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June 14, 1946

D. I. C.

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CT-3563

CT-3563

District Engineer
Manhattan District
Box E
Oak Ridge, Tenn.

Attention: Dr. T. S. Chapman

Dear Sir:-

We are submitting, herewith, copies 1A and 4A of
the M.I.T. Progress Report (A-1) for May, 1946.

Very truly yours,

M.I.T. METALLURGICAL PROJECT

A. R. Kaufmann
A. R. Kaufmann
Director

ARK:LR
Enc.

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IIThis document consists of 27 Pages.PROGRESS (A-1) REPORT FOR MONTH OF MAY, 1946

June 14, 1946

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1.

Progress Report
Month of May, 1943

1. Abstract
A. R. Kaufmann

CT-3563

H A thin-walled graphite tube can be used as part of the hot top in place of the aluminum tubing formerly used in the casting of $4\frac{1}{2}$ " billets. Boron can be largely removed from beryllium by distillation of the metal.

A, K Tensile testing of extruded beryllium indicates that yield points of about 30,000 lbs. per sq. in. with a 2% elongation in the extrusion direction can be obtained by proper annealing of the extruded bars. The tensile properties are much lower perpendicular to the extrusion direction and annealing does not remove this effect.

A, K, I A Beryllium tubing 2" O.D. by $1\frac{1}{2}$ " I.D. has been made by extrusion. Extruded "V" flake beryllium deteriorates badly upon standing in air.

CLASSIFICATION CANCELLED
DATE 12-15-55
For The Atomic Energy Commission

H. F. Cansell
Chief, Declassification Branch

B-7-3

2. Casting and Distillation of Beryllium

2.1 Casting - P. Corzine

Production of billets for extrusion has continued. Several Brush crucibles were tested and one type was found to be superior to any used before. This crucible was made of a 50-50 mixture of Brush BeO and Brush BeO which had been fused by the Norton Company. It was used for four melts before it failed, whereas previously not more than one or, possibly two, melts were obtained per crucible.

Work is proceeding on the problem of casting a copper heat exchanger.

Analytical results are still inconclusive as to the removal of calcium in the vacuum melting process. Present results indicate that about 0.2% calcium remains in those batches of Brush metal for which calcium was added to the magnesium used in the reduction process.

In casting $4\frac{1}{2}$ " extrusion billets, the aluminum tubing which was used as a hot top has been replaced with a graphite sleeve of the same I.D. and with a $3/16$ " thick wall. Hot top action appears to be satisfactory with this arrangement.

2.2 Distillation - S. Siegel

Boron analyses have indicated that beryllium metal distilled from commercial purity vacuum cast metal contains considerably less boron than the charged metal. The results, for a distillation run in which 920 grams of metal were distilled into a BeO chamber, were as follows:

Distilled metal	Boron 1 p.p.m.
Residual metal (metal which did not distill over)	Boron 20 p.p.m.
Charged metal	Boron approximately 5 p.p.m. (calculated)

The rate of distillation during this run was approximately 11.8 lbs/hr./sq. ft. of bath surface at a distillation temperature of 1500°C . Further work to check these results will be done during the coming month.

Tensile specimens for the determination of the ductility of distilled beryllium have not yet been machined.

Progress Report
Month of May, 1946

3. Physical Metallurgy P. Gordon

3.1 Tensile Testing of Extruded Beryllium - P. Gordon, J. Connelly, and R. Fellingner.

3.11 Introduction. Tensile tests on extruded rods of beryllium and dilute binary alloys of beryllium completed during 1945 (see M.I.T. Progress Report for May, 1945, GT-3060) indicated that:

- a) In the as-extruded condition (extrusion temperature = 1250° - 1350° F, reduction 16-1) tensile strengths of about 45,000 to 50,000 p.s.i. were obtainable but the corresponding ductility was very low, about 0.1 to 0.1% elongation.
- b) After annealing in the range 725° C to 800° C, elongations of over 2% could be produced without impairing the strength and, in some cases, with an increase in strength.
- c) The various alloy additions had no significant effect on the tensile properties.

A second series of tensile tests has been completed. These tests were conducted on extruded rods of beryllium and on beryllium alloys of 5%, 1% and 3% aluminum. The series of tests was designed as a survey investigation of the effects of the following factors on the tensile properties:

- a) Extrusion temperature
- b) Heat treatment after extrusion
- c) Aluminum additions
- d) Direction of testing with respect to the extrusion direction.

