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Title: COMPOSITE LINER, MULTI-MEGABAR SHOCK DRIVER DEVELOPMENT

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Composite Liner, Multi-Megabar Shock Driver Development*

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Abstract

The multi-megabar shock driver development is a series of experiments in support of the Los Alamos High Energy Density Physics Experimental Program. Its purpose is to develop techniques to impact a uniform, stable, composite liner upon a high Z target to produce a multi-megabar shock for EOS studies. To date, experiments have been done on the Pegasus II capacitor bank with a current of ~12 MA driving the impactor liner. The driving field is ~200 T at the target radius of 1cm. Data will be presented on the stability and uniformity of the impactor liner when it impacts the target cylinder. Three experiments have been done with emphasis on liner development. Shock pressures greater than a megabar have been produced with an Al target cylinder. A Pt target cylinder should produce shock pressures in the 5-megabar range.

Introduction

Work at Los Alamos toward producing multi-megabar shocks in high Z materials is important in equation of state studies. The goal of the work is to produce shock pressures of 15 megabars on Atlas, a 23MJ pulsed power machine presently under construction at Los Alamos. The preliminary experiments conducted on Pegasus, a 4.3 MJ machine, have been done to examine liner stability and to develop diagnostic techniques. The experiments are conducted in a coaxial geometry with a cylindrical liner impacting upon a cylindrical target. The impactor liner is driven by JxB forces from a current pulse supplied by a capacitor bank. The experiments on Pegasus have been done with a current pulse of 12 MA with a rise time of ~ 7μs. Atlas will be capable of providing a current pulse of ~30MA with a rise time of ~5μs. The liner must be designed so that the inner surface is solid when the target is struck by the impactor. The liner must be thick enough so that magnetic diffusion does not allow the driving current to penetrate and melt the inner surface of the liner. This constraint must be balanced by designing a liner to be thin enough to achieve the highest possible velocity upon impact with its inner surface intact. High Z materials yield the highest shock pressures, but would necessarily make a massive liner that would not have sufficient velocity for the required shock pressures. Therefore, composite liners have been used to balance these constraints. An Aluminum liner with a high Z inner coating gives the best compromise. The disadvantage of this procedure is that the shock duration lasts only for a 2-way acoustic transit time of the thickness of the high Z layer.

Experimental Procedure

The composite liners used thus far on Pegasus have been an Al liner with a Pt inner layer. Since these experiments have been developmental, the production of maximum shock pressures has not been an issue. For this reason, (and for economics), the target cylinder has been Al instead of Pt. Megabar I used a larger diameter (4cm), thinner, liner. The perturbations on the outer surface of the liner actually penetrated into the Pt. liner during the implosion. This performance was unsatisfactory. Megabar II was a smaller, thicker, Al liner. This liner performed satisfactorily. Megabar III was the Megabar II liner with a 1g coating of Pt on its inner surface (15 microns thick). The load is shown below in Fig.1

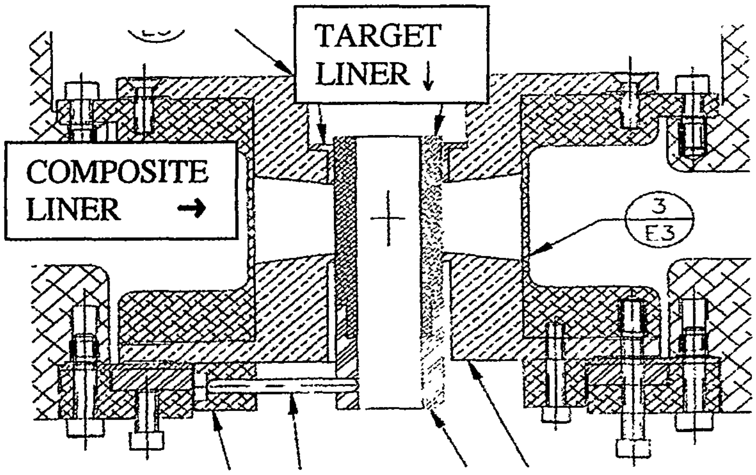
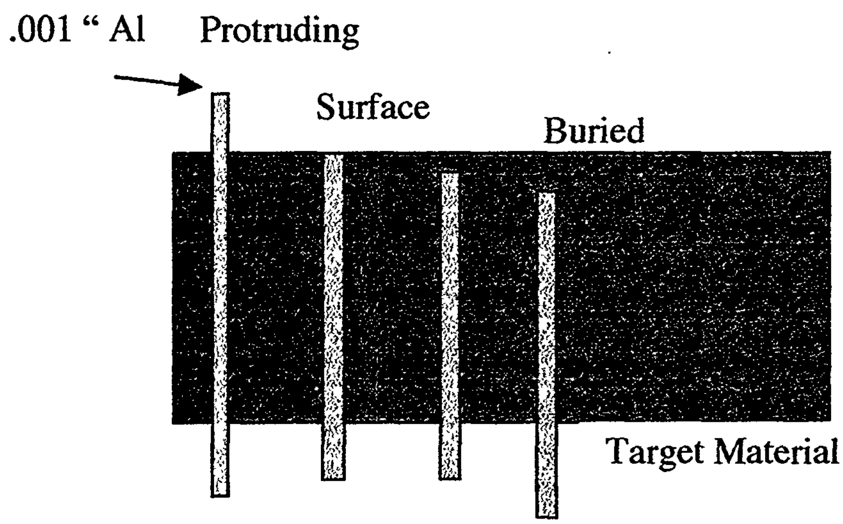


Fig.1 Megabar III load.
Impactor cylinder radius=2.4cm, height=2cm, mass=10g; inner coating of Pt=15 microns thick, mass=1g; target cylinder is Al, radius=1.1cm. The "glide planes" are sloped to provide good current contact during the run-in of the impactor liner.

