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WANL-TME-489

AUGUST 21, 1963

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**RECLAMATION OF
BERYLLIUM SCRAP**

(Title Unclassified)

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September 4, 1963

Mr. R. W. Schroeder
NASA - Lewis Research Center
Space Nuclear Propulsion Office
21000 Brookpark Road
Cleveland 35, Ohio

Attention: Mr. J. Lombardo

Subject: WANL-TME-489
Reclamation of Beryllium Scrap

Gentlemen:

The attached subject report presents the results of an investigation of the technological and economical feasibility of using AEC owned beryllium scrap as source material for NERVA requirements. A description of the amount and type of scrap in question is presented along with a discussion of methods of reclaiming beryllium scrap. In addition, estimates of potential cost savings that might be realized through utilization of scrap is included.

Very truly yours,

H. F. Faught
Program Manager
NERVA Nuclear Sub System

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BERYLLIUM SCRAP RECLAMATION

D. L. Harrod

August 22, 1963

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INTRODUCTION

This report presents the results of an investigation of the technological and economical feasibility of using AEC owned beryllium scrap as source material for NERVA requirements.

Due to the high cost of beryllium it is the customary practice of producers, fabricators, and users alike to collect beryllium scrap, usually machine chips, and to return the scrap to the metal production process. In fact, most of the structural grades of beryllium produced today contain a high percentage of recycled scrap. The word scrap, when used in connection with beryllium, should not carry any junk-yard type connotation; most of the beryllium scrap used today is generated in-house by the beryllium producers themselves, and is of very high quality.

The primary impetus for considering reclamation of the AEC owned beryllium scrap is the possible money savings that might be realized. Aside from a possible direct reduction in cost of reflectors, utilization of the scrap would relieve the government of the financial burden of storing the AEC scrap, a stockpile which might easily double in size due to NERVA requirements alone. It is mandatory, however, that the reclamation be effected in a manner that will not degrade the quality of the ensuing product with respect to chemical, physical and mechanical properties.

The question of reusing beryllium reflectors inevitably arises in any discussion of reclamation of the AEC owned scrap. However, the reuse potential of beryllium reflectors, that is, the possibility of using a given reflector over and over again in subsequent reactors, is a separate problem and is only indirectly related to reclamation of the scrap. Thus, any decision to reuse or not to reuse reflectors should be made independently of any consideration of the AEC scrap. Likewise, any decision to reclaim or not to reclaim the scrap should be made independently of any consideration of reuse of reflectors. The only real link between these two problems arises in connection with the decision as to the chemistry desired in powder produced through reclamation of the scrap. The reuse question is presently being analyzed by a committee at WANL and this report makes no attempt to anticipate the findings of that committee. Rather, reference to reuse of reflectors is made only when necessary for purposes of clarification.

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SUMMARY

An investigation has been conducted to establish the technological and economical feasibility of using AEC owned beryllium scrap as source material for NERVA beryllium requirements. It has been established that reclamation is technically feasible and that it will be necessary to exert only a few minor controls on the reclamation process in order to insure maximum integrity of the finished product. There are indications that substantial money savings might be realized via reclamation of the scrap; however, the actual savings that might be realized can be ascertained only by requesting bids on specific proposals.

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THE AEC OWNED SCRAP

The AEC owns about 67,000 pounds of beryllium scrap which is located at the Y-12 Plant in Oak Ridge, Tennessee. An inventory in June, 1963 showed the scrap to consist of the following:

- (1) 1,400 lb. of Virgin Ingots: These are virgin ingots weighing about 65 pounds each. These ingots were bought from Brush at a price of about \$49 per pound.
- (2) 28,000 lb. of Clean Chips: These are dry machine chips that were generated in machining operations that did not employ cutting fluids.
- (3) 17,000 lb. of Wet, Oily, or Dirty Chips: Some of these chips or shavings are real fine, while some are about $1/64" \times 1/4" \times 1/2"$.
- (4) 8,000 lb. of Dirty, Unblendable Powder: This powder is mostly minus 200 mesh size, but there are some chips in it. A large part of this powder came from floor sweepings.
- (5) 12,000 lb. of Solid Scrap: This scrap consists of various size pieces - rectangular and round bars, tubing, rings, and various odd shapes. Most of the pieces are small but a few pieces may weigh as much as 100 pounds. Some of these pieces may be broken, rejected, or obsolete parts and may have to be cut up in order to destroy their classified shape.
- (6) 122 lb. of Real Clean Powder
- (7) 520 lb. of Real Dirty Powder

Table I summarizes the amount and type of scrap located at the Y-12 Plant.

