A major purpose of the Technical Information Center is to provide the broadest dissemination possible of information contained in DOE's Research and Development Reports to business, industry, the academic community, and federal, state and local governments.

Although a small portion of this report is not reproducible, it is being made available to expedite the availability of information on the research discussed herein.

1

LA-UR -89-2622

Los Alamos National Laboratory is operated by the University of California for the United States Department of Energy under contract W-7405-ENG-36

LA-UR--89-2622

DE89 016599

TITLE: CALIBRATION CURVES FOR SOME STANDARD GAP TESTS

AUTHOR(S): Allen L. Bowman and Stanley C. Sommer

SUBMITTED TO: 1989 DEA-A-76-G-1218 meeting, August 22-24, 1989, at Picatinny Arsenal, New Jersey

MASTER

Los Alamos Los Alamos National Laboratory Los Alamos, New Mexico 87545

FORM NO 836 R4
ST NO 2629 5/81

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

CALIBRATION CURVES FOR SOME STANDARD GAP TESTS

Allen L. Bowman and Stanley C. Sommer
Los Alamos National Laboratory
Los Alamos, New Mexico 87545 USA

INTRODUCTION

The relative shock sensitivities of explosive compositions are commonly assessed using a family of experiments that can be described by the generic term "Gap Test." These gap tests include a donor charge, a test sample, and a spacer, or gap, between two explosive charges. The donor charge, gap material, and test dimensions are held constant within each different version of the gap test. The thickness of the gap is then varied to find the value at which 50% of the test samples will detonate. The gap tests measure the ease with which a high-order detonation can be established in the test explosive, or the "detonability,"[1] of the explosive. Test results are best reported in terms of the gap thickness at the 50% point. It is also useful to define the shock pressure transmitted into the test sample at the detonation threshold. This requires calibrating the gap test in terms of shock pressure in the gap as a function of the gap thickness. It also requires a knowledge of the shock Hugoniot of the sample explosive.

The calibration curves (pressure and particle velocity as a function of gap thickness) of the NOL Large Scale Gap Test (LSGT) (developed at the Naval Surface Weapons Center, White Oak, Maryland) have been determined experimentally,[2] and some calibration data exist for other gap tests that are in use at present. These experiments are difficult and expensive to perform, and, thus, detailed experimental calibration curves are not available for all gap tests. We used the 2DE reactive hydrodynamic code[3] with Forest Fire burn rates[4] for the donor explosives to calculate calibration curves for several gap tests. The model calculations give pressure and particle velocity on the centerline of the experimental set-up and provide information about the curvature and pulse width of the shock wave.

EXPERIMENTS AND MODELS

We modeled the LSGT, the Expanded Large Scale Gap Test (ELSGT) (also developed at the Naval Surface Weapons Center), the Los Alamos National Laboratory Standard Gap Test (LANLGT), and the Small Aquarium Test (SAQT) (developed at Naval Weapons Center, China Lake, California). The LSGT[2] and the SAQT[5] use the same donor, a pentolite cylinder (ρ=1.56) 2 in. long and 2 in. in diameter. The ELSGT,[6] which is really just a larger version of the LSGT, uses a pentolite donor 3-3/4 in. long and 3-3/4 in. in diameter. The LANLGT[1] uses a PBX 9205 donor (a plastic-bonded explosive with 92% RDX, 6% polystyrene, and 2% dioctyl phthalate) 4 in. long and 1-5/8 in. in diameter. The LSGT and ELSGT use polymethyl methacrylate (Plexiglas) for the gap material, which has the same diameter as the donor. The LANLGT uses 2024 Dural for the gap material, and the SAQT uses the water in which the test assembly is immersed for the gap material.

The calculations model the gap test assemblies in axisymmetric (cylindrical) geometry. Gap lengths of 4 to 6 in. are used in the models. The cell spacing is 1.032 mm in the LANLGT model and 1.27 mm in the other three tests. The donor explosives are initiated with a hot spot of fully reacted explosive (gaseous products) in which the density and energy are initialized to the C-J isentrope at 1.02 x C-J pressure. The hot spot for the pentolite donors is 2.54 mm long by 3.81 mm radius to model the effect of the detonator. The hot spot for the LANLGT is 3.06 mm long by 15.9 mm radius to model the effect of the booster pellet. The SAQT model is surrounded by water that extends through continuum boundaries, while the other tests are modeled in air.

RESULTS AND DISCUSSION

The behavior of the donor and gap for each test are shown with a series of isopycnic (constant density) contour plots. The curvature of the shock front is derived from these plots. The calibration curves of pressure and particle velocity are presented in both tabular and graphical form. The pulse width at the centerline is obtained from x-t diagrams that show the shock front, the point at which the pressure has decayed to 1/e times the peak pressure, and the back surface of the gap (the interface between the water and the donor products for the SAQT). The calculated pressure calibration curve for the LSGT is compared with the experimental curve[2] in Fig. 1. The calculated curves for the ELSGT and the SAQT are in similarly good agreement with experimental data.

