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EXPERIMENTAL PROGRAM TO STUDY
THE MECHANICAL PROPERTIES OF BERYLLIUM
-- A STATUS REPORT

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INTRODUCTION

Recently, a study of the equation of state of beryllium was initiated as a joint program of B, H and K Divisions of this Laboratory and Sandia Laboratories, Albuquerque. Measurements of thermodynamic properties are being done by Bert Abey and co-workers in K Division. The major effort in measuring the mechanical properties is being done by Jim Asay and co-workers at Sandia. This report will briefly describe the latter experiments.

THE SHOCK-WAVE EXPERIMENTS

Figure 1 shows the experimental design. The flyers are launched by a gas gun and strike a Be target backed by a LiF window. A VISAR monitors the motion of the Be-LiF interface. The flyers are backed by either a low impedance material to obtain a release profile, or by a high impedance material to get re-shock data. Table I lists the materials and thickness of each component plus the velocity of the flyer required to achieve approximately 10, 17.5, and 25 GPa in the initial shock.

KOVEC simulations of each of the six experiments were done. Standard EOS were used when available. The data for those materials not in the KOVEC library are given in Table II.

The results of the simulations are shown in Figures 2a-c and in Table I. The rounding of the elastic wave is due to strain-rate effects as is the small cusp at ~ 1 μ s seen in Fig. 2a. The rounding on release is due

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principally to the Bauschinger effect. Both effects, constructed from other data, are modeled in these calculations.

The small increase in velocity seen in Figs. 2a and c at ~ 0.8 and $1.1 \mu s$, respectively, is due to the elastic precursor in Be reflecting first from the Be-LiF interface as a rarefaction and then from the Be-flyer interface as a small shock. It is not seen in Fig. 2b because both the flyer and target are Be.

The effect of the yield strength of the LiF window is negligible, contributing $\sim 0.8\%$ to the stress at 99 kb. Asay intends to repeat all the above experiments with 8mm thick samples to get more information on rate effects.

In addition, a number of "pressure shear loading" experiments are projected. In these experiments, an elastic impactor strikes γ -cut quartz which in turn sends out both a quasi-longitudinal wave and a quasi-shear wave into the Be sample. In this way, longitudinal and shear wave loading can be done simultaneously up to ~ 20 kb peak stress. This should give more accurate data on yield strength increase with pressure.

Extant Be shock-wave data of interest to our programs do not exceed 24 kb peak stress. Asay's work should provide the requisite data to test our equations of state and constitutive models at more relevant stress levels.

Additional work on the mechanical properties will be undertaken by C. Honodel of B Division, who will do cylinder deceleration experiments similar to those of Wilkins and Guinan.⁹ This should provide data on the yield strength at large strains.

The majority of experiments will be done using specification 1162 Be, but a few shots are scheduled with specification 1319 material.

FIGURE 1.

TABLE I

Problem	V_F (mm/ μ s)	B		A		σ (kb)	η	T(K)	Y(kb)
		Material	Thickness (mm)	Material	Thickness (mm)				
1	0.835	2-cut Sapphire	3.125	PMMA	3.125	99	1.074	332	5.3
2	0.835	"	"	WC	3.125	119	1.087	338	5.6
3	0.2065	Be	4.0	PMMA	3.125	179	1.128	367	6.3
4	0.2065	"	"	Cu	2.5	265	1.182	387	7.4
5	0.199	Cu	2.5	PMMA	3.125	258	1.174	407	7.3
6	0.199	"	"	WC	3.125	316	1.210	422	8.0

TABLE I

TABLE II

Material	ρ_0 ($\frac{g}{cc}$)	C ($\frac{cm}{\mu s}$)	S	γ_D	a	γ_0 (Mb)	G_0 (Mb)	G_p/G_0 (MP^{-1})	References
WC	14.9	0.52	1.16	1.5	0	0.051	2.53	----	1,2
LiF	2.637	0.509	1.405	1.69	0.34	0.0036	0.490	5.0	3-7
Al ₂ O ₃	3.985	1.119	1.0	---	---	---	---	---	8

FIGURE 2

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