The scrap, per se, is not classified but it is located in a highly classified area. It is sorted reasonably well, but, in general, no particular background history on it is known. Most of it originated at the Y-12 Plant but some of it came from other sources. Up until about 1961 the Y-12 Plant served as a common storage facility for AEC owned beryllium scrap.

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TABLE 1 - The Y12 Scrap

<u>Weight lb.</u>	<u>Description</u>
1,400	Virgin Ingots
28,000	Clean, Dry Machine Chips
17,000	Wet, Oily, or Dirty Chips
8,000	Dirty, Unblendable Powder
12,000	Solid Scrap
122	Real Clean Powder
520	Real Dirty Powder
<hr/>	
67,042	TOTAL AMOUNT OF SCRAP AT Y-12 (June, 1963 Inventory)

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TECHNICAL CONSIDERATIONS

A. Methods of Reclaiming Scrap

It is generally recognized that the properties of powder products depend not only upon composition but also upon the size, shape, and size distribution of the powder particles employed in making the product. It is important, therefore, to know the physical nature as well as the chemistry of powder produced through the reclamation of scrap. In connection with this, then, it is necessary to know where scrap enters the metal production process.

Figures 1 and 2 present flow charts which show the metal production processes employed by the various beryllium producers. The point at which scrap is returned to the process depends upon the nature of the scrap, i.e., its chemistry, type and degree of contamination, and physical form. It also depends upon the chemistry desired in the finished powder.

As an illustration of current practices, Brush produces three structural grades of hot pressed block as shown by the specifications in Appendix I. The S-100-C Grade is produced from nearly all virgin powder, i.e., from ore. The S-200-C Grade is produced from a blend of recycled scrap and virgin powder, about 60% recycle and 40% virgin powder. Whereas, the S-300-C Grade is produced from nearly all recycled scrap.

The highest purity grade of beryllium available on a commercial basis is produced by the electrolytic process. (Throughout this report, electrolytically refined beryllium is meant when reference is made to high purity.) Typical of this grade is General Astrometals CR-N Grade as shown in Appendix I. When this grade is called for, the chemistry requirements are so stringent as to preclude the blending of powders; hence, scrap would have to be returned to the electrolytic stage of processing. The resulting powder would be chemically and physically indistinguishable from powder produced from ore.

In producing powder of the composition called for in WANL PD Specification 30018 (which is equivalent to Brush's S-200-C Grade) it is customary to blend virgin powder of relatively high purity with recycle powder of relatively low purity so as to yield a blend having the average composition required. Note that S-200-C is obtained from a blend of S-100-C and S-300-C. For this grade, then, scrap might be returned to the process at various points. Dirty or contaminated scrap would have to be returned to the chemical or electrolytic states of the process and the resulting powder would be physically and chemically the same as virgin powder. If scrap

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BERYLLIUM METAL FLOW CHART
THERMAL REDUCTION PROCESS

FIGURE 1

BERYLLIUM METAL FLOW CHART
ELECTROLYTIC PROCESS

FIGURE 2

is returned to the vacuum melting stage (or at any earlier stage) then the physical characteristics of the resulting powder would be the same as for virgin powder. Some scrap might be returned directly to the attritioning mills and, again, the resulting powder would have the same physical characteristics as virgin powder. And, lastly, clean powder scrap might even be returned directly to the blenders.

In the latter cases, where scrap is returned to the attritioning, or blending, and perhaps the melting stages, it would be necessary to rely upon non-destructive tests to insure that the resulting components are free of foreign matter, e.g., a broken drill bit.

