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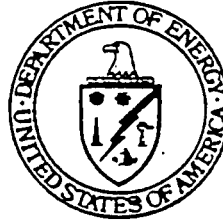
BERYLLIUM

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Prepared by William C. Rask
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I. SUMMARY

The central issue of continuing beryllium supply is a manufacturing capacity designed to meet all of DOE/DOD/NASA/U.K. needs. The market for beryllium metal is small (presently approximately 30 tons/year) and indications are that it could become much smaller. In fact, a shrinking market is the primary threat to a continuing commercially viable beryllium metal industry. It is just this aspect of the problem that points to the need for careful study of future beryllium needs, and to the supply alternatives that would meet those needs.

In a very real sense, the shrinking metallic beryllium market has caused numerous negative impacts upon the beryllium industry and the metallic beryllium users since the early 1960's. Just prior to this period (i.e. 1957-58), the U.S. beryllium producers, Brush Wellman, Inc. (BWI) and Kawecki Berylco Industries (KBI), built substantial new beryllium metal production plants (100,000 pounds of metal per year) with AEC capital backing based on "projected Government needs." They had undertaken substantial financial liabilities for the new production plants the output of which tied directly to Government end-use. In order to enhance the industry position, a Comptroller's decision was issued in 1964 and an AEC "make-buy" policy was developed in 1966 to maintain a viable metallic beryllium industry. Governmental beryllium needs continued to decline and future projections did not suggest any increase so both firms diversified starting in the early 1970's.

Beryllium metal products had become an increasingly smaller proportion of the total sales of both firms by the mid 1970's. Within the BWI beryllium product line, direct Government products dropped to nine percent. Similarly, less than two percent of KBI sales were for direct Governmental end-use. As a result, by the end of 1973, BWI closed their production facilities at Cleveland, Ohio and KBI closed their Yonkers, New York plant. The beryllium production facilities of each firm were now operating at approximately 20 percent capacity. As early as January 1974, concern was expressed within the weapons complex that one of the firms might close down metal operations entirely as a result of low product need. It was felt that beryllium production capability

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was needed in-house as a backup in order to maintain a state of readiness, and that a satisfactory quantity of scrap should be kept on hand for potential reprocessing.

Early in 1975, a near crippling blow was delivered with the issuance of OSHA's Proposed Rule making for beryllium exposure, followed by their DEIS in 1977. OSHA's proposals significantly changed the exposure limits by requiring a 30 to 50-fold decrease. Neither producer had consistently met the current standard (AEC exposure standard developed in 1949) in some steps of the production process, especially in the beryllium metal processes. The proposed standard would have a serious, adverse impact on their business, particularly those processes supporting defense needs for beryllium metal and, to a lesser extent, oxides. Both corporations were firmly committed to continued production of the less hazardous beryllium alloys because of the volume and profitability of this line of business and would make the significant investment necessary to meet a new standard. However, the Government contracts were usually relatively short term, provided a small profit, and could not support significant capital investment. The industry recognized its responsibility to the community, the stockholders, and the nation, and they believed that the beryllium metal technology and capacity extant in their facilities were national assets. However, each corporation stated that, under the proposed OSHA Standards and the need for significant investment, under-utilized capacity, and the minimal profits for Government products, the Government work would probably be discontinued.

Consulting engineering firms for both BWI and KBI recommended improvements that could bring the companies into compliance most of the time with the current exposure standard, but the consultants stated that the proposed standard was neither economically nor technically obtainable in the beryllium powder metal operations.

Industry reacted strongly to the proposed standard, and expressed shock and concern at the OSHA and NIOSH methods employed to support the proposed standard. The DOE recommended that the DOL reevaluate the proposed change in light of the absence of good reliable scientific evidence that the current

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standard was established at an unsafe level, and because the engineering complications and costs to assure the proposed reduction in beryllium exposure levels would be disproportionate to the small exposure reductions involved.

