for coining. After careful loading, the resintered compacts are pressed under a pressure of 31 tsi for 15 seconds, to obtain the desired dimensions. The coined compacts are ejected from the die and are transferred to the inspection area.

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- Title: - Absorber Plate Sub-core Inspection and Weighing
- Purpose: - This specification covers visual inspection and weighing of absorber sub-cores.
- Process: - Each sub-core "green" compact is visually inspected for cracks, chips and flaws after it is placed on the sintering boat. If a sub-core is found to have a minor visual defect, such as a slightly chipped corner, it is weighed for acceptance or rejection. Deviation from the charged weight shall not exceed + 0.9% or - 1.2%.

Handling of green sub-cores must be minimized because they are extremely fragile.

After final sintering and coining, the sub-cores are again inspected for chipping and spallation. All visually acceptable sub-cores are weighed to determine the average weight loss due to oxide reduction during the sintering process for good sub-cores. Each sub-core with minor visual defects is weighed to determine acceptability. Deviation in weight from the average sub-core final weight shall not exceed + 0.9% or - 1.2%.

Each sub-core is measured with a micrometer after coining to determine if the compact meets the thickness requirement of 0.327 ± 0.002 in.

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- Title: - Absorber Core Storage
- Purpose: - This specification covers absorber sub-core storage procedure.
- Process: - Each acceptable lot of cores is wrapped in paper. These packages are marked to identify batch number and are inserted in an ordinary desiccator if storage time is to be less than 48 hours. If a storage time of more than 48 hours is required, a vacuum desiccator is used.

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- Title: - Absorber Cover Plate and Frame Preparation
- Purpose: - This specification outlines procedures for preparation of cover plates and frames for absorber plates.
- Process: - The billet components consist of two wrought stainless steel cover plates, a frame into which the europium oxide compacts are inserted, an evacuation tube, three sub-cores containing the europium oxide, and five stainless steel foils.

A. Stainless Steel Cover Plates (Specification CM-14A)

The cover plates are fabricated from 5/16 in. plate (minimum thickness of 0.318 in.) which may require cold rolling to the specified thickness of 0.320 ± 0.002 inches. The plates are sheared to 4-3/4 in. x 4-3/4 in. $\pm 1/16$ in. which allows a 3/16 in. overlap on all sides of the cover plate on the frame. Since only very small reductions are necessary during cold rolling, it is recommended practice to shear the received plate to the above dimensions and to reduce to the required thickness by cross-rolling.

B. Picture Frames (Specification CM-14A)

Picture frames are machined from 1 inch plate. Since the billet is to be subsequently evacuated prior to rolling, holes are drilled into the frame to provide a free path for evacuation. It is important that the finished plate be free of potential defects caused by the drilled holes. By the design, in shearing and machining the plate to final size, these regions will be in the scrapped portion of the plate. An entrance hole, 0.225 in. in diameter, is drilled in the geometric center of the tail edge of the plate frame to a depth of 3/8 inch. A corresponding 0.225 in. diameter hole is drilled through the frame perpendicular to and meeting the end of the first hole to form a "T".

C. Evacuation Tube (AISI Type 304 or 347 S. S.)

The tube for evacuation of the billet interior is Type 304 or 347 stainless steel with a nominal outside diameter of 0.225 in., an inside diameter of 0.175 in. and a length of 12 in.

D. Foils (Specification AP-124)

Foils are cut to a size determined by available space and by assembly technique.

- Title: - Absorber Plate Billet Assembly
- Purpose: - This specification covers procedures for assembling cover plates, sub-cores, foils, picture frame and evacuation tube into a billet for hot rolling.
- Process: - The evacuating stem is inserted approximately 1/8 in. into the hole provided in the frame and is TIG welded to the frame with Type 347 stainless steel filler rod. The tube is purged with an inert gas during welding to prevent melting of the tube wall.

Immediately prior to billet assembly, the picture frame and cover plates are thoroughly degreased. Mating surfaces of the picture frame and cover plates are scratch brushed with a power-driven stainless steel brush to remove surface oxide. It is imperative that the stainless steel brush be kept clean. The cover plates and frame are washed in a hot halogen and boron free detergent solution at 160-180°F, and rinsed in 160-180°F water until all traces of detergent have been removed. The components are then air dried.