Fiber optic pins are inserted into the target liner to measure the time of arrival of the liner and the shock velocity. The pin arrangement is shown below.

CROSS SECTION OF OPTICAL IMPACT PINS IN THE TARGET



Optical fibers are encased in .029" diameter hypodermic tubing and inserted into the target material as shown. Foil on the end of the pin keeps out ambient light. The fibers light up due to heating when a shock enters the end. At the output end of the fibers, photomultiplier tubes detect the signals and send them to digitizers.
Buried pins measure shock speed in the target material.

Fig.2 Arrangement of fiber optic pins in the target cylinder. (shown horizontal; cylinder is vertical)

Radiographs are taken at three radial positions and times to monitor the implosion quality. They yield both quantitative and qualitative data. The inferred velocity is consistent with the pin measurement. The layout is shown in Fig.3 below.

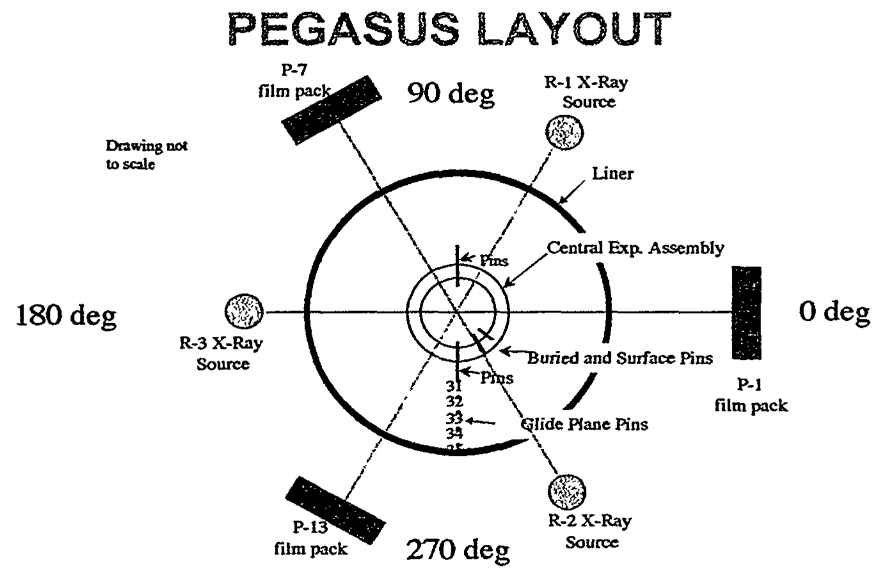


Fig.3 Layout of flash radiography

Fig. 3 above shows the location of the radiographs. Radiographs were taken at 7.2μs, 7.6μs and 7.95μs after current start.

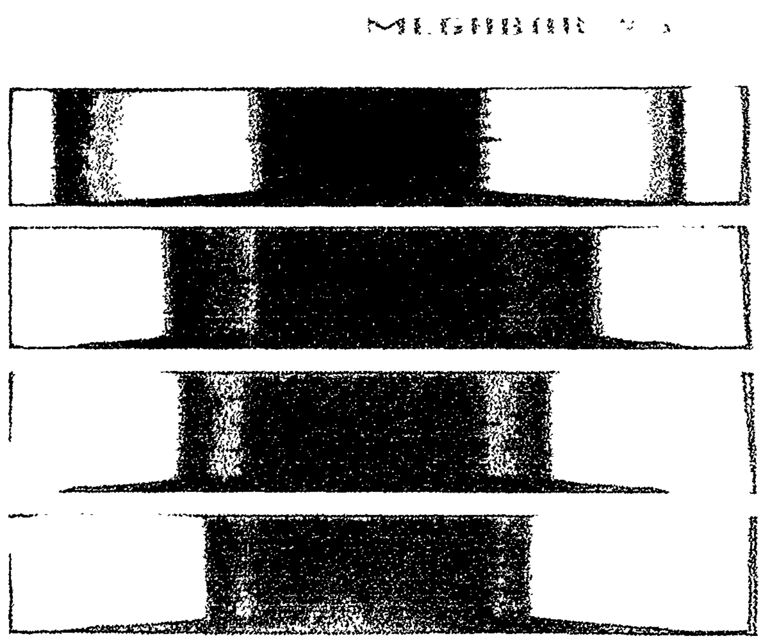


Fig.4

Fig.4 is (from top to bottom) the static radiograph, and implosion pictures at 7.2μs, 7.6μs, and 7.95μs. The fiber optic pins can be seen protruding from the target cylinder in the static picture. While the outer surface of the impactor liner has perturbations, the fiber optic pins show that the inner Pt. surface is uniform to within 20 microns. The velocity at impact as measured by the pins is~7mm/μs. This would be expected to produce a shock pressure of over 1-MB in the Al target liner. The pins also showed that the implosion was off center by ~0.4mm. This amount of variation could easily be explained by tolerance buildup in the assembly of the power flow channel.

Conclusions

The preliminary megabar experiments on Pegasus have demonstrated that a stable, composite, liner can be made to impact a target in a convergent cylindrical geometry and produce shock pressures in excess of 1 megabar. The diagnostics have been demonstrated to be accurate enough to make the pertinent measurements. These results support design work for experiments on Atlas, which will produce shock pressures of 15 megabars.

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