MASTER

325
8-4-64

FABRICATION OF BNL STANDARD COBALT-60 SOURCE

A. OLTMANN AND O.A. KUHLM

February 1964

BROOKHAVEN NATIONAL LABORATORY

ASSOCIATED UNIVERSITIES, INC.

under contract with the

UNITED STATES ATOMIC ENERGY COMMISSION

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

BNL 848 (T-334), February 1964
Fabrication of BNL Standard Cobalt-60 Source
A. Oltmann and O. A. Kuhl

ERRATA and AMENDMENTS

Page 2, Figure 2 - Delete scale

Page 3, Figure 4 - Should read,
Details of stainless steel parts, second encapsulation.

Page 4, Figure 6 - Should read,
Details of first encapsulation.

Page 10, Figure 22 - Delete scale

Page 4, Figure 6 - 12" Dimension should be $12\frac{1}{2}$ " before weld.

Page 15, par. 3.6 - Width should be .735 - .740 in.

Page 23, Fig.

should be

Last paragraph of section 7.9 should read:
A dot will be added on one end only to designate the
"A" end (see BNL inspection sheet). A line $1/32$ in. wide and
 $1/32$ in. deep will be added to the other end starting with the
B4 batch.

FABRICATION OF BNL STANDARD COBALT-60 SOURCE

A. OLTMANN AND O.A. KUHL

February 1964

**BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK**

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

PRINTED IN USA
PRICE 75 CENTS

Available from the
Office of Technical Services
Department of Commerce
Washington 25, D.C.

June 1964

900 copies

ABSTRACT

The BNL standard source is a cobalt-60 gamma irradiation source consisting of a strip of cobalt approximately 12 inches long which has been doubly encapsulated in stainless steel, once before activation and again after activation. In this report a description is given of the procedures and equipment used in the preparation and fabrication of these sources to meet the specifications of the Savannah River Plant (SRP).

FABRICATION OF BNL STANDARD COBALT-60 SOURCE

FIRST ENCAPSULATION

The design criteria for the first encapsulation of the BNL standard source (Figures 1 and 2) are listed in detail in the appendix, entitled "BNL Spec R155-W1." This specification not only describes the raw materials that must be used, but also details the cleaning and handling procedures that must be observed during fabrication. Physical sizes of the various components and inspection requirements are also given in great detail.

A development program was initiated at BNL, and at its conclusion a method of fabrication was evolved with which parts were produced that were acceptable to E.I. du Pont de Nemours and Co. for activation at SRP.

Fabrication Procedures and Equipment

Raw Materials. None of the materials used in the fabrication of the source and the outer can were available at the BNL Metals Warehouse. A description of the required material is given below, together with the sources of supply.

The cobalt strips were of 99.5% pure cobalt, made by a powder metallurgy process, rolled, slit, and ground to size as shown in Figure 3. Two sources of supply were used, namely, the Kulite Tungsten Corp. of Ridgely, N. J., and Sherritt-Gordon Mines, Ltd., of Canada. The stainless steel tubing was standard warehouse stock, redrawn to BNL tolerances and cut into the exact length required (see Figure 4). J. Bishop and Co. of Malverne, Pa., furnished this part.

The aluminum parts were made by Alcoa. The outer can was drawn from a 1245 alloy, the "D" bars were extruded from 6063 alloy, and the end caps were impact-extruded from 1245 sheet stock and then finish machined. This expensive method of fabrication was used to avoid the possibility of minute lengthwise cracks or "micropipes."

All the above suppliers submitted certified material analyses with their shipments. All parts were inspected by the BNL Quality Control Group. The cobalt received 100% inspection, as did the small stainless steel end pieces which were made by a local machine shop.

The stainless steel tubes and the aluminum end pieces received about 15% inspection. The aluminum tubing and extrusion, which came in 20-foot lengths, received a thorough sample inspection for drawing tolerances and 100% inspection for general finish and straightness.

Fabrication. The detail parts are machined to the dimensions shown in Figures 2 to 6, inspected for compliance with the drawing tolerances, and then cleaned as specified in the appendix.

The stainless steel tubes are flattened in three steps, as shown in Figures 7 to 10, with use of a hardened tool steel die and an internal strip to prevent bowing. No lubricants are used in these steps, and white cotton gloves are worn. These parts are again inspected and given a methanol bath with subsequent hot air drying. One end piece is then welded in place (see Figure 11). The press used for flattening the tubes, all cleaning equipment, and the final assembly bench are located in a "clean room" (Figure 12).