The billet is assembled by stacking the three sub-compacts in the frame hole. To prevent contact of the compacts with the frame and potential reaction of europium oxide with wrought stainless steel, foils are placed around the periphery of the frame hole prior to insertion of the stack of sub-compacts. Between each sub-compact, a foil is placed to improve the compact to compact bonding during hot rolling. Foils are placed at the cover plate-compact interfaces and held in place by bending the edges of the foil over the sub-compact. After insertion of the compacts and foils, cover plates are placed on top and bottom of the frame and held in place by "C" clamps. The cover plates overhang the frame by approximately 3/16 in. on all sides to facilitate welding.

Cover plates are attached to the frame by TIG welding. Two heavy weld passes employing a Type 347 stainless steel filler rod are made completely around the periphery of the two frame-cover plate joints. All welds are brushed and exam-

ined for flaws. The sealed billet is leak tested under water with a 20 lb. internal helium pressure applied through the evacuation stem. The billets are then evacuated to a final vacuum of less than 10 microns mercury. During this operation, the billet is heated to approximately 500°C to drive off any water vapor and entrapped gases. The heating is continued until there is no indication of loss in vacuum; at which time, the evacuation stem is sealed by hot forging.

Figure 3. Absorber Plate Exploded View Prior to Hot Rolling
(Dwg. AES-514)

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Title: - Hot Rolling of Absorber Plates

Purpose: - This specification covers hot rolling of the absorber plate billets to obtain clad to frame and clad to core bonds and to reduce the billets to final absorber plate thickness.

Process: - The assembled and evacuated billets are hot rolled to a final thickness of 0.156 in. $\pm$ 0.004 in. on a rolling mill of adequate size. A furnace capable of maintaining 2100°F over a muffle length of 40 in. is recommended. The muffle is purged from the rear with hydrogen gas with an inlet dew-point of less than -60°F as measured by an Alnor Dewpointer or equivalent. A gas flow rate should be high enough to prevent oxidation during heating and also to promote the reduction of oxide scale formed during rolling.

The billets are heated to 2100°F for at least 90 minutes prior to the first pass and are reheated for at least 5 minutes between subsequent passes. The reheat time is reduced to 3 minutes between each pass near completion of the hot rolling. After the final pass, the plates are replaced in the muffle for a 5 minute anneal and then are air cooled. The billet side containing the hot forged evacuation stem is gripped so that the opposite end can enter into the rolls. This practice is continued throughout the hot rolling to assure a single rolling direction although the billet is rotated 180 degrees about its longitudinal axis between passes. The hot rolling is performed in approximately 22 passes using 10% reductions in thickness during each pass as indicated by mill settings. Lighter reductions are made, as required, to roll to 0.156 in. $\pm$ 0.004 in. near the end of the fabrication schedule. The plate thickness is measured over the core area with a micrometer to determine the actual thickness of the hot rolled plate. As the thickness of the plate approaches 0.170 in., core length is measured between subsequent passes with a tape to ensure that the plate cores are not rolled over-length. The core length can be readily measured in this manner since the core can be delineated from the wrought stainless steel by a difference in heat color.

Special care must be exercised during rolling to minimize cambering or "rainbowing" of the plates which tends to decrease the amount of stainless steel along the inactive edge in the final machined plate.

After cooling and prior to end trimming, the hot-rolled plates are numbered consecutively, starting with "1" for the first plate processed. Numbers one-half inch high are stamped on the inactive section at the stemless end of the plate. After the plates have been properly identified, they are sheared on a power driven shear to a total length of 34 in. The trailing end of the plate is sheared to within 1 1/2 in. of the core.

Title: - Pickling

Purpose: - This specification covers the pickling of stainless steel components to remove oxides and other surface contaminants or adherents that may interfere with subsequent processing, or that are detrimental to the final product. The following pickling solution is not to be used for pickling the composite plates after flatten annealing or brazing.

