Dist. Category UC-45

ESTABLISHMENT OF A CORNER TURNING
TEST CAPABILITY

Robert W. Ashcraft
&
George T. West

DEVELOPMENT DIVISION

NOVEMBER 1978

Process Development
Endeavor No. 106

MASTER

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor their employees, nor any of their contractors, subcontractors, or 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.

Printed in the United States of America
Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
Price: Printed Copy \$4.00 ; Microfiche \$3.00

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.

DISCLAIMER

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

ESTABLISHMENT OF A CORNER TURNING TEST CAPABILITY

Robert W. Ashcraft

&

George T. West

DEVELOPMENT DIVISION
(November 1978)

Process Development
Endeavor No. 106

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or 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.

ABSTRACT

A corner turning test capability has been established. While the test is not suited to be the sole criterion for lot qualification, it provides valuable information regarding explosive behavior near failure. Light enhancement and film record analysis techniques are discussed.

INTRODUCTION

The project reported herein had the following objectives:

1. Establish a technique similar to that of the LASL cylinder-on-cylinder corner turning test.
2. Determine the feasibility of using the technique for qualification of future TATB PBX lots.
3. Document the test procedure.

A technique has been established and is documented herein. Although the test results provide important information for lot qualification and explosive behavior, the resolution of the test is

not sufficient to be the sole criterion for acceptance or rejection of explosive lots.

TECHNICAL DISCUSSION

Test Description

In the cylinder-on-cylinder corner turning test, a long (at least 5 diameters) runup pellet of the test material near its failure diameter (20% greater than failure diameter was chosen for these tests) is used to initiate a larger pellet (see Fig. 1).

The runup pellet is initiated by an SE-1 detonator and a 13 mm diameter by 13 mm long PBX 9407 pellet followed by a 19 mm diameter by 25 mm long PBX 9404 pellet.

Fig. 1. Cylinder-on Cylinder Corner Turning Test

As described in other reports(1), TATB has unusual detonation wave propagation effects. Most "well behaved" explosives appear to detonate in all directions from the initiation point at about the same velocity (see Fig. 2), while TATB does not appear to detonate in the area adjacent to the initiation area (see Fig. 3).

Fig. 2.- Detonation Propagation in a "Well Behaved" Explosive

Fig. 3. Detonation Propagation in TATB Explosive

In the corner turning test, the breakout distance determined is a measure of the explosive's ability to "turn the corner," in other words to detonate in all directions. A "well behaved" explosive would have a very small (if not unmeasurable) breakout distance.

(1) R. K. Jackson, et.al., *Initiation and Detonation Characteristics of TATB*, "Proceedings of the Sixth Symposium (International) on Detonation" (August 24-27, 1976).

Light Enhancement Techniques

Three problems were encountered during the exploratory phases of the development of the test. The first problem encountered was a lack of sufficient light emanating from the detonating TATB PBX (RX-03-BB, a 92.5/7.5 weight percent TATB/Kel-F PBX, was chosen for these experiments). Two light enhancement techniques were tried and evaluated.

In the first light enhancement technique, a very thin coating of a mixture of aluminum silicofluoride and water (50/50 weight percent) was sprayed on the acceptor pellet along the outer edge and parallel to the pellet's cylindrical axis. While this technique provided adequate light on Kodak 2479 film with normal development (5 minutes in D-19, 21 C), the technique is sensitive to the particle size of the aluminum silicofluoride (one micron appeared to be a good size for the large particles), the consistency of the mixture (about that of a good paint) and the air brush used (the Badger Model 150 was the best tried). Also, since the aluminum silicofluoride is a poison(2), special precautions were needed in the spraying operation. All spraying was done under a hood and the operator wore a respirator and rubber gloves. The best set of instructions seemed to be that of "just barely covering the yellow RX-03-BB with a white coating." This technique was used with three 25 mm thick port glasses (tinted green), on twenty-two of the twenty-four tests. Best film magnification was 0.5 with a streak camera writing rate of 10 mm/ μ sec.

The second technique(3) utilized cigarette paper as a flasher gap material.

A narrow (2-4 mm) strip of cigarette paper was fixed onto the acceptor pellet using transparent tape. Although it did not produce the same level of light enhancement, this technique appears to be adequate with one 25 mm thick port glass (three port glasses caused too much light loss) and Tri X film developed in D-19 for 12 minutes at 21 C. Film magnification of 1 and streak camera writing rate of 10 mm/ μ sec were used. This technique is characterized by two significant advantages over the former:

1. It is non-toxic
2. It is easily applied.

Determination of Breakout Point

Another problem arose in shot assembly and in locating the breakout point with respect to a known location on the acceptor pellet. It was necessary to press-to-shape five 20 mm long pellets to form the donor charge. In order to minimize discontinuity effects due to glue gaps between the pellets, small semicircular pieces of plexiglas were used at each gap to hold the pellets together. Two fiducial copper wires (0.254 mm diameter) were placed across the light enhancing materials at nominally 6 mm and 32 mm from the donor end of the acceptor pellet. The exact distances were determined by scribe marks placed outside the field of view of the streak camera.