In terms of the Y-12 scrap, two cases are distinguished depending upon the chemistry desired in the final product:

(A) To obtain high purity (so called low scandium) powder, the electrolytic process should be employed. The scrap would have to be returned to the electrolytic stages of the process and the resulting powder would be equivalent, chemically and physically, to virgin powder. No special controls would have to be exercised to insure standard quality in the final product.

(B) To obtain commercially pure beryllium equivalent to the grade called for in WANL PD Specification 30018, the following considerations apply:

- (a) The Virgin Ingots might be returned directly to the attritioning mills.
- (b) The Clean, Dry Machine Chips might be returned to the attritioning mills. The chips would first be submitted to a cleaning process to remove any foreign matter; however, it would be necessary to rely upon non-destructive tests to insure that the resulting powder is, in fact, free of foreign matter.
- (c) The solid scrap, in general, would have to be returned to the process at least as far back as the vacuum melting stage in order to render it suitable for attritioning.
- (d) The Real Clean Powder might be returned directly to the blenders.
- (e) The Wet, Oily, or Dirty Chips, the Dirty, Unblendable Powders, and the Real Dirty Powder would have to be returned to the chemical or electrolytic stage of processing.

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The above considerations are lenient in that they allow for the return of the scrap at the latest possible stages of the metal producing process. A closer evaluation of the scrap might indicate that all of it, save perhaps for the Virgin Ingots, should be returned to the chemical or electrolytic stages of processing.

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B. Previous Reclamation of the Y-12 Scrap

Various vendors at various times have reprocessed some of the Y12 scrap. In one agreement, Brush received a total of 19,400 pounds of scrap and returned 19,000 pounds of spec grade powder (S-200-C Grade) at a fixed price. However, Brush did not use the scrap in supplying the 19,000 pounds of powder. Brush personnel claim that later when they did recycle the scrap they experienced difficulty. They found excessive radiographic indications in the form of puff balls and striations when hot pressed block containing the recycled scrap was radiographed. However, it is not clear that Brush can support this experience with facts. Y12 personnel claim that Brush had trouble meeting their spec, namely, the BeO content. But if Brush did not use the scrap in supplying the powder then their failure to meet the spec had nothing to do with the reclamation of the scrap.

Both General Astrometals and Ber Met electrolytically reprocessed some of the Y-12 scrap in a batch process in order to demonstrate that the scrap could be reclaimed to yield a high purity (so called low Sc) grade of powder. Subsequent to this, Y-12 sent out requests for bids on the conversion of 6,000 pounds of scrap to a high purity (low Sc) spec. General Astrometals, Ber Met, Brush and Berylco all quoted the job but Brush and Berylco wanted relief on a number of elements. The contract was never let.

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ECONOMIC CONDITIONS

A. NERVA Beryllium Requirements

Thus far, four beryllium reflectors have been purchased for NERVA reactors, these being for the NRX-A 1, 2, 3, and 4 test reactors. It is anticipated that an additional ten reflectors will be procured from the third quarter of FY-64 through the fourth quarter of FY-65. Table II lists the approximate weights of beryllium components in an NRX-A type reflector. From this Table it is noted that a finished machined reflector weighs about 2,000 pounds and that about 4,000 pounds of raw material in the form of hot pressed block is required to yield the finished parts.

For a conversion yield of 75%, the Y-12 scrap will yield about (67,000 lb. $\times$ 75% =) 50,000 pounds of powder. This amount of powder will provide the raw material for about (50,000/4,000 =) 12 reflectors and will generate about 25,000 pounds of scrap in the process.

B. Estimating Cost Savings

Without soliciting specific bids it is not possible to give even a rough estimate of the actual money savings that might be realized by reclaiming the AEC owned scrap. The following considerations, however, indicate that a potential savings does exist.

Beryllium scrap has a market value ranging from about \$8 to \$18 per pound, depending upon the nature of the scrap. Brush's published price list on scrap is shown in Appendix II. Y-12 has been offered about \$10 per pound for the scrap, but have not been willing to sell for this price. Y-12's book value for the scrap is \$24 per pound; however, this value is presently being re-evaluated and may be changed.