Process: - The work is pickled in an aqueous solution of 15 percent nitric acid and 5 percent hydrofluoric acid (15% HNO_3 , 5% HF) at one hundred thirty-five degrees Fahrenheit (135°F) until the surface is clean. After pickling, the work is immediately and thoroughly washed with water to remove all traces of acid. The time required for pickling will increase as the acid is depleted. Periodic checks of the acid concentration shall be made. Pickling of the fuel plates in any solution containing a halide ion, or reducing in nature, shall not be allowed subsequent to removal of the scale from the hot rolled plates.

Health Hazard:- This acid solution will attack the human body very rapidly; therefore, the pickling tanks should be well hooded and exhausted. Protective clothing, helmets and gloves are a prerequisite to entering the pickling area. Water showers and eye sprays are to be provided for rapid removal of any acid that may be accidentally splashed on the personnel.

Safety: - Some acid concentrations react violently; therefore, the mixing sequence will be to put the measured proportion of water required in the pickling tank and then slowly add the required amounts of acids while stirring the bath.

Equipment: - Acid resistant tanks. Carbon block or plastic lined tanks are recommended.

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- Title: - Flatten Annealing of Absorber Plates
- Purpose: - This specification covers annealing and flattening of the absorber plates to prevent warpage of the absorber plates during subsequent machining and shearing operations.
- Process: - Each sheared plate is covered on one side with a thin coat of a mixture containing one part by volume of Fisher 5F Precisionite levigated alumina or equivalent and ten parts of water. A 3 in. camel's hair brush, or spraying, is used to apply an even coating. The coated plates are allowed to dry for at least 15 minutes. The jig is composed of two platens for clamping the absorber plates together. Six absorber plates are stacked together, coated side adjacent to uncoated side. The stack is placed between the platens, and the clamping bolts are firmly tightened. The loaded assembly is dried in an oven at 330°F for a minimum of 4 hours. Annealing is accomplished in an atmosphere furnace at a temperature of 1832°F ± 25°F. An atmosphere of dry hydrogen with an inlet dewpoint of at least -60°F as measured by an Alnor Dewpointer or equivalent is used. A gas flow rate is used that is high enough to prevent oxidation during heating and to reduce oxide scale formed during the rolling operation.

Furnace temperature at insertion of the loaded platen assembly should not exceed 570°F. The muffle is purged with dry helium prior to insertion of the plates and during the period between 570°F and 1200°F. At 1200°F the helium atmosphere is replaced by dry hydrogen. A flow rate sufficient to bright anneal stainless steel is necessary. The temperature is increased to 1832°F at a rate of approximately 540°F per hour. The plates are held at 1832°F for two hours and then slowly furnace cooled to 570°F. At this temperature, the hydrogen atmosphere is replaced with a dry helium purge; the assembly removed from the furnace; and air cooled. After disassembly, the absorber plates are scrubbed under flowing water to remove the coating alumina, air dried, and inspected again for defects.

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- Title: - Absorber Plate Preliminary Machining
- Purpose: - This specification covers the preliminary machining of absorber plates.
- Process: - To assure a true plate reference edge for radiographically locating the absorber core, it is necessary to machine one edge of the plate. A stack of six plates is edge aligned on the bed of a milling machine. A series of skim cuts are made to a total depth of approximately 1/4 in. or until smooth uniform plate edges are obtained. The edges of the plates are filed to remove machining burrs.

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- Title: - Absorber Plate Radiography and Core Layout
- Purpose: - This specification covers the radiography and core layout necessary for subsequent shearing and machining operations.

Process: A. Radiography

Edge machined plates are radiographed to delineate the core in the composite plate for subsequent layout. The plates are positioned on cassettes containing a fine-grained film such as Eastman type "M" and exposed to an X-ray source positioned 54 in. above the cassette for 4 minutes. Without using lead filters and with an X-ray source power setting of 130 kv and 10 ma., suitable radiographs are obtained.

B. Marking of Plate for Shearing and Final Machining

Measurements at three locations along the core length are made and transposed to the plate to delineate the core on the plate surface. The measurements are taken with reference to the machined edge of the plate. After the position of the core is located, the resulting core width is subtracted from the required plate width and the difference is equally divided and marked at the three reference locations. These markings serve as the width boundaries during machining to final size. The location of the trailing end of the core is critical since a minimum of 1/4 in. of inactive stainless steel at this end is specified. The end is located from the radiograph and a mark is scribed 1/4 in. from the core end. From this scribe mark, the final plate length of 26-1/16 in. is measured to the opposite end of the plate and a mark is scribed.

