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PBX 9502 CORNER TURNING
TEST FIRE AND DATA ANALYSIS

Rex Avara

QUALITY DIVISION

FEBRUARY 1979

Process Development

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ABSTRACT

This report describes the test fire and data analysis of one technique to be utilized in lot characterization of PBX 9502. The corner turning distance is expected to vary ± 2.1 mm on lot-to-lot variation, primarily due to density variations in the PBX 9502. The uncertainty of these measurements is estimated to be ± 0.2 mm as determined from errors of the systems and techniques employed in the tests.

INTRODUCTION

The corner turning test measures the detonation breakout position, along the cylindrical surface, of an end detonated piece of PBX 9502. The test charge piece, 50 mm diameter x 50 mm long, is initiated at the central area of one end by two PBX 9502 booster charges (18 mm diameter x 50 mm long). The high explosive assembly is shown in Fig. 1. An SE 1 detonator and two pellets (PBX 9407 and PBX 9404) act as a standard donor to initiate the PBX 9502 booster charges. The two booster charges provide adequate "run-up" length for reproducible conditions prior to test charge initiation.

A detonation breakout position is determined by observing the first emergence of light on a 50 mm diameter test charge cylindrical surface. Light emission is accomplished by shocking a thin layer of trapped air on the test charge surface, i.e., air being contained within a 0.025 mm thick cigarette paper (flasher) which is covered by transparent Mylar tape.

Fig. 1. Corner Turning Explosive Assembly

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The Mylar tape temporarily quenches light immediately after a shock wave transits the flasher.

Streak photography is employed to record the first emission of light by observing a narrow slit portion of the test charge flasher (slit aligned parallel to pellet axis) while the test charge image moves normal to its axis. The results are recorded on film for precise measurement of the first light relative to a small "blanked" area (fiducial) on the flasher paper. A 0.254 mm diameter copper wire, aligned normal to the slit viewing area, covers the flasher and provides a fiducial blank. This wire is aligned at a pre-determined position for

reference measurement to the test charge/booster junction (or corner). Two wires are used in case of partial streak record loss.

TEST FIRE ASSEMBLY

The explosive components are bonded together with Eastman 910 while slightly compressed to achieve minimum glue gaps at the junction surfaces. Glue fixtures are utilized to assure mutual alignment of matching component axes within 0.08 mm. This includes allowed tolerances of ± 0.05 mm diameter for machining the explosive components. Refer to Fig. 2 for bonding sequence. The flasher is prepared and attached prior to detonator assembly.

Fig. 2. Bonding of Explosive Components

Fig. 3 shows preparations for the flasher gap and fiducial wires. A cigarette paper is cut and placed on a clean smooth surface, i.e., glass, and covered with a strip of clear Mylar tape, then tamped with a smooth instrument. The flasher assembly is then transferred to the side of a test charge and taped tightly. A split marking fixture (glue fixture No. 3) provides reference edges for marking fiducial wire locations and center lines on the test charge.

Two fiducial wires are attached across the flasher at the marked positions (10 mm and 20 mm). Black tape is used to reduce side flash during streak photography. Refer to Fig. 4 for the completed assembly. A precision metric scale is attached for determining the image magnification on a streak record film. Finally, a det adapter is bonded to the PBX 9404 pellet and the shorted detonator is installed and locked with an SE 1 lock nut. Note that the det adapter fits to the PBX 9407 pellet to assure detonator concentricity.

Fig. 3. Fiducial Wire and Flasher Gap Preparation

Fig. 4. Completed Explosive Assembly

The completed assembly is then measured for fiducial wire positions using a Gaertner M912 cathetometer. The cathetometer allows accurate measurements (± 0.05 mm maximum) of the wire locations referenced to the test charge/booster junction (corner). Duxseal is then applied at the booster/PBX 9404 junction to retard flash and detonation products during streak photography.

The assembly is installed in an environmental box for temperature control during test fire (see Fig. 5). The support blocks are located, using V blocks at the boosters, to assure the

test charge center line is parallel to the plate glass viewing window. The test piece is then rotated for proper center line height of the flasher, and bonded to the support blocks. A thermocouple is bonded to the 50 mm test charge cylindrical surface (opposite the flasher side) with Devcon 5 minute epoxy, then covered with a small amount of Duxseal for thermal protection from ambient air. This wire is run out of the box with the det leads. Air and test piece temperatures are monitored during test fire operations for controlling a test piece temperature to match conditions recorded with the cathetometer measurements.

