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Annular Precision Linear Shaped Charge Flight Termination System for the ODES Program*

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Abstract

The work for the development of an Annular Precision Linear Shaped Charge (APLSC) Flight Termination System (FTS) for the Operation and Deployment Experiment Simulator (ODES) program is discussed and presented in this report. The Precision Linear Shaped Charge (PLSC) concept was recently developed at Sandia. The APLSC component is designed to produce a copper jet to cut four inch diameter holes in each of two spherical tanks, one containing fuel and the other an oxidizer that are hyperbolic when mixed, to terminate the ODES vehicle flight if necessary. The FTS includes two detonators, six Mild Detonating Fuse (MDF) transfer lines, a detonator block, detonation transfer manifold, and the APLSC component.

PLSCs have previously been designed in ring components where the jet penetrating axis is either directly away or toward the center of the ring assembly. Typically, these PLSC components are designed to cut metal cylinders from the outside inward or from the inside outward. The ODES program requires an annular linear shaped charge.

The (Linear Shaped Charge Analysis) LESCA code was used to design this 65 grain/foot APLSC and data comparing the analytically predicted to experimental data are presented. Jet penetration data are presented to assess the maximum depth and reproducibility of the penetration. Data are presented for full scale tests, including all FTS components, and conducted with nominal 19 inch diameter, spherical tanks.

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Acknowledgments

The communications, guidance and budget support provided by Mike Rogers and Jim Duggar (8115) from the Space Programs Department were essential in meeting the Flight Termination System development milestones.

The following work was conducted at the Pantex Plant under the direction of Steve Hallett:

1. The annular linear shaped charges explosive loading procedures were developed and the components were loaded with LX-13/XTX-8003 explosive;
2. The environmental tests were conducted;
3. Tests to evaluate various PLSC tamping materials were conducted;
4. Full scale tests with two spherical tanks were conducted;
5. The special shipping container was designed and DOE approval obtained;
6. Margin and reproducibility tests were conducted; and
7. The above work was documented.

Reuben Weinmaster (2652) and Tino Casaus (2652) were responsible for the design and fabrication of the MC4237 detonator and detonator block for this program. Joe Curzi (2653) was responsible for the design and fabrication of the MDF transfer lines and detonation transfer, distribution manifold. Ken Shelton (2852) was responsible for all the design definition drawings.

Contents

1.0	Introduction.....	7
2.0	Customer Requirements.....	8
3.0	Flight Termination System Configuration.....	8
3.1	APLSC	8
3.2	Detonator.....	8
3.3	Detonator Block.....	9
3.4	MDF Transfer Lines.....	9
3.5	Distribution Manifold	9
4.0	LESCA Code Analysis.....	9
5.0	Development Tests	9
5.1	APLSC "LINEAR" Jet Penetration.....	9
5.2	APLSC "RING" Jet Penetration.....	10
5.3	Detonator.....	10
5.4	MDF Transfer Lines.....	10
5.5	Environmental	11
5.6	FTS Components Explosive Loading.....	11
6.0	Summary	11
	References.....	13

Tables

1	FTS Components, Quantity, Hazard, Explosive Weights and Drawing Numbers
2	APLSC Cutter Summary.....
3	Detonator Firing Characteristics.....
4	APLSC Cutter Development Test Penetration Data/Tamper Material Study.....
5	Measured Flyer Velocity (VISAR).....
6	ODES Environmental Qualification Test Matrix.....
7	ODES Environmental Qualification Testing Stimulus Definition.....
8	ODES/FTS Components Summary Data

Figures

1	ODES Flight Termination System Components
2	ODES Fuel/Oxidizer Tanks/FTS System Actual Configuragion
3	ODES APLSC Cutter.....
4	APLSC Cutter/Fuel Tank Cross-Section.....
5	APLSC Cutter Cross-Section Detail.....

Contents (continued)

6	MC4237 Detonator.....
7	MC4237 Detonator - MDF Transfer Line Interface
8	PEEK Detonator Block/MDF Transfer Line Assembly (MDF Line Side).....
9	PEEK Manifold/Detonator Transfer Distribution Configuration.....

10	Transfer Line/FTS Cutter, Fuel Tank Assembly
11	APLSC Jet Penetration versus Standoff/Aluminum 6061-T6 Target
12	APLSC Jet Penetration versus Distance/Aluminum 6061-T6 Target
13	APLSC Ring Cutter Jet Penetration versus Positin/Steel Target.....
14	APLSC Jet Penetration versus Confinement/Tamping Material Density
15	MC4237 Detonator Flyer Velocity versus Time and Distance
16	MC4237 Detonator Function Time versus Bridgewire Current
	Appendix A - ODES Flight Termination System Drawings
	Appendix B - MC4237 Detonator Data
	Appendix C - Mild Detonating Fuse (MDF) Transfer Line Data.....
	Appendix D - LESCA Code Information
	Appendix E - FTS Environmental Tests Configurations, Fixture, Pre- and Post-Test Configurations.....

Annular Precision Linear Shaped Charge Flight Termination System for the ODES Program*

1.0 Introduction

The Precision Linear Shaped Charge (PLSC) concept was recently developed at Sandia National Laboratories.¹⁻¹¹ PLSCs were designed for Department of Energy programs with the following requirements:

1. Less explosive to sever a given target,
2. More reproducible target severance in order to take advantage of the jet penetration as well as the associated fracture,
3. Less total component weight
 - A. Explosive,
 - B. Liner/wedge area
 - C. Tamper/confinement,
4. Less total volume,
5. Less collateral damage to adjacent components
 - A. Air shock
 - B. Pyro-shock through connecting materials
 - C. Missile fragment damage,
6. Precise cuts or severance of targets.

The work for the development of an Annular Precision Linear Shaped Charge (APLSC) Flight Termination System (FTS) for the Operation and Deployment Experiment Simulator (ODES) program is discussed and presented in this report. On command, the APLSC component is designed to produce a copper jet to cut four inch diameter holes in each of two spherical, stainless steel fuel and oxidizer tanks to terminate the ODES vehicle flight if necessary. The fuel and oxidizer combine and spontaneously combust without external ignition stimulus due to the hyperbolic nature of the materials. The FTS includes two detonators, six MDF transfer lines, a detonator block, two detonation transfer manifolds, and two APLSC components.

PLSCs have previously been designed in ring components where the jet penetrating axis is either directly away or toward the center of the ring assembly. Typically these PLSC components are designed to cut metal cylinders from the outside inward or from the inside outward. The ODES program requires an annular linear shaped charge; that is, the jet axis is cutting at 90 degrees relative to the center of the ring assembly. Because of the unsymmetrical collapse of the copper liner, the jet that is formed is skewed relative to the spherical target at impact. This is the first annular cutting PLSC component designed at Sandia.

The LESCA code was used to design this 65 grain/foot APLSC and data comparing the analytically predicted to experimental data are presented. Jet penetration data are presented to assess the maximum depth and reproducibility of the penetration. Data are presented for full scale tests, including all FTS components, and conducted with nominal 19 inch diameter, spherical stainless steel tanks.

2.0 Customer Requirements

The FTS customer requirements are as follows:

1. Design a PLSC to cut 4.0 inch diameter hole in 0.021 inch thick by 18.87 inch diameter, cryo-formed stainless steel (304) spheres;
 - A. Two spherical tanks (one fuel and one oxidizer) per flight vehicle,
 - B. Two PLSC assemblies per flight vehicle;
2. FTS components must be water sealed;
3. After functioning, cutter and other FTS components must break up and disperse;
4. Components shelf life of at least ten year; and
5. MDF lines required to transfer detonation from the detonator to each of six PLSC cutter interfaces.

