Beryllium File

470.1 Be

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OFFICE MEMORANDUM

TO : D. K. Froman, Technical Associate Director
DATE: February 14, 1952

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FROM : E. R. Jette, CMR-Division Leader

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SUBJECT: MANUFACTURE OF SHOCK RESISTANT BERYLLIUM

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The following is a statement of the problem and of certain information needed in an investigation to find a method of manufacture of shock resistant beryllium. Information needed falls into three classes: I. How the billet of beryllium which is to be fabricated into bar was made. II. The exact conditions of the extrusion. (It is assumed that extrusion will be used but the investigation is not necessarily limited to this method of fabrication. If some other method is used, the corresponding types of information must be supplied.) III. The tests and testing methods. (Here the main interest is to assure standardization of shop methods of preparing test pieces of standard sizes and shapes, and standardization in detail of the testing procedures themselves. This is particularly necessary since work will be conducted in several places.)

If the Brush, MIT, LASL arrangements are completed, Brush would have sole responsibility for I, MIT for II, and all three contributers would have to agree on III. LASL would be generally responsible for the technical direction of the entire program, as well as for developing suitable tests to determine the suitability of the material for its ultimate usage.

A list of items of information desired is given below. It is to be emphasized that this list does not specify what procedures are to be used in making the billets. What we ask for is a sufficiently detailed account of how each individual billet was made so that results obtained from it can be compared with results from other billets, and that a succession of billets with the same characteristics can be made. Similarly, regarding the extrusion process, we do not specify the nature or types of extrusion procedures which might be involved in the experimental program. We only ask that the information indicated be given for each extrusion made.

<u>The Problem</u>: To develop a method of manufacture of 7/8" diameter beryllium rod with high resistance to impact shocks.

Notes: a) This is limited to one size (7/8" diameter) and one shape (rod).

b) High resistance to impact shock has in the past been considered as due to good ductility combined with high strength in the metal. This may not be true, but seems to be a reasonable working hypothesis.

c) The word "manufacture" here implies that the method is sufficiently well standardized and <u>described</u> so that rod of a given set of characteristics can be made as often as desired without producing large proportions of discarded or off-standard metal.

d) It is our belief that the whole chain of operations leading to the production of the Be billet which is to be extruded (or otherwise fabricated) to shape, is equally as important as the extrusion or

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fabrication method. For this reason, we ask for so much information on both phases of the problem.

The Information Desired

I. The complete history of the manufacture of the billet including the following items:

Note: It will be obvious that if Brush supplies loose powder to MIT, information beyond item 4 will be unnecessary.

1. Method of production of metal to be used for powder including source of raw material.

2. Method of preparation of powder.

3. Chemical analysis of powder, including nitrogen, "insoluble matter", fluorine or other element which is characteristic of the process for making the original raw metal.

4. Particle size distribution including distribution below 325 mesh - by electron microscope, if necessary.

5. Method of making billet, including temperatures, pressures, compression ratio, time at temperature and pressure, atmosphere, canning material, etc.

6. Other operations, e.g., rolling, forging, scalping, etc., if performed.

7. Density of final billet.

8. Analyses from at least six different points on the billet including "insoluble matter" and nitrogen. Indicate sampling method and location of samples on the billet. The "insoluble matter" should be identified by X-ray diffraction and, if necessary, special chemical analyses. Obviously the method of dissolving the metal should not be so drastic that inclusions such as BeO and others that might be suspected are dissolved. It seems important that the amount, nature and, if possible, the sizes of such stress raisers be known.

9. Radiograph each billet before processing to rod.

10. For each method of billet manufacture, determine the grain size distribution by sectioning a representative billet. This billet should have previously been radiographed.

Note: We believe that all heating (including billets) should be done in <u>dry</u> argon or helium, unless the object is canned.

II. The following information is desired on each extrusion made:

1. Type and material of the billet can. Method of loading and sealing. Gas atmosphere inside can.

2. Heating time and temperature of billet. Time must be sufficient to get uniform temperature throughout billet.

3. Extrusion temperature if different from 2.

4. Reduction in area.

5. Ram speed as function of time during extrusion.

6. Extrusion pressure, preferably as a function of time.

7. Temperature of rod as it emerges from die.

8. Cooling time down to, e.g., 250°C. Perhaps this could be recorded in several steps, such as 900°, 750°, 500°, 250°, or continuously. A possible alternate to this would be to run the rod into a trough filled with a quenching oil.

9. Straightening method used, if any. (Technique should avoid necessity for straightening.)

10. Type and shape of die, material of die, initial temperature of die, use of graphite or other materials between billet and ram, lubrication of die, if any.

11. Quenching temperature and other conditions, if quenching is done.

III. <u>Tests and Testing Methods</u>

The predominant tests so far have been ultimate tensile strength and percent elongation. Occasionally, the density and hardness have been measured. Microscopic studies of grain size, inclusions, etc., have been made in a number of cases. We propose that the following tests be made routinely:

1. Ultimate tensile strength.

2. Yield strength (0.2% offset).

3. Percent elongation.

4. Hardness at locations to be selected.

5. Microscopic examination including measurement of grain size distribution on both transverse and longitudinal sections.

6. Some form of impact test using a round rod test specimen without a notch.

Since tests 1, 2, 3, and 6 involve test specimens somewhat different from the usual sizes, and since Be is particularly notch sensitive, agreement must be reached on the exact shop methods to be used in making the test pieces. Agreement must also be reached on the d[redacted]sting procedure, e.g., strain rate, types of grips, reference points for percent elongation measurement, etc. Whether an impact test (6.) should be made and what form it should take must be discussed.

LASL will be responsible for devising other tests, to be carried out only at LASL, some of which approach the "ultimate use test".

The method of hardness testing must be agreed upon and also certain fixed points chosen at which the tests are made.

On the microscopic examination, the chief points to be decided for the routine tests are the type of illumination (e.g., bright versus polarized light) and the selection of two magnifications for photomicrographs to accompany the records.

IV. Suggestions:

The following suggestions are advanced here to forestall possible questions as to the justification for putting such large amounts of material back into scrap. We believe the information to be gained is worth the cost.

A. Method should be developed to assure that heating time is sufficient to get uniform temperature throughout the billet.

B. Effect of heating time and temperature on the grain size within the billet should be determined in connection with the extrusion process.

C. What is the effect of the canning material on the composition of the outer layers of billets or extruded rod? Is this strictly a surface layer? Should it be removed? If not removed, will it affect the physical properties of the final rod?

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