Beryllium powder equivalent to WANL PD Specification 30018 Grade sells for about \$59 per pound. A published price list on powder is shown in Appendix III.

It was previously mentioned that various vendors have either reprocessed or quoted to reprocess some of the Y-12 scrap. The conversion costs, either contractual or quoted, have ranged from about \$20 to \$45 per pound, depending upon the chemical and physical properties desired in the finished powder. For present purposes it is assumed that conversion costs \$25 per pound for PDS 30018 Grade beryllium.

TABLE II
APPROXIMATE WEIGHTS OF BERYLLIUM COMPONENTS
(Pounds)

	Number Per Reflector	Raw Material Per	Pre-Machined Part Per	Finish Machined Part Per
		Blank Reflector	Piece Reflector	Piece Reflector
Sector	12	300 3600	145 1740	121 1452
Control Drum	12	50 600	40 480	37 444
Shim Rod	168	1.5 252	.7 117	.7 117
Reflector	1	4452 lb.	2337 lb.	2013 lb.

Raw Materials Blanks

Pre-Machined Parts

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From the above figures, namely, scrap is worth \$10/lb., powder costs \$59/lb., and conversion costs \$25/lb., and assuming that conversion is 75% efficient, the following conclusions might be reached:

- (a) The scrap (sold on the open market) is worth $(10 \times 67,000 =)$ \$670,000.
- (b) Conversion would yield about $(67,000 \times 75\% =)$ 50,000 lb. of powder at a cost of about $(50,000 \times 25 =)$ \$1,250,000.
- (c) 50,000 lb. of powder (purchased outright) would cost $(59 \times 50,000 =)$ \$2,950,000.

Thus, as scrap, the scrap is worth about \$670,000 or \$10 per pound. As powder, the scrap appears to be worth about \$1,700,000, i.e., $(c) - (b)$, or about $(1,700,000/50,000 =)$ \$34 per pound. It should be borne in mind that these figures merely serve to indicate that a potential dollar savings does exist.

C. Negotiating Reclamation of the Scrap

There are a number of ways in which negotiations could be conducted so as to utilize the scrap and the following lists some of these ways:

- (i) The simplest way would be for the AEC to place the scrap on the open market and sell it to the highest bidder. This procedure should be followed unless it can be demonstrated that reclamation will yield a higher dollar per pound return on the scrap.
- (ii) Either WANL or the AEC could supply the vendor x-pounds of scrap and in return receive either hot pressed block or rough-machined parts at a fixed price. The scrap generated during machining operations would have to be accounted for.
- (iii) Either WANL or the AEC could supply the vendor x-pounds of scrap and in return receive y-pounds of spec grade powder at a fixed price. Further negotiations would then be necessary in order to get the powder fabricated into component parts.

It should be noted that at the present time there are some serious unresolved problems, and these problems will no doubt place limitations on negotiation of scrap reclamation. In particular, Brush is the only vendor that has demonstrated their in-house capability for making hot pressings large enough to meet reflector sector and control drum requirements, and so far

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the other vendors have not been able to demonstrate that they can successfully subcontract fabrication to outside firms. If this situation persists, then procurement plan (ii) above could be negotiated only with Brush. Procurement plan (iii) above could be negotiated with all four of the major vendors through the powder stage, but fabrication of the powder would still be limited to negotiations with Brush.

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PURITY CONSIDERATIONS

It is commonly assumed that reference to high purity beryllium is intimately related to a consideration of the reuse potential of reflectors. This need not necessarily be so, however, and it is the purpose of this section to clarify this point.