3.0 Flight Termination System Configuration

The FTS components and actual configuration are shown in Figures 1 and 2, respectively. The FTS components drawings are included in Figures A1 through A11 in Appendix A. The FTS includes the APLSC cutter, detonator, transfer lines, manifold, detonator block, and seals as listed in Table 1. Table 1 also lists the component quantities, hazards, explosives weights, and part drawing numbers.

3.1 APLSC

The ODES APLSC cutter and tank configurations are shown in Figures 3 through 5. The drawings are shown in Figures A1 - A7 in Appendix A. The cutter is shown mounted on the spherical tank in Figure 3. A cross-sectional view of the cutter and tank is illustrated in Figure 4. A detailed cross-sectional view of the cutter is shown in Figure 5. The 0.012 inch thick copper liner includes a 76 degree apex angle as shown in Figure 5. The APLSC diameter at the liner apex is 4.0 inches. The coreload of the LX-13/XTX-8003 explosive is nominally 65 grains/foot. The top tamper plate material is aluminum 7075-T6. The bottom, standoff plate material is also aluminum 7075-T6. The APLSC parameters are summarized in Table 2.

3.2 Detonator

The MC4237 detonator¹² was designed for a previous program and was selected for this program and is shown in Figure 6. The drawings are shown in Figures A12 through A15 of Appendix A. The detonator is a low energy, hot wire device with a CP explosive (51 mg) deflagration to detonation column and includes a HMX explosive (11 mg) output

pellet. The detonator firing characteristics are listed in Table 3. The HMX drives a 0.005 inch thick, Hastelloy flyer plate. The explosive column diameter is 0.079 inch. The detonator and MDF transfer line interface is shown in Figure 7. The standoff between the detonator Hastelloy flyer plate and MDF aluminum cover is 0.080 inch. A standoff interface is used because this design permits looser tolerances in the interface design. A contact detonator requires very close tolerances to eliminate air gaps at this interface. Detonator performance data are presented in Appendix B.

3.3 Detonator Block

The detonator block is made of PEEK material and provides the housing for the two MC4237 detonators. A drawing of the detonator block is included in Figure A10 of Appendix A. This block couples two detonators to two MDF transfer lines as shown in Figure 8.

3.4 MDF Transfer Lines

The MDF transfer lines are shown in Figures 1 through 5, and 7 through 10. Figure 9 shows one transfer line at one end of the manifold and two at the other end. Figure 10 shows the transfer line APLSC cutter interface. The drawings of the transfer lines are included in Figures A11, A16 and A17 of Appendix A.

3.5 Distribution Manifold

The detonation transfer PEEK manifold is shown in Figure 9. The 0.050 inch cylindrical cavities in the manifold are loaded with 20 mg of LX-13/XTX-8003 extrudable explosive. A drawing of the manifold is included in Figure A9 of Appendix A.

4.0 LESCA Code Analysis

The LESCA code³⁻⁶ was used in the design of the APLSC component. Table D1 in Appendix D lists the LESCA input parameters. Table D2 lists the LESCA code predicted jet penetration versus standoff data for the APLSC design. Figures D1 and D2 show the LESCA model geometry and APLSC - aluminum target configuration, respectively. The LESCA predicted jet penetration and experimental data are presented as a function of standoff in Figure D3 in Appendix D.

5.0 Development Tests

Most of the development tests for the APLSC cutter were conducted at the Pantex Plant.¹³⁻¹⁵ The development tests for the MC4237 detonator were conducted at Pacific Scientific, Energy Dynamics Division and at Sandia. The MDF transfer line tests were conducted at EG&G Mound Laboratories and at Sandia.

5.1 APLSC "LINEAR" Jet Penetration

Although the target material for the ODES program is 304L stainless steel, an aluminum target was initially used in development tests primarily because the jet penetrations are larger and therefore the optimum standoff and jet penetration reproducibility are easier to

measure in an aluminum target. Additionally, a six inch long linear segment of APLSC was initially used to measure the jet penetration performance. Figure 11 shows the configuration of this six inch long APLSC tester. Measured APLSC jet penetration in an aluminum 6061-T6 target versus standoff data are also shown Figure 11. The optimum standoff was selected to be 0.125 inch from several repeated variable standoff tests. Measured jet penetration versus distance along the aluminum target data are shown in Figure 12 for an APLSC - target constant standoff of 0.125 inch. These type tests were conducted to measure the reproducibility of the jet penetration as a function of distance. The data of Figures 11 and 12 were reproduced here from Reference 13 as representative of the many developments tests conducted for the program. Detailed jet penetration data and information are included in References 13 through 15.

5.2 APLSC "RING" Jet Penetration

Actual APLSC ring configuration component measured jet penetration versus position around the ring (0 to 360 degrees) data are shown in Figure 13 for a flat steel target. This figure includes data for aluminum and for Lexan APLSC confinement/tamping housings. Initially a Lexan housing was desirable because this permitted a visual inspection of the explosive loading (inspection for voids). However, the Lexan cracked in certain areas around bolt holes and the long term seal at the "O" ring sections was questionable after the salt fog environmental tests. Therefore, aluminum was eventually chosen for the APLSC housing (confinement/tamping). Table 4 lists the coreload, tamper material, target material, mean jet penetration and APLSC configuration. APLSC jet penetration versus confinement or tamping material density data are shown in Figure 14.

5.3 Detonator

The MC4237 detonator typical flyer plate velocity versus time and displacement data are shown in Figure 15. Similar additional data are shown in Figures B1 through B7 in Appendix B. The data from these figures were used to obtain the 0.080 inch standoff used between the detonator and the MDF transfer lines in the detonator block assembly.

The detonator function time as a function of bridgewire current data are shown in Figure 16. The function time varies between about 1.3 to 3.9 milliseconds for the 3.5 amp firing current specified in Table 3. Table 5 summarizes detonator data including test temperature, function time, and flyer plate velocity (at standoff or distance of 0.080 inch) from nine tests.

5.4 MDF Transfer Lines

The MDF transfer lines are similar to the MC3487 lines used in a previous program. The transfer line, aluminum flyer velocity versus time and distance data are shown in Figures C1 through C4 in Appendix C. The aluminum flyer is accelerated to its maximum velocity in a distance of less than 0.5 mm. However, a standoff between the transfer line end tip or aluminum flyer and the LX-13/XTX-8003 explosive of 0.080 inch was selected so the standoff washers for the detonator and for the end tip were the same to avoid a mix-up in the FTS component assembly.

5.5 Environmental

The environmental tests and data are documented in detail in Reference 14. The experimental matrix prepared for this screening experiment is listed in Table 6. The orthogonal design chosen was a modified two¹¹ array capable of accommodating up to 11 factors at two levels. This particular design does not allow flexibility with regard to combining factors to provide more levels or identifying main factor interaction effects. Eight critical factors or environments were selected for this experiment. They include thermal cycling, humidity cycling, axial and lateral acceleration, mechanical shock, sinusoidal and random vibration, and exposure to vacuum during test fire. Test amplitudes or levels assigned to each environment are listed in Table 7.

All of the FTS components except the detonator were subjected to the eight environments listed in Table 6. Figures E1 through E5 in Appendix E show the FTS components. The FTS assembly is shown mounted on the environmental test fixture in Figures E1 and E2. After the environmental tests, the FTS components including the detonators were functioned in the configuration shown in Figure E3. The stainless steel hemispherical tanks were filled with water to simulate the liquid fuel. The post-test hardware are shown in Figures E4 and E5.