Fig. 5. Test Fire Assembly Environmental Box

TEST FIRE OPERATIONS

A setup box (Fig. 6) is used prior to test fire to minimize temperature control difficulties. This box simulates a TF assembly in the streak camera optics shown in Fig. 7. A 1 mW He-Ne laser, inserted into the optical train, provides visual alignment of the setup box, or test part. The box is moved for correct position of the focused laser spot, then tilted for angular alignment by observing the beam reflected from the plate glass window. The streak camera external optics image the test piece, or setup chart, at the slit plate. This image, which is masked by the slit, is reimaged onto the film plane by the camera internal optics (see Fig. 8). A static photograph of the setup resolution chart is obtained to verify magni-

fication of 1.00 ± 0.05 and acceptable image quality. A perimeter line drawn around the setup box aids in initial alignment of a test fire environmental box to the table top.

Prior to test firing, the environmental box is purged with air which is temperature controlled to match conditions (21 C nominal) during the explosive assembly and cathetometer measurements. Previous environmental tests indicate that when the box is purged as described above, the temperature inside the explosive changes approximately 0.1 C per minute with a 7 to 10 minute time lag when referenced to a covered thermocouple on the outer surface. Consequently, the desired temperature is maintained for at least 15 minutes prior to test firing. Allowed temperature variation is ± 1 C.

Fig. 6. Test Fire Setup Box

CORNER TURNING TF OPTICS SETUP

Fig. 7. Streak Camera External Optics

Fig. 8. Streak Camera Internal Optics

During test firing, the streak camera rotating mirror sweeps an image along the film plane at a nominal writing rate (image velocity) of 10 mm/ μ s. A test fire is time synchronized to the streak camera by reference to a generated electronic signal taken from the rotating mirror via reflected infrared lights. A capacitor charged to 2.5 KV discharges only when proper mirror speed and image position are accomplished simultaneously, firing the detonator.

The streak image is recorded on Kodak TRI-X pan film along with static photographs of the test shot and slit overlay (Fig. 9). The film is developed in Kodak D19 developer (full strength) at 21 C for 12 minutes, then forwarded to the analyst after stop and fix baths.

Fig. 9. Corner Turning Streak Record

DATA REDUCTION

Film records are analyzed on an Oscar-S film reader at approximately 18:1 magnification. A precision scale is measured from the static photograph to calculate the camera/Oscar magnification.

$$\text{Mag.} = 2.54 \left(\frac{\text{X Counts for 1.0 cm}}{1000} \right) \quad (1)$$

Streak camera writing rate is calculated from the writing arm length and the rotating mirror camera (RMC) period.

$$\text{WR} = \frac{4000}{\text{RMC Period}} \quad (2)$$

The writing rate is calculated to verify consistence in curvature of streak records and is not used in data processing. It is held to within 0.2% from a nominal 10 mm/ μ s.

Fiducial wire separation distance is measured from the static photograph and compared for agreement of 0.07 mm to the corresponding cathetometer measurement. Disagreement will indicate errors in the reader magnification and/or cathetometer. During part build-up, a similar comparison is performed for cathetometer agreement to a precision height gage.

A digitized curve of the streak profile is obtained with alignment referenced to the static slit line. The data field consists of approximately 125 X-Y coordinate readings. This field, approximately 8 mm wide on the X-axis, is controlled for symmetry of the Y-axis ranges. The two fiducial blanks are kept just out of the field to assure consistant data point intervals of approximately 0.06 to 0.07 mm. Either of the two fiducial blanks serves as a reference for the data coordinate axis; however, due to the non-symmetry of the streak trace, the X-axis must be zero near fiducial blank No. 2.

These data are curve fitted by polynomial regression to a third degree equation.

$$Y = b_0 + b_1X + b_2X^2 + b_3X^3 \quad (3)$$

Constants b_1 , b_2 , and b_3 are used to calculate the X coordinate of the detonation breakout position.

$$X = \frac{-b_2 + (b_2^2 - 3b_1 b_3)^{1/2}}{3b_3} \quad (4)$$

The fiducial blank No. 2 center line coordinate is added to this and the sum is subtracted from the cathetometer measurement of the corner distance from fiducial wire No. 2 center line. The result is the distance from corner to breakout.

Finally, the standard error of estimate for Y (SEOE) and standard errors of the regression coefficients are calculated to check reliability of the data. Table I lists some typical data obtained from a shot record on TRI-X film. The corresponding plot is shown in Fig. 10.

