LOX/Hydrocarbon Rocket Engine Analytical Design Methodology Development and Validation

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May 1993

Prepared for
Lewis Research Center
Under Contract NAS3–25556
LOX/HYDROCARBON ROCKET ENGINE
ANALYTICAL DESIGN METHODOLOGY
DEVELOPMENT AND VALIDATION

(Contract NAS 3-25556)

Final Report

VOLUME II
APPENDICES

Prepared
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MEASURED MANIFOLD AND CHAMBER MEAN PRESSURES VERSUS TIME PLOT FOR ALL SUCCESSFUL TESTS
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This Appendix contains plots of selected pressure measurements as a function of time from the initial fireswitch (FS-1) activation. These plots were prepared from digital data obtained from the analog-to-digital converter for all 27 tests, where meaningful operation was achieved, in order to assess the combustion stability or instability characteristics of the combustor. The plots start at FS-1 + 1.10 seconds, which is the approximate time that the LOX/TEA + TEB ignition occurs. This hypergolic propellant combination is used as a combustion source to ignite the LOX/RP-1 propellants. Test data is plotted until well after the test shutdown switch (FS-2) in order to show pressure decays during the shutdown transient. Information contained in these plots are identified below:
**PLOTTED PARAMETERS**

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<td>POJ</td>
<td>LOX Injector Manifold Pressure</td>
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<tr>
<td>PFJ</td>
<td>RP-1 Injector Manifold Pressure</td>
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<tr>
<td>DPO</td>
<td>LOX Injector ΔP (POJ-Pc-3)</td>
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<td>DPF</td>
<td>RP-1 Injector ΔP (PFJ-Pc-3)</td>
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<tr>
<td>DPF/Pc</td>
<td>DPF/Pc-3</td>
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</tbody>
</table>
ROCCID SUBSCALE INJECTOR
PERFORMANCE PARAMETERS

TEST DATE 04-08-91 AT 1750 HOURS  DURATION 1.823 SECONDS
TEST NUMBER KFN7-D01-IJ-013  TEST STAND E-4
A-11

RCCID SUBSCALE INJECTOR
PERFORMANCE PARAMETERS

GenCorp
AEROJET

TEST DATE 04-09-91 AT 1347 HOURS
DURATION 1.823 SECONDS
TEST NUMBER KFN7-001-1J-015
TEST STAND E-4

0 PC-F PSIA
1 POJ PSIA
2 PFJ PSIA
3 OPO PSIA
4 OPI PSIA
5 OPO/PC PSIA
6 OPI/PC PSIA
ROCCID SUBSCALE INJECTOR
PERFORMANCE PARAMETERS

TEST DATE 04-10-91 AT 1341 HOURS  DURATION 1.403 SECONDS
TEST NUMBER KFN7-001-1J-019  TEST STAND E-4
A-18

ROCCID SUBSCALE INJECTOR PERFORMANCE PARAMETERS

GENCORP AEROJET

TEST DATE 04-17-91 AT 1000 HOURS  DURATION 1.825 SECONDS
TEST NUMBER KFN7-001-1J-023  TEST STAND E-4
ROCCID SUBSCALE INJECTOR PERFORMANCE PARAMETERS

TEST DATE 04-30-91 AT 1441 HOURS  DURATION 1.693 SECONDS

TEST NUMBER KFN7-001-1J-030  TEST STAND E-4
GenCorp
AEROJET
ROCCID SUBSCALE INJECTOR PERFORMANCE PARAMETERS
TEST DATE 05-01-91 AT 1102 HOURS DURATION 1.904 SECONDS
TEST NUMBER KFN7-001-1J-031 TEST STAND E-4
ROCCID Subscale Injector Performance Parameters

GenCorp AEROJET

Test Date 05-02-91 at 1336 Hours
Duration 1.805 Seconds
Test Number KFN7-001-IJ-037
Test Stand E-4
ROCCID SUBSCALE INJECTOR PERFORMANCE PARAMETERS

TEST DATE 05-03-91 AT 1314 HOURS  DURATION 1.943 SECONDS
TEST NUMBER KFN7-001-1J-040  TEST STAND E-4
APPENDIX B

TIME SERIES, AMPLITUDE AND FREQUENCY EVOLUTION, AND POWER SPECTRAL ANALYSIS OF CHAMBER PRESSURE FOR ALL UNSTABLE-COMBUSTION TESTS
## INDEX OF TEST DATA PLOTS

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**Note:** See Foreword (next page) for explanation of information contained in the 3 plot set for each test.
FOREWORD

Unstable operation was observed during 16 of the 27 valid tests conducted during the ROCCID validation test program. For each of these unstable tests, the following information is contained in this appendix:

1. High Frequency Chamber Pressure Transducer playback of the pressure amplitude versus time prior to and during the observed unstable combustion event. Sample format for this plot is as follows:

   Time Scale Start Time as Referenced from Test Initiation Switch (FS-1)

   Test No.