The test data suggests that no apparent adverse effects resulted from the environments tested in this experiment. Additionally, there appears to be no cause for further investigations involving any of the previously tested environments. All ODES FTS cutter assemblies included in the study initiated reliably and the tests resulted in statistically identical performance.

5.6 FTS Components Explosive Loading

The explosive loading procedures developed for the FTS cutter are discussed in detail in Reference 13.

6.0 Summary

The characterization and development of the ODES FTS components was presented. This development work has successfully demonstrated the reliable functioning of the FTS components. Table 8 lists summary data for all components of the ODES FTS.

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Tables

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**Table L. FTS Components, Quantity, Hazard, Explosive Weights
and Drawing Numbers**

	<u>Component</u>	<u>Qty.</u>	<u>Hazard</u>	<u>Expl. Wt.</u>	<u>Total Wt. (g)</u>
1.	Cutter Assy	2 ea.	Class C. Expl	4.07 g/ea.	8.07
2.	Transfer Line A	2 ea.	Class C Expl.	40 mg/ea.	0.08
3.	Transfer Line B	4 ea.	Class C Expl.	50 mg/ea.	0.20
4.	"Y" Manifold	2 ea.	Class C Expl.	20 mg/ea.	0.04
5.	MC4237 Detonator	2 ea.	Class C Expl.	62 mg/ea.	0.38
6.	Detonator Block	1 ea.	None	None	
7.	Aluminum Seal/MDC	2 ea.	None	None	

Total 8.77g

Reference Documents:

A53943-A	Bracket, Manifold
R26364-D	ODES Cutter Assembly
R26366-C	Plate, Base, Cutter
R26367-C	Plate, Cover, Cutter
R26368-A	Ring, Shape, Cutter
A52884-B	Ring, Support, Cutter
395553	Det Block
395571	Transfer Line A
395571	Transfer Line B
393581	Manifold
AY342416	Seal/MDC
AY412315	Detonator/MC4237
AY390780	Detonator Barrel

Table 2. APLSC Cutter Summary

Liner

1. Material: Copper
2. Thickness: 0.012 inches
3. Apex angle: 76 degrees
4. Flange type
5. Cutting Diameter: 4.0 inches
6. Cut length: 1.047 feet

Explosive

1. Type: LX-13/XTX-8003
2. 80% petn, 20% Sylgard
3. 65 grain/foot
4. Extrudable
5. Weight: 4.1 grams

Confinement/Tamper

1. Material: Aluminum 7075-T6

Standoff

1. 0.125 inches

Maximum Jet Penetration

1. Steel (1018): 0.145 inches
2. Aluminum (6061-T6): 0.30 inches

TABLE 3. DETONATOR FIRING CHARACTERISTICS

MC4237 "CP" Detonator

Firing current	=	3.5 amp, 10 msec pulse
No fire capability	=	>1 amp, 5 min pulse
ESD capability	=	Survive Fisher model
Bridgewire	=	$1 \pm .01$ ohm
Explosive	=	≈ 62 mg = 11 mg HMX 51mg CP
Connector	=	MC3237

**Table 4. APLSC Cutter Development Test Penetration Data/
 Tamper Material Study
 Standoff: 0.125 inches**

<u>Test Number</u>	<u>Coreload (gr/ft)</u>	<u>Tamper</u>	<u>Target</u>	<u>Mean Penetration (in)</u>	<u>APLSC Config.</u>
1	67.9	LEXAN	Al	0.180	ST
2	66.7	LEXAN	Al	0.181	ST
3	67.8	LEXAN	Al	0.177	ST
4	86.8	DELRIN	Al	0.266	ST
5	86.1	DELRIN	Al	0.259	ST
6	63.3	Al	Al	0.281	ST
7	66.0	Al	Al	0.297	ST
8	65.9	Al	Al	0.300	ST
9	67.5	Al	Al	0.288	ST
10	70.1	Steel	Al	0.399	ST
11	69.5	Steel	Al	0.352	ST
12	67.5	Al	Steel	0.145	Ring
13	66.2	Al	Steel	0.145	Ring
14	68.5	Al	Steel	0.145	Ring

ST - Straight/6" long

Ring - Jet cutting diameter of 4.0 inches

TABLE 5.

MEASURED FLYER VELOCITY (VISAR)

TEST NUMBER	UNIT ID	TYPE	TEMPERATURE (DEG F)	FUNCTION TIME (ms)	FLYER VEL (MM/US)*
35	033	6	AMB	1.53	3.0
37	034	6	AMB	1.72	3.0
40	035	6	-65	1.97	2.9
36	038	4	AMB	2.00	2.8
38	039	4	AMB	1.69	2.7
41	040	4	-63	1.62	2.8
44	048	7	AMB	-	2.7
45	049	7	AMB	1.57	2.8
46	057	7	-64	1.69	2.9

* AT 2-MM PROPAGATION

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Table 6. ODES Environmental Qualification Test Matrix (2^{11} orthogonal distribution array)

Test No.	Thermal (1)	Humidity (2)	Axial Acceleration (3)	Lateral Acceleration (4)	Mech Shock (5)	Sinusoidal Vibration (6)	Random Vibration (7)	Vacuum (8)	Penetration (in)	Standard Deviation (in)
1	No	None	None	None	None	None	None	Ambient	0.264	0.056
2	No	None	None	None	None	Maximum	Maximum	Minimum	0.291	0.050
3	No	None	Maximum	Maximum	Maximum	None	None	Ambient	0.339	0.032
4	No	Cycle	None	Maximum	Maximum	None	Maximum	Minimum	0.247	0.047
5	No	Cycle	Maximum	None	Maximum	Maximum	None	Minimum	0.351	0.028
6	No	Cycle	Maximum	Maximum	None	Maximum	Maximum	Ambient	0.309	0.044
7	Cycle	None	Maximum	Maximum	None	None	Maximum	Minimum	0.368	0.026
8	Cycle	None	Maximum	None	Maximum	Maximum	Maximum	Ambient	0.278	0.045
9	Cycle	None	None	Maximum	Maximum	Maximum	None	Minimum	0.266	0.044
10	Cycle	Cycle	Maximum	None	None	None	None	Minimum	0.270	0.053
11	Cycle	Cycle	None	Maximum	None	Maximum	None	Ambient	0.326	0.039
12	Cycle	Cycle	None	None	Maximum	None	Maximum	Ambient	0.268	0.051

Table 7. ODES Environmental Qualification Testing Stimulus Definition

Thermal Cycling	Cycle; 40 - 120°F, 1.8°/min, 1 hr dwell at extremes, 24 cycles
Humidity	Cycle; 88% RH @ 88°F - 59% RH @ 105°F (5 hr dwell at extremes, 10 cycles)
Axial Acceleration*	-7/+20 g
Lateral Acceleration*	Maximum, 7 g (any direction (no individual axis resolution)
Mechanical Shock*	Maximum, 7 g at 20 Hz - 2000 g at 15 Hz
Sinusoidal Vibration*	Maximum, 10 g from 31 - 2000 Hz
Random Vibration*	0.072 g ² /Hz from 20 - 2000 Hz (10 sec/axis)
Vacuum	0.1 psia vacuum (function at environment)

Table 8. ODES/FTS Components Summary Data

I. MC4237 Detonator

- A. Drawings: AY412315, P.S. 412315, AY390780
- B. Total weight H.E. 11 mg HMX, 51 mg CP = 62 mg total
- C. Torque spec.: 15 ± 1 in/lb
- D. Fire characteristics, 3.5 amp, 10 msec, bridgewire: 1 ohm
- E. Flyer plate
 - 1. Diameter: 0.125"
 - 2. Thickness: 0.005"
 - 3. Material: (Hastelloy) B-2
 - 4. Flyer velocity versus time or distance plots:
Max. flyer velocity: 2.7-3.0 mm/ μ s
- F. Quantity required per flight: 2 ea

II. Annular PLSC

- A. Drawings:
 - 1. Design layout DL-R26364
 - 2. Assembly R38668
 - 3. Ring support A52884
 - 4. Base cutter R26366
 - 5. Plate cover R26368
 - 7. Seal AY342416
- B. Total H.E. weight 4.07 gm LX-13
- C. Next assembly torque spec. - 28-30 in-lb/Locktite 242
- D. Total jet penetration depth in S.S.: 0.148 inches
- E. Quantity required per flight: 2 each
- F. Total component weight 530 gm w/o H.E. (534 w/H.E.)