After the machining reference lines are scribed, additional lines 1/8 in. outside of the machining lines are located at the ends and along both sides. These lines represent the sheared length and width dimensions. The identifying number is again stamped at the leading end of the plate in the nominal 5 in. length of inactive stainless steel within the machining line boundaries.

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- Title: - Absorber Plate Shearing
- Purpose: - This specification covers the shearing of absorber plates prior to final machining.
- Process: - To minimize the amount of wrought stock removal during machining, the plates are sheared to within 1/8 in. of the final machined dimensions. The plates are sheared on a power-driven shear suitable for 3/16 in. thick stainless steel. In shearing to width dimensions, the plates are positioned and clamped to the shear table with three bar-type clamps equally spaced along the plate length. Clamping is not required for shearing the plate ends.

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- Title: - Absorber Plate Core Alignment Inspection and Final Machining
- Purpose: - This specification covers final core alignment radiography and final machining.
- Process: - A. Inspection for Core Alignment

Prior to machining the absorber plate, the core alignment is checked. The 1/8 in. excess wrought stock provides ample room for re-alignment if required. The core alignment is inspected by radiographic examination. Radiographs are obtained in the same manner as employed prior to shearing.

B. Machining of Absorber Plates to Final Dimensions

Each plate is first machined to final width dimensions. The sheared absorber plate is placed on the table of a vertical milling machine. A 3/8 in. aluminum plate is positioned between the absorber plate and the table to elevate the absorber plate. Using a dial gauge indicator, the machining scribe marks are aligned with the traverse of the table and held in position by bar-type clamps at the plate ends. Three additional bar clamps are positioned and firmly locked along the plate length in such a manner as to permit machining along one side of the plate. After checking the plate alignment, the plate edge is machined to the scribed line. The three bar clamps are then removed without disturbing the plate and re-positioned on the opposite side of the plate. After rechecking the plate alignment, the remaining plate edge is machined to the scribed line. The width dimension is inspected with a micrometer. The end of the plate at which the minimum 1/4 in. inactive stainless steel end is specified is likewise individually machined to the scribed machining mark. This is accomplished after machining the second plate edge by leaving the plate locked in position and removing the appropriate end bar clamp. Six plates which have been machined at the critical end are stacked together, butted against an end plate and gang milled to final length.

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- Title: - Absorber Plate Final Inspection
- Purpose: - This specification covers the final radiographic, visual and dimensional inspection of absorber plates.
- Process: - Final Inspection of Plates: All absorber plates are inspected to ensure that they meet final dimensions. The over-all length, width and thickness measurements are made.

The finished machined plates are then radiographed to delineate the inactive stainless steel. Measurements are made from the radiographs to determine acceptance. Plates shall not have less than 0.080 in. or more than 0.125 in. inactive stainless steel at any point along the edges. Plates shall not have less than 3/16 in. at the end specifying a nominal 1/4 in. inactive stainless steel.

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Title: - Absorber Plate Inspection for Alpha Contamination

Purpose: - This specification covers the sampling and Alpha counting of cleaned absorber plates, prior to assembly, to determine the level of surface contamination.

Process: - The absorber plates will be subjected to an alpha count to determine if any possible surface contamination exists. The plate shall be checked for alpha contamination by means of gas flow proportional counting or a similar method. Alpha contamination equivalent to 0.5 micrograms of U-235 per square foot shall be the maximum allowable level of contamination. It is assumed that one microgram of U-235 per square foot is equivalent to 150 disintegrations per minute per square foot of plate surface.

The plate identity and amount of contamination will be recorded.

Calibration: - The alpha counting device shall be calibrated using a standard source previously calibrated by the National Bureau of Standards.

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- Title: - Assembly and Welding of Absorber Sections
- Purpose: - This specification covers the assembly and welding of absorber plates into absorber sections.
- Process: - Two absorber plates are joined into a right angle ell section by TIG welding. Two of the assembled ell sections are joined by TIG welding to form a rectangular parallelepiped with a square cross section. No filler metal is required.

