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FINAL REPORT
FOR PYROTECHNIC STUDY AND TEST

(LANL SUBCONTRACT 9X51-D9928-1)
(UPHX ACCOUNT T0619)

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TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE NUMBER</u>
INTRODUCTION	1
"LINE" CHARGE	1
"WALKING" CHARGE	3
PYROTECHNIC TESTING	6
APPENDIX A	
1. COMMENTS ON VIDEO COVERAGE	10
2. ANALYTICAL DATA	11

INTRODUCTION

Unidynamics/Phoenix entered into LANL contract #9-X51-D9928-1 on March 11, 1991. The contract was to perform chemical analysis, and provide analytical data, provide test data from functioning units, build and test pyrotechnic devices and fabricate and test approximately 100 pyrotechnic devices to approximate the chemical and functioning characteristics of the devices from the Army inventory.

Because of government regulations, it became near impossible to ship the units from White Sands to Unidynamics. Consequently a series of functional tests were conducted at White Sands Missile Range. Comments on the functional tests are included herein.

In addition, small scale tests were conducted at Unidynamics. These tests were to demonstrate a so called "line" charge and a "walking" charge. A discussion of these two charges is presented.

The program was put on hold on November 6, 1991 and subsequently reopened to prepare and submit this report.

"Line" Charge. The line charge was to demonstrate the capability (in a sub scale test) of the near instantaneous ignition and burning of a pyrotechnic charge up to 20 foot long with an approximate 20 sec burn time.

The sub scale test was composed of the following.

1. Magnesium/Teflon/red lead oxide/fluorel (60/30/5/5) per 107 PPR.
2. 15 Pellets were pressed at 120 K psi.
3. Length - 1.323 inches (average).

4. Diameter - 1.252 inches.
5. Pellet weight - 49.98 gms (average).
Total weight of 15 pellets 750 gms.

The pellets were inhibited on all surfaces with 3 layers of 10% fluorel in MEK. The solvent was dried off between each of the inhibited layers. The pellets were wrapped on the outside diameter with 3M #425 aluminum tape as the final layer of inhibitor. An 0.080 inch diameter hole was drilled through each pellet along one edge, lengthwise, of the grain.

FITCO Cord 107PPR-05 LN 3337 was threaded through the 0.080 inch diameter holes of the pellets and the pellets were taped together. FITCO was run the entire length of the 15 pellets.

FITCO is made of the same material as the pellets but is extruded into a fuse or string like cord. It burns slow unconfined but very rapidly on the surface in a hole as used here.

The unit was tested on August 23, 1991 and worked as planned. The charge ignited along its entire length and burned for approximately 8 seconds.

Two copies of a video tape of the test is included with this report.

In practice an approximate 20 foot long charge burning for approximately 20 seconds is desired. A 2½ inch diameter pellet or a brick configuration pellet with a 2½ inch burn web would provide the burn time desired. We have a die that is 2.55 inch by 4.70 inch which could be used to make pellets that could be strung together to make a 20 foot train.

No further work was conducted on the line charge as the feasibility had been proven.

"Walking" Charge

"Walking" charge so called as it was to burn at a rate of a person walking or 2 to 5 ft/sec. An internal literature search was conducted. Several years ago Unidynamics conducted a study program to provide a 30-60 in/sec burn rate aluminum sheathed cord for propellant ignition. We found that burning rate compositions in this regime were nonexistent; however, we developed two materials with the desired burning rate. One was zirconium/red lead oxide (Zr/Pb_3O_4) (36/64 percent by weight) which proved to be very good and worked well. It had a burning rate of 41 in/sec in the aluminum sheathed cord. Unfortunately because of the fine particle size (less than 2 micron) zirconium the mixture was very sensitive to ignition to the point that it was too hazardous to handle and has not been used at Unidynamics since that program.

The other pyrotechnic developed was molybdenum/potassium perchlorate ($Mo/KClO_4$) (90/10). The $Mo/KClO_4$ in aluminum sheathed cord burned at a rate of 39 in/sec.

A 2 Kg batch of $Mo/KClO_4$ (90/10) was prepared as lot EL28455.

Mo particle size	-	1.9 micron (average)
$KClO_4$ particle size	-	3-7 micron

One 1½ inch diameter pellet of this formulation was tested and burned near instantaneously. It was decided that this formulation was much too fast for this application so it was mixed with a slow burning formulation of tungsten/ $BaCrO_4$ /potassium perchlorate/superfloss, (W/B/K/S).

Pellets were pressed and a walking charge assembled by inhibiting the grains with epoxy and wrapping the outside with 3M #425 aluminum tape. The small charge was tested on September 13, 1991 and the results of this test are shown in the video tape. The

charge burned much too fast and left a cloud of smoke. It became obvious that this general formulation type was not going to work.