III. MDF Lines

- A. Drawings assembly 395572
- B. Quantity required per flight: 4 each 14.25", 2 each 20.25"
- C. Total H.E. weight 40 mg and 50 mg HNAB w/PETN pellets 2 gr/ft
- D. End tip
 - 1. Flyer diameter: 0.078 inches
 - 2. Flyer thickness: 0.005 inches
 - 3. Flyer material: Aluminum
 - 4. Flyer velocity versus time or distance: 3.0 mm/ μ s, x 70.5 mm
- E. Explosive: 2 gr/ft, type: HNAB/w/PETN Pellets, diameter: 0.051 in.
- F. Sheath - Material: glass insulation, O.D. 0.115 in.
- G. Total wt: 0.05 lb for all 6 lines

Table 8. ODES/FTS Components Summary Data (Continued)

IV. Distribution Manifold

- A. Drawings: Manifold 383581
- B. Quantity required per flight: 2 ea
- C. Explosive:
 - 1. Type: LX-13
 - 2. Weight: 20 MG
- D. Material: Peek
- E. Torque: 28-30 in-lb (Locktite 242)

V. Detonator Block

- A. Drawings: 393591
- B. Quantity required per flight: 1 each
- C. Material: Peek
- D. Total component weight: 0.06 lb ea
- E. Torque: 18-20 in-lb

VI. Flyer Standoff Washers

- A. Drawings:; Seal, MDC AY342416
- B. Quantity: 6 each identical
- C. Material: Aluminum heat treated to almost dead soft condition, spec. 9907000
- D. Location: Detonator interface with transfer lines and at cutter interface with transfer lines

VII. Lock Wires

- A. Quantity: All connections
- B. Material: Stainless steel
- C. Diameter: 0.021"
- D. Length: As required
- E. Locations: All lines, manifold, detonators

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Figures

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Operational Deployment Experiment (ODES) Flight Termination System

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FIGURE 1. O.D.E.S. FLIGHT TERMINATION SYSTEM COMPONENTS

FIGURE 2. O.D.E.S. FUEL/OXIDIZER TANKS/FTS SYSTEM ACTUAL CONFIGURATION

FIGURE 3. O.D.E.S. APLSC CUTTER

FIGURE 4. APLSC CUTTER/FUEL TANK CROSS-SECTION

FIGURE 5. APLSC CUTTER CROSS-SECTION DETAIL

MC4237 DETONATOR

BARREL
(HASTELLOY - B2)

CLOSURE DISK
(HASTELLOY - B2)

HMX - OUTPUT
INCREMENT

CP - 3 DDT
INCREMENT

CP - 3 DDT
INCREMENTS

FIGURE 6. MC4237 DETONATOR

FIGURE 7. MC4237 DETONATOR - MDF TRANSFER LINE INTERFACE

FIGURE 8. PEEK DETONATOR BLOCK /MDF TRANSFER LINE ASSEMBLY (MDF LINE SIDE)

FIGURE 9. PEEK MANIFOLD/DETONATION TRANSFER DISTRIBUTION CONFIGURATION

FIGURE 10. TRANSFER LINE/FTS CUTTER, FUEL TANK ASSEMBLY

FIGURE 11. APLSC JET PENETRATION VERSUS STANDOFF/
ALUMINUM 6061-T6 TARGET

FIGURE 12. APLSC JET PENETRATION VERSUS DISTANCE/ALUMINUM 6061-T6 TARGET

ODES PLSC Penetration Test

Ring configuration

FIGURE 13. APLSC RING CUTTER JET PENETRATION VERSUS POSITION/STEEL TARGET

FIGURE 14. APLSC JET PENETRATION VERSUS CONFINEMENT/TAMPING MATERIAL DENSITY

time, usec
19-JUL-90
13:21:55

DAT:TBEL.M42
DAT:TBEL.N42

FIGURE 15. MC4237 DETONATOR FLYER VELOCITY VERSUS TIME AND DISTANCE

MC4237 CP DETONATOR FUNCTION RESULTS

FIGURE 16. MC4237 DETONATOR FUNCTION TIME VERSUS BRIDGEWIRE CURRENT

Appendix A

Contents

ODES Flight Termination System Drawings

Figures

A1	ODES FTS Assembly.....	47
A2	APLSC Design Layout.....	48
A3	APLSC Cutter Assembly.....	49
A4	APLSC Aluminum Support Ring.....	50
A5	APLSC Aluminum Base Plate	51
A6	APLSC Aluminum Cover Plate	52
A7	APLSC Copper Liner.....	53
A8	MDC Seal.....	54
A9	Detonator Transfer, LEXAN, LX-13 Manifold	55
A10	PEEK Detonator Block.....	56
A11	MDF Transfer Line Assembly	57
A12	MC4237 Detonator Configuration	58
A13	Detonator Barrel Subassembly	59
A14	Detonator Bridged Header Subassembly	60
A15	Detonator Loaded Header Subassembly	61
A16	MDF Transfer Line Cup/and Cover.....	62
A17	MDF Transfer Line HMX Output Pellet.....	63

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NOTES:

1. ITEM 7 TO BE INSTALLED INTO ITEM 4 WITH "TWO" TORQUE.
2. ITEMS 5 AND ITEMS 6 TO BE INSTALLED INTO ALL MATING PARTS WITH 541 IN LBS OF TORQUE.
3. LOCK WIRES TO BE INSTALLED FOR 3018004 AFTER ALL PARTS HAVE BEEN ASSEMBLED.

ITEM	DESCRIPTION	DATE	BY
1	ASSEMBLY		
2	ASSEMBLY		
3	ASSEMBLY		
4	ASSEMBLY		
5	ASSEMBLY		
6	ASSEMBLY		
7	ASSEMBLY		

ITEM	DESCRIPTION	DATE	BY
1	ASSEMBLY		
2	ASSEMBLY		
3	ASSEMBLY		
4	ASSEMBLY		
5	ASSEMBLY		
6	ASSEMBLY		
7	ASSEMBLY		

FIGURE A1. O.D.E.S. FTS ASSEMBLY

1. GENERAL REQUIREMENTS AND DRAWING INTERPRETATIONS ARE DEFINED IN 9900000.
2. MARK DRAWING NUMBER AND ISSUE IN APPROXIMATE LOCATION SHOWN, METHOD OPTIONAL.
3. MATERIAL: ALUMINUM, 7075-T6.