   Pressure Amplitude as Measured from PCHF1 Transducer in PSI/100 (Note: 0.0 Represents Steady State D.C. Value)
(2) Power Spectral Density (PSD) analysis of the high frequency pressure amplitude recorded signal. Sample format for this plot is as follows:

![Graph](image)

**Time Period from FS-1 Over Which PSD is Obtained**

**Test No.**

**Effective Bandwidth**

**Frequency (Hertz/100) of the Pressure Amplitude Signal**

**Autospectral Density (PSD)**

- Time Period: 1.46 - 1.49 sec
- Window: None
- Distinct AVG: 165
- Bandwidth = 5.35E+05
- Variance = 5.35E+05
(3) Power Spectral Analysis of the high frequency pressure amplitude signal. Sample format for this pot is as follows:

- **Test No.**
- **Time Interval for Each Segment**
  - FS1.1
  - 4 sec
- **Individual PSD Time Segment**
- **Effective Bandwidth**
- **Frequency (Hertz/1000) of the Pressure Amplitude Signal**
  \[
  \left( \frac{\text{Pressure Amplitude @ a Given Frequency}}{\text{Bandwidth}} \right)^2 / 10
  \]
SPECTRA OF PCHF1 (PS1) : 19 SEGMENTS

FSI+1.4 to FSI+1.5 sec
KFN7-D01-1J -004
SEGMENT TIME= 5.000E-03
DAMPLITUDE= 100.
DF, / SEGMENT= 200.
DH / SEGMENT= 63.2
AUTOSPECTRAL DENSITY OF PCH#1 (PSI)

FS1: 1.38 - 1.41 sec.
KFN7-001-1J -018
WINDOW = NONE
DISTINCT AVG = 5
BANDWIDTH = 165
VARIANCE = 1.348E+05
ROCCID Test Program

Time zero = FS1 + 1.18 sec
KFN7-001-1J -022

PCHR1 (PSI) | TIME (SEC) (10^-2)
---|---
-37.5| 0.00
-25.0| 1.25
-12.5| 2.50
0.0| 3.75
12.5| 5.00
25.0| 6.25
37.5| 7.50
| 8.75
| 10.00
SPECTRA OF PCH1 (PSI)  19 SEGMENTS

FS1+1 1B to FS1+1 2B sec
KFN7-D01-1J -022
SEGMENT TIME= 5.000E-03
AMPLITUDE = 400.
DF / SEGMENT= 200.
DH / SEGMENT= 316.
AUTOSPECTRAL DENSITY OF PCF1 (PSI)

FSI: 1.24 - 1.27 sec
KFN7-001-1J -022
WINDOW = NONE
DISTINCT AVG = 5
BANDWIDTH = 165
VARIANCE = 1.967E+06
ROCCID Test Program

Time zero = FS1+1.29 sec
KFN7-D01-1J-025

PCHF2 (PSI)

TIME (SEC)

0.00 1.25 2.50 3.75 5.00 6.25 7.50 8.75 10.00

(10^-2)
AUTOSPECTRAL DENSITY OF PCHF2 (PSI)

FSI+ 1.35 - 1.38 sec.
KFN7-001-1J -025
WINDOW = NONE
DISTINCT AVG = 5
BANDWIDTH = 165.
VARIANCE = 2.657E+05
AUTOSPECTRAL DENSITY OF PCH1 (PSI)

- FS1+ 1.42 - 1.45 sec.
- KFN7-001-1J -02B
- WINDOW = NONE
- DISTINCT AVG = 5
- BANOWIDTH = 165
- VARIANCE = 2.297E+05

B-35
G (UNITS SQUA./HZ)

10^-1
10^0
10^1
10^2
0.0  15.0  30.0  45.0  60.0  75.0  90.0  105.0  120.0
FREQUENCY (10^2)
AUTOSPECTRAL DENSITY OF PCHF1 (PSI)

FS1+ 1.82 - 1.85 sec  
KFN7-D01-1J -029  
WINDOW = NONE  
DISTINCT AVG= 5  
BANDWIDTH = 165.  
VARIANCE = 3.346E+05

B-38

G(UNIT S.SQD./HZ)

10^2

10^3

10^4

0.0 15.0 30.0 45.0 60.0 75.0 90.0 105.0 120.0

FREQUENCY (10^2)
AUTOSPECTRAL DENSITY OF PCHF1 (PSI)