The full significance of the proposed standard impact was the potential closure of the beryllium industry plants, and this became a very real possibility. The first response was naturally one of "safety-stock." Such a procurement would total several million dollars and concern arose over the potential impact on the industry when such a large purchase was to be followed by no orders for several years. Therefore, it was decided to step back and assess the total industry impact before such an acquisition was initiated. A fact finding committee (The Beryllium Task Group) was organized in January 1978 for this purpose. The Task Group was directed by AL, and included RFP, ORO, LANL, LLNL and MA.

Beryllium metal was confirmed to be an established material with a long history of application in DOE programs because it possesses a unique combination of physical and mechanical properties that are not equaled by other materials. The key properties that play a part in the selection of beryllium, include its high strength to weight ratio, its stiffness, a comparatively high melting point, and its thermal conductivity in contrast to a very low thermal expansivity. Beryllium's high scattering and low-absorption cross section make it an excellent neutron moderator and reflector. Beryllium is used in weapon systems as structural material, thermal heat sink, neutronic tamper and [] It is also used in guidance systems, optics, propulsion thrust chambers, and x-ray windows.

Beryllium oxide is an electrically insulating, thermally conducting, refractory material used principally in electronic devices throughout industry as a tamper, as a dissolvable mandrel for making seamless vessels and [] in thermonuclear weapons. Similarly, beryllium when alloyed with copper, significantly increases the conductivity for which it is used throughout industry in integrated circuitry and other electrical/electronic components.

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By March of 1978, the Task group had pretty well defined the impact of OSHA's proposed standard on DOE's national defense programs, concluding that: (1) The primary producers in the beryllium industry would be severely affected by the proposed standard to the extent that assurance of continuing beryllium metal supply was greatly jeopardized and oxide supplies were threatened. (2) Beryllium metal and oxide were materials that could not be replaced in current and future nuclear weapons without extreme and unacceptable performance and cost penalties, and (3) Assurance of continuing sources of domestic supply for these materials must be maintained. These conclusions and the supporting back-up information were formalized in a two volume report, "Impact on U.S. DOE National Defense Programs of Proposed DOL (OSHA) Beryllium Standards," Volume I dated May 2, 1978 and Volume II (SRD) dated March 15, 1978.

Among the options developed in the 1978 Task Group Report were the following: (1) Establish within the DOE complex the capability for metallic beryllium and beryllium oxide production beginning with the procurement of beryllium ores through Government-Owned Contractor-Operator (GOCO) facilities. (2) Encourage private industry to maintain their facilities and personnel to provide for the DOE needs, through subsidies, large price increases, or direct provision of capital funds. This would include financing and appreciable upgrading of the existing facilities. This was not well received by either BWI or KBI. (3) Convert the GSA beryl stockpile to metallic beryllium and beryllium oxide to support DOE needs. Although this should not be exclusively separated as a stand-alone option, it was highlighted in the report since it would meet the DOE requirements for many years. (4) This option is similar to Option 1, but the GOCO facility would have the capability of producing metallic beryllium and beryllium oxide beginning with the procurement of beryllium hydroxide. Industry would continue their present mining and milling operations, and would provide an hydroxide product to meet DOE needs as well as commercial market needs for beryllium oxide and beryllium alloys.

At that time, a worst case scenario that assumed a cessation of beryllium metal supply within three years seemed quite probable. No matter what

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OSHA's standard would ultimately be, nor what its fate in the courts, beryllium procurement costs would increase, perhaps dramatically, to offset both the costs of compliance and of violations of the standards. The cessation in beryllium supply from industry could very well result from either the decision of industry or a possible decision of DOE if procurement costs became excessive. Supplies of beryllium oxide powder probably would continue to be available since it was an integral and critical "feed" material to the industry for other (ceramic) products.