Should an effort be made to reuse reflectors then, indeed, it would be necessary to use the highest purity grade of beryllium available in such reflectors. If it is assumed that reflectors will not be reused, it is then generally inferred that there would be no need to pay a premium for the high purity grade when the PDS 30018 grade is quite adequate for non-reusable reflectors. However, there are advantages to be derived from the use of high purity beryllium even if reuse of reflectors is not contemplated. With the information presently available it is not possible to adequately evaluate the significance of these potential advantages but they will be listed for future reference; they are:

- (1) Accessibility: Should it be necessary to gain access to a reflector after a hot test, e.g., for post-mortem evaluation, then the high purity grade would be advantageous.
- (2) Disposition of Spent Reflectors: Since the post-irradiation activity that will be coming from PDS 30018 grade beryllium is expected to be too high to permit reuse of reflector, it is reasonable to assume that this activity level will be high enough to require special facilities for storing or disposing of spent reflectors. Should this be the case, the use of high purity beryllium might eliminate this problem and hence offset the premium paid for the material.
- (3) Reclamation of Spent Reflectors: Spent reflectors will eventually become scrap. The use of high purity beryllium will offer advantages of (a) yielding a very high grade of scrap, and (b) permitting utilization of spent reflectors as scrap much sooner than would PDS 30018 grade beryllium.

It is to be noted that with respect to mechanical and physical properties, the differences that exist between the PDS 30018 grade and the high purity grade are of no consequence. The only important difference between these two grades of beryllium derives from induced radioactivity subsequent to the exposure of the beryllium to an irradiation field. This post-irradiation activity in turn is a function of the type and amount of impurities present in the beryllium.

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CONCLUSIONS AND RECOMMENDATIONS

As a result of this investigation the following conclusions and recommendations are made:

- 1) There are no a priori objections against reclamation of the AEC owned beryllium scrap. However, it will be necessary to exert some control on the reclamation process so as to insure maximum integrity of the finished product. Thus, in each reclamation proposal it will be necessary to know just how the vendor intends to reprocess the scrap. For instance, no scrap, even powder scrap, should be returned to the blending stage of the metal production process.
- 2) The vendors claim that they cannot quote on any proposal involving the scrap unless they know the exact nature of the scrap involved. It is recommended that the vendors be invited to examine and evaluate the scrap. An effort should then be made to classify the scrap as to type and quality such that this nomenclature can be used in subsequent procurement actions.
- 3) It is recommended that a cost analysis, including requests for bids from the vendors, be made for each of the possible methods of negotiation of scrap reclamation, and that both the PDS 30018 grade and the high purity grade be considered.
- 4) If possible, reclamation of the scrap should be negotiated in such a way that WANL will not take ownership responsibility for either scrap or powder.
- 5) Before final negotiations can be conducted on reclamation of the scrap it will be necessary to arrive at a decision on the chemistry required in the finished product, hence a decision on how the scrap is to be reprocessed. This decision must await an analysis of (a) the question of reuse of reflectors and/or (b) the potential advantages of using high purity beryllium even without reuse consideration, i.e., accessibility and disposition requirements on spent reflectors. A decision in favor of high purity for either of these reasons would permit final negotiations on scrap reclamation without affecting a subsequent decision on the other question. Based on the advantages of the high purity powder and on the cost comparisons obtained in this investigation, it is suggested that the high-purity powder has a high probability of costing less when all costs are considered.

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APPENDIX I

COMPOSITIONS OF VARIOUS GRADES OF VACUUM HOT PRESSED BERYLLIUM

<u>Elements</u>	<u>Brush Structural Grades</u>			<u>General Astrometals</u>
	<u>S-100-C</u>	<u>S-200-C</u>	<u>S-300-C</u>	<u>Nuclear Grade</u> <u>Cr-N</u>
Beryllium Assay, % Min.	98.5	98.0	97.4	99.0
BeO, % Max.	1.2	2.0	3.0	0.9
Al, % Max.	0.14	0.16	0.18	0.03
C, % Max.	0.15	0.15	0.20	0.04
Fe, % Max.	0.16	0.18	0.20	0.05
Mg, % Max.	0.08	0.08	0.08	0.005
Si, % Max.	0.08	0.08	0.12	0.01
Other Metallics, % each, Max.	0.04	0.04	0.06	
B, % Max.				0.0002
Cd, % Max.				0.0002
Ca, % Max.				0.02
Cr, % Max.				0.003
Co, % Max.				0.0005
Cu, % Max.				0.01
Pb, % Max.				0.0025
Li, % Max.				0.0003
Mn, % Max.				0.003
Mo, % Max.				0.002
Ni, % Max.				0.025
Ag, % Max.				0.001
Sc, % Max.				0.00001