Two graphite jigs are required for the assembly and welding of the absorber sections. The first jig, used to form the ells, is a rectangular block 2.307 in. square by 26 1/16 in. long. The longitudinal edges are beveled at a 95° angle to yield a 5/8 in. flat surface. The second jig is composed of two wedges, 29 in. long and 1.960 in. wide, tapering from 1.850 in. to 0.650 in. The two jigs are shown in Fig. 4, (AES 618).

Plate No. 1 serves as the base plate and is positioned on two 1 x 2 in. parallel bars equally spaced on a surface plate. The plate end opposite the identifying number is butted against an angle plate. The solid graphite block is positioned on plate No. 1 and is butted against the angle plate. The right side of the block should lie approximately 0.156 in. inside the edge of the base plate. This dimension is adjusted for the specific thickness of plate No. 2. Plate No. 2 is placed perpendicular to the surface plate with the edge butting the parallel bars and the inner surface butting the edge of plate No. 1. Care is taken to assure that the identifying number is opposite the end of the plate adjacent to the angle plate, and is on the outside of the assembly.

The assembly is rigidly clamped in both directions with "C" clamps. The end of the two plates with the 1/4 in. nominal inactive stainless steel is checked to be certain the ends butt against the angle plate.

The joint between plate No. 1 and No. 2 is TIG welded. Tack welds are first made at both ends and at the three inch intervals along the joints. The welds are made by the previously

qualified procedure. Three inch welds are made starting at the ends; further three inch welds are made, alternating from both ends, until the joint is completed. After cooling to room temperature the "C" clamps are removed. The preceeding assembly and welding operations are repeated for plates No. 3 and No. 4. Both ell sections may be made around the block simultaneously if desired.

One of the ell sections formed is placed on the parallel bars. The split wedge jig is fitted together on the ell section so that the vertical dimension, across the two wedges, is approximately 2.307 in. The second ell section is placed in the jig to form the box section. Care must be taken to insure that the 1/4 in. nominal inactive end of each ell section is at the same end. The assembly is clamped on the absorber center-line in the vertical direction with "C" clamps. The over-all external dimensions should be checked with a micrometer to assure that the external dimensions, as measured by the micrometer, and the internal dimensions, as indicated by the jig thickness, will produce an absorber dimensionally satisfactory. The split jig may be adjusted slightly as required to vary the internal and external dimensions.

Additional clamping may be done horizontally across the assembly at the top and bottom to insure a tight edge joint. The four corners are alternately tack welded, and tack welds are made at three inch intervals along the joint. Three inch welds are made on the two joints, starting from each end and alternately on the two joints. The joints are completely welded by repetition of this procedure, from ends to center and on both joints alternately.

While the welded absorber section is still warm, the clamps are released and the split-graphite block is removed by gently tapping the thin end of one of the wedges.

All welds are brushed and inspected for weld defects. The entire inner surface is scratch brushed with a long-handled stainless steel brush to remove graphite particles and surface oxide.

Figure 4. Absorber Section Assembly Jig (Dwg. AES-618)

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- Title: - Absorber Handle Attachment
- Purpose: - This specification covers attachment of the absorber handle pin.
- Process: - The handle pin hole is drilled in the absorber plates either before or after as welding into a box section. The end containing the identifying plate numbers is centered on a drill press table and a 0.378 inch ("V" letter drill) diameter hole is drilled through the two absorber plates. Absorber handle pin is machined to specifications and then is placed in the drilled hole with approximately a 1/16 in. recess on both absorber plate outer surfaces. The pin is attached by heliarc welding, using type 347 stainless steel filler rod.

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- Title: - Absorber Section Cleaning
- Purpose: - This specification covers cleaning of the absorber section.
- Process: - The assembled absorber section is cleaned to remove all excess weld metal and discoloration. Removal of the excess weld material and discoloration is accomplished by abrading the entire outer surfaces of the section with fine grained emery paper or a rotary stainless steel brush. The edges of the absorber are then rounded to a radius of approximately 1/32 in. by hand filing. Upon completion of the mechanical cleaning, the absorber is wiped with a cloth containing a small amount of acetone to remove the fine metal filings.

