JA2 Electrothermal-Chemical (ETC) Firings With Modified 400-kJ Pulser

M. Del Guercio
I. Stobie
W. Oberle

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13. **ABSTRACT (Maximum 200 words)**

A 300-kJ pulse-forming network (PFN) with a pulse width of 1.2 ms was upgraded to 400-kJ maximum energy output and 2.4-ms pulse width by increasing the number of its six capacitors and by replacing its six inductors by larger ones. As the new pulser was desired to also provide the shorter original pulse of 1.2 ms, tests were performed in which only four of its eight new banks were left connected. A match of the new pulser output parameters was found when the new PFN charging was varied from 3 kV to 4 kV to match the same output energy levels as with the previous 300-kJ pulser. Also, the modified pulser showed that for a 1.2-ms pulse width and PFN charging voltages of 4 kV and 5 kV, there was a noticeable increase on the propellant (JA2 disks) burn rate when compared with previous pulser data.
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1. BACKGROUND

Electrothermal-chemical (ETC) closed chamber firings were conducted in March 1994 with the purpose of characterizing JA2 propellant (disc configuration) by plasma augmentation. These were short-pulse (1.2 ms) and low-energy (15 kJ) firings utilizing a pulse-forming network (PFN) with a total energy capability of 300 kJ. Specifically, this pulser consisted of a total of six 830-µF capacitors and six 10-µH inductors with a fixed pulse length of 1.2 ms (Figure 1). The PFN schematic and the 120-cm³ closed chamber vessel setup are in Appendix A. Appendix B contains firing information data sheets for these firings.

![PFN Schematic](image)

Figure 1. 300-kJ pulser.

To better investigate the impact of an electrically generated plasma on propellant combustion, it was decided to increase the pulse duration. Thus the PFN was upgraded to a total energy capability of 400 kJ by increasing the number of capacitors and inductors to eight each, increasing its pulse length to 2.4 ms. The two capacitors added were of the same values as the existing capacitors. The inductors, however, were replaced by eight new ones of 30 µH each (Figure 2). It was also desirable for the new pulser to have the flexibility to produce a comparable 1.2-ms pulse length.

New test firings were conducted in January and February 1995 with the upgraded pulser. The objectives of these tests were to determine: a) the right number of capacitors and larger inductors to leave connected to the circuit to obtain a comparable 1.2-ms pulse profile to the previous PFN and b) the charging voltage on the modified PFN to match the energy of the previous firings.
Microcap III\textsuperscript{1} simulations were used to determine that a combination of four capacitors and four new inductors with a charging voltage of 4 kV (Table 1) gave the best 1.2-ms pulse approximation (1.3 ms). The charging voltage was then increased from the 3 kV used with the old configuration of six capacitors and six inductors, to 4 kV on the modified PFN. This left four capacitors and four of the new 30-μH inductors connected to the bus. The current, voltage, and energy of both previous and new firings are shown in Figures 3a and 3b, respectively.

Table 1. Modified Pulser

<table>
<thead>
<tr>
<th>Shot ID</th>
<th>Propellant Type</th>
<th>Propellant Weight (g)</th>
<th>Charging Voltage (kV)</th>
<th>Energy Output (kJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>01245S1</td>
<td>JA2 Disks</td>
<td>27.15</td>
<td>3.7</td>
<td>8.10</td>
</tr>
<tr>
<td>01305S2</td>
<td>JA2 Disks</td>
<td>27.23</td>
<td>3.8</td>
<td>7.00</td>
</tr>
<tr>
<td>01315S3</td>
<td>JA2 Disks</td>
<td>27.11</td>
<td>5.0</td>
<td>33.0</td>
</tr>
<tr>
<td>02015S4</td>
<td>JA2 Disks</td>
<td>27.26</td>
<td>4.4</td>
<td>8.00</td>
</tr>
<tr>
<td>02095S5</td>
<td>JA2 Disks</td>
<td>27.23</td>
<td>4.0</td>
<td>18.0</td>
</tr>
<tr>
<td>02105S7</td>
<td>JA2 Disks</td>
<td>27.13</td>
<td>4.0</td>
<td>23.0</td>
</tr>
</tbody>
</table>

\textsuperscript{1}Microcap III A Circuit Analysis Software, Spectrum Software, Sunnyvale, CA.
2. TEST OBJECTIVES

The purpose of the firings was to reproduce the results of the previous tests with the lower energy pulser (Figure 1). Six firings were conducted with variation in thePFN charging voltage from 3 kV to 5 kV (Table 1). Firings with the modified pulser (Table 1) shows that the PFN charging voltage was increased to match the output energy of the previous firings of Table 2. Discrepancies in the data resulted
Table 2. 1.2-ms Pulser