3.12 Experimental Procedure. The tensile tests were carried out on a 20,000 lb. capacity, Tinius-Olsen hydraulic testing machine. The method of measuring elongation is illustrated in Figure 1. Two dial gages, graduated to 0.0001", were firmly clamped on opposite sides of the specimen by means of two steel crossbars. Because of the small size of the specimen (1" gage length, 0.200" diameter), it was necessary to attach the steel crossbars to the threaded ends of the specimen rather than along the gage length itself. The measured elongation, therefore, included not only that occurring within the gage length, but also that of the thicker portions of the specimen lying between the two crossbars. Elongations have been reported as measured, however, and should be considered only as comparative, rather than absolute values. It has been estimated that the true elongations are approximately 80% of the reported values. Because of this discrepancy, no attempt has been made to calculate elastic moduli from the stress-strain curves plotted.

The tensile properties reported are the ultimate strength, the ultimate per cent elongation, and the yield strength. Since beryllium does not exhibit a definite yield point similar to that of steel, and

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Figure 1. Strain Measuring Apparatus

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3. Physical Metallurgy (Cont'd)

since, even in the "elastic" range of deformation most of the stress-strain curves were actually not quite straight lines, it became necessary to establish an arbitrary definition of yield strength. The slightly curved, elastic portions of the curves were extrapolated upwards, and the yield strength was chosen as that stress at which the actual stress-strain curve deviated from the extrapolated curve by an amount equal to 0.01% elongation.

One-half inch rods of unalloyed beryllium were obtained by extrusion with a 16-1 reduction in area at temperatures of 1200°, 1250°, 1350°, 1500° and 1650°F. Similarly, 1% aluminum alloys were extruded at 1350° and 1650°F, and in addition a 3% aluminum alloy and a 5% aluminum alloy were extruded at 1650°F, all with a 16-1 reduction in area. For the directionality tests, a 4" x 1/2" slab of unalloyed beryllium, extruded at 1870°F with about 8-1 reduction in area, was prepared.

The extruded rods were examined metallographically at intervals of one foot along the entire length, and sections of the rods (chiefly the end sections) discarded if cracks or extrusion defects were observed, or if the grain size was noted to be considerably different from the average for the particular rod. In spite of this examination, however, extraneous effects were undoubtedly not completely eliminated.

The portions of the rods deemed usable were cut into 4" lengths and machined into tensile specimens. Tensile tests were then run in duplicate: in the as-extruded condition, and after annealing for 3 hours at 1110°F (600°C), at 1380°F (750°C), and at 1650°F (900°C). After testing, the samples were sectioned, polished and examined metallographically under polarized light (unetched) for correlation of the microstructures with the tensile properties.

Samples for studying the effect of the direction of test with respect to the extrusion direction were cut from the 4" x 1/2" slab at angles of 0°, 45° and 90° to the extrusion direction and were tested only in the as-extruded condition and after annealing for 3 hours at 1650°F (900°C) and at 1830°F (1000°C).

Heat treating at 1110°F was carried out in air, but at all higher temperatures vacuum heating was employed.

3.13 Discussion of Results. A complete list of the test results (exclusive of the directionality tests) is given in Tables II to X. The curves and photomicrographs in Figures 2 to 9, and the data in Table I, however, more readily illustrate the significance of the results and will be used as the basis for discussion.

3.131 Effect of Extrusion Temperature. The extrusion temperature exerts considerable influence on the tensile properties of extruded, unalloyed beryllium. As shown in Figure 2, in the as-extruded condition the strength values vary inversely and the per cent elongation varies directly with the extrusion temperature. After extruding

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EFFECT OF EXTRUSION TEMPERATURE

FIG. 2

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3. Physical Metallurgy - (Cont'd)

at 1200°F ultimate strengths of over 50,000 p.s.i. are obtained with the yield strengths very close to 100% of the ultimate, but these values are accompanied by only about 0.2% elongation. With an extrusion temperature of 1650°F, the ultimate strength drops to just over 30,000 p.s.i., and the yield strength is correspondingly low, but the elongation is improved somewhat to about 0.5%.