The cobalt strip is then inserted into the partially completed sheath, and the last end piece is put in place. Again white gloves are worn to prevent contamination of the parts. Both the cobalt and the stainless steel end pieces are given a methanol bath and a hot air drying before insertion. The final weld is then made, and the finished assemblies are leak-tested (Figures 13 to 15). The assemblies that pass the leak test are cleaned again and stored in plastic bags. Those that do not pass are taken apart, the cobalt strip is cleaned for reuse, and the rest of the assembly is thrown away. Experience with "leakers" has been very good; rejects average about 1%. The next operation is to clean all the aluminum parts as described in the appendix. The end caps are then numbered in accordance with the numbering system described in section 7 of the appendix. One end cap is welded to the externally chamfered end of the aluminum tube.

The aluminum "D" bars have been separated into 3 or 4 piles according to thickness. The encapsulated cobalt strips are given a final flattening to remove all springback, thicknesses are measured, all strips are weighed, and an average weight

Figure 1. BNL standard source.

Figure 3. First encapsulation.

Figure 2. Exploded view of slug.

Figure 4. Details of stainless steel parts, first encapsulation.

Figure 5. Details of aluminum parts, first encapsulation.

Figure 6. Details of second encapsulation.

Figure 7. Sheath before flattening.

Figure 8. Sheath flattening, first stage.

Figure 9. Sheath flattening, second stage.

Figure 10. Sheath flattening, final stage.

Figure 11. Stainless steel welding jig.

Figure 12. "Clean room."

Figure 13. Leak-testing equipment.

Figure 14. Leak-testing of encapsulated cobalt strips.

Figure 15. Close-up of test specimen.

Figure 16. Die-sizing equipment.

Figure 17. Detail of sizing die.

Figure 18. BNL tube gauge.

TO:

DATE:

FROM:

BNL COBALT SLUG, METALLURGICAL EXAMINATION

SLUG NO.:

MEASUREMENT POSITION:

GAP MEASUREMENT, MILS:

LOCATION:	POSITION						AVERAGE
	A		B		C		
	EDGE	CENTER	EDGE	CENTER	EDGE	CENTER	
1 Al-Al							
2 Al-S							
3 S-Co							
4 Co-S							
5 S-S							
6 S-Co							
TOTALS*							
7 Co-S							
8 S-S							
9 S-Co							
10 Co-S							
11 S-Al							
12 Al-Al							
TOTALS*							

*SPECIFICATION: 3 MILS (2 MILS MAXIMUM, INDIVIDUAL).

ALUMINUM: WELD AND CLADDING THICKNESS, MILS

MEASUREMENT	A CAP	A	B	C	C CAP
THROAT, MIN.		X	X	X	
PENETRATION, MIN.		X	X	X	
CLADDING, MIN.					
CLADDING, MAX.					

Figure 20. SRP final inspection sheet.

Figure 22. Typical cross section of slug. (6X.)

Figure 21. Sectioned slug.

weighed and the diameters are measured in two planes at the three places where SRP will cut and prepare the test sections. This information is recorded for all slugs on the form shown in Figure 19. The slugs are then cleaned with steel wool and hot water, and, after they have dried, are wrapped in a paper towel and inserted into a cardboard tube to protect them during shipping.

Upon arrival at SRP all the slugs are again leak-tested and checked for outside dimensions and other items described in the appendix. A number of the slugs are then sectioned (Figures 21 and 22); the sections are polished and examined under a microscope, and the end welds are checked in a comparator. The information is entered on the appropriate form (Figure 20). Evaluation of the slugs is based on the requirements given in section 7 of the appendix.

Equipment and Tooling. Besides the run-of-the-mill machine shop equipment, such as lathes, milling machines, an arbor press, and a buffing wheel, the only major pieces of equipment used are the following:

1. Hannifin 75-ton hydraulic press (Figure 12).
2. Tempco 25-ton hydraulic press with 18-in. stroke (Figure 16).
3. Tube gauge made by BNL (Figure 18).
4. Leak-test apparatus made by BNL (Figures 13 and 14).