FS1+ 1.71 - 1.74 sec.
KFN7-D01-1J -030
WINDOW =NONE
DISTINCT AVG= 5
BANDWIDTH = 165.
VARIANCE = 2.685E+04

G(UNITS SQRD./HZ)

10^3

10^2

10^1

10^0

0.0 15.0 30.0 45.0 60.0 75.0 90.0 105.0 120.0

FREQUENCY (10^2)
SPECTRA OF PCHF1 (PS1): 19 SEGMENTS

FS1+1.51 to FS1+1.61 sec
KFN7-D01-1J-037
SEGMENT TIME = 5.00E-03
DAMPLITUDE = 4.00
DF/SEGMENT = 200
DH/SEGMENT = 3.16

G (UNITS**2)/HZ

FREQUENCY (HZ)

(10^3)
SPECTRA OF PCHF1 (PS1)  19 SEGMENTS

FS1+1.34 to FS1+1.44 sec
KFN7-D01-1J -03R
SEGEMENT TIME = 5.000E-03
DAMPLITUDE = 400.
DF / SEGMENT = 200.
OH / SEGMENT = 316.

G (UNITS**2)/HZ

FREQUENCY (HZ)
AUTOSPECTRAL DENSITY OF PCH#1 (PSI)

FS1+ 1.40 - 1.43 sec
KFN7-001-1J-03B
WINDOW = NONE
DISTINCT AVG = 5
BANDWIDTH = 155
VARIANCE = 7.859E+05
SPECTRA OF PCHF1 (PS1)  19 SEGMENTS

FS1+1 50 to FS1+1 60 sec
KFN7-001-1J-039
SEGMENT TIME = 5.000E-03
AMPLITUDE = 20.0
DF / SEGMENT = 200.
DH / SEGMENT = 15.8
AUTOSPECTRAL DENSITY OF PCH1 1 (PSI)

 FS1+ 1.56 - 1.59 sec
 KFN7-D01-1J -039
 WINDOW = NONE
 DISTINCT AVG= 5
 BANDWIDTH = 165
 VARIANCE = 4.875E+04
Time zero = 5 x 1.4 sec
KFN7-001-1-J-040

ROCCIO Test Program
AUTOSPECTRAL DENSITY OF PCHF5 (PSI)

FS1: 1.46 - 1.49 sec
KFN7-001-1J -040
WINDOW = NONE
DISTINCT AVG = 5
BANDWIDTH = 155
VARIANCE = 5.446E+04
APPENDIX C

TIME SERIES, AMPLITUDE AND FREQUENCY EVOLUTION, AND POWER SPECTRAL ANALYSIS OF MANIFOLD AND CHAMBER PRESSURES AND ACCELERATIONS FOR TEST 004
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ALL DATA OBTAINED FROM TEST NO. KFN7-D01-1J-004

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<td>POJHF</td>
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<tr>
<td>AZ</td>
<td>C-29</td>
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<td>C-31</td>
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</table>

**Symbol**  
**Parameter Definition**

- **PCHF**: High Frequency Chamber Pressure (PSI)
- **POJHF**: High Frequency LOX Injector Manifold Pressure (PSI)
- **PFJHF**: High Frequency RP-1 Injector Manifold Pressure (PSI)
- **AX**: Accelerometer X Axis (g's)
- **AY**: Accelerometer Y Axis (g's)
- **AZ**: Accelerometer Z Axis (g's)
FOREWORD

Included in this appendix is a complete display of high frequency measurements obtained during test KFN7-D01-1J-004. A total of 10 parameters are displayed including five high frequency chamber pressure measurements (see Figure 51 of Volume I for measurement locations), one each high frequency pressure measurements located in the injector manifold inlet pipes of the fuel and oxidizer circuits, and three accelerometer recordings obtained from a tri-axial accelerometer mounted on the injector assembly. High frequency amplitude versus time, power spectral analysis and power spectral density plots for each of the 10 parameters are included. The plot formats are the same as those described in Appendix B.
SPECTRA OF PCHF1 (PSI) - 19 SEGMENTS

FS1+1 A to FS1+1.5 sec
KFN7-D01-1J-004
SEGMENT TIME = 5.000E-03
DAMPLITUDE = 100
DF / SEGMENT = 200
DH / SEGMENT = 63.2

G (UNITS**2)/HZ VERSUS FREQUENCY (HZ)

(-4.0) (-2.0) (0.0) (2.0) (4.0) (6.0) (8.0) (10.0) (12.0)