In addition to the options developed by the Task Group the following action items were based on the rationale that the best possible course of action would be to prevent this worst case:

- Through independent experts, have the beryllium as a carcinogen issue restudied, using all the data thus far developed and conducting additional studies as required.
- Immediately take all necessary steps to bring the DOE and DOD joint position to the attention of DOL, the State Department and the White House.
- Intensify Government (USDOE) control of beryllium scrap generated in its production operations..
- Evaluate the provision for guaranteed purchases of beryllium metal and oxide for stockpile and current use for DOE/DOD/GSA.
- Evaluate Government financing of the achievement of compliance in industrial facilities that are operating close to the current standard.
- Evaluate the building by Government of new plants to be managed by a beryllium company if possible.

The Office of Military Applications in DOE (MA) approved the Task Group Report and directed the group to proceed immediately with all of the recommended action items plus an examination of the feasibility of an in-house beryllium production capability. During the remainder of 1978 there was an ever-increasing threat of a loss of beryllium supply through the issuance of the proposed OSHA standard. By now this was expected during the early part of 1979.

Four key events happened in 1979 with respect to the continuing shrinking market syndrome for metallic beryllium. Two sounded a positive note and two were not so helpful.

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1. A visit to the U.K. found that their scrap recycling process capabilities/capacity would support DOE's short-term beryllium powder needs.

2. DOL published the Beryllium Final Environmental Impact Statement (FEIS) based on the original proposed standard, however it was withdrawn when a similar standard for benzene was rejected by an Appeals Court. This action was followed in 1980 by a Supreme Court concurrence in the Appeals Court decision.

3. KBI's Hazelton, Pennsylvania beryllium facilities closed, the third to do so since the decline in demand began in the mid 1960's. This was not only a plant closure, but KBI terminated all metallic beryllium operations after an internal review and analysis by their new owner, Cabot Corporation. This termination resulted in several serious losses to the beryllium supply situation. Among these were the cessation of the beryllium metal production capacity of KBI, a competitive environment of at least two primary producers, high purity beryllium powder capability from the electrolytic flake process, and the technical expertise of KBI.

4. With the retreat of KBI from the metallic beryllium industry, BWI became the sole source supplier for DOE beryllium metal and beryllium oxide needs. They strengthened their position in the market place further by procuring beryl ore on the foreign markets. The most direct impact on the product users was an overall product line price increase of 44 percent. BWI claimed this was a one-time price increase to make the metallic beryllium business profitable and did not take into account any additional price increases that might be required to cover costs for upgrading their facilities to meet the present or proposed OSHA beryllium exposure standards.

In July 1980, the Beryllium Coordinating Committee was established, the Beryllium Supply Program was formalized in September 1980, and MA issued mandates for research for long-term solutions to the problem. These mandates required the development of Government long-range beryllium projections of demand and, to meet these projections, the examination of two primary options - beryllium scrap recycling processing and optimization of virgin metal production. This research is to be concluded with a comprehensive analysis and evaluation.

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The long-range beryllium projections are to include the DOE nuclear weapon production, DOD missions, [] nuclear weapons programs, NASA programs, and other governmental requirements (such as nuclear reactors). Alternate designs, substitute materials, range of material needs, range of material grades, and alternate fabrication processes are to be factored into future projections.

The beryllium scrap recycling processing research is to examine material source projections as well as the recycling processes themselves. The material sources are to include an examination of the present DOE, DOD, GSA and NASA stockpiles; future scrap generation of beryllium from these agencies; and the classification and quantification of such material sources by "clean," "contaminated," and "radioactively contaminated." The recycling processes are to include: electrorefining, casting, powder producing, classification, blending, consolidation, forming, and radioactive decontamination.

The optimization of virgin metal production is to provide a comprehensive review of existing beryllium production operations (BWI facilities), a comprehensive investigation of state-of-the-art operations (present technology dates back to the 1940's), construction of subscale equipment models for demonstration purposes, operation of the subscale equipment models, and concluding with a comprehensive analysis and report.