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- Title: - Absorber Section Numbering
- Purpose: - This specification covers the numbering of absorber sections.
- Process: - A number 1/2 in. in height is stamped on each plate on the end of the absorber which has the nominal 5 in. length of inactive stainless steel. The absorbers are numbered serially, starting with No. 1 and progressing to sequentially higher numbers and including a Fabricator's symbol.

The stamping of the absorber is done immediately before assembly of the absorber section. The location of this number is shown on the applicable drawing.

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- Title: - Absorber Section Final Inspection
- Purpose: - This specification covers final inspection of completed absorber sections.
- Process: - The absorber section is inspected visually for possible flaws such as pits, surface scratches, indentations, and improper welds in accordance with qualification requirements.

The cross-sectional width, length and squareness of each absorber is dimensionally inspected. The cross-sectional width of the absorber is measured with a 3 in. micrometer at five locations along the length. Two measurements, 90 degrees apart, are taken along the centerline of the section at distances of 1, 6, 13, 19 and 23 in. from the critical (pinless) end of the absorber. The measurements of each absorber are recorded on the inspection record shown in Fig. 5. Absorbers shall not have width dimensions outside the limits of 2.619 in. $\pm$ 0.010 in.

The absorber length, measured with a calibrated straight edge, must be within the required specification of 23 3/8 in. $\pm$ 1/16 in.

The absorber is checked for squareness on a surface plate. Any evidence of twist or other manifestation of out-of-squareness requires that the section be subjected to insertion through the final inspection box. This box is designed with internal dimensions of 2.650 x 2.650 in. and 26-1/16 in. long. Binding shall not be exhibited at any point during this test.

ABSORBER SECTION ASSEMBLY AND INSPECTION SHEET

INSPECTION DATA							
Cross-Sectional Width Measurements							
Width (A) (In.)				Width (B) (In.)			
Location	Top	Middle	Bottom	Location	Top	Middle	Bottom
1				1			
6				6			
13				13			
19				19			
25				25			

Average Width (A) _____ in. + _____ Average Width (B) _____ in. + _____

ASSEMBLY DATA	
Plate No.	Required Dimensions
1. _____	Cross-Sectional width
2. _____	Width (A) _____ in.
3. _____	Width (B) _____ in.
4. _____	Length _____ in.

TEST BOX INSPECTION

Acceptable	Slight Bind	Reject
Inspected By _____		
Remarks: _____		

Position	Length Inches	Visual Inspection			
		Defect	No	Yes	Reject
Edge		Discontinuous weld			
Center		Weld Cracking			
Edge		Excessive weld			
		Acceptable surface condition			
		Miscellaneous			

ABSORBER FABRICATION RECORD

Type Unit _____ Destination _____ Shipped _____ Identification Number _____

Figure 5. Absorber Section Assembly and Inspection Sheet

Title: - Inspection of Absorber Sections Selected for Post-Irradiation Examination

Purpose: - This specification covers the special inspection requirements of absorber sections that will be removed from the reactor for examination at the end of core life or any other time.

The inspection shall entail:

1. Absorber plate thickness
2. Absorber section width
3. Absorber section length

Process: - 1. Absorber Plate Thickness

The thickness of each absorber plate is measured at one inch (1 in.) intervals along the longitudinal centerline and along lines three-quarters of an inch ($3/4$ ") each side of centerline. The first reading of each traverse will be taken at one inch from unnumbered end of absorber plate. These measurements are made with a deep-throated micrometer and shall be reported to the nearest one-thousandth of an inch (0.001 in.).

- 2. Absorber Section Width

The absorber section width parallel and perpendicular to the handling pin is measured at one inch (1 in.) intervals along the centerline and along lines three-quarters of an inch ($3/4$ in.) each side of centerline. The first reading of each traverse will be taken one inch (1 in.) from the unnumbered or unpinned end. These readings will be made with a three inch (3 in.) micrometer and will be reported to the closest one-thousandth of an inch (0.001 in.).