PART OR CONTROL NUMBER		REVISION			
ISS	REV	PREPARED BY	DESCRIPTION	DATE	APPROVED
A		MACHIN-0275/0433		2-27-91

SHEET	-	-	-	-	-	TITLE	(U) TITLE CLASSIFICATION
ISSUE	A	-	-	-	-	RING, SUPPORT, CUTTER (U)	
PART CLASSIFICATION	UNCLASSIFIED						
DRAWING CLASSIFICATION	UNCLASSIFIED					SEE DRAWING NUMBER	
						C	A52884
STATUS SL-REL-2-27-91		SHEET 1 OF 1		SCALE 1/1			
				ORIGIN SL-CVCS-REV4.0			

FIGURE A4. APLSC ALUMINUM SUPPORT RING

FIGURE A7. APLSC COPPER LINER

STANDARD FORM NO. 64

AY342416-000

INDEX	DESCRIPTION	RECEIVED BY	DATE	QTR	YR
A	C. OLSON, 2456/J. HAEGLAN, 2513		11/24/80		YB
B	CHANGED: .195 .193 WAS .180.185
C. OLSON, 2456/J. HAEGLAN, 2513		11/27/80		
C	CHANGED: THE 2456 WAS THE 2450, 2451.
TITLE WAS 2456.
C. OLSON, 2456/J. HAEGLAN, 2513		12/10/80		YB
D	CHANGED 1952-1955 WAS 192-.193
.192-.195 WAS 193-.195
C. OLSON, 2456/J. HAEGLAN, 2513		3/9/81		YB

<p>E</p>	<p>J. CRAWFORD 567BX J. HARLAN 2513 L. CARR 824BX 811988BX C 1. RELOCATED SURFACE FINISH SYMBOLS 2. DELETED NOTE 1 3. REVISED NOTE 2</p>	<p>6-2-81</p>	<p>CRAWFORD</p>	<p><i>PC 6-1-81</i></p>
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TIE SC'BX DEC 2

W. E. B. DUBOIS

UNCLASSIFIED

DECLASSIFICATION LEVEL
UNCLASSIFIED

103167
JAN 19 1138

FIGURE A8. MDC SEAL

GENERAL REQUIREMENTS AND DRAWING INTERPRETATIONS:
AS DEFINED IN 980000.

REPORT NUMBER	REPORT DATE	REPORT BY	REPORT FOR	DATE	TIME	LOC
A		M. LOWEY	252/			R.E.
		R. WINDERS	212/			
		C. GUN	212

X-X. NOTICES

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0000	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99
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GEOMETRIC PRECISION

FIGURE A9. DETONATION TRANSFER MANIFOLD

NOTES:

1. LAMER WELD ITEM 1 TO ITEM 2 PER 0PAB31045.

2. AFTER LAMER WELDING ITEM 1 TO ITEM 2, THE CHARGE SHALL BE LOADED AS FOLLOWS:

OUTPUT CHARGE, HOK (ITEM 3):
CONSOLIDATE IN TWO INCREMENTS OF 0.5 ± 0.5 mg
EACH AT 275.0 ± 3.4 MPa (40,000 ± 500 psi).

DOT CHARGE, CP (ITEM 4):
CONSOLIDATE IN FOUR INCREMENTS OF 7.7 ± 0.5 mg
EACH AT 44.9 ± 3.4 MPa (15,000 ± 500 psi).

3. AFTER LOADING, DRY CHARGE ASSEMBLY IN A VACUUM OVEN AT 65°-77° C AT 20 KPa MAX PRESSURE (24 INCHES MINIMUM VACUUM) FOR FOUR HOURS MINIMUM AND STORE IN DESICCATOR.

4. THE LAST INCREMENT OF ITEM 4 SHALL BE PRESSED TO A STOP FLUSH TO 0.002 ABOVE SURFACE 'X'.

CONTROL NO.
AY391548-000

REVISIONS					
REV	DATE	PREPARED BY	DESCRIPTION	CHKD	APPD
A		H. CHWEE, 2650/ V. TAMBELL, 2512/ L. ALLEN, 2512			S.T.
SER/DIG 8927580C 1-12-92					
B		S.H. YOUNG MD/V. TAMBELL 2512	01/16/91	BT	RAS
H. BELLERS/MC000031370-C					

56

REV	DATE	DESCRIPTION	CHKD	APPD
1	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
2	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
3	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
4	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
5	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
6	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
7	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
8	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
9	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
10	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
11	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
12	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
13	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
14	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
15	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
16	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
17	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
18	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
19	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
20	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
21	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
22	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
23	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
24	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
25	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
26	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
27	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
28	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
29	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
30	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
31	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
32	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
33	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
34	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
35	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
36	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
37	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
38	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
39	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
40	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
41	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
42	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
43	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
44	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
45	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
46	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
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68	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
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72	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
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75	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
76	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
77	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
78	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
79	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
80	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
81	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
82	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
83	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
84	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
85	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
86	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
87	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
88	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
89	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
90	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
91	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
92	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
93	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
94	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
95	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
96	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
97	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
98	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
99	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS
100	01/16/91	BARREL, DETONATOR SUBASSEMBLY	BT	RAS

FIGURE A10. DETONATOR BARREL SUBASSEMBLY

NOTES:

1. RESISTANCE WELD ITEM 2 TO PINS PER EN277242. WELD SAMPLE SHALL BE THE FIRST AND LAST PART OF A CONTIGUOUS RUN.

2. THE INSULATION RESISTANCE BETWEEN RINGS SHALL EXCEED 50 MEGOHMS WHEN MEASURED WITH A VOLTAGE OF 525 ± 20 VOLTS RAMP (NOMINAL VOLTAGE RISE 100 VOLTS/SEC-0.0 BETWEEN 100 AND 700 LEVELS). IT WILL BE MEASURED 1000.

SOURCED VIEW
SCALE 2X/1

REV	DATE	DESCRIPTION	DATE	BY	APP
1	11/15/71	REVISED BY M. CHAVEZ, 2655/ S. JARRELL, 2613/ L. ALLEN, 2613			
2	11/15/71	REVISED BY S. H. YOUNG FOR T. JARRELL 2613	11/15/71	OT	2613
3	11/15/71	REVISED BY M. JARRELL FOR T. JARRELL 2613	11/15/71	OT	2613

REV	DATE	DESCRIPTION	DATE	BY	APP
1	11/15/71	REVISED BY M. JARRELL FOR T. JARRELL 2613	11/15/71	OT	2613
2	11/15/71	REVISED BY S. H. YOUNG FOR T. JARRELL 2613	11/15/71	OT	2613
3	11/15/71	REVISED BY M. JARRELL FOR T. JARRELL 2613	11/15/71	OT	2613

FIGURE A11. DETONATOR BRIDGED HEADER SUBASSEMBLY

NOTES:

CONSOLIDATE 38 ±2 mg OF ITEM 2 IN TWO INCREMENTS.
FIRST INCREMENT OF 15 ±1 mg SHALL BE PRESSURE
LOADED AGAINST THE BRIDGEWIRE USING 275 ±7 MPa
(40,000 ±1000 psi) PRESSURE. SECOND INCREMENT
OF 15 ±1 mg SHALL BE DEAD STOP LOADED FLUSH TO
2.982 ABOVE INDICATED SURFACE. OVERALL TIME SHALL
BE 38 ±5 SECONDS.

2. AFTER LOADING, DRY CHARGE ASSEMBLY IN A VACUUM
OVEN AT 45°-77° C AT 24 MPa MAX PRESSURE
24 IN MIN VACUUM FOR FOUR HOURS MINIMUM AND
TOPE IN DESICCATOR.

