DETONATION PRESSURE MEASUREMENT
WITH AQUARIUM TESTS

Paul E. Kramer

DEVELOPMENT DIVISION

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Mason & Hanger-Silas Mason Co., Inc.
Pantex Plant
P. O. BOX 647
AMARILLO, TEXAS 79177
806-335-1581

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ABSTRACT

Many of the technical problems of applying the detonation electric effect to aquarium tests were solved but additional tests are required to determine if the method is operational.

In the meantime, questions about the aquarium test itself have arisen which will require investigation.

DISCUSSION

The aquarium test has been used at Pantex for several years to measure detonation pressures of explosives. Previous reports(1) discussed attempts to use the detonation electric effect (DEE) to replace optical (streak camera) coverage of these tests. One report(2) indicated that problems encountered in these efforts had prompted investigation of alternate methods. During the current period, emphasis returned to the use of DEE.

In this method, a Plexiglas disc is supported a small distance (~ 3 mm) from the output face of the test explosive. The resulting gap is filled with distilled water and DEE is used to determine when the detonation-shock wave crosses the two interfaces (explosive-water and water-Plexiglas). Early in the work, it was found that the Plexiglas had to be supported directly on the explosive output face to provide the necessary dimensional stability. It was found that an aluminum ring slightly smaller than the circumference of the explosive cylinder worked well and also provided shielding from electrical noise generated at places other than the output face. The entire shot assembly was immersed in water, with a small opening in the aluminum spacer ring allowing water flow between the gap region and the surrounding bath.

The signal at the explosive-water interface is difficult to monitor and in many tests the background noise level prevented reception of a good signal. For purposes of noise suppression, the water bath was replaced with oil and the water gap region was sealed. The signals obtained with this configuration were significantly better than obtained previously, but it was found that thermal expansion forces generated within the sealed gap caused enough distortion to seriously affect the shock transit times.

The sealed gap assembly was modified by drilling two small holes in the aluminum spacer ring. These holes are small enough to prevent mixing of the oil and water, yet large enough to allow relief of expansion-induced

(1) P. E. Kramer, *Sensitivity and Performance Testing of High Explosives* (January-December 1974).

(2) P. E. Kramer, *Sensitivity and Performance Testing of High Explosives*, MHSMP-75-40S (July-September 1975).

pressure. Also, water is injected through the holes into the gap just prior to firing so that potential problems from extended exposure to water are eliminated.

Eight assemblies using a 56 mm diameter by 56 mm long piece of LX-14 on a P-022 lens were prepared. Four had a gap of about 2.5 mm and four were about 3.2 mm. The tests were conducted and good DEE signals were obtained. Although the scatter in each group was larger than desired, the averages of the two groups were essentially identical. After using the shock data to calculate pressure and particle velocity in the water, the detonation pressure for the LX-14 was calculated assuming an ideal gas equation of state for the detonation products. The resulting value was 34.3 GPa, a disappointing result because earlier work at Pantex on similar formulations indicates a pressure of 36 to 36.5 GPa for LX-14. A standard aquarium shot (optical) was then conducted with the same test geometry and yielded a value of 34.0 GPa. Thus, excellent agreement was obtained between the optical and DEE methods in the same geometry but these results are in serious disagreement with previous measurements.

It was at this point that questions about the aquarium test and our understanding of it began to arise.

Data from one aquarium test on RX-04-EE, an almost identical formulation, indicated a pressure of 36.0 to 36.5 GPa for that explosive. A magnesium flyer plate series had also been conducted. The results of that series had been rather strange but were interpreted to yield a pressure of 35.5 to 36.0 GPa. Both of those results were obtained with 76 mm diameter by 114 mm long explosive samples initiated by a P-040 lens.

An additional series of aquarium shots was conducted using 56 mm diameter LX-14 samples in these configurations:

1. 56 mm long, initiated by SE-1 detonator and a 13 mm x 13 mm PBX 9407 booster.
2. 112 mm long, same initiation.
3. 56 mm long, initiated by P-040 lens.

Pressure measurements for all tests were in the range of 33-34 GPa.

These results were somewhat consistent with previous test results on RX-04-EG, another HMX/Estane formulation. Based on HMX/Estane aquarium test results with P-040 initiated 76 mm diameter by 114 mm long specimens, RX-04-EG had been expected to exhibit a pressure of about 38 GPa. Four aquarium shots with P-022 initiated pieces of 51 mm diameter (lengths of 51 and 76 mm) gave values of 35 to 36 GPa. (Tests with LX-10 and PBX 9404 had shown excellent agreement between the same two geometries.)

At present there are at least four possible explanations:

1. The aquarium test is much more geometry dependent than previously believed.
2. The detonation pressures of HMX/Estane formulations are much lower than previously believed.
3. The detonation pressures of HMX/Estane formulations are very diameter dependent (this is quite unlikely at these diameters).
4. HMX/Estane formulations behave abnormally in aquarium tests.

CONCLUSIONS

Definite progress has been made in the application of DEE to aquarium tests and good agreement with optical results has been achieved for one explosive in one geometry. Scatter in the results needs to be reduced. Investigation should continue into other explosives and other geometries.

In the meantime, serious questions about either the aquarium test or our understanding of it have arisen. These problems indicate the need for extensive investigation of geometry effects and into the possibility that some explosives are not suited to aquarium testing for reasons presently unknown.