- 3. Absorber Section Length

The over-all length of the absorber section along the longitudinal centerline of each absorber plate will be measured with a thirty-six inch (36 in.) vernier caliper. These measurements

will be reported to the nearest one-thousandth of an inch (0.001 in.).

General Provisions

The location of each absorber plate in the absorber section should be carefully noted as should the location of external measurements.

IV. DRAWINGS

<u>Part Name</u>	<u>Drawing Number</u>
Absorber Section Assembly	C9 - 13 - 1053
Absorber Plates	C9 - 13 - 2215
Pin (Absorber Section)	A9 - 13 - 2216

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DATE	LET.	REVISION RECORD	AUTH.	DR.	CHK.

PART NO. C9-13-1053

SM TYPE 3 CORE

3	1	A9-13-221G	PIN
2	2	C9-13-2215-2	ABSORBER PLATE
1	2	C9-13-2215-1	ABSORBER PLATE
PC NO	QW	DWG. NO. OR MATERIAL	DESCRIPTION

ALCO ALCO PRODUCTS, INC.
NUCLEAR POWER ENGINEERING DEPT.
SCHENECTADY, N. Y., U. S. A.

SCALE FULL	REV.	DR.	321-62
MATERIAL SPEC.	TR.	CHK.	67 3-23-62
	APPR.	3-23-62	
	APPR.		
	MET.	3-23-62	

NAME ABSORBER SECTION
ASSEMBLY
PART NO. C9-13-1053

BREAK SHARP EDGES
REMOVE ALL BURRS

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES.
TOLERANCES ON FINISHED
FRACTIONAL DIMENSIONS
TO BE ± .005

✓ FINISH AS INDICATED
IN MICROSECS.
① MACHINE FINISH - BRUSH
⑩ FLAME CUT OR SAW

ASSEMBLED SECTION MUST FIT WITHIN
A THEORETICAL STRAIGHT BOX OF THESE
DIMENSIONS 26 1/16 LONG WITHOUT INTERFERENCE.

DATE	LET.	REVISION RECORD	AUTH.	DR.	CHK.

PART NO. C9-13-2215

PART NO	HOLE
C9-13-2215-1	"V" (.377) DRILL
C9-13-2215-2	OMIT

SM TYPE 3 CORE

BREAK SHARP EDGES
REMOVE ALL BURRS

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON FINISHED
FRACTIONAL DIMENSIONS
TO BE $\pm \frac{.010}{16}$

✓ FINISH AS INDICATED
IN MICROINCHES
① MACHINE FINISH-ROUGH
⑩ FLAME CUT OR S.W

ALCO		ALCO PRODUCTS, INC. NUCLEAR POWER ENGINEERING DEPT. SCHENECTADY, N. Y., U. S. A.	
SCALE	FULL	DR.	3-21-62
MATERIAL SPEC.	C9-13-1053	TP.	3-21-62
SEE ABSORBER SPECIFICATION		CHK.	5-23-62
		APPR.	3/13/62
		APPR.	
		MET.	3/13/62
NAME		ABSORBER PLATES	
PART NO.		C9-13-2215	

PART NO.

A9-13-2216

DATE	LET.	REVISION RECORD	AUTH.	DR.	CHK.

SM TYPE 3 CORE

BREAK SHARP EDGES

125/ALL OVER

BREAK SHARP EDGES
REMOVE ALL BURRSUNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES.
TOLERANCES ON FINISHED
FRACTIONAL DIMENSIONS
TO BE $\pm \frac{1}{64}$ ✓ FINISH AS INDICATED
IN MICROINCHES.f₁ MACHINE FINISH - ROUGHf₁₀ FLAME CUT OR SAW

ALCO PRODUCTS, INC.

NUCLEAR POWER ENGINEERING DEPT.

SCHENECTADY, N. Y., U. S. A.

SCALE FULL	REF. C9-13-1053	DR.	J. J. J. 3-23-62
MATERIAL SPEC. SEE ABSORBER SPECIFICATION		TR.	
		CHK.	KJ 3-23-62
		APPR.	Secunda 3/23/62
		APPR.	
		MET.	E.C. Edgar 3-23-62

NAME
PIN ABSORBER ASS'Y

PART NO.

A9-13-2216