The microstructures of the as-extruded samples are represented in Figure 3. The samples extruded at 1200°, 1250° and 1350°F reveal essentially completely stressed structures, whereas those extruded at 1500° and 1650°F appear to be mainly recrystallized. This means that the upper temperature of cold working during extrusion (10-1 reduction in area) is between 1350° and 1500°F. However, even in the 1500° and 1650°F samples some evidence of unrecrystallized, twisted grains may be seen. These grains are usually found in the central portions of the samples -- the sections which have received the least amount of working during extrusion.

If tests are made after annealing at 1110°F, the same general trends in the tensile properties as a function of extrusion temperature can be observed (Figure 2) as in the unannealed samples. At higher annealing temperatures, however, some new effects are observed. These effects may be more conveniently studied as a function of heat treatment temperature.

3.132 Effect of Annealing Temperature. The curves of Figure 4 illustrate the variations in tensile properties as a function of annealing temperature after extruding at 1200°, 1350°, 1500° and 1650°F.

For the 1200°F extrusion, the strength values are relatively high and the ductility very low in the as-extruded condition. The deformation which does take place during the tensile tests is almost entirely elastic, as may be seen in the stress-strain curves of Figure 5. The microstructure (Figure 6) reveals a completely cold-worked appearance. Annealing at 1110°F has little effect on the tensile properties, and correspondingly, no change is noticed in the microstructure. If the annealing temperature is raised to 1380°F, however, the elongation is sharply increased to over 2 per cent, while the strength values, particularly the yield strength, are decreased appreciably. The elongation is now mostly plastic. The microstructure reveals that the 1380°F anneal has been sufficient to cause essentially complete recrystallization, although in the longitudinal direction (direction of extrusion) there is still evidence of the banding, or fibring, prevalent in the unannealed structure. Raising the annealing temperature to 1650°F drops the ultimate and yield strengths still further, but the elongation remains high. The microstructure shows a completely recrystallized, equiaxed grain structure with the banding virtually eliminated, and indicates appreciable grain-growth.

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Figure 3. Photomicrographs of beryllium as-extruded at various temperatures. Unetched. Polarized light. Original magnification, 50X; reduced to 25X in rephotographing.

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EFFECT OF HEAT TREATMENT

FIG. 4

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FIG. 5

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Transverse

Longitudinal

AS EXTRUDED AT 1200°F

Transverse

Longitudinal

EXTRUDED-1200°F
ANNEALED-1110°F

Transverse

Longitudinal

EXTRUDED-1200°F
ANNEALED-1380°F

Transverse

Longitudinal

EXTRUDED-1200°F
ANNEALED-1650°F

Figure 6. Photomicrographs of beryllium extruded at 1200°F and annealed at various temperatures. Unetched. Polarized light. Original magnification, 50X; reduced to 25X in rephotographing.

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3. Physical Metallurgy (Cont'd)

The curves of ultimate strength, yield strength and per cent elongation as a function of annealing temperature after extrusion at 1350°F (Figure 4) reveal the same general trends exhibited by those for extrusion at 1200°F. With extrusion temperatures at 1500° and 1650°F (Figures 4 and 7), however, some new effects may be observed. Annealing at 1380°F for both these cases not only increases the ductility considerably, but also raises the ultimate and yield strengths to values considerably above the as-extruded quantities. Annealing at 1650°F brings the strength properties down, but continues to raise the ductility. Metallographic examination, represented by the photomicrographs of Figure 8 on beryllium extruded at 1500°F, reveals no significant change in the microstructure as a result of the 1380°F anneal, so that here the improvement in the tensile properties cannot be associated with general recrystallization. The as-extruded samples are already in a recrystallized condition. It is possible that the improvement is a result of stress relief and, perhaps, the recrystallization of a few grains which had received comparatively small amounts of working during the extrusion. The decrease in yield strength and ultimate strength resulting from the 1650°F anneal appears to be caused by grain growth.