58

CONTROL NUMBER		REVISIONS			
REV	DATE	DESCRIPTION	BY	CHKD	APPD
A		M. CHAVEZ, 2655/ M. TAMBELL, 2512/ L. ALLEN, 2612			D.T.
AY391547-000		AER/OIER 8927580C	1-17-78		
B		S.H. YOUNG MD/T. TAMBELL 2512	81/14/91	GT	RAI
		M. BELLER/AC0716313-D-C			

REV	DATE	DESCRIPTION	BY	CHKD	APPD
1	7/8	9/10/11/12/13/14/15/16/17/18/19/20/21/22/23/24/25/26/27/28/29/30/31/32/33/34/35/36/37/38/39/40/41/42/43/44/45/46/47/48/49/50/51/52/53/54/55/56/57/58/59/60/61/62/63/64/65/66/67/68/69/70/71/72/73/74/75/76/77/78/79/80/81/82/83/84/85/86/87/88/89/90/91/92/93/94/95/96/97/98/99/100			
2	1/2	3/4	5/6	7/8	9/10
3	11/12	13/14	15/16	17/18	19/20
4	21/22	23/24	25/26	27/28	29/30
5	31/32	33/34	35/36	37/38	39/40
6	41/42	43/44	45/46	47/48	49/50
7	51/52	53/54	55/56	57/58	59/60
8	61/62	63/64	65/66	67/68	69/70
9	71/72	73/74	75/76	77/78	79/80
10	81/82	83/84	85/86	87/88	89/90
11	91/92	93/94	95/96	97/98	99/100
12	101/102	103/104	105/106	107/108	109/110
13	111/112	113/114	115/116	117/118	119/120
14	121/122	123/124	125/126	127/128	129/130
15	131/132	133/134	135/136	137/138	139/140
16	141/142	143/144	145/146	147/148	149/150
17	151/152	153/154	155/156	157/158	159/160
18	161/162	163/164	165/166	167/168	169/170
19	171/172	173/174	175/176	177/178	179/180
20	181/182	183/184	185/186	187/188	189/190
21	191/192	193/194	195/196	197/198	199/200
22	201/202	203/204	205/206	207/208	209/210
23	211/212	213/214	215/216	217/218	219/220
24	221/222	223/224	225/226	227/228	229/230
25	231/232	233/234	235/236	237/238	239/240
26	241/242	243/244	245/246	247/248	249/250
27	251/252	253/254	255/256	257/258	259/260
28	261/262	263/264	265/266	267/268	269/270
29	271/272	273/274	275/276	277/278	279/280
30	281/282	283/284	285/286	287/288	289/290
31	291/292	293/294	295/296	297/298	299/300
32	301/302	303/304	305/306	307/308	309/310
33	311/312	313/314	315/316	317/318	319/320
34	321/322	323/324	325/326	327/328	329/330
35	331/332	333/334	335/336	337/338	339/340
36	341/342	343/344	345/346	347/348	349/350
37	351/352	353/354	355/356	357/358	359/360
38	361/362	363/364	365/366	367/368	369/370
39	371/372	373/374	375/376	377/378	379/380
40	381/382	383/384	385/386	387/388	389/390
41	391/392	393/394	395/396	397/398	399/400
42	401/402	403/404	405/406	407/408	409/410
43	411/412	413/414	415/416	417/418	419/420
44	421/422	423/424	425/426	427/428	429/430
45	431/432	433/434	435/436	437/438	439/440
46	441/442	443/444	445/446	447/448	449/450
47	451/452	453/454	455/456	457/458	459/460
48	461/462	463/464	465/466	467/468	469/470
49	471/472	473/474	475/476	477/478	479/480
50	481/482	483/484	485/486	487/488	489/490
51	491/492	493/494	495/496	497/498	499/500
52	501/502	503/504	505/506	507/508	509/510
53	511/512	513/514	515/516	517/518	519/520
54	521/522	523/524	525/526	527/528	529/530
55	531/532	533/534	535/536	537/538	539/540
56	541/542	543/544	545/546	547/548	549/550
57	551/552	553/554	555/556	557/558	559/560
58	561/562	563/564	565/566	567/568	569/570
59	571/572	573/574	575/576	577/578	579/580
60	581/582	583/584	585/586	587/588	589/590
61	591/592	593/594	595/596	597/598	599/600
62	601/602	603/604	605/606	607/608	609/610
63	611/612	613/614	615/616	617/618	619/620
64	621/622	623/624	625/626	627/628	629/630
65	631/632	633/634	635/636	637/638	639/640
66	641/642	643/644	645/646	647/648	649/650
67	651/652	653/654	655/656	657/658	659/660
68	661/662	663/664	665/666	667/668	669/670
69	671/672	673/674	675/676	677/678	679/680
70	681/682	683/684	685/686	687/688	689/690
71	691/692	693/694	695/696	697/698	699/700
72	701/702	703/704	705/706	707/708	709/710
73	711/712	713/714	715/716	717/718	719/720
74	721/722	723/724	725/726	727/728	729/730
75	731/732	733/734	735/736	737/738	739/740
76	741/742	743/744	745/746	747/748	749/750
77	751/752	753/754	755/756	757/758	759/760
78	761/762	763/764	765/766	767/768	769/770
79	771/772	773/774	775/776	777/778	779/780
80	781/782	783/784	785/786	787/788	789/790
81	791/792	793/794	795/796	797/798	799/800
82	801/802	803/804	805/806	807/808	809/810
83	811/812	813/814	815/816	817/818	819/820
84	821/822	823/824	825/826	827/828	829/830
85	831/832	833/834	835/836	837/838	839/840
86	841/842	843/844	845/846	847/848	849/850
87	851/852	853/854	855/856	857/858	859/860
88	861/862	863/864	865/866	867/868	869/870
89	871/872	873/874	875/876	877/878	879/880
90	881/882	883/884	885/886	887/888	889/890
91	891/892	893/894	895/896	897/898	899/900
92	901/902	903/904	905/906	907/908	909/910
93	911/912	913/914	915/916	917/918	919/920
94	921/922	923/924	925/926	927/928	929/930
95	931/932	933/934	935/936	937/938	939/940
96	941/942	943/944	945/946	947/948	949/950
97	951/952	953/954	955/956	957/958	959/960
98	961/962	963/964	965/966	967/968	969/970
99	971/972	973/974	975/976	977/978	979/980
100	981/982	983/984	985/986	987/988	989/990
101	991/992	993/994	995/996	997/998	999/1000

FIGURE A12. DETONATOR LOADED HEADER SUBASSEMBLY

NOTES:

1. GENERAL REQUIREMENTS AND DRAWING INTERPRETATIONS ARE DEFINED IN 9900000.
2. MATERIAL: POLYETHERETHER KETONE, MOLDING COMPOUND, (PEEK).
3. THIS AREA MUST BE FREE OF LOOSE OR PARTIALLY ATTACHED MATERIAL.

PART NUMBER	REV	DATE	PREPARED BY	DESCRIPTION	DATE	CHKD	APRD
A	1		M. CHAVEZ, 2852/ R. WEINMASTER, 2512/ C. CASALS, 2512				R.W.
B	1		ADDED .125 SLOT & NOTE 3 M. CHAVEZ, 2852/ J. QURZI, 2513				R.W.