(0.0) (50.0) (100.0) (150.0) (200.0) (250.0) (300.0)
SPECTRA OF PCH#3 (PS1)  10 SEGMENTS

FS1+1.4 to FS1+1.5 sec
KFN7-D01-1J -004
SEGMENT TIME = 5.000E-03
DAMPLITUDE = 100.
OF / SEGMENT = 200.
DH / SEGMENT = 63.2
AUTOSPECTRAL DENSITY OF PCHF3 (PSI)

FSI+ 1.46 - 1.49 sec.
KFN7-D01-1J-004
WINDOW = NONE
DISTINCT AVG = 5
BANDWIDTH = 165
VARIANCE = 3.314E+05
APPENDIX D

ROCCID VALIDATION HARDWARE DESIGN DRAWING PACKAGE
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<td>D-11/D-17</td>
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<td>Chamber Body Forging</td>
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<tr>
<td>Chamber Proof Plate</td>
<td>1200977A</td>
<td>1 + ADCN</td>
<td>D-25/D-26</td>
</tr>
<tr>
<td>1/4 Wave Tube Resonator</td>
<td>1206426</td>
<td>1</td>
<td>D-27</td>
</tr>
<tr>
<td>Resonator Cavity Blank</td>
<td>1206431</td>
<td>1</td>
<td>D-28</td>
</tr>
<tr>
<td>Bomb Adapters</td>
<td>1201080A</td>
<td>1</td>
<td>D-29</td>
</tr>
</tbody>
</table>
NOTES:

1. INTERPRET DRAWING PER ATC-STD-490.
2. CLEANLINESS PER ATC-STD-490, LEVEL VC.
3. MAKE PER ATC-STD-490 WITH 120076 AND APPLICABLE DATA.
4. SURFACE FINISH TO BE WITHIN DIAMETER SHOWN.

1.020 DIA THRU:
40.0 A85 [510-50]
16 HOLES IS SPACED
APPENDIX E

ADVANCED DOCUMENT CHANGE NOTICES FOR THE ROCCID DESIGN DISCLOSURE
TEST ASSEMBLY IN THE FOLLOWING ORDER:

A. LEAK TEST ASSEMBLY PER ATC-47063, METHOD II, USING CLEAN DRY NITROGEN AT 50 ±5 PSIA. HOLD FOR 5 MINUTES MINIMUM. NO LEAKAGE ALLOWED.

B. FLOW TEST WITH CLEAN WATER (PER ATC-STD-4940, LEVEL 1000) AS FOLLOWS:
   1. PERFORM VISUAL PATTERN CHECK PER COGNIZANT DESIGN ACTIVITY.
   2. THE OXIDIZER AND FUEL CIRCUITS SHALL BE FLOWED SEPARATELY AT SEVERAL FLOWRATES BELOW CAVITATION ONSET (~ 50 PSIg ΔP). FOR EACH DATA POINT RECORD THE MANIFOLD ΔP, FLOWRATE, NOMINAL WATER FLOW TEMPERATURE AND ACTUAL OUTPUT FREQUENCY OF FLOWMETER. CALCULATE Kω:

   \[ Kw = \frac{w}{(\Delta P) (Sg)} \]

   WHERE: \( w \) = FLOWRATE, LB/SEC
   \( \Delta P \) = INLET - OUTLET PRESSURE, PSI
   \( Sg \) = SPECIFIC GRAVITY OF WATER AT FLOW TEMPERATURE
**TEST ASSEMBLY IN THE FOLLOWING ORDER:**

A. **ULTRASONIC INSPECT BRAZE JOINT PER ATC-STD-4819, TYPE I. ACCEPTANCE PER COGNIZANT DESIGN ACTIVITY.**

B. **PROOF TEST BRAZE JOINT BY FLOWING CLEAN WATER (PER ATC-STD-4940, LEVEL 1000) SIMULTANEOUSLY THRU THE OXIDIZER AND FUEL CIRCUITS TO ATMOSHERE. HOLD FOR APPROXIMATELY FIVE MINUTES.**

   **OXIDIZER CIRCUIT:**
   - MANIFOLD P = 750 ±10 PSI; APPROX FLOW = 175 LB/SEC
   - **FUEL CIRCUIT:**
   - MANIFOLD P = 710 ±10 PSI; APPROX FLOW = 85 LB/SEC

C. **REPEAT ULTRASONIC INSPECT OF BRAZE JOINT PER ATC-STD-4819, TYPE I. NOTE ANY DIFFERENCES. ACCEPTANCE PER COGNIZANT DESIGN ACTIVITY.**