<table>
<thead>
<tr>
<th>Shot ID</th>
<th>Propellant Type</th>
<th>Propellant Weight (g)</th>
<th>Charging Voltage (kV)</th>
<th>Energy Output (kJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>03154S1</td>
<td>JA2 Disks</td>
<td>27.50</td>
<td>3</td>
<td>16.0</td>
</tr>
<tr>
<td>03154S2</td>
<td>JA2 Disks</td>
<td>27.69</td>
<td>3</td>
<td>16.0</td>
</tr>
<tr>
<td>03184S3</td>
<td>JA2 Disks</td>
<td>34.50</td>
<td>3</td>
<td>16.0</td>
</tr>
</tbody>
</table>

from unexpected shorts or large decreases in efficiency. The test (ident 02095S5) that matched the previous results of March 1994 (ident 03154S2) had a charging voltage of 4 kV and an energy of approximately 18 kJ. Load current profile and energy and power outputs of ident 03154S2 are shown in comparison to load current and energy and power outputs of ident 02095S5 in Figures 4a–c.

3. SUMMARY OF RESULTS

Calculated burn rates (BRLCB\textsuperscript{2} code) for Tables 1 and 2 firings are shown in Appendix D. Pressure output and electrical energy for each firing are shown in Appendix C. Figure 5a shows a comparison of the burn rates of Table 2 firings with the 1.2-ms pulser. Above 100 MPa, these burn rates are in good agreement; however, firings 03154S2, 03184S3, and 03154S1 show no enhancement on the burn rate during or after the input of electrical energy.

Figure 5b shows a comparison of the burn rates of Table 1 firings done with the upgraded pulser. Table 1 ident 01315S3, 02105S7, and 02095S5 (Figure 5b) show an increase on their burn rates. The electrical energy input ends at about 1.5 ms, which is the decay point of the input current curve to the ETC fixture, and according to the BRLCB output data file, that point corresponds to 70 MPa.

From 40 MPa to 220 MPa, ident 01315S3, 02105S7, and 02095S5 show a burn rate percent difference respect to the 12103S2 ident base line of 80%, 44%, and 30%, respectively. From 70 MPa to 220 MPa, the percent differences in the same order are 56%, 20%, and 35%.

Figure 4a. Load current vs. time.

Figure 4b. Energy vs. time.

Figure 4c. Power vs. time.
Figure 5a. Table 2 burn rates.

Figure 5b. Table 1 burn rates.
4. CONCLUSION

The increase in energy on the output pulse of the modified PFN due to the larger inductors contributed to the increase in energy (Appendix C, Figures C-7, C-10, and C-12) for idents 02095S5, 01315S3, and 02105S7 from 18 kJ to 33 kJ and 23 kJ, respectively, compared to the 16 kJ firings of Table 2. This increase in energy is significantly reflected on their burn rates (Figure 5b).
APPENDIX A:

ETC 120-cm$^3$ CLOSED CHAMBER FIRING MATRIX
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Figure A-1. Pulser schematic and ETC closed chamber setup.
<table>
<thead>
<tr>
<th>ID No</th>
<th>Loading Density (g/cm³)</th>
<th>Electrical Energy (kJ)</th>
<th>EE Density (kJ/g)</th>
<th>Charging Voltage (kV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>03154S1</td>
<td>0.21</td>
<td>16</td>
<td>0.58</td>
<td>3</td>
</tr>
<tr>
<td>03154S2</td>
<td>0.23</td>
<td>16</td>
<td>0.58</td>
<td>3</td>
</tr>
<tr>
<td>03184S3</td>
<td>0.29</td>
<td>16</td>
<td>0.46</td>
<td>3</td>
</tr>
<tr>
<td>01245S1</td>
<td>0.23</td>
<td>8</td>
<td>0.29</td>
<td>3.7</td>
</tr>
<tr>
<td>01305S2</td>
<td>0.23</td>
<td>7</td>
<td>0.26</td>
<td>3.8</td>
</tr>
<tr>
<td>01315S3</td>
<td>0.23</td>
<td>33</td>
<td>1.22</td>
<td>5</td>
</tr>
<tr>
<td>02015S4</td>
<td>0.23</td>
<td>8</td>
<td>0.29</td>
<td>4.4</td>
</tr>
<tr>
<td>02095S5</td>
<td>0.23</td>
<td>18</td>
<td>0.66</td>
<td>4</td>
</tr>
<tr>
<td>02105S7</td>
<td>0.23</td>
<td>23</td>
<td>0.85</td>
<td>4</td>
</tr>
</tbody>
</table>
APPENDIX B:

FIRING INFORMATION DATA SHEETS
ETCETM1 INFORMATION SHEET FOR ETC CLOSED CHAMBER FIRING
DATE: 03/15/94 SERIES RUN#: 1 PROJECT: 129.0 CLOSED CHAMBER
PROPELLANT TYPE: JA2 perf: LOT #: RAD-PE-792-71 SAMPLE TREATMENT: 70F
SAMPLE WEIGHT: 27.52g GRAIN DIMENSION: 0.6"L, 0.3"D: 0.03 WEB
CHAMBER VOLUME: 129.44c c CALCMAX PRESSURE: 300MPa WINDOW: 2ms

