

one must change units of m from gravitational units to absolute units, using

$$W = mg_0 \quad (3)$$

Here, g_0 is a conversion factor and definitely a constant. (It is unfortunate that people associate g_0 with gravity.) One now has

$$d^2y/dt^2 = -g - (g_0\beta\rho/2)V(dy/dt) \quad (4)$$

In similar fashion, one gets

$$d^2x/dt^2 = -(g_0\beta\rho/2)V(dx/dt) \quad (5)$$

The remaining equations in Blum's paper are now easy to correct, as follows. Wherever g is multiplied by β , it should be the conversion factor g_0 , and wherever g is divided by V^2 , this is the gravitational acceleration $g(y)$. In addition to this, the statements under Blum's Eq. (26) should be modified, and his Eq. (45) should read

$$J(y) = g_0 \int_0^y \rho dy \quad (6)$$

which is easier to evaluate.

As mentioned earlier, these corrections do not invalidate the calculations made in the paper, nor is it this author's purpose to be supercritical of a fine paper. However, this failure to distinguish gravitational acceleration from the conversion factor relating mass in gravitational units to mass in absolute units is a common error and leads to much confusion. It is unfortunate that the word "pound" is allowed to serve the dual role of a force unit as well as a mass unit and that a hybrid system is used continually. It would be better if either the gravitational system of units were adopted consistently and the slug allowed to become a respectable mass unit for all technical work, or the absolute system of units were adopted with stature given to the poundal as a force unit.

The ballistic pendulum data indicated impulse levels five times larger than measured on a thrust stand that had the entire accelerator system mounted on it. The tendency to obtain a larger impulse with a ballistic pendulum than on a thrust stand apparently has been observed by other investigators also.

A recent conference⁶ concerned with the exchange of information on thrust, mass, and power measurements of electric propulsion devices, and attended by those companies actively engaged in the field of electric propulsion, revealed that investigators in the electric propulsion field are using direct measuring thrust stands for performance analysis. None of the attendees reported the use of a ballistic pendulum.

References

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Comment on "Stresses and Strains in Solid Propellants During Storage"

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Comment on "Use of Ballistic Pendulums With Pulsed Plasma Accelerators"

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IN a recent note,¹ the authors concluded on the basis of only probe and calorimetric measurements that the impulse delivered by a pulsed plasma accelerator could not be determined reliably by a ballistic pendulum. This result is not surprising, for, even based upon the most elementary mechanical considerations, the nature of the momentum transfer from a pulsed plasma accelerator to the pendulum at best can be estimated only within a factor of 2. Indeed, matters are generally worse in that pressure force terms, temporal momentum variations, and ablative contributions from the surface of the pendulum introduce further departures between indicated impulse and the actual impulse. An excellent discussion of thrust of intermittent propulsive devices is presented, for example, in Ref. 2.

The shortcomings in determining reliable, accurate impulse data of a pulsed plasma accelerator by means of a ballistic pendulum have been reported previously.^{3,4} In Ref. 4, impulse measurements of a pulsed plasma accelerator as obtained directly on a thrust stand have been compared with the results obtained by using a carefully designed ballistic pen-

AN analysis of the expected deformation in a perforated, horizontal grain of viscoelastic propellant attached to a rigid case has been reported recently by Lianis.¹ However, as noted by Lianis, the calculated displacements were suspiciously large, and long-time creep data were needed for a better evaluation of the expected deformation.

The results of long-time creep compliance tests conducted in this laboratory show, as Lianis suspected, that extrapolation of the relatively short-time compliance data reported by Blatz² is not valid but results in an inordinately large predicted displacement.

Creep data for two propellants with different binder systems are shown in Figs. 1 and 2. As the figures indicate, it is possible to fit the data at long times (>50 hr) with a constant creep rate function, but it is not possible to deduce this function from creep tests of only a few hours duration.