D. **LEAK TEST ASSEMBLY PER ATC-47063, METHOD II, USING CLEAN DRY NITROGEN AT 50 ±5 PSIA. HOLD FOR 5 MINUTES MINIMUM. NO LEAKAGE ALLOWED.**

E. **FLOW TEST WITH CLEAN WATER (ATC-STD-4940, LEVEL 1000) AS FOLLOWS:**
   1. PERFORM VISUAL PATTERN CHECK PER COGNIZANT DESIGN ACTIVITY.
   2. **THE OXIDIZER AND FUEL SHALL BE FLOWED SEPARATELY AT THE FOLLOWING FLOW RATES: OXIDIZER: 25, 35, 45, 55, 65; FUEL: 20, 25, 35, 40, 45. FOR EACH DATA POINT RECORD THE MANIFOLD ΔP, FLOWRATE, NOMINAL WATER FLOW TEMPERATURE AND ACTUAL OUTPUT FREQUENCY OF FLOWMETER. CALCULATE K_w:**

\[
K_w = \frac{\dot{w}}{(\Delta P) (S_g)}
\]

**WHERE:**
- \(\dot{w}\) = FLOWRATE, LB/SEC
- \(\Delta P\) = INLET - OUTLET PRESSURE, PSI
- \(S_g\) = SPECIFIC GRAVITY OF WATER AT FLOW TEMPERATURE
<table>
<thead>
<tr>
<th>SH</th>
<th>ZONE</th>
<th>ITEM</th>
<th>IS;</th>
<th>WAS;</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>4 F</td>
<td>3</td>
<td>.172 DIA THRU</td>
<td>.172 DIA THRU</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SPOTFACE 1.25 DIA</td>
<td>C'BORE 3916 DIA X 3.00 DEEP</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>PORT PER MS33649-04</td>
<td>SPOTFACE 1.25 DIA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>PORT PER MS33649-04</td>
</tr>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>6 F</td>
<td>4</td>
<td>1.062 DIA THRU</td>
<td>1.062 DIA THRU</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>18 HOLES</td>
<td>SPOTFACE 2.50 DIA FAR SIDE ONLY, 18 HOLES</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1 C</td>
<td>5</td>
<td>1.062 DIA THRU</td>
<td>1.062 DIA THRU</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SPOTFACE 2.50 DIA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>FAR SIDE ONLY</td>
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16 PL EQ SP
16 PL EQ SP
### IS;

<table>
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<tr>
<th>SH</th>
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<th>PART NO.</th>
<th>DESCRIPTION</th>
<th>QTY</th>
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<tbody>
<tr>
<td>1</td>
<td>2 A</td>
<td>6</td>
<td>1200976-2</td>
<td>RETAINER</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>2 A</td>
<td>6</td>
<td>AR 00426 RTVGE 627</td>
<td>SILICON SEALANT</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>2 A</td>
<td>6</td>
<td>M551937-6C</td>
<td>BOLT, EYE</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>2 A</td>
<td>6</td>
<td>M535691-41</td>
<td>NUT, HEX</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>2 A</td>
<td>6</td>
<td>1206429-1</td>
<td>INSERT</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>2 A</td>
<td>6</td>
<td>-1</td>
<td>CHAMBER</td>
<td>1</td>
</tr>
</tbody>
</table>

### WAS;

<table>
<thead>
<tr>
<th>SH</th>
<th>ZONE</th>
<th>ITEM</th>
<th>PART NO.</th>
<th>DESCRIPTION</th>
<th>QTY</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>2 A</td>
<td>6</td>
<td>AR 00426 RTVGE 560</td>
<td>SILICON SEALANT</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>2 A</td>
<td>6</td>
<td>M551937-6C</td>
<td>BOLT, EYE</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>2 A</td>
<td>6</td>
<td>M535691-41</td>
<td>NUT, HEX</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>2 A</td>
<td>6</td>
<td>1206429-1</td>
<td>INSERT</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>2 A</td>
<td>6</td>
<td>-1</td>
<td>CHAMBER</td>
<td>1</td>
</tr>
</tbody>
</table>
IS;

RADIUS THE ORIFICE INLETS USING ONE OF THE FOLLOWING PROCESS:

A. ELECTROPOLISH INDICATED SIDE USING A SOLUTION OF 50% PHOSPHORIC ACID/50% DEIONIZED WATER AND 100 AMPS/FT² CURRENT. CONTINUE PROCESS UNTIL 0.001-0.0015 INCHES OF MATERIAL IS REMOVED AND ORIFICE INLETS HAVE A SLIGHT RADIUS.

