SPRAYED PETN CHARGES

J. K. Boettner

*JUNE 1971
FINAL REPORT
P.O. F29601-70-7-0007*

Test Fire Report Prepared

For

*Air Force Weapons Laboratory
Kirtland AFB, New Mexico*

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

Mason & Hanger-Silas Mason Co., Inc.
Pantex Plant

P. O. BOX 647
AMARILLO, TEXAS 79105
806-335-1581

operated for the
ATOMIC ENERGY COMMISSION
under

U. S. GOVERNMENT Contract DA-11-173-AMC-487 (A)

SPRAYED PETN CHARGES

J. K. Boettner

June 1971
Final Report
P.O. F29601-70-7-0007

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Test Fire Report Prepared
for
Air Force Weapons Laboratory
Kirtland AFB, New Mexico

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

**Portions of this document may be illegible
in electronic image products. Images are
produced from the best available original
document.**

SPRAYED PETN CHARGES

ABSTRACT

A project for the Air Force Special Weapons Center^a is to develop, test, and deliver thin explosive matrices on aluminum and/or copper foil Mylar laminates. This report briefly discusses problems encountered with the recording of manganin pressure gage data.

DISCUSSION

Firing Site work began on this project November 5, 1970. Early work consisted of familiarization of the manganin gage power supply, gages, and gage mounting techniques by the operating personnel. Four tests were fired on November 5 and 6 as an early attempt at recording pressure and impulse from HE loads(1). The tests were mounted in a vertical position so a framing camera record could be made for each. Problems encountered during this series were noise on the manganin gage oscilloscope records induced from the capacitor discharge current, and extreme sloping of the "baseline" of the pulsed manganin gages. HE tests were discontinued at this time until the gages and the power supplies could be studied for causes of the sloping "baselines."

The pressure recording system was checked by connecting a gage to a power supply, and after balancing the gage bridge, triggering the system. An oscilloscope recording was made for each of the remaining gages, with only one of the remaining gages showing an adversely sloped "baseline." This gage burned out when pulsed a second time for verification.

Testing continued with the capacitor bank at this point. A Manganin gage was mounted in the gage block, and a bare aluminum mesh was fired over the face of the gage in an effort to determine the extent of the noise in the system. The oscilloscope and gage power supply were isolated from electrical ground and from the gage block. The gage block was also isolated from ground. The power supply was not triggered when the capacitor bank fired, so that a measure of noise being induced into the system could be determined. The noise was random in frequency and amplitude and lasted for approximately the same length of time as the capacitor discharge current.

In an effort to shield the signal cables from outside electromagnetic fields, aluminum foil was wrapped around the cables and tied to the same ground as the capacitor. The oscilloscope and gage power supply remained isolated from ground. No improvement in noise was noted.

Connecting the gage block to ground resulted in the increase of noise amplitude and duration due to the capacitor current shorting to the block upon burst of the aluminum mesh.

^aAFSWC delivery order F29601-70-7-0007.

(1) "Shaped PETN Charges," G. T. Schmitz, Pantex MHSMP-71-19.

At this point it was decided that a quarterwave tuning stub (an open ended coaxial cable) placed at the gage would help eliminate the higher frequency noise that was being induced into the system at that point. The power supply and the oscilloscope monitoring the gage were isolated from ground, and the test fire consisted of bare aluminum mesh. Several tests were conducted in this manner in which varying lengths of tuning stub were used in an effort at optimizing the system. Although a 9-inch tuning stub did not eliminate the high frequency noise at the time of mesh burst, it did substantially reduce the high frequency noise after that time.

It then became apparent that some lower frequency interference needed to be eliminated. A quarterwave tuning stub was applied to the signal line at the input to the gage power supply. Again several tests were made to optimize the system. Addition of this stub necessitated a change in the previous one, until relatively noise-free records could be obtained with a 12-foot stub at the gage and an 83-foot stub at the gage power supply. However, noise still persisted for 1 μ sec after mesh burst time.

A negative signal of approximately 0.5 volt was recorded at approximately 1.5 μ sec after mesh burst with this system, and the introduction of HE to the mesh resulted in a negative signal of approximately 0.8 volt at the same relative time. The polarity of this "signal" was opposite to that expected. Using another power supply resulted in a positive signal, but further testing revealed it to be an induced signal and not one resulting from the pressure pulse. Fig. 1 is a typical recording of the gage output. It should be noted that, for some unexplained reason, a signal like that of Fig. 1, even with the same test conditions, did not appear again. Fig. 2 is a basic diagram of the instrumentation setup.