PFN PULSE LENGTH: 1.2ms PNF SCHEMATIC: 4 caps @ 3200uF ea. 46ind @ 10uH @
PFN Vin DC: 10kV: EXPECTED ENERGY: 16kJ @ 70% eff: WINDOW: 2ms
PEARSON'S CAL: K=2630;
Vessel's ROGOVSKY K: NA ; pfn's ROGOVSKY K: 2 CAL: K=86.45E+06

Muzzle GAGE1 SN(P1): C47189 SIDE GAGE2 SN(P2): C42442
gage1: lrstdegf coeff: 5.76E-02; gage2: lrstdegf coeff: 6.0E-02

CALIBRATION

*****SCOPE A*****  *****SCOPE B*****
CAL (DC) VOLTAGE IN: NA  CAL (DC) VOLTAGE IN: 8.0 V
DISK ID: ETC#1 DISK ID: 120cc#2
TRACK ID: NA TRACK ID: 5

CAL#1 (gage#1)/CHAN 1A: NA  CAL#1 (gage#1)/CHAN 1A: 8.0 V
CAL VOLTAGE OUT: CAL VOLTAGE OUT:
CAL#2 (gage#2)/CHAN 1B: NA  CAL#2 (gage#2)/CHAN 2A: 8.0 V
CAL VOLTAGE OUT: CAL VOLTAGE OUT:

FIRING

*****SCOPE A*****  *****SCOPE B*****
DISK ID: ETC#1 DISK ID: 120cc#2
TRACK ID: 10 TRACK ID: 6
SENSITIVITY: MIN SENSITIVITY: MIN

CHANNEL WINDOW S. RATE CHANNEL WINDOW S. RATE
1A: P1 50ms 20uA xpt 1A: P1 NA
1B: P2 50ms 20uA xpt 2A: P2 NA
2A: dI/dt 4ms .5us xpt 2A: NA
2B: V 4ms .5us xpt 1B: ROGOVSKY#2
ROGOVSKY#1 (m.A/V.s) ROGOVSKY#2 (m.A/V.s)

PRESSURE MAX(MPa) PRESSURE MAX(MPa): 273
SCOPE ID: B SCOPE ID: B
GAGE ID: #1 GAGE ID: #2

ETCETM1 INFORMATION SHEET FOR ETC CLOSED CHAMBER FIRING
DATE: 03/15/94 SERIES RUN#: 2 PROJECT: 129.0 CLOSED CHAMBER
PROPPELLANT TYPE: JA2 perf: LOT #: RAD-PE-792-71 SAMPLE TREATMENT: 70F
SAMPLE WEIGHT: 27.692g GRAIN DIMENSION: 0.6"L, 0.3"D: 0.03 WEB
CHAMBER VOLUME: 129.44c c CALCMAX PRESSURE: 300MPa WINDOW: 20ms

PFN PULSE LENGTH: 1.2ms PNF SCHEMATIC: 4 caps @ 3200uF ea. 46ind @ 30uH @
PFN Vin DC: 10kV: EXPECTED ENERGY: 16kJ @ 70% eff: WINDOW: 2ms
PEARSON'S CAL: K=2630;
Vessel's ROGOVSKY K: NA ; pfn's ROGOVSKY K: 2 CAL: K=86.45E+06

Muzzle GAGE1 SN(P1): C47189 SIDE GAGE2 SN(P2): C42442
gage1: lrstdegf coeff: 5.76E-02; gage2: lrstdegf coeff: 6.0E-02

CALIBRATION

*****SCOPE A*****  *****SCOPE B*****
CAL (DC) VOLTAGE IN: NA  CAL (DC) VOLTAGE IN: 8.0 V
DISK ID: ETC#1 DISK ID: 120cc#2
TRACK ID: NA TRACK ID: 7

CAL#1 (gage#1)/CHAN 1A: NA  CAL#1 (gage#1)/CHAN 1A: 8.0 V
CAL VOLTAGE OUT: CAL VOLTAGE OUT:
CAL#2 (gage#2)/CHAN 1B: NA  CAL#2 (gage#2)/CHAN 2A: 8.0 V
CAL VOLTAGE OUT: CAL VOLTAGE OUT:

FIRING

*****SCOPE A*****  *****SCOPE B*****
DISK ID: ETC#1 DISK ID: 120cc#2
TRACK ID: 11 TRACK ID: 8
SENSITIVITY: MIN SENSITIVITY: MIN