It is evident that not only the extrusion temperature but also the annealing treatment have a large effect on the tensile properties of extruded beryllium. On the basis of the data described above, it seems probable that for each extrusion temperature there is a unique annealing temperature which will produce the optimum combination of ductility and strength. Of the three annealing temperatures used in this survey investigation, 1380°F is closest to the proper temperature for the entire range of extrusion temperatures studied. However, it is believed that for extrusion temperatures of 1500°F and above the optimum annealing temperature will be found to be somewhat higher than 1380°F. Even though, in this case, 1380°F raised both the strength and ductility of the extruded samples, the value of elongation, about 1½%, was not as high as that obtained for annealing at 1650°F, nor for the samples extruded at lower temperatures and annealed at 1380°F. More complete investigation will very likely find an annealing temperature which will produce high strengths accompanied by elongations of over 2%. For extrusion temperatures of 1350°F and below, the data indicate that an annealing temperature of 1380°F is somewhat high, since elongations of over 2% are obtained but at appreciable sacrifice in ultimate and, particularly, yield strength.

It is necessary, therefore, to study a greater number of annealing temperatures to arrive at the optimum heat treatment for each extrusion temperature. The present evidence seems to imply that for each extrusion temperature an annealing treatment may be found which will produce tensile strengths of 45,000 to 50,000 p.s.i. combined with high yield strengths and elongations of over 2 per cent, that this annealing temperature is to be found in the neighborhood of 1300° to 1500°F, and

EFFECT OF HEAT TREATMENT

FIG. 7

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Figure 8. Photomicrographs of beryllium extruded at 1500°F and annealed at various temperatures. Unetched. Polarized light. Original magnification, 50X; reduced to 25X in rephotographing.

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3. Physical Metallurgy (Cont'd)

that as the extrusion temperature goes up the optimum annealing temperature also rises.

3.133 Effect of Aluminum Additions. Curves of the tensile properties of extruded aluminum-beryllium alloys as a function of the aluminum content are presented in Figure 9. The alloys were extruded at 1650°F with a 16-1 reduction in area.

The curves show only minor, and in general, inconsistent changes in the tensile properties effected as a result of aluminum additions up to 3 weight per cent. This is true in both the as-extruded condition and after annealing at 1110°, 1380°, and 1650°F. The presence of aluminum, however, may lower the optimum annealing temperature; for it should be noted that, for the alloys, an annealing temperature as low as 1110°F is sufficient to raise the elongation to the near-maximum value of about 2 per cent.

Similar data have been obtained for the 1 per cent aluminum alloy extruded at 1350°F, and here too, the alloy showed no significant improvements in tensile properties over those of unalloyed beryllium.

3.134 Effect of Test Direction with Respect to Extrusion Direction. The previous discussion has been based entirely on tests in which the samples were stressed in a direction parallel to the extrusion direction. However, in many of the structural uses for which beryllium may conceivably be applicable, it will be important to know whether the ultimate properties of the material vary with direction. It is known that extruded beryllium not only exhibits a banded, or fiber, structure (Figures 3, 6 and 8) but also displays a marked degree of preferred orientation. These factors lead to the belief that the tensile properties would vary with the angle between the test direction and the extrusion direction. That this is actually the case is revealed quite clearly by the ultimate strength data listed in Table I.

A comparison of the ultimate strength values for designations 1, 4 and 5 in Table I shows that in the as-extruded condition, the strength in a direction perpendicular to the extrusion direction is only about half of that obtained when the sample is taken parallel to the extrusion direction. For an angle of 45°, the strength is intermediate between the values for the 0° and 90° directions.

Because it had been observed that the banded structure present in extruded beryllium can be eliminated by annealing at temperatures of 1650°F and above, it was considered possible that such annealing might also erase the directional difference in tensile strength. Specimens cut both parallel to and perpendicular to the extrusion direction were, therefore, heat treated for three hours at

EFFECT OF ALUMINUM ADDITIONS
EXTRUSION TEMPERATURE-1650°F.

3. Physical Metallurgy (Cont'd)

1650° and 1830°F. The test results on these specimens (designations 2, 3, 5 and 6 in Table 1) show that the annealing does not have the desired effect on the strength, even though metallographic examination indicated complete removal of the banding in the heat treated specimens. The directional effect then is more probably associated with preferred orientation and some optical evidence of preferred orientation was noted even in those specimens heated at 1830°F.