SECTION X-X

SHEET	1	2	3	4	5	6	TITLE
TABLE	B						BLOCK DETONATOR (U)
PART CLASSIFICATION	UNCLASSIFIED						FMF: O.D.E.S.
OWNING CLASSIFICATION	UNCLASSIFIED						SIZE OWNING NUMBER 393591
STATUS	SA-REL-10-1-92						ORIGIN SA-ANG-VI.2

FIGURE A13. PEEK DETONATOR BLOCK

1. WARNING: HAZARDOUS MATERIAL, HANDLE WITH CARE.
2. ASSEMBLE SUBSEQUENTLY PER 93363150.
- ▶ APPLY ADHESIVE ITEM 6 TO ITEM 1 (NOT LINE) ALONG AREAS SHOWN 360° AROUND AND LOCATE BOTH ENDS OF ITEM 1 IN ITEM 2 AS SHOWN AND DONE PER 93363150.
- ▶ RESIDUAL ADHESIVE IS PERMISSIBLE NOT TO EXCEED THE DIAMETER OF ITEM 2 OR EXTEND BEYOND ITEM 2 IN EXCESS OF .150 MAX.

DEBITION AGENCY PART NUMBER	PART CLASSIFICATION	"X"
393572-00	UNCLASSIFIED	14, 25
393572-01	UNCLASSIFIED	20, 25

MDF LINE
ITEM 1

EM	2140575-01	ADHESIVE, EPOXY, AN-MYDOR CURED						
2	395573	CLIP (U)						5
2	395571	Pellet (U)						4
2	393583	NUT (U)						3
2	393582	CAP, B&O (U)						2
1	395572	MOF (LINE)						1
NA	M070270	ASSEMBLY AND INSPECTION						
NA	55393198-000	ASSEMBLY PROCEDURES						
NA	9919100	MARKING, GENERAL METHODS						
NA	9900000	GENERAL REQUIREMENTS						
NO	PART COVERED, NO.	DESCRIPTION, MATERIAL					NOTE	ITEM
	ALT.-ALTERNATE	AS-AS REQ'D	AS-AS REQ'D FOR ASBY	IS-EXPENSE MATERIAL	IS-SEGMENT	IS-PROCESS METHOD		
	S-KEY FILE PART CLASSIFICATION UNCLASSIFIED GROUPING CLASSIFICATION UNCLASSIFIED		1 2 3 4 5 6 A UNCLASSIFIED UNCLASSIFIED		TITLE TRANSFER LINE ASSEMBLY (U) P/LF, O.O.E.S. SIZE GROUPING NUMBER 0			
START SA-REL-5-7-82 CASE 14219 SCALE 1:1 S-KEY 17 GROUP SA-ANS-VI.2			395572					

FIGURE A 14. MDF TRANSFER LINE ASSEMBLY

FIGURE A16. MDF TRANSFER LINE HMX OUTPUT PELLET

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Appendix B

Contents

MC4237 Detonator Data.....	66
-----------------------------------	-----------

Tables

B1 MC4237 Header Loading Parameters	67
B2 MC4237 Barrel Loading Parameters	68

Figures

B1 MC4237 Flyer Velocity versus Time and Distance (Test #33).....	69
B2 MC4237 Flyer Velocity versus Time and Distance (Test #35).....	70
B3 MC4237 Flyer Velocity versus Time and Distance (Test #36).....	71
B4 MC4237 Flyer Velocity versus Time and Distance (Test #37).....	72
B5 MC4237 Flyer Velocity versus Time and Distance (Test #38).....	73
B6 MC4237 Flyer Velocity versus Time and Distance (Test #40).....	74
B7 MC4237 Flyer Velocity versus Time and Distance (Test #44).....	75
B8 MC4237 Bridgewire Current, Voltage and TOAD versus Time Data	76
B9 MC4237 Flyer Bridgewire Current, Voltage and TOAD versus Time Data .	77
B10 MC4237 Bridgewire Current, Voltage and TOAD Data versus Time	78

APPENDIX B

MC4237 DETONATOR DATA

The MC4237 detonator flyer plate velocity versus time and displacement data are shown in Figures B1 through B7. This data were obtained with a VISAR diagnostic system. The data of Figures B1 through B7 are used to determine the standoff for the detonator flyer plate from the MDF transfer line aluminum end tip cover plate. The optimum standoff of 0.080 inches (2.0 mm) was chosen from these data. The detonator bridgewire current versus function time data are shown in Figure B8 for the MC4237 detonator as well as for other similar CP explosive detonators (MC3990, BNCP, Standard detonator development data). Typical current, voltage and Time Of Arrival Data (TOAD) are shown in Figures B9 and B10.

TABLE B1. MC4237 HEADER LOADING PARAMETERS

BRIDGEWIRE MATERIAL	<i>0.0022" STABLOHM 675 - C SHAPED</i>
RESISTANCE RANGE	<i>1.0 +/- 0.1 OHMS</i>
NUMBER OF BW's	<i>1</i>

DIMENSIONS

DIAMETER	<i>0.139" / 0.141"</i>
DEPTH	<i>0.062" / 0.064"</i>

FIRST LOAD

PRESS SETTING	<i>598 lbs TO A PRESSURE</i>
DWELL TIME	<i>30 SEC</i>
WEIGHT	<i>0.0140 +/- 0.0005 GRAMS</i>
POWDER DEPTH	<i>0.029" / 0.031"</i>
POWDER TYPE	<i>CP</i>

SECOND LOAD

PRESS SETTING	<i>598 lbs TO A STOP</i>
DWELL TIME	<i>30 SEC</i>
WEIGHT	<i>0.0140 +/- 0.0005 GRAMS</i>
POWDER DEPTH	<i>FLUSH TO +0.002" ABOVE</i>
POWDER TYPE	<i>CP</i>

TABLE B2. MC4237 BARREL LOADING PARAMETERS

DIMENSIONS

DIAMETER	0.077" / 0.078"
DEPTH	0.288" / 0.292"

FIRST LOAD

PRESS SETTING	185 lbs TO A PRESSURE
DWELL TIME	30 SEC
WEIGHT	0.0055 +/- 0.0005 GRAMS
POWDER DEPTH	0.249" / 0.251"
POWDER TYPE	HMX

SECOND LOAD

PRESS SETTING	185 lbs TO A PRESSURE
DWELL TIME	30 SEC
WEIGHT	0.0055 +/- 0.0005 GRAMS
POWDER DEPTH	0.211" / 0.212"
POWDER TYPE	HMX

THIRD LOAD

PRESS SETTING	46 lbs TO A PRESSURE
DWELL TIME	30 SEC
WEIGHT	0.0078 +/- 0.0005 GRAMS
POWDER DEPTH	0.142"
POWDER TYPE	CP

FOURTH LOAD

PRESS SETTING	46 lbs TO A PRESSURE
DWELL TIME	30 SEC
WEIGHT	0.0078 +/- 0.0005 GRAMS
POWDER DEPTH	0.071"
POWDER TYPE	CP

FIFTH LOAD

PRESS SETTING	46 lbs TO A PRESSURE
DWELL TIME	30 SEC
WEIGHT	0.0078 +/- 0.0005 GRAMS
POWDER DEPTH	FLUSH TO +0.002" ABOVE
POWDER TYPE	CP

DAT:TBEL.M33
DAT:TBEL.N33

time, usec
13-JUL-90
10:03:09

FIGURE B1. MC4237 FLYER VELOCITY VERSUS TIME AND DISTANCE (TEST #33)

FIGURE B2. MC423 FLYER VELOCITY VERSUS TIME AND DISTANCE (TEST #35)

FIGURE B3. MC4237 FLYER VELOCITY VERSUS TIME AND DISTANCE (TEST #36)