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APPENDIX II

THE BRUSH BERYLLIUM COMPANY
ELMORE, OHIO

August 1, 1962

BERYLLIUM SCRAP PURCHASE SCHEDULE

Specifications required by the majority of beryllium users make mandatory the adoption of terms and specifications for purchasing beryllium scrap which can be achieved if normal care and caution is exercised in accumulating, sorting and handling.

Effective this date, The Brush Beryllium Company will purchase beryllium metal scrap to the extent of its requirements. under the following terms and conditions.

ALL BERYLLIUM SCRAP PRICES ARE BASED ON BERYLLIUM CONTENT

1. SOLID SCRAP: Beryllium metal solid scrap pieces. bar ends, plates, sheet, strip, punchings, etc., clean and free of contamination.
2. MACHINE CHIPS: Clean, dry, free of contamination, containing no cutting oil or other lubricants.
3. MACHINE CHIPS: Clean and free of contamination, except for cutting oil.
4. CONTAMINATED SCRAP: Chips, powder, saw sludge, etc.

For Items 1 through 4 the following specifications will apply on reclaimed material.

Beryllium Assay		97.4 min.	
BeO	3.0 max.	Fe	.20 max.
Al	.20 max.	Si	.20 max.
C	.20 max.	Any other Metallic Impurities	.10 max.

Also note paragraph "A" Terms and Conditions

Description	
Item 1 - Solid	\$18.00/lb. contained beryllium
Item 2 - Machine Chips	18.00/lb. contained beryllium
Item 3 - Machine Chips	17.00/lb. contained beryllium
Item 4 - Contaminated Scrap	8.00-15.00/lb. of contained beryllium recovered

*Price allowed for this type material will vary depending upon cost of reclamation.

For Scrap which after processing does not meet the above specifications.

- (a) The Brush Beryllium Company will make offer based on its processed value, or
- (b) The Brush Beryllium Company will return reclaimed scrap with complete chemical analysis and bill customer for processing and analytical cost.

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- A. Beryllium metal scrap contaminated with radioactive material or high nuclear absorption elements such as boron, lithium, cadmium, cobalt, etc., is not subject to prices quoted. Contact mill.
- B. All scrap shipments are subject to our chemical analysis and Quality Control inspection at the receiving plant. The chemical analysis and mill weights will determine the beryllium content and the classification of scrap. Mill credit will be allowed in accordance with the foregoing schedule. Full weight credit will be allowed on all beryllium assaying 98% and over.
- C. In event the material fails to meet the requirements, the vendor will be notified and the material held for the vendor's instructions as to disposition per paragraph 6, Page 1. A minimum of thirty (30) days is required for processing and analysis of scrap. Settlement will be made within 60 days of receipt of material.
- D. If scrap is purchased on the basis of samples provided by the seller, and the material received is not representative of the samples offered, we reserve the right to return all or any part of the shipment at the seller's expense, including reimbursement to Brush of any freight charges paid on incoming materials.
- E. Material must be packed in convenient containers, in accordance with I.C.C. Tariff No. 10, with gross net and tare weights clearly shown thereon. GENERAL CLEANLINESS AND ABSENCE OF FOREIGN MATERIALS MUST BE MAINTAINED. If return of shipping container is desired, we must be notified at time of shipment. Containers will be returned, freight collect.
- F. All shipments of beryllium metal scrap must be classified and designated on Bills of Lading and other shipping documents as "BERYLLIUM METAL SCRAP, CLASS B POISON, N.O.S." label.
- G. Actual freight will be allowed on all shipments of more than fifty pounds, net, from any point east of the Mississippi River. Freight will be allowed up to a maximum of ten dollars (\$10.00) per cwt. on all shipments originating west of the Mississippi River. We reserve the right to designate the carrier and routing. In event our designation of carrier and routing is not followed, any excess freight charges incurred will be charged to the shipper's account.