Table I. Typical Shot Data with TRI-X Film (Shot No. 22-10-10-2-78)

X Coordinate of Breakout (mm)	4.715
Fiducial Blank 2 Coordinate (mm)	0.583
Coefficient	
b_1	-0.58878
b_2 (mm ⁻¹)	0.049115
b_3 (mm ⁻²)	0.001884
Standard Error (%)	
b_1	0.8
b_2	2.5
b_3	4.8
Std. Error of Estimate for Y (mm)	0.014
Corner to Fiducial Wire 2 (mm)	19.975
Corner Breakout (mm)	14.68
Magnification	17.766
Number of X-Y Data Points	126

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Shot No. 22-10-10-2-78
 $sb_1/b_1 = 0.8\%$
 $sb_2/b_2 = 2.5\%$
 $sb_3/b_3 = 4.8\%$
 $SEOE = 0.014 \text{ mm}$
 $\text{Corner Dist.} = 14.676 \text{ mm}$

Scale: $x = 0.10 \text{ mm}$
 $y = 0.033 \text{ mm}$

Fig. 10. Plot of Cubic Curve Fit (Cross Denotes Data Points and Dot Denotes Curve Fit)

Other curves were considered before selecting Equation 3 for analysis. Table II presents the F values, SEOE, and standard errors of regression

coefficients of polynomial equations up to 8 degrees (each equation considered sequentially) for the example in Table I.

Table II. F Values and Standard Errors for 1° to 8° Equations

Degree	F Value	SEOE (mm)	sb_1 (%)	sb_2 (%)	sb_3 (%)	sb_4 (%)	sb_5 (%)	sb_6 (%)	sb_7 (%)	sb_8 (%)
1	0.845	0.454	109							
2	11495	0.030	0.6	0.6						
3	44156	0.014	0.8	2.5	4.8					
4	35600	0.013	1.6	11.2	17.0	30.6				
5	47166	0.010	1.8	7.9	14.2	11.7	10.2			
6	49796	0.009	2.9	77.5	32.5	25.7	20.4	16.7		
7	42578	0.009	4.4	14.0	52.3	55.7	63.1	79.6	100	
8	38269	0.009	5.5	60.0	95.9	72.2	60.4	53.7	50.8	33.3

The second degree appears to be a reasonable fit, but inspection of plots reveal a biased shift (approximately +0.15 mm) of the breakout point (using a 9 mm data field) due to non-symmetry of data (see Fig. 11). The higher degree equations produce small residuals, but the dependence of

breakout point to coefficients prohibit accurate calculations for equations higher than three degrees. The F values are all adequate with exception of the linear equation. The cubic equation was chosen over other polynomials as well as logarithmic curves, exponential curves, etc.

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Shot No. 22-10-10-2-78

sb1/b1 = 0.6%

sb2/b2 = 0.6%

SEOE = 0.030 mm

Corner Dist. = 14.827 mm

Scale: x = 0.10 mm

y = 0.033 mm

Fig. 11. Plot of Quadratic Curve Fit (Cross Denotes Data Points and Dot Denotes Curve Fit)

Table III lists the corner to breakout distance for six shots fired during technique development. Test charge density is included; however, these tests were performed for testing development, and were not selected for variation in density. The expected lot-to-lot variation of ± 2.1 mm is estimated from these shots and similar tests performed by LASL.

Table III. Corner Turning Distances of Six Shots

Shot No.	PBX 9502 Density (g/cm ³)	Breakout Distance (mm)
22-7-7-2-78	1.8991	15.69
22-7-19-1-78	1.8992	16.65
22-10-2-1-78	1.8930	16.04
22-10-3-1-78	1.8924	15.77
22-10-10-2-78	1.8927	14.68
22-10-11-1-78	1.8929	15.87
Mean		15.8
Std. Dev.		0.6

ERROR ANALYSIS

Four of the corner turning tests were recorded on Kodak 2479 RAR film. One of these films was pushed one stop in the developer in an attempt to increase optical density on the streak. This resulted only in an increase of "fog," or background density. Fiducial blanks were difficult to read on the 2479 film tests and consequently required a reduction in reader magnification. The standard deviation for reading the fiducial blank coordinate is 0.03 mm (sample size 30) on 2479 film at 12:1 reader magnification. One of these records was read seven times without changing the magnification or fiducial blank coordinate. The resulting standard deviation of the breakout (Equation 4) is 0.043 mm and the estimated true standard deviation is 0.046 mm.