B. MICRO BLAST INDICATED SIDE USING 100 MICRON SILICON CARBIDE GLASS BEADS FOR ~10 SEC. CONTINUE PROCESS UNTIL ALL BURRS ARE REMOVED AND A 0.001-0.0015 INCH RADIUS IS ACHIEVED ON THE ORIFICE INLETS.

WAS;

ELECTROPOLISH INDICATED SIDE USING A SOLUTION OF 50% PHOSPHORIC ACID/50% DEIONIZED WATER AND 100 AMP/FT² CURRENT. CONTINUE PROCESS UNTIL 0.001-0.0015 INCHES OF MATERIAL IS REMOVED AND ORIFICE INLETS HAVE A SLIGHT RADIUS.
<table>
<thead>
<tr>
<th>SH</th>
<th>ZONE</th>
<th>ITEM</th>
<th>WAS;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1A</td>
<td>1</td>
<td>WAS;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AR</th>
<th>WELD ROD</th>
<th>ER316</th>
<th>AWS A5.9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ASSY</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>WELD ROD</td>
<td>ER308</td>
<td>AWS A5.9</td>
<td>8</td>
</tr>
<tr>
<td>1</td>
<td>14713</td>
<td>52823</td>
<td>BUTT WELD HUB</td>
<td>7</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>52823</td>
<td>2&quot;GR 20 SCH 160</td>
<td>SA182-F316</td>
</tr>
<tr>
<td>1</td>
<td>-3</td>
<td>BOSS</td>
<td>CRES</td>
<td>5</td>
</tr>
<tr>
<td>1</td>
<td>-6</td>
<td>OUTER RING</td>
<td>CRES ASTM A473 OR ASTM A167 TYPE 304</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>-6</td>
<td>INNER RING</td>
<td>CRES ASTM A473 OR ASTM A167 TYPE 304</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>-2</td>
<td>OUTER RING</td>
<td>CRES ASTM A473 OR ASTM A167 TYPE 304</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>-1</td>
<td>INNER RING</td>
<td>CRES ASTM A473 OR ASTM A167 TYPE 304</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX F
NONCONFORMANCE REPORTS
# Nonconformance Report

## Part Numbers
- 1206432
- KFN 600

## Work Order
- N/A

## Shop Order
- N/A

## Supplier Name
- Viking Metallurgical

## Supplier Number
- N/A

## P.O. Number
- L823696H

## Distribution No.
- N/A

## Previous NR Number
- N/A

## Item

<table>
<thead>
<tr>
<th>Description</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>B/P note 5 requires ultrasonic inspection to ATC-STD-4819 with acceptance to ATC-Std 4006 Class II. Forging is rejected to Class II</td>
<td>Accept As Is providing the forging will meet Ultrasound Inspection per ATC-STD-4819 with acceptance to ATC-STD-4006 Class IV. Also, provide all available records substantiating the material meets MIl-S-5000E requirements.</td>
</tr>
<tr>
<td>and Class III. Forging is acceptable to Class IV.</td>
<td></td>
</tr>
</tbody>
</table>

## Corrective Action
- The heat of 4340AQ used was not adequate for Class II sonic requirement.
- Purchase better quality stee; Next Purchase Order.

## Signature
- CCA Signature
- Date

## Approval
- MIB/ERB
- Date
**NONCONFORMANCE REPORT**

**PART NUMBER:** 1206429  
**DASH REV.:** N/C  
**NOMENCLATURE:** INSERT THRUST CHAMBER

<table>
<thead>
<tr>
<th>ITEM</th>
<th>NONCONFORMANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Resin Content</td>
</tr>
<tr>
<td></td>
<td>31±4% is</td>
</tr>
<tr>
<td></td>
<td>36.83 FWD</td>
</tr>
<tr>
<td></td>
<td>36.61 AFT</td>
</tr>
</tbody>
</table>

**CAUSE:** Us As Is: the higher resin content will not affect the performance of the liner in the hot fire environment.

**DISPOSITION/COMMENTS:**

**21. MBREA APPROVALS:**

**23. CAUSE:**

**24. CORRECTIVE ACTION:** Raise part resin content limits, or procure MX2600 with a lower resin content which would not be their standard product.

**25. EFFECTIVITY:** Date: Serial Number: Etc.
## Nonconformance Report

**Item:** Resin Content

<table>
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<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin Content</td>
<td>31 ± 4%</td>
</tr>
<tr>
<td>Forwards</td>
<td>36.89</td>
</tr>
<tr>
<td>Aft</td>
<td>36.23</td>
</tr>
</tbody>
</table>

### Us As Is

The higher resin content will not affect the performance of the Insert in the hot fire environment.