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~~RESTRICTED DATA~~

~~Atomic Energy Act 1954~~

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WANL-TME-489

- H. No scrap is to be shipped to us without written shipping authorization or Purchase Order. Please direct all inquiries to the attention of the Purchasing Department, Elmore, Ohio.

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~~Atomic Energy Act of 1954~~

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Beryllium Metal
Beryllium Copper
Beryllium Master Alloys
Beryllium Oxide

APPENDIX III

Revision of May 14, 1962
The Brush Beryllium Company
5209 Euclid Avenue
Cleveland 3, Ohio

PRICE LIST
QMV[®] BERYLLIUM METAL POWDER
STRUCTURAL AND FUEL GRADES*

		<u>SP-100</u>			<u>SP-200</u>	<u>SP-300</u>
				1755 17 ± 5 Micron		
From	Up To But Not Including	-200 Mesh	-17 Micron		-200 Mesh	-200 Mesh
2 oz.	1 lb.	7.00/oz.	8.00/oz.	9.60/oz.	6.00/oz.	5.00/oz.
1 lb.	100 lbs.	74.50/lb.	85.70/lb.	109.40/lb.	66.00/lb.	60.00/lb.
100 lbs.	1,000 lbs.	70.50/lb.	81.10/lb.	99.40/lb.	62.00/lb.	56.00/lb.
1,000 lbs.	5,000 lbs.	67.50/lb.	77.60/lb.	86.00/lb.	59.00/lb.	53.00/lb.
5,000 lbs.	10,000 lbs.	65.50/lb.	Consult Mill	Consult Mill	57.00/lb.	51.00/lb.
10,000 lbs.	20,000 lbs.	63.50/lb.	Consult Mill	Consult Mill	55.00/lb.	49.00/lb.
Over 20,000 lbs.		62.50/lb.	Consult Mill	Consult Mill	54.00/lb.	48.00/lb.

NUCLEAR GRADES*

2 oz.	1 lb.	7.70/oz.	7.30/oz.	7.00/oz.
1 lb.	100 lbs.	82.00/lb.	78.20/lb.	74.50/lb.
100 lbs.	1,000 lbs.	77.60/lb.	74.00/lb.	70.50/lb.
1,000 lbs.	5,000 lbs.	74.30/lb.	70.90/lb.	67.50/lb.
5,000 lbs.	10,000 lbs.	72.00/lb.	68.80/lb.	65.50/lb.
10,000 lbs.	20,000 lbs.	69.90/lb.	66.70/lb.	63.50/lb.
Over 20,000 lbs.		68.80/lb.	65.60/lb.	62.50/lb.

*Copies of Specifications Available on Request

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~~RESTRICTED DATA~~
~~Atomic Energy Act, 1954~~

APPENDIX III
(Cont.)

THE BRUSH BERYLLIUM COMPANY

PRICE LIST - QMV[®] BERYLLIUM METAL POWDER (Continued)

An extra charge of 10% should be added to the base price for screening of QMV[®] beryllium powder to any standard mesh or sieve size, down to -325 mesh, other than -200 mesh. This extra charge will be minimum of \$25 per order. When standard mesh or sieve size other than -200 mesh is specified, chemical composition will be the same as for -200 mesh, except for beryllium oxide content. For example, beryllium oxide content of SP-100 powder to -200 mesh is 1.2% maximum. In the case of -325 mesh, the beryllium oxide content will be approximately 1.6% maximum.

Prices quoted are for powder supplied against standard specifications. For individual specifications other than standard, consult mill.

An extra charge of 20 cents per pound should be added to the base price when 100% radiographic inspection is specified.

PRICES: F. O. B. Elmore, Ohio

TERMS: 1/2% - 10 days
net - 30 days

ALL PRICES SUBJECT TO CHANGE WITHOUT NOTICE. PRICES ON DATE OF SHIPMENT WILL APPLY.