After Kodak TRI-X pan film was acquired, two additional corner turning tests were fired. Optical density, on the film, increased considerably and the streak record produced improved definition. Reader magnification was increased to 18:1 and reading tests were repeated as described above. The standard deviation for reading a fiducial blank on TRI-X film is 0.004 mm, and the standard deviation ($n = 7$) of the breakout (Equation 4) is 0.01 mm.

This standard deviation (0.01 mm) represents the repeatability of reading and curve fitting the particular streak record itemized in Table I. This should be representative of other records with equivalent curvature and statistical quality, i.e., SEOE and standard errors of coefficients.

The data from one reading, on TRI-X film, are presented in Table I. The SEOE and standard errors of coefficients agree with the mean values for all of the seven readings. The estimated ranges of the SEOE and coefficient errors are listed in Table IV. These are slightly larger than maximum values from shots recorded on TRI-X film.

Table IV. Expected Maximum Values for Curves

SEOE	=	0.015 mm
sb ₁ /b ₁	=	0.9%
sb ₂ /b ₂	=	2.7%
sb ₃ /b ₃	=	5.3%

The six corner turning tests reveal only slight variations of streak curvatures whose effects on the variant of SEOE and coefficient errors are immeasurable. Writing rate variant is maintained to $\pm 0.2\%$ for consistency of curvature. If greater deviations occur, special consideration will be given to determine any effects. During the six tests, calculated writing rates varied only 0.08% from 10 mm/ μ s.

Although the repeatability standard deviation (0.01 mm) adequately describes reading ability, the standard errors of regression coefficients represent the reliability of the breakout point from Equation 4. Effects of the regression errors on Equation 4 are estimated by a Monte-Carlo program. Basically, the Monte-Carlo technique involves defining the individual errors associated with the parameters in Equation 4. Once the magnitude and probability distribution have been assigned for each error, the Monte-Carlo program operates on Equation 4 with the assigned errors. The program computes a single value for the measurement system using component values randomly selected from the assigned component distributions. This is a repetitive procedure and a total of 2000 points are generated for a measurement system. A histogram is plotted and a standard deviation is obtained for 2000 points. The frequency distribution indicates

expected behavior of Equation 4 due solely to the assigned errors.

Equation 4 is expressed for error analysis as:

$$Q(1) = \frac{(-X(2) + \sqrt{(X(2)**2 - (3*X(1)*X(3)))})}{(3*X(3))} \quad (5)$$

where $X(1) = -0.58878$
 $\sigma = 0.0053$

$X(2) = 0.049115/\text{mm}$
 $\sigma = 0.00133/\text{mm}$

$X(3) = 0.001884/\text{mm}^2$
 $\sigma = 0.00010/\text{mm}^2$

These regression coefficients are taken from Table I and their errors are assigned from Table IV. The Monte-Carlo histogram for Q(1) is presented in Fig. 12 and the corresponding statistical data are tabulated in Table V. Note that B Sub2

Fig. 12. Monte Carlo Histogram for Cubic Curve Fit Errors

Table V. Monte-Carlo Statistics for Cubic Curve Fit Errors

(Sample Size - 2000)

Mean	4.70109
Standard Deviation	0.09695
Range	0.68635
Variance	0.00940
Maximum X	5.05239
Maximum Possible X	5.05239
Upper 3 Sigma Limit	4.99196
Minimum X	4.36603
Minimum Possible X	4.36603
Lower 3 Sigma Limit	4.41023
Most Likely Value	4.71484
Mode	4.73000
Median	4.71000
Sum. X	0.94021897D 04
Sum. X Square	0.44219376D 05
Correction Term	0.44200586D 05
Sum. Small X Square	0.18790702D 02
Std. Dev. (Mean)	0.21679542D-02
Variance (Mean)	0.47000255D-05
Normality Test	
Third Moment	-0.20572592D-04
Forth Moment	0.26923831D-03
SQRT B Sub 1	-0.22590170D-01
B Sub 2	0.30500773D 01

should be numerically near 3.0 for a normally distributed histogram. The Monte-Carlo standard deviation (0.097 mm) is greater than the repeatability tests suggest. This is a consequence of the irregularities found on a streak signature and curve fitting errors of the model (Equation 3). Inhomogeneities within the flasher paper produce sporadic exposure variations along the streak record. These are reduced by selection of flasher papers, but are not totally eliminated.