The entire assembly was held together with plexiglas plates at each end of the assembly, and these were connected by three threaded rods. Without the fiducial wires, it was very difficult to precisely estimate the distance of the breakout point from either end of the pellet.

(2) *N. Irving Sax, Dangerous Properties of Industrial Materials, Van Nostrand Reinhold Co., 1975.*

(3) *Private Communication, A. W. Campbell, LASL.*

Obtaining meaningful data from the streak camera film record presented the next problem. A typical film record is shown in Fig. 4. Although it appears to be easy to just read the location of the breakout directly at the point of minimum time, attempts to do so produced considerable scatter in the estimate of the breakout distance. As the reader magnification is increased, the "peak" appears to become flatter and the trace itself becomes less distinct. A more analytical approach, described below, yielded the best results.

The first step in calculating the breakout point was to obtain a set of distance-time points in the vicinity of the estimated breakout. The set of points should extend far enough to adequately describe the curvature of the streak image, but not too far or the function needed to adequately fit the data will be too complicated. A range including 3 to 4 mm on either side of the estimated breakout was found to be a suitable compromise, i.e., 3 to 4 mm of actual distance on the pellet. The film magnification was used to find the range on the streak record (the approximate values of the magnification were either 1.0 or 0.5). Approximately 40 readings were taken

on each record with nearly equal spacing on the independent variable (distance).

The next step was to determine a suitable model to fit to the data. Fig. 5 is a plot of the first and second differences as functions of distance for a typical record. The first differences have a strong linear trend and the second differences are approximately constant, which implies time is a quadratic in distance.

Least squares regression was used to obtain the best fit quadratic for each data set. The model was of the form

$$t = AX^2 + BX + C \quad (1)$$

where t is time, X is distance, and A , B , and C are the parameters determined by the curve fit. Differentiating the model and equating the derivative to zero gives

$$\frac{dt}{dX} = 2AX + B = 0 \quad (2)$$

Hence, the distance (X) for which time is a minimum is

$$X = -\frac{B}{2A} \quad (\text{Breakout Point}) \quad (3)$$

Fig. 4. Typical Streak Record

Fig. 5. Plot of First (Δt) and Second ($\Delta^2 t$) Differences as Functions of Distance for Shot No. 2178-5-12-1

The computer program also provides the standard errors of the regression parameters A and B denoted by S_A and S_B , respectively. The standard error of the breakout point can be computed by the relation

$$S_X = \sqrt{\left(\frac{\partial X}{\partial A} S_A\right)^2 + \left(\frac{\partial X}{\partial B} S_B\right)^2} \quad (4)$$

For equation (3), this relation becomes

$$S_X = \sqrt{\frac{(BS_A)^2 + (AS_B)^2}{2A^2}} \quad (5)$$

Thus, equations (3) and (5) give the breakout point and its standard error based on the quadratic regression.

A best fit cubic equation was applied on a portion of the data sets. There was a slight improvement in the goodness of fit of the cubic to the data, but the breakout point was not significantly different from the value calculated from the quadratic. Also, the standard error of the breakout point from the cubic was an order of magnitude larger than the standard error of the breakout point from the quadratic. Hence, the cubic fits gave no improvement over the quadratics.

Useable Data

Since a possible application of the test was lot qualification, two significantly different RX-03-BB batches were used to determine the ability of the technique to detect known differences. The principal difference in the two batches was in particle size distribution (see Table I).

Table I. RX-03-BB Batch Parameters

Formulation No.	TATB Weight %	Particle Size Distribution Weight Percent Less Than			
		(50 μ)	(40 μ)	(20 μ)	(10 μ)
6217-145-03	91.76 $\pm$ 0.24	41.57	25.14	14.36	8.96
7137-145-02	92.47 $\pm$ 0.14	71.43	59.08	38.23	24.63

Data from the ten successful tests are shown in Table II. The ambient temperature is the outside air temperature (shaded) in the vicinity of the shot. It was not controlled. Internal temperature of the acceptor pellet was not monitored, but the shots were exposed to ambient temperatures for 3 to 4 hours.