3.11. Conclusions. The following conclusions may be drawn from the data presented:

- a) In the as-extruded condition, the strength of unalloyed, extruded beryllium is higher and the ductility lower, the lower the extrusion temperature.
- b) Annealing at 1110°F produces little change in the tensile properties of unalloyed, extruded beryllium.
- c) Annealing at 1380°F raises the elongation of extruded beryllium to over 2 per cent. For extrusion temperatures of 1200° to 1350°F, such annealing lowers the yield and tensile strengths but for extrusion temperatures of 1500° to 1650°F, the strength values are increased.
- d) Raising the annealing temperature to 1650°F produces grain growth accompanied by a decrease in yield and ultimate strengths but, in general, no decrease in ductility.
- e) It is probable that the annealing temperature for optimum tensile properties rises as the extrusion temperature is raised and that for extrusion temperatures of 1500°F and above, this optimum temperature is somewhat above 1380°F, for extrusion temperatures of 1350°F and below it is somewhat below 1380°F.
- f) Extrusion at temperatures of 1350°F and below produces cold-worked, highly stressed material exhibiting a definitely banded structure. Extrusion at temperatures of 1500°F and above leaves the material in an essentially recrystallized condition (for 16-1 reduction).
- g) Annealing at 1380°F is sufficient to recrystallize the cold-worked grains except for those few grains, usually near the rod axis, which have received relatively little working.
- h) The banded structure prevalent in the as-extruded stock can be essentially eliminated by annealing at temperatures above 1650°F.
- i) Aluminum additions up to 3 per cent by weight have little effect on the tensile properties of extruded beryllium.
- j) The direction of testing with respect to the extrusion direction has a large influence on the tensile properties of extruded beryllium. For extrusion at 1870°F with 8-1 reduction in area, the ultimate strength at an angle of 90° to the extrusion direction is only about half that parallel to the extrusion direction.

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3. Physical Metallurgy (Cont'd)

3.1 Conclusions (Cont'd)

- k) Though annealing at 1650° and 1830°F causes the disappearance of the banded structure in the extruded material, it does not eliminate the directional difference in tensile strength.

3.2 Production of Beryllium Single Crystals - L. Gold

Several preliminary attempts to prepare single crystals of beryllium by the technique of lowering the melt through a temperature gradient in a specially prepared vacuum furnace have been made. These attempts have to date been unsuccessful, chiefly as a result of two difficulties: the burning out of the furnace winding and the violent splashing of the molten beryllium. It is believed these difficulties may be easily overcome.

Two single crystals of copper were quite readily produced using the above technique. The molten copper was lowered through the furnace at a rate of approximately one inch per hour. The single crystals produced were in the shape of a 2" diameter cylinder superimposed on an inverted cone, the total length of the crystals being about 1".

Two attempts to prepare large crystals of beryllium by grain growth at high temperatures have proven fruitless. No marked grain growth was observed in a specimen held for three days at 1035°C, nor in a specimen raised and lowered several times through a temperature gradient at elevated temperatures.

3.3 Crystal Orientation by Optical Methods - L. B. Friar

Work on the investigation of the various etchants for use with the optical methods of determining crystal orientation was continued during the month. Results to date have been disappointing and, as yet, it has proven impossible to develop recognizable crystallographic planes by means of either chemical or vacuum etching.

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4. Fabrication

H. Bethke, S. Arnold, J. Connelly, and B. Bergson

The welding of beryllium was attempted using copper strips and filler rods. The welds were found to be very brittle; in fact, even during single pass welding, partial cracking set in before the completion of the weld. In all cases using copper filler rod, complete cracking occurred when multiple passes were made.

Tube welding, using filler rods of 2S aluminum, on a special rotating assembly was unsuccessful due to burning through. By using a preheat to 500°C, slowing down the torch speed, and lowering the amperage, a weld was obtained which was sound throughout about three-quarters of its length.

Rolling and extrusion processes were limited to the production of fabricated specimens for California and Site "Y" and to the manufacture of $\frac{1}{2}$ " x 4" flat stock and of 2" O.D. by $1\frac{1}{4}$ " I.D. tubing for M.I.T. The tubing was made using a drilled billet and floating mandrel.

The motor driven bend tester has been completed for the testing of rolled flatstock.

A program has been undertaken for the swaging of beryllium for the production of small rods for welding purposes.

A quantity of the special "V" beryllium flake which was washed with carbon tetrachloride and then extruded into flat stock some time ago was found to deteriorate upon standing in air as a result of the formation of surface blisters containing a white powder. A similar phenomenon has been observed with extruded Clifton flake but to a much smaller extent. This action is believed to be due to the slow hydrolysis of Be_2C with a resultant change in volume. Samples of carbide made here which have been weathered in air give a diffraction pattern which agrees fairly well with that of the powder collected from the "V" flake.