CHANNEL WINDOW S. RATE CHANNEL WINDOW S. RATE
1A: P1 50ms 20uA xpt 1A: P1 NA
1B: P2 50ms 20uA xpt 2A: P2 NA
2A: dI/dt 4ms .5us xpt 2A: NA
2B: V 4ms .5us xpt 1B: ROGOVSKY#2
ROGOVSKY#1 (m.A/V.s) ROGOVSKY#2 (m.A/V.s)

PRESSURE MAX(MPa) PRESSURE MAX(MPa): 273
SCOPE ID: B SCOPE ID: B
GAGE ID: #1 GAGE ID: #2
ETCTML1 INFORMATION SHEET FOR ETC CLOSED CHAMBER FIRING
DATE: 03/18/94
SERIES RUN#4:3 PROJECT: 129.0 CLOSED CHAMBER
PROPELLANT TYPE: J27perf; LOT #: RAD-PE-792-71 SAMPLE TREATMENT: 70F
SAMPLE WEIGHT: 34.5g GRAIN DIMENSION: 0.6"L, 0.3"D; 0.03 WEB
CHAMBER VOL: 129.4cc CALCMAX PRESSURE: 300MPa WINDOW: 2ms
HIGH DEN. LOADING
PFN PULSE LENGTH: 1.2ms PFN SCHEMATIC: 6cap@830uf ea.66ind@ 10uHsa
PFN Vin DC: 13.0kV; EXPECTED ENERGY: 16kJ@ 70%effic; WINDOW: 12ms
PEARSON'S CAL K: 2630;
veg's ROGOVSKY#1CAL K: 82.45e+06

MUZZLE GAGE#1 SN(P1): C47189
SIDE GAGE#2 SN(P2): C42442

gage#1: lstdeqfit coeff: 5.76E-02; gage#2: lstdeqfit coeff: 6.0E-02

CALIBRATION

**** SCOPE A*****

CAL (DC)VOLTAGE IN: NA
DISK ID: ETC#1
TRACKID: NA

CAL#1(gage#1)/CHAN 1A: NA
VCA VOLTAGE OUT:
CAL#2(gage#2)/CHAN 1B: NA
VCA VOLTAGE OUT:

**** SCOPE B*****

CAL (DC)VOLTAGE IN: 8.0 V
DISK ID: 120cc#2
TRACK ID: 9

CAL#1(gage#1)/CHAN 1A: NA
VCA VOLTAGE OUT:
CAL#2(gage#2)/CHAN 2A: 8.0 V
VCA VOLTAGE OUT:

**** SCOPE A*****

DISK ID: ETC#1
TRACK ID: 12
SENSITIVITY: MIN

CHANNEL WINDOW S. RATE
1A: P1 50ms 20uxsxpnt
1B: P2 50ms 20uxsxpnt
2A:di/dt 4ms .5uxsxpnt
2B: v 4ms .5uxsxpnt
ROGOVSKY#1 (m.A/V/s)

PRESSURE MAX(MPa)
SCOPE ID:B
GAGE ID: 1

**** SCOPE B*****

DISK ID: 120cc#2
TRACK ID: 10
SENSITIVITY: MIN

CHANNEL WINDOW S. RATE
1A: P1 NA
1B: P2 NA
2A: NA
2B: ROGOVSKY#2

PRESSURE MAX(MPa): 400
SCOPE ID: B
GAGE ID: 2

ETCTML1 INFORMATION SHEET FOR ETC CLOSED CHAMBER FIRING
DATE: 03/09/95
SERIES RUN#5: PROJECT: 129.0 CLOSED CHAMBER
PROPELLANT TYPE: J27perf; LOT #: RAD-PE-792-71 SAMPLE TREATMENT: 70F
SAMPLE WEIGHT: 27.23g GRAIN DIMENSION: 0.6"L, 0.3"D; 0.03 WEB
CHAMBER VOL: 129.4cc CALCMAX PRESSURE: 300MPa WINDOW: 4ms
HIGH DEN. LOADING
PFN PULSE LENGTH: 1.2ms PFN SCHEMATIC: 6cap@830uf ea.66ind@ 10uHsa
PFN Vin DC: 13.0kV; EXPECTED ENERGY: 16kJ@ 70%effic; WINDOW: 2ms
PEARSON'S CAL K: 2630;
veg's ROGOVSKY#1CAL K: 82.45e+06; pfn's ROGOVSKY#2CAL K: 80.49E+06

MUZZLE GAGE#1 SN(P1): C47189
SIDE GAGE#2 SN(P2): C19928

gage#1: lstdeqfit coeff: 5.76E-02; gage#2: lstdeqfit coeff: 6.0E-02

CALIBRATION

**** SCOPE A*****

CAL (DC)VOLTAGE IN: NA
DISK ID: ETC#1
TRACKID: NA

CAL#1(gage#1)/CHAN 1A: NA
VCA VOLTAGE OUT:
CAL#2(gage#2)/CHAN 1B: NA
VCA VOLTAGE OUT:

**** SCOPE B*****

CAL (DC)VOLTAGE IN: 8.0 V
DISK ID: 120cc#4
TRACK ID: 16

CAL#1(gage#1)/CHAN 1A: NA
VCA VOLTAGE OUT:
CAL#2(gage#2)/CHAN 2A: 8.0 V
VCA VOLTAGE OUT:

**** SCOPE A*****

DISK ID: ETC#1
TRACK ID: 5
SENSITIVITY: MIN

CHANNEL WINDOW S. RATE
1A: P1 50ms 20uxsxpnt
1B: P2 50ms 20uxsxpnt
2A:di/dt 4ms .5uxsxpnt
2B: v 4ms .5uxsxpnt
ROGOVSKY#1 (m.A/V/s)

PRESSURE MAX(MPa)
SCOPE ID:B
GAGE ID: 1

**** SCOPE B*****

DISK ID: 120cc#4
TRACK ID: 17
SENSITIVITY: MIN

CHANNEL WINDOW S. RATE
1A: P1 20ms 5uxsxpnt
1B: P2 20ms 5uxsxpnt
2A: NA
2B: ROGOVSKY#2

PRESSURE MAX(MPa): 300
SCOPE ID: B
GAGE ID: 2
APPENDIX C:

EXPERIMENTAL PRESSURE AND PULSER ENERGY OUTPUT
Pressure and PFN energy output for idents 03154S1, 03154S2, 03154S3, and 02095S5 are shown in Figures C-1 thru C-8, as ident 02095S5 was the closest match for these three previous firings.

![Figure C-1](image1)

**Figure C-1.** *Ident 03154S1 (ETC firing), pressure vs. time.*

![Figure C-2](image2)

**Figure C-2.** *Ident 03154S1 (ETC firing), energy vs. time.*
Figure C-3. Ident 03154S2 (ETC firing), pressure vs. time.

Figure C-4. Ident 03154S2 (ETC firing), energy vs. time.
Figure C-5. Ident 03154S3 (ETC firing), pressure vs. time.

Figure C-6. Ident 03154S3 (ETC firing), energy vs. time.
Figure C-7. Ident 01315S3 (ETC firing), pressure vs. time.

Figure C-8. Ident 01315S3 (ETC firing), energy vs. time.
Figure C-9. Ident 02095S5 (ETC firing), pressure vs. time.

Figure C-10. Ident 02095S5 (ETC firing), energy vs. time.
Figure C-11. Ident 02105S7 (ETC firing), pressure vs. time.

Figure C-12. Ident 02105S7 (ETC firing), energy vs. time.
APPENDIX D:

BURN RATES
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Figure D-1. Burn rate ident 03154S1.
ETC BURN RATE ANALYSIS
BRLCB V3.0
ADVANCED BALLISTIC CONCEPTS BRANCH - BRL

Project: ja2
Inf File: 03154s1.inf
P/T File: 03154s1.pvt
Smoothed: 03154s1.pdt
EE File: A:03154s1AD
Fired on: 03/15/94

FIRING REMARKS:
JA2 DISKS, ETC 3KV, 6CAPS & 6 IND, 1.2ms pulse
REDUCTION REMARKS:
03/15/94

IGNITER INFORMATION
The Igniter Used Is: Black Powder Lot: FFFG
The Source For The Igniter Is: Pellets, Milan Ord.

IGNITER THERMOCHEMICAL PROPERTIES:
Impetus (J/g) : 290.0 Molecular Weight : 66.37000
Flame Temperature (K): 2188.0 Colume (cc/g) : .78500
Density (g/cc) : 1.75000 Gamma : 1.21840

PROPELLANT INFORMATION
The Propellant Used Is:
Lot:
The Source For The Propellant Is:

Propellant Thermochemical Properties: Following
Sheets of Output

PROPELLANT GRAIN GEOMETRY
Grain Type: 1-Perf. Cyl.
Length --- (cm.): .139700
Outer Diam.(cm.): 2.882900
Perf Diam. (cm.): 1.270000
Inner Web (cm.): .806450

Bomb Information
Gage Information

Bomb Type: Closed Chamber
Bomb Vol (cc): 129.4
Gage I.D. : C42442
Input Voltage: 8.0000
Constants For Fit: A+Bx+C^2
A: .75318E-01
B: .63631E-01
C: -.42344E-06

Temperature and Charge Mass Information

Propellant Mass (g) : 27.5000 Igniter Mass (g) : .0000
Initial Temp. Prop.(K): 294.0 Initial Temp.(K): 294.0
Initial Bomb Temp. (K): 294.0
Number of Propellant Grains: 23.39
Number of Wildpoint Passes: 1 Wildpoint Tolerance: 5.000
Number of Smoothing Passes: 1 Smoothing Option: 1
Bridge Length: 15

OUTPUT FILE: 03154s1.op7
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

Total # Layers = 1
Chamber Volume (cm3) = 129.400
Heat-Loss-Fraction (n-d) = .000