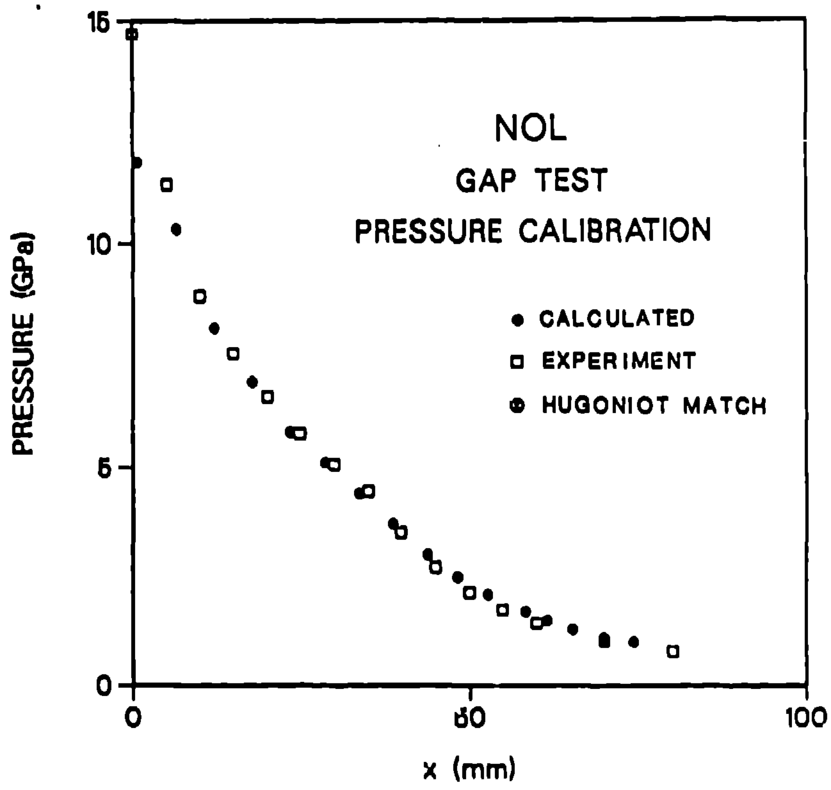

Fig. 1. Pressure calibration for the NOL LSGT.

Previous model calculations on the LSGT[7] generated a pressure calibration curve that was significantly higher than the experimental curve. The improved results are due to changing the burn model for the pentolite from a C-J volume burn[8] to a Forest Fire burn.[4] This was done by using an experimental Pop Plot for pentolite at (ρ=1.67) (Ref. 9) and changing it to the donor density (ρ=1.56) using a method proposed by Forest.[4] The modification in the donor burn model moved the calibration curve into agreement with the experimental results and provided calculated detonation thresholds in the SAQT that agree well with the experiment.[10]

REFERENCES

1. M. J. Urizar, S. W. Peterson, and L. C. Smith, "Detonation Sensitivity Tests," Los Alamos Scientific Laboratory report LA-7193-MS (1978).

2. J. O. Erkman, D. J. Edwards, A. R. Clairmont, Jr., and D. Price, "Calibration of the NOL Large Scale Gap Test: Hugoniot Data for Polymethyl Methacrylate," Naval Ordnance Laboratory report NOLTR 73-15 (1973).

3. J. D. Kershner and C. L. Mader "2DE: A Two-Dimensional Continuous Eulerian Hydrodynamic Code for Computing Multicomponent Reactive Hydrodynamic Problems," Los Alamos Scientific Laboratory report LA-4846 (1972).

4. C. A. Forest, "Burning and Detonation," Los Alamos Scientific Laboratory report LA-7245 (1978).

5. K. J. Graham, H. P. Richter, C. D. Lind, and A. H. Lepie, "Shock Sensitivity of Damaged Explosives and Propellants," presented at the 1987 JANNAF Propulsion Systems Hazards Meeting, US Army Missile Command, Redstone Arsenal, Alabama, March 30-April 3, CPIA Publication 464, pp. 145-154 (1987).

6. T. P. Liddiard and D. Price, "The Expanded Large Scale Gap Test," Naval Surface Weapons Center report NSWC TR 86-32 (1986).

7. A. L. Bowman, J. D. Kershner, and C. L. Mader, "A Numerical Model of the Gap Test," Los Alamos Scientific Laboratory report LA-8408 (1980).

8. C. L. Mader, Numerical Modeling of Detonations (University of California Press, Berkeley, 1979).

9. D. Price, A. R. Clairmont, Jr., and J. O. Erkman, "The NOL Large Scale Gap Test. III. Compilation of Unclassified Data and Supplementary Information for Interpretation of Results," Naval Ordnance Laboratory report NOLTR 74-40 (1974).

10. A. L. Bowman and S. C. Sommer, "Analysis of the Aquarium Gap Test," LA-UR-88-891, presented at the 1988 JANNAF Propulsion Systems Hazards Subcommittee Meeting, The Aerospace Corporation, Los Angeles, California, March 28-30 (1988).