### Corrective Action

- **Burnout Method for Silica Phenolic Materials:** Historically has been higher than the raw material certifications (Fibrate Certs Report 92%).
- **Flow Draining Cure:** Also the required cure cycle reduces resin flow during cure.

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>C.A. 123456</td>
<td>1-4-91</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
NONCONFORMANCE REPORT

1. PART NUMBER: 1200729
2. NOMENCLATURE: INJECTOR CORE
3. SERIAL NO.
4. PROGRAM: 3D SUBSCALE
5. LOT SIZE: 1
6. ACC.: 1
7. DISC.: 1

8. WORK ORDER: S/0 4444
9. SHOP ORDER: 10. OPER. NO.
11. SUPPLIER NAME: MARTINEZ & TUREK
12. P.O. NUMBER: L823839
13. DISTRIBUTION NO.
14. PREVIOUS NR NUMBER

14. NONCONFORMANCE

(A) DWG. ZONE, SPEC., PARA., SHOP ORDER OPER., ETC. AS APPLICABLE
(B) STATE REQUIREMENT (C) INSPECTION RESULTS

<table>
<thead>
<tr>
<th>ITEM</th>
<th>(A) CAUSE QPCgien (B) FREQ OCCUR</th>
<th>MRP ITEMS</th>
<th>DISPOSITION/COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>REF. DWG. SHEET 4/7, ZONE: F-8</td>
<td></td>
<td>Us As Is; the smaller diametrical dimension will not affect the assembly nor will it jeopardize the seal of the o-ring.</td>
</tr>
<tr>
<td></td>
<td>SHOULD BE: $11.336+.000  .002</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IS: $11.331 at 68°F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>REF. DWG SHEET 3/7, ZONE: A-3</td>
<td></td>
<td>Us As Is; the difference of .001&quot; in channel depth will not change the flow characteristics to detriment the hardware performance.</td>
</tr>
<tr>
<td></td>
<td>SHOULD BE: .022 + .001 @ 8 places,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(BRAZE CHANNEL DEPTH)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IS: ACCEPTABLE AT (7) LOCATIONS,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1) LOCATION ($1.888) FOUND TO BE</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>.024&quot; DEEP.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

17. INITIATOR IDENTITY: S. NICKERSON
19. REVIEWED BY:
21. MRB/VERB APPROVALS

22. MRB/VERB RESEND DECISIONS

23. CAUSE: OPERATOR ERROR

24. CORRECTIVE ACTION

OPERATOR HAD PROPER INSTRUCTIONS AND DID NOT FOLLOW.
THIS OPERATOR HAS BEEN COUNSELED ON CRITICAL NATURE
OF THIS ASSEMBLY. VERBAL WARNING ISSUED.

25. EFFECTIVITY: (DATE/Serial Number/etc.)

DISCREPANT MATERIAL DISPOSITION

RESPONSIBILITY: GFM MFG

DISCREPANT MATERIAL DISPOSITION

RESPONSIBILITY: GFM MFG

DISCREPANT MATERIAL DISPOSITION

RESPONSIBILITY: GFM MFG

DISCREPANT MATERIAL DISPOSITION

RESPONSIBILITY: GFM MFG

DISCREPANT MATERIAL DISPOSITION

RESPONSIBILITY: GFM MFG

DISCREPANT MATERIAL DISPOSITION

RESPONSIBILITY: GFM MFG

DISCREPANT MATERIAL DISPOSITION

RESPONSIBILITY: GFM MFG

DISCREPANT MATERIAL DISPOSITION

RESPONSIBILITY: GFM MFG
**NONCONFORMANCE REPORT**

**ITEM**
1. **REF:** DWG. SHEET -4, Zone: D-5
   Should be: Ø 0.156 +0.005 ±0.001, 7-Holes Eq. Spaced
   (See Attached for Discrepant locations) 7 pls.

**IS:** True position varies up to 0.020.

Accept as is providing all metal chips have been deburred so there will be nothing dislodged during testing.

**DISCREPANT MATERIAL DISPOSITION**

<table>
<thead>
<tr>
<th>RESPONSIBILITY</th>
<th>CMG</th>
<th>GY</th>
<th>HIS</th>
<th>SHIPRTN</th>
<th>SALVAGE</th>
<th>PHOIL MGR'S</th>
<th>DATE</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**CORRECTIVE ACTION**

Due to the length of the drill required to complete this configuration (Approx. 5" Long) Deflection occurred thus causing drilled hole to be off location.

Operator has been instructed to pilot drill holes first and then bore to size.