28
Figure D-2. Burn rate ident 03154S2.
ETC BURN RATE ANALYSIS

BRLCB V3.0
ADVANCED BALLISTIC CONCEPTS BRANCH - BRL

Project: ja2
Inf File: 03154s2.inf
P/T File: 03154s2.pvt
Smoothed: 03154s2.pdt
EE File: A:03154s2.e
Requested by: guercio
Created From .MAS File: ja2.mas
Calculation Output File: 03154s2.out
Graphics File: 03154s2.dat

FIRING REMARKS:
JA2 DISKS, ETC, 3KV, 1.2ms pulse, 6cps& 6 ind

IGNITER INFORMATION
The Igniter Used Is: Black Powder Lot: FFFG
The Source For The Igniter Is: Pellets, Milan Ord.

IGNITER THERMOCHEMICAL PROPERTIES:
Impetus (J/g) : 290.0 Molecular Weight : 66.37000
Flame Temperature (K): 2188.0 Colume (cc/g) : .78500
Density (g/cc) : 1.75000 Gamma : 1.21840

PROPELLANT INFORMATION
The Propellant Used Is: Lot:
The Source For The Propellant Is:

Propellant Thermochemical Properties: Following Sheets of Output

PROPELLANT GRAIN GEOMETRY
Grain Type: 1- Perf. Cyl.
Length --- (cm.): .139700
Outer Diam.(cm.): 2.882900
Perf Diam. (cm.): 1.270000
Inner Web (cm.): .806450

Bomb Information
Bomb Type :Closed Chamber
Bomb Vol (cc): 129.4
Bomb I.D. : C42442
Input Voltage: 8.0000
Constants For Fit: A+Bx+C*x^2
A: .75318E-01
B: .63631E-01
C: -42344E-06

Gage Information
Gage I.D. : C42442

Temperature and Charge Mass Information
Propellant Mass (g): 27.6920
Igniter Mass (g): .0000
Number of Propellant Grains: 23.56

Number of Wildpoint Passes: 1
Wildpoint Tolerance: 5.000
Number of Smoothing Passes: 1
Smoothing Option: 1
Bridge Length: 15
1 OUTPUT FILE: 03154s2.op7

***************************************************************

Total # Layers = 1
Chamber Volume (cm3) = 129.400
Heat-Loss-Fraction (n-d) = .000
Time Step (mil-sec) = .20000000E-01 Max Time Steps = 1200

30
Figure D-3. Burn rate ident 03184S3.
ETC BURN RATE ANALYSIS
BRLCB V3.0
ADVANCED BALLISTIC CONCEPTS BRANCH - BRL

Project: ja2  Requested by: guercio
Inf File: 03184s3.inf  Created From .MAS File: ja2.mas
P/T File: 03184s3.pvt  Calculation Output File: 03184s3.out
Smoothed: 03184s3.pdt  Graphics File: 03184s3.dat
EE File: A03184SSE.AD
Fired on: 03/18/94 SERIES III
FIRING REMARKS:
J22 DISKS, ETC. 1.2ms, 3kv, 6ind & 6 caps
high density loading

IGNITER INFORMATION
The Igniter Used Is: Black Powder  Lot: FFFG
The Source For The Igniter Is: Pellets, Milan Ord.

IGNITER THERMOCHEMICAL PROPERTIES:
Impetus (J/g): 290.0  Molecular Weight: 66.37000
Flame Temperature (K): 2188.0  Covolume (cc/g): .78500
Density (g/cc): 1.75000  Gamma: 1.21840

PROPELLANT INFORMATION
The Propellant Used Is: Lot:
The Source For The Propellant Is:
Propellant Thermochmical Properties: Following
Sheets of Output

PROPELLANT GRAIN GEOMETRY
Grain Type: 1-Perf. Cyl.
Length (cm.): .139700
Outer Diam. (cm.): 2.882900
Perf Diam. (cm.): 1.270000
Inner Web (cm.): .806450

Bomb Information

Gage Information
Bomb Type: Closed Chamber  Gage I.D. : C42242
Bomb Vol (cc): 129.4  Input Voltage: 8.0000
Constants For Fit: A+Bx+C^2
A: .75316E-01
B: .65031E-01
C: -.42344E-06

Temperature and Charge Mass Information

Propellant Mass (g): 34.5000  Igniter Mass (g): .0000
Number of Propellant Grains: 29.35

Number of Wildpoint Passes: 1  Wildpoint Tolerance: 5.000
Number of Smoothing Passes: 1  Smoothing Option: 1
Bridge Length: 15

1 OUTPUT FILE: 03184s3.op7
******************************************************************************

******************************************************************************

Total # Layers = 1
Chamber Volume (cm^3) = 129.400
Heat-Loss-Fraction (n-d) = .000
Figure D-4. Burn rate ident 0131553.
ETC BURN RATE ANALYSIS
BRLCB V3.0
ADVANCED BALLISTIC CONCEPTS BRANCH - BRL

