MASTER

LIGHT PRODUCTION AT AN
EXPLOSIVE/AIR INTERFACE

C. E. Canada

DEVELOPMENT DIVISION

OCTOBER - DECEMBER 1976

*Normal Process Development
Endeavor No. 231*

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operated for the
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
under
U S GOVERNMENT Contract EY 76 C 04 0487

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ABSTRACT

Detonation front arrival time measurements are compared for an optoelectronic and an antenna technique. Fiber optics and photodiodes are used for the optoelectronic method while the antenna technique depends on radiated signals at an explosive/air interface.

Analysis indicates that signals measured by the respective techniques are not caused by the same physical mechanism; thus, even though the results are not directly comparable the signals should be self-consistent for a given technique. The optical signals were found to have greater jitter in time and larger variation in magnitude than those signals obtained by the antenna technique.

DISCUSSION

One test currently used at Pantex(1) to determine sensitivity to initiation of an acceptor explosive from a smaller diameter donor (such as MDF) depends on the generation of an electromagnetic signal when a detonation front arrives at an explosive/air interface. A typical test assembly used to determine sensitivity to initiation consists of a detonator, several MDF segments separated by sub-mil air gaps, and an acceptor pellet stack. Pulses generated at the air gaps and at the output surface of the acceptor stacks are monitored using an antenna as described by B. Hayes(2).

It should be noted that this radiation is probably not produced by the same mechanisms as those producing signals described by B. Hayes(3). Signals observed here are on the order of 0.1 volts whereas those described by Hayes had magnitudes of a few millivolts. Further, the MDF segments had to be electrically isolated for a signal to be measured here. The radiation observed by B. Hayes should be independent of such isolation.

The antenna monitored radiation observed here is probably the same as that radiation producing the prelight observed by R. Worley(4) in his studies of light production in a flasher gap. He identified four mechanisms within a flasher gap with the light produced called prelight, airglow, flasher light and afterglow. Prelight is produced when the detonation front is at or near a high explosive air interface and is thus not associated with the barrier forming the flasher gap. The duration of this radiation appears to be less than a nanosecond while frequencies involved encompass at least the entire visible spectrum.

Airglow arises from partial ionization of oxygen within a flasher gap before the shock front impacts the flasher barrier. This light also is independent of the barrier forming the flasher gap.

Flasher light which has a duration of about 20 ns arises when the shock front impacts the barrier thus increasing the ionization level of the gases within the air gap.

Afterglow which has an intensity greater than airglow typically exists until light quenching mechanisms dominate.

Although air gaps conveniently provide necessary electrical isolation discussed above, these gaps have been responsible for detonation propagation failures(5). An optoelectronic system to be described herein appeared to be a solution to these failures since it would not be necessary to completely sever the MDF column, only to notch it.

EXPERIMENTAL TECHNIQUE AND RESULTS

The optoelectric system used here was designed and constructed by L. D. Hanes(6). Fiber optics and photodiodes are used to provide measurable electronic signals. The photodiode circuit is shown in Fig. 1 and described in Reference 6, where the antenna technique is illustrated by Fig. 2. Optical signals are expected from each of the five fiber optics shown in the figure while radiation detectable by the antenna is expected at each of the three air gaps.

The initial experimental plan was to compare data from 0.21 g/m, 1.05 g/m and 2.10 g/m MDF (PETN). Previously data had been obtained from 0.21 g/m MDF(1), but observed jitter times implied that propagation failures could be expected. Data comparisons for 0.21 g/m MDF between optoelectric and interface produced signals were thus to provide assurances that propagation failures could be prevented by notching rather than severing the explosive column.

Unfortunately for the five tests conducted using 0.21 g/m MDF, none detonated the full length of the MDF. In three of these tests the detonation stopped at the first notch; in the other two the detonation stopped at the second notch. In none of the tests did the detonation cease at an air gap. However, the first air gap (nearest the detonator) could well have disturbed the detonation front so that any further perturbation would cause failure. Sufficient data were not taken to clarify where failure started so perturbation magnitudes arising from notching and severing are still undefined.

Data obtained are illustrated in Fig. 3. The oscillogram at the top shows signals from the antenna while the oscillogram at the bottom shows signals from the photodiodes. The bottom trace on each oscillogram is an expanded portion of each top trace.

Typical signals detected by the antenna have durations less than 10 ns whereas a typical optical signal has an envelope exceeding 500 ns and a risetime on the order of 50 ns. The optical envelope should contain parts of all four light phases described in Reference 3. However, most of the optical signals observed do not have fast-rising leading edges as they would have if the leading edge were produced by prelight radiation. Thus, optical envelopes seen here probably contain airglow, flasher light and afterglow components whereas the prelight component appears to be absent.

Fig. 1. Photodiode Circuit

Fig. 2. Test Assembly

Fig. 3a. Record from the Antenna Technique

Fig. 3b. Record from the Optoelectronic Technique

Even though different mechanisms may produce the signals for the two techniques, signals generated by a given technique should be self-consistent in time. Jitter in time should thus provide a quantitative comparison between the techniques.

Average velocities and standard deviations from the antenna technique were 7.10 ± 0.17 and 7.02 ± 0.11 km/s for the 1.05 and 2.1 g/m MDF respectively; corresponding values from the optical technique were 7.21 ± 0.20 and 7.03 ± 0.50 km/s, respectively. These values were obtained by reading the extreme leading edge of each signal measured.

CONCLUSIONS

For the systems compared the antenna technique clearly provides more readable signals with smaller jitter. Further, even though the air gaps have caused detonation failures, notching of the explosive column has not provided a useful alternative, at least for the tests conducted here.

It should be noted that these conclusions are strongly dependent on the geometry examined. They hold for explosive trains where light produced is viewed from a side on direction, but different results would probably be found if the light were viewed in a head-on direction.

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