FIGURE B4. MC4237 FLYER VELOCITY VERSUS TIME AND DISTANCE (TEST #37)

FIGURE B5. MC4237 FLYER VELOCITY VERSUS TIME AND DISTANCE (TEST #38)

FIGURE B6. MC4237 FLYER VELOCITY VERSUS TIME AND DISTANCE (TEST #40)

FIGURE B7. MC4237 FLYER VELOCITY VERSUS TIME AND DISTANCE (TEST #44)

CP DETONATOR FUNCTION TIME vs CURRENT

FIGURE B8. DETONATOR BRIDGEWIRE CURRENT VERSUS FUNCTION TIME

MC4237 UNIT 045-13 SHOT 43

FIGURE B9. MC4237 BRIDGEWIRE CURRENT, VOLTAGE AND TOAD VERSUS TIME DATA

FIGURE B10. MC4237 BRIDGEWIRE CURRENT, VOLTAGE AND TOAD DATA VERSUS TIME

Appendix C

Contents

Mild Detonating Fuse (MDF) Transfer Line Data

Figures

C1	MDF Transfer Line End Tip Flyer Velocity versus Distance and Time (Test #15).....	81
C2	MDF Transfer Line End Tip Flyer Velocity versus Distance and Time (Test #16).....	82
C3	MDF Transfer Line End Tip Flyer Velocity versus Distance and Time (Test #18).....	83
C4	MDF Transfer Line End Tip Flyer Velocity versus Distance and Time (Test #17).....	84

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FIGURE C1. MDF TRANSFER LINE END TIP FLYER VELOCITY VERSUS DISTANCE AND TIME (T #15)

FIGURE C2. MDF TRANSFER LINE END TIP FLYER VELOCITY VELOCITY VERSUS DISTANCE AND TIME (T #16)

DAT: DONM.M18
 DAT: DONM.N18
 time, usec
 15-MAR-90
 15:53:06

FIGURE C3. MDF TRANSFER LINE END TIP FLYER VELOCITY VERSUS DISTANCE AND TIME (T #18)

FIGURE C4. MDF TRANSFER LINE END TIP FLYER VELOCITY VERSUS DISTANCE AND TIME (T #17)

Appendix D

Contents

LESCA Code Information

Tables

D1	LESCA Code Input Parameter File.....	87
D2	APLSC LESCA Code Predicted Penetration versus Standoff	88

Figures

D1	LESCA Code Geometric Model of APLSC	89
D2	APLSC-Aluminum Target Configuration/Jet Penetration Data.....	90
D3	LESCA Code Predicted versus Experimental Jet Penetration versus Standoff Data	91

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TABLE D1. LESCA CODE INPUT PARAMETER FILE

Input file name = odes65a1.DAT =>

MASS	LENGTH	TIME	IACCEL	IGURZN	IAXIS	IBREAK	ISMDET	IINTER	IPENET
GM	CM	MICROSEC	4	1	2	2	2	2	2

MZ	NZ	ETYPE	DEXP	VDET	RT2E	GAMMA
1	25LX13		1.530E+00	7.260E-01	2.500E-01	2.770E+00

DLIN	VBLKL	CUTJET	T2	TBCON	YLIN	NLIN	NL	DISPER
8.960E+00	3.940E-01	1.200E+00	1.900E+00	5.500E+00	2.200E-03	1	3	4.000E+00

LINEAR PARAMETERS

3.800E+01	2.423E-01	2.950E-02
-----------	-----------	-----------

Hit return to continue

DCON	NC
2.700E+00	4

CONFINEMENT PARAMETERS

2.730E+01	3.332E-01	0.000E+00	1.600E+00
-----------	-----------	-----------	-----------

HDET	SDET	H	HOFF	ZLNGTH	TOFSET	DTFAC	MPZ
4.370E-01	1.000E+00	3.185E-01	2.950E-02	1.524E+01	3.000E+00	5.000E-01	60

NSOFF	SOFMIN	SOFMAX	NTL	CHKANG
0	2.540E-01	7.600E-01	1	1.909E+00

DTAR	TARTHK	UMIN	HOLEC	YTAR	XNUTAR	VBLKT	RT
2.770E+00	1.000E+00	1.350E-01	0.000E+00	3.800E-02	3.300E-01	5.370E-01	1.205E-01

CPLOT	DPLOTT	CSHADE	CPRPRT	CMOVIE	CPDETL
PLOT	1.000E+03	NOSHAE	NOPROPORT	MOVIE	NOPDETAIL

CPRINT	DPRNTT	IZSKIP	CDEBUG
NOPRINT	5.000E+00	1	NODEBUG

Do you wish to revise the input file? (=Y)

TABLE D2. APLSC LESCA CODE PREDICTED PENETRATION VS. STANDOFF

```

JET FRONT VALUES AT TIME = DPRNTT = 5.000000
  I      J      THETA      VX      VZ      VMAG
  1      1-3.036E+01 3.582E-01 1.145E-01 3.760E-01
  1      2-3.036E+01 3.582E-01 1.145E-01 3.761E-01

```

Variable standoff - penetration summary

Standoff - Penetration (CM-CM)

0.251	-	0.789
0.275	-	0.804
0.299	-	0.817
0.323	-	0.809
0.346	-	0.799
0.370	-	0.791
0.394	-	0.774
0.418	-	0.758
0.442	-	0.744
0.466	-	0.725
0.490	-	0.709
0.514	-	0.694
0.538	-	0.675
0.562	-	0.659
0.585	-	0.644
0.609	-	0.626
0.633	-	0.612
0.657	-	0.598
0.681	-	0.580
0.705	-	0.567
0.729	-	0.549
0.752	-	0.383

Variable standoff penetration computation completed
 LSCAP run completed for input file odes65al.DAT

Do you wish to end LSCAP modeling session? (=Y)

ODES65ST.DAT - 8-FEB-90 - 14:47:50 -

GR/FT FACTOR = 470.31
 LINER GR/FT = 115.22
 TAMPER GR/FT = 1376.6
 HE GR/FT = 63.683
 TOTAL GR/FT = 1555.5

FIGURE D1. LES CA CODE GEOMETRIC MODEL OF APLSC

ODES65AL.DAT - 19-FEB-91 - 15:25:28 -
VARIABLE STANDOFF TEST

FIGURE D2. APLSC-ALUMINUM TARGET CONFIGURATION/JET PENETRATION DATA

ODES65AL.DAT - 19-FEB-91 - 15:25:28 -
VARIABLE ORIENTATION PERFORMANCE SUMMARY

FIGURE D3. LESCA CODE PREDICTED VERSUS EXPERIMENTAL JET PENERATION VERSUS STANDOFF DATA

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Appendix E

Contents

FTS Environmental Tests Configurations, Fixture, Pre- and Post-Test Configurations

Figures

E1	FTS Assembly/Environmental Test Fixture Configuration.....	95
E2	Environmental Test Assembly	96
E3	FTS Hemispheres Assembly	97
E4	Post-Environmental Test Results	98
E5	Post-Test Holes in Water-filled Hemispherical Tanks.....	99

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FIGURE E1. FTS ASSEMBLY/ENVIRONMENTAL TEST FIXTURE CONFIGURATION

FIGURE E2. ENVIRONMENTAL TEST ASSEMBLY

FIGURE E3. FTS HEMISPHERES ASSEMBLY

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FIGURE E4. POST-ENVIRONMENTAL, TEST RESULTS

FIGURE E5. POST-TEST HOLES IN WATER-FILLED HEMISPHERICAL TANKS

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