For purposes of comparison with Lianis' results, one calculates that for the propellant shown in Fig. 1, in a configuration wherein $R = 20$ cm and $\mu = 2$, the maximum surface radial displacement u is

$$u_{\max} = \{39.0 + [0.045(t)/\text{hr}]\} \times 10^{-3} \text{ cm}$$

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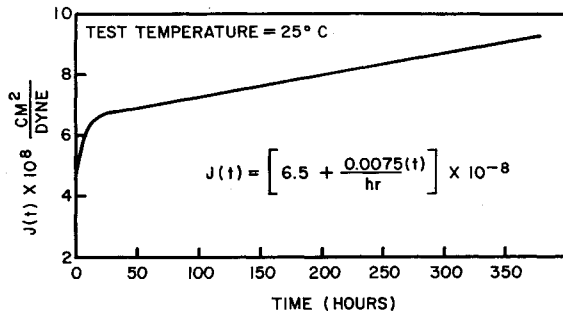


Fig. 1 Creep function of propellant X

The density was taken as 1.8 g/cm³, a realistic figure for the propellant shown. After a storage period of 22 days and 9 hr, the maximum radial displacement becomes 6.32×10^{-2} cm, as compared with 1 cm obtained by Lianis from extrapolation of Blatz's data. This result does not lead one to predict failure at relatively short storage times. It may, in fact, be shown that, based upon the data presented in Fig. 1, a storage period of 890 days would be required to obtain a maximum displacement of 1 cm.

It is interesting to note that, although the propellant represented in Fig. 2 is appreciably more compliant in the short-time region than that shown in Fig. 1, a calculation using the same geometric parameter and density, with the

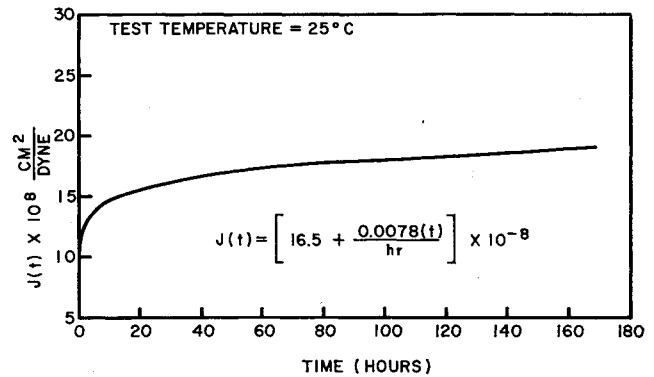


Fig. 2 Creep function of propellant Y

creep function

$$J(t) = \{16.5 + [0.0078(t)/\text{hr}]\} \times 10^{-8} \text{ cm}^2/\text{dyne}$$

shows that 813 days would be required for a 1-cm displacement. Again, failure would not be expected at short storage times.

References

- ¹ Lianis, G., "Stresses and strains in solid propellant during storage," ARS J. **32**, 688-692 (1962).
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AIAA-ASME Hypersonic Ramjet Conference

(Secret)

NAVAL ORDNANCE LABORATORY

APRIL 23-25, 1963

WHITE OAK, MARYLAND

The aim of this conference is to provide the specialists in airbreathing propulsion with a coverage in depth on the subjects of hypersonic ramjets and advanced airbreathing systems. The closest previous approach to this problem was the unclassified Fourth AGARD Propulsion and Combustion Colloquium held in Italy in 1960. Since that time, interest in applications of hypersonic ramjets in launching systems, for aerospace planes, for research aircraft and other manned aircraft, and for missiles has grown considerably.

In addition to the growing interest in airbreathing systems potentialities, many fundamental and applied research projects in the categories listed below should be reaching appropriate reporting stages during the winter, and more ambitious testing techniques are being established all the time. Hence, the meeting will be of value not only to scientists conducting fundamental studies, but to propulsion engineers, systems analysts, vehicle designers, government and military sponsors directly concerned with such work, and industrial research managers who have invested funds in it. However, the program committee wishes to emphasize that the papers accepted must be objective and of high technical caliber and should not contain material (such as descriptions of company capabilities and sales pitches) that is irrelevant to the objective of presenting and evaluating technical data.

The meeting will be confined to single sessions consisting of approximately six papers each. Sessions are as follows: Advanced Airbreathing Systems, Research on Fundamentals, Hypersonic Air Inlets, Advanced Airbreathing Combustion Research, Kinetics and Nozzle Research, and Testing Techniques for Hypersonic Airbreathers.

It is expected that each accepted classified paper will be published by the author's employer and will be available by May 1, 1963 to those who submit properly endorsed requests through appropriate channels.

See December 1962 ARS Journal, page 1845, for further details