Further testing revealed that grounding the oscilloscope made little difference in the basic noise level and duration.

At this point it was decided to determine what effect the gage orientation with respect to the direction of capacitor current discharge had upon the amount of noise induced at the gage. The oscilloscope records indicated that although there was some reduction in noise amplitude when the gages were oriented in such a manner so as to minimize magnetic pick-up from the capacitor discharge current, the bulk of the noise still remained in the system.

Upon consultation with J. Suttle and Lt. M. Hill, Air Force Special Weapons Center, Kirtland AFB, it was decided to enclose the gage in a Faraday shield. This was done by covering the "face" of the gage, which was mounted in a copper sleeve, with a piece of 1 mil brass shim. The brass shim and the copper sleeve were then connected to the coaxial shield of the gage signal cable with a short piece of copper ribbon. The gage oscilloscope was grounded and constituted the only ground point in the instrumentational system. The gage oscilloscope trace was "blown" off-screen within 1 μ sec after initiation of current to the mesh, and remained off-screen for a period of time greater than 50 μ sec. A possible explanation for this is that some of the current from the capacitor bank shorted to the Faraday Shield and flowed to ground through the gage signal cable shield, thus causing a voltage drop at the oscilloscope input sufficient to drive the trace off-screen.

The next test was essentially the same as that just outlined, except that the single grounding point was a wire attached to the Faraday Shield (see Fig. 3), still attached to the coaxial shield of the signal cable, and to a metal stake driver into the earth at a nearby point. The gage oscilloscope and the gage power supply were isolated from ground. Although the oscilloscope trace did not go off-screen as quickly with this arrangement, little difference was noted between the two tests.

For a third test, the system ground was returned to the oscilloscopes and the quarterwave tuning stubs were removed from the signal cable. Furthermore, the gage block and the gage power supplies were isolated from ground. The gage block was covered with a sheet of 10 mil Mylar in order to inhibit any arcing of the high voltage mesh firing system to the gage block and Faraday Shield surrounding the Manganin gages. Although noise was still present at the time of mesh burst, the oscilloscope trace returned to "baseline" approximately 3 μ sec after mesh burst. The trace was relatively noise free for the remainder of the sweep.

Because time was growing short, it was decided to accept this system for the attempt at recording the pressure generated by the proposed HE systems. Consequently, a PETN loaded (0.022-inch average thickness) 7-1/2 x 7-1/2 inch aluminized Mylar mesh test piece was fired and monitored with two Manganin pressure gages. The oscilloscope recordings are shown in Fig. 4. From these records it is immediately obvious that there is a significant difference ($\sim 31 \mu$ sec) in the arrival time of the pressure pulse to the two gages. The Manganin gages indicated pressures of 3.9 kbars and 6.5 kbars respectively. Impulse measurements were taken by a compressible copper ball placed in an aluminum housing beneath an aluminum slug which is driven down by the test explosive. The impulse measurements are obtained by measuring the amount of deformation of the copper ball caused by the impact of the aluminum slug. Measurements obtained in this manner revealed an explosive impulse of 24 to 26 ktaps (1 tap = 1 dyne-sec/cm² = bar- μ sec).

Since there was a significant difference in the arrival times and because the measured pressure was low, it was surmised that a "sweeping" detonation had occurred across the face of the test piece. Consequently, a Beckman & Whitley Model 189A high speed framing camera was used with a similarly loaded test piece to verify this supposition. The first indication of detonation appeared 4 μ sec after the burst of the mesh. Furthermore, only a small amount of the HE had been consumed 9 μ sec later. Thus, it seems quite likely that a sweeping detonation had occurred on the previous instrumented test. Fig. 5 shows the framing camera record of this test. A second test was performed in which only an aluminized Mylar mesh was fired. The framing camera record indicated that the mesh was consumed within 1 μ sec, and therefore could not account for the long delay time associated with the HE of the previous test.