The uncertainty of a breakout distance results from accumulated errors of the following:

1. Cubic curve fitting (just discussed).
2. Cathetometer measurement to fiducial wire.
3. Optical distortion of streak camera and film reader.

4. Locating the fiducial blank on a streak.
5. Determining the magnification from a static photograph.
6. Alignment of the test charge to slit.

Effects of these errors are simulated on the following Monte Carlo equation corresponding to the data in Table I.

$$Q(2) = X(4) - (17.766*(Q(1) + X(5)))/(X(6) + X(7)). \quad (6)$$

where $X(4) = 19.975 \text{ mm}$
 $\sigma = 0.025 \text{ mm}$

$X(5) = 0.583 \text{ mm}$
 $\sigma = 0.004 \text{ mm}$

$X(6) = 17.766 \pm 0.3\%$
 (rectangular probability distribution)

$X(7) = 0.0$
 $\sigma = 0.02$

Equation 6 represents adding the fiducial blank center line coordinate [X(5)] to Equation 4 [Q(1)] and subtracting the results from the cathetometer measurement of corner distance from fiducial wire center line [X(4)]. Optical distortion errors are assigned to the magnification factor [X(6)] which is also affected by film reading errors [X(7)] from the steel scale's image. Optical distortion is measured from a precision grid pattern which has been contact printed onto film, then calibrated at the Metrology Laboratory for actual coordinate dimensions at nominal 20 C. Cathetometer errors are determined by repeated measurements of calibrated steel gage blocks, assembled to simulate measurements from corner to fiducial wire center. The histogram and statistical data from Equation 6 are presented in Fig. 13 and Table VI,

Table VI. Monte-Carlo Statistics for Corner Distance per Cubic Curve Fit

(Sample Size - 2000)

respectively. Note that additional system errors have little accumulative affect on the total system uncertainty.

Although curve fitting errors are most significant, direct reading of the breakout point is not considered reliable because of the large radius of curvature. Difficulty is also encountered when irregularities occur along this curvature. A reduced data field (4 mm) can be fitted to a quadratic equation, decreasing the non-symmetry effects, but both regression coefficient errors increase to 1.8% (60 data points). The resulting Monte Carlo standard deviations are 0.12 mm (curve fit) and 0.12 mm (breakout distance).

Mean	14.69217
Standard Deviation	0.10070
Range	0.64852
Variance	0.01014
Maximum X	14.99598
Maximum Possible X	15.37470
Upper 3 Sigma Limit	14.99428
Minimum X	14.34746
Minimum Possible X	13.80981
Lower 3 Sigma Limit	14.39007
Most Likely Value	14.67716
Mode	14.67000
Median	14.69000
Sum. X	0.29384350D 05
Sum. X Square	0.43174028D 06
Correction Term	0.43172001D 06
Sum. Small X Square	0.20271240D 02
Std. Dev. (Mean)	0.22517427D-02
Variance (Mean)	0.50703451D-05
Normality Test	
Third Moment	0.17634949D-04
Forth Moment	0.30298936D-03
SQRT B Sub 1	0.17282189D-01
B Sub 2	0.29493529D 01