SECOND ENCAPSULATION

Upon completion of reactor irradiation at SRP, the slug (Figure 2) will be shipped to BNL in a 7-ton shipping cask (Figure 23). The aluminum can will be stripped from the four stainless steel encap-

Figure 23. Shipping cask.

Figure 24. Interior of preparation cell in BNL High Intensity Radiation Development Laboratory.

ulated cobalt sources by remote manipulation in the preparation cell (Figure 24) at the BNL High Intensity Radiation Development Laboratory. Each strip will be monitored to determine its total activity and activity distribution. It will then be inserted into a stainless steel envelope or jacket (Figure 6), one end of which has been previously

Figure 25. Operating the remote welder in the preparation cell.

welded and leak-tested, and the open end will be welded by using a remotely operated welding machine (Figure 25).

After the integrity of the weld has been tested and found satisfactory, the source element will be ready for use.

The first batch of slugs is now being irradiated at SRP and will be shipped to BNL in March 1964.

APPENDIX

BROOKHAVEN NATIONAL LABORATORY
Nuclear Engineering Department
Engineering Division

Spec R155-W1
High Intensity Radiation
Development Laboratory
June 28, 1962
Amended Aug. 29, 1962
Amended Oct. 17, 1963

PROCEDURE FOR COBALT ENCAPSULATION

1. DESCRIPTION

The cobalt encapsulation is a double encapsulation. It consists of 4 cobalt strips, 0.060 inch thick by 0.640 inch wide by 12 inches long, which are inserted into seamless stainless steel sheaths, flattened to form a tight fit. The sheaths are welded on both ends to form the first encapsulation.

A stack of 4 cobalt strips is inserted between 2 D-bars of 6063 aluminum alloy. The above assembly is pressed into a tube of 1245 aluminum, one end is welded, the whole assembly is die-sized, the open end trimmed and another end cap of 1245 aluminum sheet is welded in place. Leak tests are performed both on the stainless steel encapsulation and the final encapsulation. Welding of both stages will be done by a qualified welder using the inert gas tungsten arc method. No filler rod is used in the welding operations.

All materials will be cleaned and inspected thoroughly after each series of operations to maintain high quality throughout.

2. COMPONENT ALLOYS

2.1 Cobalt: Reactor grade, minimum purity 99.5%, strips rolled and ground to size.

2.2 Stainless Steel: Type 321 for sheath, Type 304 for filler piece.

2.3 Aluminum: 6063-T6 for D-bars.

2.4 Aluminum: 1245 or C-64 for can (extrusion).

2.5 Aluminum: 1245 or C-64 sheet for end caps.

COBALT CHEMICAL COMPOSITION

*Co	99.97%
Ni	.37%
Cu	.005%
S	.001%
Fe	.0018%
C	.012%

*Includes Ni.

1245 ALUMINUM CHEMICAL COMPOSITION

Aluminum	99.45 - 99.60% minimum
Copper	0.01% maximum
Iron plus Silicon	0.55% maximum
Iron	2 x Si minimum
Boron	0.001% maximum
Cadmium	0.003% maximum
Manganese	0.03% maximum
Zinc	0.03% maximum
Titanium	0.03% maximum
Lithium	0.008% maximum
Tin	0.01% maximum
Lead	0.01% maximum
Bismuth	0.01% maximum
Chromium	0.03% maximum
Nickel	0.01% maximum
Magnesium	0.01% maximum

TYPE 321 STAINLESS STEEL COMPOSITION

Carbon	0.08% maximum
Manganese	2.00% maximum
Phosphorous	0.04% maximum
Sulfur	0.03% maximum
Silicon	1.00% maximum
Chromium	17.00 to 19.00%
Nickel	8.00 to 11.00%
Titanium	0.40% minimum
Copper	0.15% (see note)
Molybdenum	0.22% (see note)

Note: Actual % of first and second batch.