Project: ja2
Info File: 01315S3.inf
P/T File: 01315S3.pvt
Smoothened: 01315S3.pdt
EE File: A:01315S3E.AD
Created From .MAS File: ja2.mas
Calculation Output File: 01315S3.out
Graphics File: 01315S3.dat
Requested by: guercio
Fired on: 01/31/95
FIRED REMARKS:
ETC, 5kV, 1.2 ms pulse length, 4 caps & 4 inductors
27.11g JA2 disks

IGNITER INFORMATION
The Igniter Used Is: Black Powder
Lot: FFFG
The Source For The Igniter Is: Pellets, Milan Ord.

IGNITER THERMOCHEMICAL PROPERTIES:
Impetus (J/g) : 290.0 Molecular Weight : 66.37000
Flame Temperature (K) : 2188.0 Covolume (cc/g) : .78500
Density (g/cc) : 1.75000 Gamma : 1.21840

PROPELLANT INFORMATION
The Propellant Used Is:
Lot:
The Source For The Propellant Is:

Propellant Thermochemical Properties: Following
Sheets of Output

PROPELLANT GRAIN GEOMETRY
Grain Type: 1-Perf. Cyl.
Length --- (cm.): .139700
Outer Diam.(cm.): 2.682900
Perf Diam. (cm.): 1.270000
Inner Web (cm.): .806450

Bomb Information
Bomb Type : Closed Chamber
Bomb Vol (cc): 129.4

Gage Information
Gage I.D. : C19928
Input Voltage: 8.0000
Constants For Fit: A+8x+C^2
A: .21637E+00
B: .54171E-01
C: -.31853E-06

Temperature and Charge Mass Information
Propellant Mass (g): 27.1100
Igniter Mass (g): .0000
Number of Propellant Grains: 23.06

Number of Wildpoint Passes: 1 Wildpoint Tolerance: 5.000
Number of Smoothing Passes: 1 Smoothing Option: 1
Bridge Length: 15

1 OUTPUT FILE: 01315s3.op7
*******************************************************************************

Total # Layers = 1

Chamber Volume (cm3) = 129.400
Heat-Loss-Fraction (n-d) = .000

Time Step (mil-sec) = .50000000E-02 Max Time Steps = 1200

34
Figure D-5. Burn rate iden 0209555.
ETC BURN RATE ANALYSIS
BRLCB V3.0
ADVANCED BALLISTIC CONCEPTS BRANCH - BRL

Project: ja2  Requested by: guercio
Inf File: 02095S5.inf  Created From .MAS File: ja2.mas
P/T File: 02095S5.pvt  Calculation Output File: 02095S5.out
Smoothed: 02095S5.pdt  Graphics File: 02095S5.dat
EE File: 02095S5E.A0
Fired on: 02/09/95

FIRES REMARKS:
J2, ETC 4CAPS AND 4 IND, REPRODUCE 1.2ms pulse of 300kJ PFN
ENERGY MATCHED: 18KJ

IGNITER INFORMATION
The Igniter Used Is: Black Powder  Lot: FFFG
The Source For The Igniter Is: Pellets, Milan Ord.

IGNITER THERMOCHEMICAL PROPERTIES:
Impetus (J/g) : 290.0  Molecular Weight : 66.37000
Flame Temperature (K): 2188.0  Covolume (cc/g) : .70500
Density (g/cc) : 1.75000  Gamma : 1.21840

PROPELLANT INFORMATION
The Propellant Used Is:  Lot:
The Source For The Propellant Is:

Propellant Thermochemical Properties: Following
Sheets of Output

PROPELLANT GRAIN GEOMETRY
Grain Type: 1-Perf. Cyl.
Length --- (cm.): .139700
Outer Diam.(cm.): 2.882900
Perf Diam. (cm.): 1.270000
Inner Web (cm.): .806450

Bomb Information

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<td>Constants For Fit:</td>
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<td>B: .54171E-01</td>
<td></td>
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<td>C: -.31853E-06</td>
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Temperature and Charge Mass Information

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<td>Igniter Temp. (K):</td>
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Number of Propellant Grains: 23.16

Number of Wildpoint Passes: 1  Wildpoint Tolerance: 5.000
Number of Smoothing Passes: 1  Smoothing Option: 1
Bridge Length: 15

OUTPUT FILE: 02095S5.OP7

***************************************************************

Total # Layers = 1
Chamber Volume (cm3) = 129.400
Heat-Loss-Fraction (n-d) = .000

36
Figure D-6. *Burn rate ident 02105S7.*
ETC BURN RATE ANALYSIS

BRLCB V3.0
ADVANCED BALLISTIC CONCEPTS BRANCH - BRL

Project: ja2
Inf File: 02105S7.inf
P/T File: 02105S7.pvt
Smoothed: 02105S7.pdt
EE File: 02105S7E.AD
Fired on: 02/10/95 ETC JA2
FIRING REMARKS:
02105S7V.AD WAS LOW PASS FILTERED 5000/500HZ
NEW E-LINER/THREADED NOZZLE
E-LINER DID NOT FRAGMENT AFTER FIRING @4kJ

IGNITER INFORMATION
The Igniter Used Is: Black Powder
Lot: FFFG
The Source For The Igniter Is: Pellets, Milan Ord.