Breakout distance estimates were obtained from two independent readings of each film record by the same analyst

and by the methods described earlier in the report. A third reading was made by another analyst on the last shot in Table II. The resulting breakout distance was 18.7 mm with a standard error of 0.3 mm. Based on these results, it was concluded that breakout distance estimates made using this technique were reasonably reproducible, both on successive readings by the same analyst and on readings by different analysts.

Table II. Corner Turning Test Results

Batch Number	Acceptor Pellet Density (g/cm ³)	Ambient Temperature (C)	Breakout Distances (mm)			
			Reading 1	S _x *	Reading 2	S _x *
6217-145-03	1.8991	34	16.9	0.4	16.9	0.4
	1.8995	21	17.0	0.8	17.1	0.5
	1.8999	28	17.0	0.2	16.9	0.3
	1.9006	24	19.5	0.5	18.2	0.8
	1.9014	24	22.1	2.3	21.3	1.2
7137-145-02	1.8991	34	12.3	0.1	12.2	0.1
	1.8985	27	14.2	0.2	14.1	0.2
	1.8999	31	14.8	0.2	14.6	0.2
	1.9014	28	18.2	0.3	18.9	0.3
	1.9014	23	18.9	0.7	19.1	0.3

*S_x is the standard error of the breakout distance, as defined in Equation (5).

Plots of the two sets of breakout distances as a function of density are shown in Figs. 6 and 7. The error bands represent one standard error. These plots show that the test could distinguish between the two different RX-03-BB batches, but with fairly low confidence. The two tests on the same batch at the same density (last two lines in Table II) show that the corner turning test is adequate in terms of breakout distance reproducibility.

Data from the above table were also subjected to the statistical technique of discriminant analysis. The facts

that the two batches differed in composition and particle size distribution were ignored. However, discriminant analysis showed that breakout distance alone was insufficient to distinguish between the two batches because two shots from each batch were incorrectly classified. When breakout distance and density were entered into the discriminant analysis, all shots of one batch were correctly classified and only one shot of the other batch was incorrectly classified. Including ambient temperature did not result in any improvement in classification over that produced by breakout distance and density together.

Fig. 6. Reading No. 1 Breakout Distance Versus Density

Fig. 7. Reading No. 2 Breakout Distance Versus Density

CONCLUSIONS

A corner turning test capability has been established at Pantex. As performed on two RX-03-BB batches having known differences, the test is not suited to be the sole criterion for acceptance or rejection of RX-03-BB lots. However, the test provides useful explosive and lot behavior information.

RECOMMENDATIONS

The cigarette paper light enhancement technique is adequate and easier to

employ than the aluminum silicofluoride coating.

The quadratic fit to points read from the film provides the best estimate of breakout distance. Fiducial wires are required to provide good references to determine the breakout distance with respect to the initiated end of the acceptor pellets.

For tests on other materials and formulations, the failure diameter and steady-state detonation velocity must be known in order to determine donor pellet and acceptor pellet sizes.

DISTRIBUTION

DOE

Ralph E. Caudle
Assistant Director of Operations
Military Application
Attn: Robert E. Clough
Washington, DC

ALO

H. N. Meyer, Director
Weapons Development Division

R. R. Fredlund, Jr., Director
Classification & Technical
Information

AAO

P. M. Ramey, Chief,
Operations Branch

Mound Lab

R. T. Braun

SLL

R. D. Cozine - Org. 8180

LLL

G. L. Dittman (10 Copies)
Attn: A. C. Van Dyk

C. T. Brockett
Technical Information Dept.

LASL

E. H. Eyster - WX-DO
Attn: J. J. Wechsler

R. N. Rogers - WX-2
J. Aragon - WX-3
Report Library - ISD-4

SLA

B. E. Arthur - Org. 1570
J. C. Crawford - Org. 2500/
D. H. Anderson - Org. 2510
J. C. King - Org. 2300/
C. B. McCampbell - Org. 2310
Central Technical Files - Org. 3141

TIC

Technical Information Center (27 Copies)
Oak Ridge, TN

UK

Jack Kirkham
Atomic Weapons Research Establishment
Aldermaston, Reading, England

PX

Division Manager, Mfg. Engineering
Division Manager, Quality
Division Manager, Development
Division Manager, Safety & Fire
Protection
Education & Training Center (5 Copies)
Technical Library (5 Copies)

Circulation Copy:

- (1) Area Manager, DOE/AAO
- (2) Division Manager, Manufacturing
M&H

Circulation Copy:

- (1) Asst. Plant Manager
- (2) Plant Manager
- (3) M&H-SM Co., Inc., Lexington, KY