June 28, 1962
Amended Oct. 17, 1963

3. COMPONENT DIMENSIONS AND/OR TOLERANCES

3.1 Aluminum Can

O.D. (before die-sizing)	0.962" $\pm$.002
I.D.	0.834" $\pm$.002
Length	13 inches $\pm$ 1/32
Can Wall (after die-sizing)	0.050" $\pm$.005

3.2 Aluminum End Cap

O.D.	.834" $\pm$ 0.001
Thickness	.203 $\pm$ 0.003

3.3 D-Bar

Length	12.656" $\pm$.005
Width	0.625" $\pm$.005
Thickness	0.220" $\pm$.005
Surface	approximately 60 RMS

3.4 Stainless Steel Sheath

Thickness	0.015 minimum
-----------	---------------

3.5 Cobalt Strip

Thickness	0.060" $\pm$.001
Width	0.640" $\pm$.002
Length	12 inches $\pm$.010
Straightness	
- on flat	0.005 maximum
- on edge	0.002 maximum

3.6 Sheathed Cobalt Strips

Length	12 9/16" $\pm$ 1/32
Width	0.760" $\pm$.005
Thickness	0.092" $\pm$.002
(Thickness not to vary more than .0005 from one end to the other.)	
Straightness	
- on flat	0.005 maximum
- on edge	0.005 maximum end to end
Weld	a) No pin holes or porosity.
	b) No weld overhang.

June 28, 1962

Amended Oct. 17, 1963

Surface

- a) Approximately 20 RMS.
- b) No burrs. Dents and gouges not to exceed 0.005.

Ends

All end corners to be rounded,
1/32 radius minimum.

3.7 Finished Slug Dimensions

Length

Up to 13 1/16" $\pm$ 1/32
tolerance.

O.D.

0.940 $\pm$.004
and as noted below.

Weld Overhang

0.002" Maximum on radius

Weld Height

Not to exceed boss on cap.

Straightness

Must pass through a full
length 0.949 3 point contact gauge.

Surface

No dents, gouges or scratches
exceeding 1) .010" on cylindrical
surfaces or .005" on weld bead,
2) .020" on caps.

June 28, 1962

4. CLEANING PROCEDURES

4.1 Cobalt

- a. Vythene vapor degrease.
- b. Hot water rinse (170-195° F.).
- c. Methanol dehydration.
- d. Hot air drying (approximately 250° F.).

4.2 Aluminum

- a. Vythene vapor degrease.
- b. Cold water rinse.
- c. Phosphoric acid etch (18-22%, room temperature).
- d. Cold water rinse.
- e. Hot water rinse (170-195° F.).
- f. Methanol dehydration.
- g. Hot air drying (approximately 250° F.).

4.3 Stainless Steel

- a. Vythene vapor degrease.
- b. Cold water rinse.
- c. Methanol dehydration.
- d. Hot air drying (approximately 250° F.).

Note: All parts to be handled with clean, white gloves after cleaning. Store in closed containers if not used immediately.

June 28, 1962

Amended Oct. 17, 1963

DESCRIPTION OF COBALT ENCAPSULATION

5. FIRST STAGE ENCAPSULATION - STAINLESS STEEL

5.1 All parts to be inspected for dimensions and quality before cleaning.

5.2 Clean as described previously.

5.3 Inspect for cleanliness using white gloves.

5.4 Fabrication of Source

This operation must be performed with gloves and/or tongs as noted below, all equipment and dies to be free of oil.

- a. Wearing gloves, put clean tube into flat portion of pressing die and flatten to a predetermined height (approximately 1/8"). Then move flattened tube over to portion of die containing the final forming slot, insert clean stainless steel internal sizing strip and press, using approximately 20 tons of pressure.
- b. Return flattened sheath to methanol bath and air drier.
- c. Wearing gloves, inspect for scratches, imperfections and cleanliness.
- d. Wearing gloves, insert clean cobalt strip and the two stainless steel end pieces. Keep end pieces flush with ends of tube. Put into clean copper welding jig and weld without using filler rod.
- e. Inspect for weld overhang and sound welds.
- f. Leak test, using kerosene bubble test at 28" Hg vacuum.
- g. Repeat cleaning cycle and store in plastic bag, laying flat in suitable container.
- h. Just before final assembly into outer can, flatten again in hydraulic press to remove all springback.