IGNITOR THERMOCHEMICAL PROPERTIES:
Impetus (J/g) : 290.0
Molecular Weight : 66.37000
Flame Temperature (K) : 2188.0
Covolume (cc/g) : .78500
Density (g/cc) : 1.75000
Gamma : 1.21840

PROPELLANT INFORMATION
The Propellant Used Is:
Lot:
The Source For The Propellant Is:
Propellant Thermochemical Properties: Following
Sheets of Output

PROPELLANT GRAIN GEOMETRY
Grain Type: 1-Perf. Cyl.
Length --- (cm.): .139700
Outer Diam. (cm.): 2.882900
Perf Diam. (cm.): 1.270000
Inner Web (cm.): .806450

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<th>Gage Information</th>
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Temperature and Charge Mass Information

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<td>Number of Propellant Grains: 23.08</td>
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Number of Wildpoint Passes: 1
Wildpoint Tolerance: 5.000
Number of Smoothing Passes: 1
Smoothing Option: 1
Bridge Length: 15
1 OUTPUT FILE: 02105S7.OP7

***********************************************************************

***********************************************************************

Total # Layers = 1
Chamber Volume (cm^3): 129.400
Heat-Loss-Fraction (n-d): .000
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STE 0944  
FT BELVOIR VA 22060-6218 |
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US ARMY RESEARCH LAB  
ATTN AMSRL OP SD TA  
2800 POWDER MILL RD  
ADELPHI MD 20783-1145 |
| 3            | DIRECTOR  
US ARMY RESEARCH LAB  
ATTN AMSRL OP SD TL  
2800 POWDER MILL RD  
ADELPHI MD 20783-1145 |
| 1            | DIRECTOR  
US ARMY RESEARCH LAB  
ATTN AMSRL OP SD TP  
2800 POWDER MILL RD  
ADELPHI MD 20783-1145 |

ABERDEEN PROVING GROUND

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K KOMINOS
PENTAGON
WASHINGTON DC 20310-0103

1  HQDA
ATTN SARD TR
R CHAIT
PENTAGON
WASHINGTON DC 20310-0103

1  DIRECTOR
ARMY RESEARCH OFFICE
ATTN AMXRO MCS K CLARK
PO BOX 12211
RESEARCH TRIANGLE PARK NC
27709-2211

1  DIRECTOR
ARMY RESEARCH OFFICE
ATTN AMXRO RT IP LIB SERV
PO BOX 12211
RESEARCH TRIANGLE PARK
27709-2211

ABERDEEN PROVING GROUND

126  DIR, USA RL
ATTN: AMSRL-SC,
   W. MERMAGEN
   W. STUREK
   AMSRL-SC-C, H. BREAUx
   AMSRL-SC-CC,
   J. GROSH
   A. CELMIN
   AMSRL-SC-S, A. MARK
   AMSRL-SL-B, P. DEITZ (328)
   AMSRL-SL-BA, J. MORRISSEY (433)
   AMSRL-SL-BG, A. YOUNG (238)
   AMSRL-SL-BL, M. RITONDO (328)
   AMSRL-SL-BS, D. BELY (328)
   AMSRL-SL-BV, R. SANDMEYER (247)
   AMSRL-SL-I, M. STARKS (433)
   AMSRL-WT,
   D. ECCLESHALL
   I. MAY
   J. ROCCHIO
   AMSRL-WT-P, A. HORST

AMSRL-WT-PA,
R. ANDERSON
A. BIRK
C. BULLOCK
A. BRANT
L-M. CHANG
T. COFFEE
J. COLBURN
P. CONROY
M. DEL GUERCIO (5 CP)
J. DESPIRITO
S. FORTIER
J. HEWITT
S. HOWARD
A. JOHNSON
A. JUHASZ
G. KATULKA
G. KELLER
M. KIWIN
J. KNAPTON
D. KOOKER
D. KRUCZYNSKI
C. LEVERITT
M. MCQUAID
T. MINOR
M. NUSCA
K. NEKULA
W. OBERLE
P. REEVES
M. RIDGLEY
T. ROSENBERGER
C. RUTH
I. STOBBIE
P. TRAN
J. TURK
K. WHITE
A. WILLIAMS
G. WREN
AMSRL-WT-PB,
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