A study of the surface grinding of Be has been carried out by the Norton Company in an effort to determine the grinding technique which would give the least difficulty with regard to grinding cracks. A report on this work will be given later.

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5. Chemistry
W. C. Schumb and J. Turzicky

The beryllium nitride production has been completed.

Beryllium basic acetate has been prepared by dissolving the metal in hydrochloric acid followed by converting the beryllium chloride hydrate to beryllium oxide and finally dissolving the oxide in concentrated acetic acid to form the beryllium basic acetate.

The initially formed beryllium basic acetate was purified by washing and crystallizing the product. After converting the basic acetate to the oxide by prolonged hydrolysis, the oxide was submitted to the M.I.T. Spectroscopy Laboratory in order to determine the initial impurities. Two successive distillation products of the initial beryllium basic acetate were also submitted for analysis in order to trace the loss of impurities in each distillation product.

The third distillation product was divided into two portions. One portion was treated with hydrofluoric acid (in a platinum dish) in order to get rid of boron and silicon contamination. The other portion was also converted to the oxide by heating and finally igniting the basic acetate after treatment with sulfuric acid instead of hydrofluoric acid.

These two portions of the third distillation product will be compared spectroscopically with each other and with previous samples.

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Month of May, 1946

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6. Appendix

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TABLE I

ULTIMATE STRENGTH AS FUNCTION OF TEST DIRECTION WITH RESPECT TO EXTRUSION DIRECTION

<u>Designation</u>	<u>Angle with Extrusion Direction</u>	<u>Heat Treatment</u>	<u>Ultimate Strength, p.s.i.</u>
1	0° (parallel)	as extruded	31,600
2	0°	3 hrs. at 1650°F	29,500
3	0°	3 hrs. at 1830°F	21,400
4	45°	as extruded	22,700
5	90°	as extruded	15,400
6	90°	3 hrs. at 1650°F	10,700
7	90°	3 hrs. at 1830°F	10,700

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Tensile Results

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Pure Be, Extruded at 1200°F

<u>Annealing Temp., °F.</u>	<u>Yield Strength, p.s.i.</u>		<u>Ultimate Strength, p.s.i.</u>		<u>Elongation, per cent</u>	
	<u>Average</u>		<u>Average</u>		<u>Average</u>	
as extruded	49,300	49,000	51,800	52,900	0.25	0.25
as extruded	48,700		53,900		0.25	
1110	-----	-----	54,700	54,700	-----	-----
1110	-----		-----		-----	-----
1380	20,400	20,100	44,800	44,800	2.27	2.29
1380	19,800		44,800		2.31	
1650	15,900	16,700	37,400	38,000	2.23	2.38
1650	17,500		38,500		2.53	

TABLE III

Tensile ResultsPure Be, Extruded at 1250°F.

<u>Annealing Temp., °F.</u>	<u>Yield Strength, p.s.i.</u>		<u>Ultimate Strength, p.s.i.</u>		<u>Elongation, per cent</u>	
	<u>Average</u>		<u>Average</u>		<u>Average</u>	
1110	48,100	48,100	54,100	54,100	0.20	0.20
1650	17,200	17,500	33,300	34,800	1.65	1.84
1650	17,800		36,300		2.02	

TABLE IV

Tensile ResultsPure Be, Extruded at 1350°F

<u>Annealing Temp., °F.</u>	<u>Yield Strength, p.s.i.</u>		<u>Ultimate Strength, p.s.i.</u>		<u>Elongation, per cent</u>	
	<u>Average</u>		<u>Average</u>		<u>Average</u>	
as extruded	41,100	42,900	46,000	47,000	0.26	0.34
as extruded	44,600		48,000		0.12	
1110	-----	<51,000	49,000	50,500	-----	0.20
1110	51,000		52,000		0.20	
1380	21,600	21,000	37,900	39,600	1.10	1.52
1380	20,400		41,200		1.93	
1650	17,800	17,400	30,900	31,600	1.34	1.52
1650	16,900		32,300		1.69	