June 28, 1962

Amended Oct. 17, 1963

5.5 Welding Data (Stainless)

Welding Polarity	DC SP
Welding Current	50-70 Amp
Position	Horizontal
Electrode	1/16 diameter thoriated tungsten (pointed)
Torch	HW20
Cup Size	#5
Argon Flow	10 CFH
Number of Passes	1

June 28, 1962

Amended Oct. 17, 1963

6. SECOND STAGE ENCAPSULATION - ALUMINUM

6.1 All parts to be inspected for dimensions and quality before cleaning.

6.2 Clean as described previously.

6.3 Inspect for cleanliness using white gloves.

6.4 Insertion of first stage into aluminum using gloves and clean parts only assemble the slug as follows:

- a. Weld numbered end cap on tapered end of aluminum tube.
- b. Bell-mouth other end on inside to a maximum inside diameter of .840 tapering down to .834 within 5/8". Remove burrs from edge of tube.
- c. Repeat methanol and air drying cycle.
- d. Insert 4 cobalt sources and 2 aluminum "D" bars into aluminum tube. Locate "D" bars in same plane as numbers on end cap. (See paragraph 7.10 for illustration.) Total thickness of sandwich to be .835-.838.
- e. Insert internal sizing rod into open end. Coat slug with Door-Ease stick and push assembly through external sizing die.
- f. Remove excess lubricant before pulling out sizing rod.
- g. Dip open end into methanol with closed end up and air dry.
- h. Insert clean end cap with mating number and same orientation.
- i. Cut off flash of sizing operation level with cap without using lubricant (approximately 5/8").
- j. Wipe this end clean with methanol and make final weld.
- k. Leak test using kerosene bubble test at 28" Hg vacuum. Inspect for final dimensions and quality using paragraph 7.0.

June 28, 1962

Amended Oct. 17, 1963

- l. Repeat vapor degrease and cold water rinse.
- m. Wrap in paper towel and insert into cardboard tube.

6.5 Welding Data (Aluminum)

Welding Polarity	A.C. High Frequency
Welding Current	55-65 Amps
Position	Horizontal, Semiautomatic
Electrode	.040" diameter Zirtung (ball pointed)
Cup Size	#6
Torch	HW20
Argon Flow	14 CFH
Helium Flow	25 CFH
Arc Length	1/16"
Number of Passes	1 1/4

June 28, 1962

Amended Oct. 17, 1963

7. INSPECTION CRITERIA FOR COBALT SLUGS

7.1 Each slug must have an O.D. of 0.940" $\pm$:⁰⁰⁴₀₀₂ across the solid portion.

7.2 Each slug must pass through a full length 0.949" I.D., 3 points of contact, tube gauge or it will be rejected.

7.3 Each slug must be leak tight as determined by a kerosene bubble test operated at 28" Hg vacuum or it will be rejected.

7.4 Ten per cent of the slugs received at SRP will be destructively examined by sectioning the slug at approximately 2.5, 6.5 and 10.5 inches from one end. A surface will be polished and the diametrical gap, perpendicular to the flat face of the cobalt strip, will be measured with a standard Tukon hardness tester microscope. If the total radial gap across a section exceeds .003", then the entire batch will be rejected. In determining the total diametrical gap, the three center gaps are to be excluded from consideration since these do not affect heat transfer. If any one gap measurement exceeds 0.002", the entire batch will be rejected. Measurements to be averaged from edge to center.

7.5 The outside of the aluminum can on each slug must be free of dents, scratches or gouges greater than 0.010" on lateral surfaces, greater than 0.020" on the end caps, and greater than 0.005" on the weld bead or the slug will be rejected.

7.6 Throat thickness of the stainless steel and aluminum welds must be greater than 0.010", as determined by destructive examination of sample slug, or the entire lot will be rejected.

7.7 The height of the aluminum weld must not exceed the height of the boss or the slug will be rejected.

7.8 Each sectioned part of each slug destructively tested will be examined for foreign material and if detected will be sufficient cause for the rejection of the entire lot.

7.9 Each slug must be identified on both ends by source and serial number. For example, BNL slugs should be identified by a "B". Production lot numbers to be located alongside of "B". Serial numbers should be placed immediately below the "B". Letters and numerals to be 1/8" high and approximately 1/32" deep.

Serial numbers of slugs submitted to SRP prior to process approval should be numbered beginning with the numeral 1

June 28, 1962

and numbered consecutively. After process approval is granted, slugs should be numbered beginning with 100. Each separate production lot should be numbered beginning with the next higher one-hundred series. For example, the number 1-10 would indicate the tenth slug of the first lot, and 2-10 would designate the tenth slug of the second lot.

A dot will be added on one end only to designate the "A" end (see BNL inspection sheet).

7.10 The location of the numbers also indicates the location of the "D" bars within the outer tube. This information will be required when sources are to be decanned.