In March 1981, the Rocky Flats Plant (RFP) was issued a charter including two categories: (1) basic beryllium process and material development for the purposes of supporting current production, meeting future design requirements, and developing more cost-effective manufacturing processes; and, (2) the establishment of beryllium recycle technology at Rocky Flats for the purpose of providing technical and economic data relative to the feasibility of utilizing beryllium scrap for weapons production. The beryllium recycle technology charter has concentrated on scrap refining through a Beryllium Electrorefining Program (BER) with follow-on process technologies including casting, powder production, classification, blending, and consolidation. A laboratory-scale BER cell to provide operational data was designed and operated by May 1982 with output greater than 99.9 percent purity. A BER demonstration facility is now scheduled for start-up operations the first quarter of FY86.

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Information from this operation will be projected to a manufacturing beryllium scrap recycle process that will form the basis of a technical and economic report.

Basic beryllium process and material development or fabrication technology is to be concentrated in "near net shape" processing since it is the most obvious cost effective manufacturing technology applicable to beryllium. This phase is based on the powder consolidation effort.

The recycle of beryllium scrap is the basis for any beryllium supply alternative that would not use virgin ore as the primary feed source. The DOE and DOD scrap stockpiles would become important sources of beryllium if the recycle alternative were judged economical. A third source, and most significant, would be the ingots in the GSA stockpile for potential use as recycle feed stock. Therefore, it is of utmost importance that all such sources of beryllium, both contaminated and uncontaminated, be stocked until the present "Beryllium Supply Program-Option Study" is completed.

BWI was issued a contract in March 1982 that included the following tasks:

Task I - Conduct a comprehensive review of current unit operations and associated contamination levels and prepare and submit a written report of findings, conclusions and recommendations.

Task II - Perform a comprehensive investigation of the state of the art of the unit operations and recommend possible new concepts, applications and alternatives for beryllium metal processing and prepare and submit a written report thereon.

Task III - Based on the studies performed and reports submitted in accordance with Tasks I and II above, the Contractor shall construct subscale experimentation and demonstration models of recommended optimized beryllium metal production processes and operations. Written reports describing the Task III effort, including as-built drawings and specifications therefore, to comply with all applicable occupational health, environmental and safety requirements, shall be provided.

Task IV - During and after investigation and actual operation of the subscale experimentation and demonstration models, submit written reports concerning the operating characteristics and acceptability of new concepts, applications and alternatives.

Task V - Prepare and submit a comprehensive final report based on the research and development work completed in Tasks I through IV that will

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integrate and correlate investigative findings and results in a manner sufficient for assessing the merit of new concepts, applications and alternatives recommended for optimizing beryllium metal production operations.

Task I was completed July 1982 and the first half of Task II was completed in March 1983. In June 1983 the contract was modified to study the application of inert gas atomization for beryllium powder production similar to that used in the aluminum industry, including the construction and operation of a subscale demonstration unit.

RFP development work will track the BWI Contract Schedule in order to process the basic data from both these major efforts simultaneously in preparation for the final analysis and evaluation.

As stated initially in this summary, the central issue of continuing beryllium supply is a manufacturing capacity designed to meet all safety and health standards and sized to meet all of DOE/DOD/NASA/U.K. needs. The market for beryllium metal is small (at present approximately 30 tons/year) and indications are that it could become much smaller. In fact, a shrinking market is the primary threat to a continuing commercially viable beryllium metal industry. It is just this aspect of the problem that points to the need for careful study of future beryllium needs, and to supply alternatives that would meet those needs. The "Beryllium Supply Program - Options Study" is an excellent vehicle to accomplish this task.

The probable outcome of the Beryllium Supply Program would necessitate a choice or choices, between Government-Owned/Contractor-Operated or Contractor Owned/Contractor-Operated virgin beryllium metal production facilities, Government-Owned/Contractor-Operated or Contractor-Owned/Contractor-Operated beryllium metal recycle facilities, or a combination of both. BWI has repeatedly expressed an interest in operating a Government-Owned beryllium facility and has pledged the operation of their present plant until such a facility or arrangement was operational. In recent months, KBI has shown renewed interest in becoming a metallic beryllium producer.

The expeditious completion of the Beryllium Supply Program is therefore very important to assure an adequate supply of beryllium metal and oxide to the Government at a fair price.

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