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TABLE V

Tensile Results

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Pure Be, Extruded at 1500°F

<u>Annealing Temp., °F.</u>	<u>Yield Strength, p.s.i.</u>		<u>Ultimate Strength, p.s.i.</u>		<u>Elongation, per cent</u>	
	<u>Average</u>		<u>Average</u>		<u>Average</u>	
as extruded	29,600	29,600	39,400	40,400	0.58	0.62
as extruded	29,600		41,100		0.66	
1110	28,000	27,500	39,600	39,800	0.73	0.81
1110	27,000		40,000		0.88	
1380	32,200	33,300	49,200	47,800	1.13	1.22
1380	31,400		46,400		1.01	
1650	17,200	17,400	36,400	36,100	1.81	1.82
1650	17,500		35,700		1.84	

TABLE VI

Tensile ResultsPure Be, Extruded at 1650°F

<u>Annealing Temp., °F</u>	<u>Yield Strength, p.s.i.</u>		<u>Ultimate Strength, p.s.i.</u>		<u>Elongation, per cent</u>	
	<u>Average</u>		<u>Average</u>		<u>Average</u>	
as extruded	23,000	23,600	33,300	33,000	0.58	0.60
as extruded	24,200		33,000		0.61	
1110	22,600	23,200	40,000	37,700	1.50	1.24
1110	23,200		35,300		0.98	
1380	33,200	33,200	45,200	45,200	1.13	1.13
1650	15,900	15,600	35,700	34,500	2.32	2.08
1650	15,300		33,200		1.83	

TABLE VII

Tensile Results5% Al alloy, Extruded at 1650°F

<u>Annealing Temp., °F</u>	<u>Yield Strength, p.s.i.</u>		<u>Ultimate Strength, p.s.i.</u>		<u>Elongation, per cent</u>	
	<u>Average</u>		<u>Average</u>		<u>Average</u>	
as extruded	31,500	31,500	44,100	44,100	0.66	0.66
1110	22,200	22,700	42,900	43,200	1.73	1.85
1110	23,200		43,500		1.96	
1380	25,400	25,600	42,000	44,300	1.29	1.67
1380	25,800		46,600		2.04	
1650	16,200	16,200	35,700	34,500	2.33	2.10
1650	16,200		33,300		1.86	

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TABLE VIII

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Tensile Results1% Al Alloy, Extruded at 1650°F

<u>Annealing Temp., °F</u>	<u>Yield Strength, p.s.i.</u>		<u>Ultimate Strength, p.s.i.</u>		<u>Elongation, per cent</u>	
	<u>Average</u>		<u>Average</u>		<u>Average</u>	
as extruded	29,900		34,100		0.50	
as extruded	23,900	26,500	32,600	33,400	0.50	0.57
as extruded	25,200		33,500		0.50	
1110	23,900	22,800	44,700	44,000	2.09	2.18
1110	21,600		43,200		2.27	
1380	22,500	22,500	47,600	47,600	2.40	2.40
1650	14,500	15,000	33,000	33,800	1.96	1.98
1650	15,600		34,600		1.99	

TABLE IX

Tensile Results3% Al Alloy, Extruded at 1650°F

<u>Annealing Temp., °F</u>	<u>Yield Strength, p.s.i.</u>		<u>Ultimate Strength, p.s.i.</u>		<u>Elongation, per cent</u>	
	<u>Average</u>		<u>Average</u>		<u>Average</u>	
As extruded	26,800	27,500	38,000	36,800	0.51	0.46
as extruded	27,700		35,600		0.41	
1380	23,000	23,800	44,000	46,600	2.22	2.05
1380	24,600		49,100		1.88	

TABLE X

Tensile Results1% Al Alloy, Extruded at 1350°F

<u>Annealing Temp., °F</u>	<u>Yield Strength, p.s.i.</u>		<u>Ultimate Strength, p.s.i.</u>		<u>Elongation, per cent</u>	
	<u>Average</u>		<u>Average</u>		<u>Average</u>	
As extruded	29,600	30,300	39,000	39,000	0.50	0.51
as extruded	30,900		39,000		0.51	
1110	39,800	36,700	51,000	47,100	0.88	0.70
1110	33,500		43,100		0.54	
1380	19,800	21,100	41,400	43,900	1.52	1.71
1380	22,500		46,300		1.89	
1650	16,900	17,600	35,800	35,300	1.85	1.91
1650	13,200		35,800		1.90	

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