**DATE**

- **19/12/91**

**SIGNATURE**

- **C. A. L. S.**


**ATC PN# 1200729**

**-1 INJECTOR CORE**

**P.O. # L823839**

---

**View** S 42/6
9 FL THRU EQ SP
SCALE: 2/1

---

**Table: HOLE NO. & TRUE POSITION**

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<thead>
<tr>
<th>HOLE NO.</th>
<th>TRUE POSITION</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>0.006</td>
</tr>
<tr>
<td>2</td>
<td>0.020</td>
</tr>
<tr>
<td>3</td>
<td>0.006</td>
</tr>
<tr>
<td>4</td>
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<tr>
<td>5</td>
<td>0.012</td>
</tr>
<tr>
<td>6</td>
<td>0.007</td>
</tr>
<tr>
<td>7</td>
<td>0.0085</td>
</tr>
</tbody>
</table>

---

**SCALE:** 2/1

---

**2/1221**
**NONCONFORMANCE REPORT**

**PART NUMBER:** 1206423  
**REV.:** 9  
**NOMENCLATURE:** INJECTOR CORE ASSY  
**SERIAL NO.:** S/N-01  
**PROGRAM:**  
**LOT SIZE:**  
**ACC.:**  
**DISC.:**

**SHOP ORDER:** VENDOR S/O 4444  
**OPER. NO.:** martinez & Turek  
**SUPPLIER NAME:**  
**P.O. NUMBER:** 1823819  
**DISTRIBUTION NO.:**  
**PREVIOUS NR NUMBER:**

---

### 14. NONCONFORMANCE

1. **REF. DWG. #** 1200729, Sht #1, Zone: F-6

**SHOULD BE:** 10.75 ± 0.030

**IS:** 10.685

---

### 16. DISPOSITION/COMMENTS

Us As Is; the difference in length will be accommodated between the seal and the test stand interface.

---

### 23. CAUSE

This is attributed to Weld Shrinkage during the welding of -19 Assembly unto -1 Assembly.

---

### 24. CORRECTIVE ACTION

This problem has been presented to M&T Engineering

---

### DISCREPANT MATERIAL DISPOSITION

**RESPONSIBILITY:**

**DATE:**

**DATE:**

**DATE:**

---

**G.F.M. NO.:**

**PAGE 1 OF 1**

---

**TECH 00030A (REV 9/87)**
Title and Subtitle: LOX/Hydrocarbon Rocket Engine Analytical Design Methodology Development and Validation

Author(s): Karen E. Niiya and Richard E. Walker

Performing Organization: Aerojet Propulsion Division
P.O. Box 13222
Sacramento, California 95813

Sponsoring/Monitoring Agency: National Aeronautics and Space Administration
Lewis Research Center
Cleveland, Ohio 44135-3191

Abstract: This final report includes a discussion of the work accomplished on contract NAS 3-25556 during the period from December 1988 through November 1991. The objective of the program was to assemble existing performance and combustion stability models into a usable design methodology capable of designing and analyzing high-performance and stable LOX/Hydrocarbon booster engines. The methodology was then used to design a validation engine. The capabilities and validity of the methodology were demonstrated using this engine in an extensive hot fire test program. The engine used LOX/RP-1 propellants and was tested over a range of mixture ratios, chamber pressures and acoustic damping device configurations. This volume contains time domain and frequency domain stability plots which indicate the pressure perturbation amplitudes and frequencies from approximately 30 tests of a 50K thrust rocket engine using LOX/RP-1 propellants over a range of chamber pressures from 240 to 1750 psia with mixture ratios of from 1.2 to 7.5. The data is from test configurations which used both bitune and monotune acoustic cavities and from tests with no acoustic cavities. The engine had a length of 14 inches and a contraction ratio of 2.0 using a 7.68 inch diameter injector. The data was taken from both stable and unstable tests. All combustion instabilities were spontaneous in the first tangential mode. Although stability bombs were used and generated over pressures of approximately 20%, no tests were driven unstable by the bombs. The stability instrumentation included six high-frequency Kistler transducers in the combustion chamber, a high-frequency Kistler transducer in each propellant manifold, and tri-axial accelerometers. Performance data is presented, both characteristic velocity efficiencies and energy release efficiencies, for those tests of sufficient duration to record steady state values.

Subject Terms: Combustion stability; Combustion efficiency; Rocket engine design; Combustion chambers; Rocket thrust chambers; Design analysis; Injectors

Security Classification: Unclassified - Unlimited
Subject Category: 20

DISTRIBUTION/AVAILABILITY STATEMENT: Unclassified - Unlimited
Subject Category: 20

Security Classification of Report: Unclassified

Security Classification of This Page: Unclassified

Security Classification of Abstract: Unclassified

Number of Pages: 160
Price Code: A08