INTERVAL (0.0200)	FREQ
14.3000 - 14.3200	0
14.3200 - 14.3400	0
14.3400 - 14.3600	1
14.3600 - 14.3800	0
14.3800 - 14.4000	3 LLX
14.4000 - 14.4200	3 X
14.4200 - 14.4400	6 XXX
14.4400 - 14.4600	8 XXXXX
14.4600 - 14.4800	11 XXXXXX
14.4800 - 14.5000	27 XXXXXXXXXXXXXXXX
14.5000 - 14.5200	28 XXXXXXXXXXXXXXXX
14.5200 - 14.5400	40 XXXXXXXXXXXXXXXX
14.5400 - 14.5600	53 XXXXXXXXXXXXXXXX
14.5600 - 14.5800	75 XXXXXXXXXXXXXXXX
14.5800 - 14.6000	87 XXXXXXXXXXXXXXXX
14.6000 - 14.6200	142 XXXXXXXXXXXXXXXX
14.6200 - 14.6400	131 XXXXXXXXXXXXXXXX
14.6400 - 14.6600	156 XXXXXXXXXXXXXXXX
14.6600 - 14.6800	158MOLXXXXXXXXXXXXX
14.6800 - 14.7000	136MXXXXXXXXXXXXXXXX
14.7000 - 14.7200	140 XXXXXXXXXXXXXXXX
14.7200 - 14.7400	157 XXXXXXXXXXXXXXXX
14.7400 - 14.7600	135 XXXXXXXXXXXXXXXX
14.7600 - 14.7800	119 XXXXXXXXXXXXXXXX
14.7800 - 14.8000	96 XXXXXXXXXXXXXXXX
14.8000 - 14.8200	83 XXXXXXXXXXXXXXXX
14.8200 - 14.8400	71 XXXXXXXXXXXXXXXX
14.8400 - 14.8600	40 XXXXXXXXXXXXXXXX
14.8600 - 14.8800	26 XXXXXXXXXXXXXXXX
14.8800 - 14.9000	23 XXXXXXXXXXXXXXXX
14.9000 - 14.9200	17 XXXXXXXXXXXXXXXX
14.9200 - 14.9400	14 XXXXXXXXXXXXXXXX
14.9400 - 14.9600	4 XX
14.9600 - 14.9800	7 XXXX
14.9800 - 15.0000	3 ULX
15.0000 - 15.0200	0
15.0200 - 15.0400	0
15.0400 - 15.0600	0
15.0600 - 15.0800	0
15.0800 - 15.1000	0
15.1000 - 15.1200	0
15.1200 - 15.1400	0
15.1400 - 15.1600	0
15.1600 - 15.1800	0
15.1800 - 15.2000	0
15.2000 - 15.2200	0
15.2200 - 15.2400	0
15.2400 - 15.2600	0
15.2600 - 15.2800	0
15.2800 - 15.3000	0
15.3000 - 15.3200	0
15.3200 - 15.3400	0
15.3400 - 15.3600	0
15.3600 - 15.3800	0 HI

Fig. 13. Monte-Carlo Histogram for Corner Distance per Curve Fit

The incremental coordinate points (0.06 mm) are chosen to be compatible to image resolution (16 line pairs per mm) as seen on a streak record via the film reader. As an estimate of the effects of streak irregularities, the film record corresponding to Table I was hand traced (with a french curve template) from the magnified image. The smooth curve trace was read seven times without changing in the fiducial blank coordinate. Reading repeatability standard deviation (cubic curve fit) is 0.003 mm for the breakout point.

Fig. 14 shows the results of one reading which is representative of the mean values for corner distance, SEOE, and regression coefficient errors. The same data set, fit to a quadratic, is presented in Fig. 15. A reduced field (same data), fit to a quadratic, is shown in Fig. 16. It appears that an ideal flasher (i.e., uniform illumination along a slit) could reduce corner distance errors by approximately one half for cubic curve fitting. Also (in this case) a reduced field fit to a quadratic equation is promising.

Fig. 14. Cubic Curve Fit to a Smooth Traced Streak Record (Cross Denotes Data Points and Dot Denotes Curve Fit)

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Shot No. 22-10-10-2-78
sb1/b1 = 0.4%
sb2/b2 = 0.4%
SEOE = 0.023 mm
Corner Dist. = 14.811 mm

Scale: x = 0.10 mm
y = 0.033 mm

Fig. 15. Quadratic Curve Fit to a Smooth Traced Streak Record

CORNER TURNING

10107

Shot No. 22-10-10-2-78
sb1/b1 = 0.5%
sb2/b2 = 0.5%
SEOE = 0.004 mm
Corner Dist. = 14.733 mm

Scale: x = 0.10 mm
y = 0.033 mm

Fig. 16. Quadratic Curve Fit to a Smooth Traced Streak Record (With Reduced Field)

CONCLUSIONS AND RECOMMENDATIONS

Variation of corner turning breakout distance is expected to be approximately ± 2.1 mm as determined from previous tests. The expected mean breakout distance will be estimated pending more tests on lot-to-lot samples from production fabricated explosives. PBX 9502 density is expected to affect corner turning properties, and some experimental testing on density and temperature effects should provide useful information for quality control.

A three degree polynomial regression equation is selected as the best model for curve fitting data in corner turning tests. Data fields (X-axis) of approximately 8 mm enclosing about 100 data points each are used to determine breakout distances. The uncertainty of a given corner turning test is estimated to be ± 0.2 mm. This represents the 95% prediction limits from Table VI. Kodak TRI-X pan film is required for corner turning tests, and extended development time is necessary to obtain high quality streak records.

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