Testing PETN loaded aluminized Mylar mesh was discontinued at this time. Instead, efforts were focused toward the testing of PETN loaded copper mesh. In order to accommodate the capacitor bank capacity, the HE loaded copper mesh was reduced to 4 inches wide and 8 inches long. Subsequently, a copper mesh was loaded with an average thickness of 0.024 inch of PETN and fired. The pressure gage recordings (Fig. 6) indicate pressures of 8.0 and 9.4 kbars. They also indicate that a sweeping detonation had again occurred.

Consequently, a framing camera was employed to help determine the quality of the detonation. A copper mesh loaded with PETN at an average thickness of 0.0123 inch was fired. A significant amount of PETN powder found in the immediate vicinity after the shot indicated a "no-go." The framing camera record (Fig. 7) revealed some very slow reaction in the HE. Another shot was fired with the average HE thickness of 0.0311 inch. No residue was found from this test, and the framing camera record (Fig. 8) indicated a "spotty" initiation of the HE. Further analysis of the framing record indicates a detonation velocity range of 5.5 to 7.3 mm/ μ sec across the length and width of the PETN surface.

Further testing of initiating an explosive sheet by aluminum or copper mesh has been suspended.

FUTURE WORK; COMMENTS; CONCLUSIONS

A considerable amount of electrically induced noise has been encountered while trying to record, by a Manganin gage, the pressure generated from a mesh initiated explosive. This noise is present during the discharge of the main capacitor bank and interferes with the pressure data being acquired at that time.

Future work should include the development of a capacitor bank that could be quenched immediately after mesh burst so that the noise would not be present during the time of shock arrival at the Manganin gage element. An alternate solution would be to place an attenuator of sufficient thickness between the explosive face and the gage element so that the pressure pulse would be delayed to a time after the noise has subsided. Hugoniot calculations could then be applied to the data to determine the output pressure at the HE surface.

Future work should also include the development of a charge and/or an initiating system that will result in a more simultaneous output than the systems tested to date.

(a). Induced noise to the Manganin gage from the firing of an aluminum mesh.

Upper sweep: 0.5 v/cm
 Lower sweep: 5.0 v/cm
 Sweep speed: 2.0 μ sec/cm

(b). Capacitor current and dI/dt record from aluminum mesh firing.

Upper sweep: dI/dt at 200 v/cm
 Lower sweep: I at 2.0 v/cm (71.4 kamp/cm)
 Sweep speed: 1.0 μ sec/cm

Fig. 1

Fig. 2. Managnin Pressure Gage Instrumentational Set-up.

Fig. 3. Manganin Gage/Faraday Cage Arrangement

(a). Upper Sweep: 5 v/cm and 2 μ sec/cm. Lower Sweep: 5 v/cm and 5 μ sec/cm. Indicated Pressure: 6.485 kbars.

(b). Upper Sweep: 1 v/cm and 1 μ sec/cm. Lower Sweep: 2 v/cm and 2 μ sec/cm. Indicated Pressure: 3.923 kbars.

Fig. 4. Manganin Pressure Gage Recordings for a PETN Loaded Aluminum Mylar Mesh.

3.80 μ sec

5.70 μ sec

4.75 μ sec

6.65 μ sec

Fig. 5. Framing camera record showing the initiation of 0.022 inch of PETN by an aluminum mesh. The elapsed time from the first film indication of mesh burst is shown below each photograph.

(a). Upper Sweep: 1 v/cm and 1 μ sec/cm. Lower Sweep: 2 v/cm and 2 μ sec/cm. Indicated Pressure: 9.412 kbars.

(b). Upper Sweep: 1 v/cm and 1 μ sec/cm. Lower Sweep: 5 v/cm and 2 μ sec/cm. Indicated Pressure: 8.030 kbars.

Fig. 6. Manganin Pressure Gage Recordings for a PETN Loaded Mesh.

Zero

2.85 μ sec

0.95 μ sec

3.80 μ sec

1.90 μ sec

4.75 μ sec

Fig. 7. Framing camera record showing the initiation of 0.012 inch of PETN by a copper mesh. The elapsed time from the first film indication of mesh burst is shown below each photograph.

Zero

2.94 μ sec

0.98 μ sec

3.92 μ sec

1.96 μ sec

4.90 μ sec

Fig. 8. Framing camera record showing the initiation 0.031 inch of PETN by a copper mesh. The elapsed time from the first film indication of mesh burst is shown below each photograph.