The next test for the "walking" charge used magnesium/teflon of 107 PPR. The idea was to burn a segment fast then a short segment slow then another segment fast, etc. as follows

Each pellet was inhibited with 3 dips in 10% fluorel in MEK then wrapped with 3M #425 aluminum tape. Then the unit was assembled with the 3M #425 tape holding the pyrotechnics together.

The FITCO was coiled between the pellets with holes and the solid pellets. As can be seen in the video, dated September 16, 1991, this was a mistake as the coiled FITCO between the pellets burned fast and broke up the pyrotechnic train and scattered burning pellets.

This test used the last of the Mg/Tef/red lead oxide/fluorel of 107 PPR.

A 2 Kg batch (EL90884) of Mg/teflon/MnO₂/fluorel (60/30/5/5) was processed for the next test. It was found, over 20 years ago, that MnO₂ could be used instead of the environmentally undesirable lead compound so it was used for this test.

An assembly of the same configuration of the preceding test was prepared and conducted except for the following.

1. No coiled FITCO between the solid pellets and the pellets with holes.
2. Two solid pellets at the first junction and one solid pellet at the second junction.
3. There was no FITCO in the third segment - just a hole in the pellets.

The unit was tested on November 7, 1991 and worked as planned. The first segment of pellets burned and were near burned out when the next segment of pellets ignited from the longitudinally burning of the solid pellets. The second segment of solid pellet then ignited the final segment of pellets which has a hole in the pellets but no FITCO.

The original video of this test was sent to White Sands Missile Range. No copies were made of the video.

PYROTECHNIC TESTING

A number of devices were tested at WSMR during the week of 23 September 1991 and monitored by a rather large array of various types of instrumentation. This included radiometers, spectrometers and a variety of detectors and cameras. However, other than the camera records none of the data was available to Unidynamics as of this writing. Also units representative of those tested had not been made available for analytical study. Unidynamics was provided with the Los Alamos video records. The types of cameras used were:

- RCA Black and White
- Panasonic Color/Zoom
- Inframetrics 600IR
- Camcorder Video

The devices tested and monitored were:

- LUMP (Longburn Multi-Purpose) Flare
- LTS (Laser Target Simulator) - Smoke
- LTS - Flash
- MBA Smoke Packet
- MBS (Multi-Band Screening) Smoke Pot
- MBS Grenade Smoke
- HIPS (High Intensity Pyrotechnic Source) Jr.
- HIPS

The observations made visually and taken from the various video recordings. These observations and conclusions are summarized as follows:

LUMP. These units are reported to be of a magnesium/Teflon flare type. The observed burn times of units B29, B30, and B31 were in the 74 to 77 second range. The Inframetrics camera indicated B29, burned at a higher temperature during certain portions of

the burn relative to B30 and B31. Also the flame seemed to impart a greenish color indicating that boron or barium might be present. However, no recoverable residue could be found for analytical study.

Laser Target Simulators Smoke and Flash Enhanced (LTS-S & LTT-F)

These units burned with a flash producing smoke over period of approximately one second. It was difficult to visually estimate any differences between the smoke and flash enhanced units. Also the Inframetrics displays did not indicate a great deal of differences except B32 FTS-S gave lower output than the B33 to B37 units as observed from the Inframetrics records. Discussions with personnel during the time of testing, however, indicated the FTS-F units exhibited considerably more light energy output than the FTS-S units. This was based on Radiometer data. The recorded data is not available to the writer for conformation of this observation.

MBA Smoke Pack. Ignition of these units produced rapid (< 1 second) white smoke puffs with little visual light. Inframetrics records indicated a higher temperature for B42 than those for B43 and B44.

Multi-Band Screening (MBS) Smoke Pot. These items are large (77 pounds) units producing a grey to dark grey smoke. Their burn times were somewhat over three minutes. Early in the burn, unit B45 produced a higher temperature near the orifices than did units B46 and B47. Overall, the smoke production did not seem to be particularly effective, especially when considering that 77 pounds of charge is being consumed. The smaller MBA Smoke Packs, MBS Smoke Grenades and the LTS units all appear to give a more dense higher quality of smoke (white) than did the MBS Smoke Pots. Subsequent to the burns there were fairly large amounts of near black residues present. One sample (B47) was analyzed. Scanning electron microscopy/energy dispersive analysis showed

potassium and chlorine to be present. Combustion elemental analysis provided a carbon content of just under sixty percent with near negligible amounts of hydrogen and nitrogen. The data is provided in the appendix. There is some question as to the composition of the unit charge; red phosphorus/manganese dioxide and/or a potassium chlorate/organic fuel system. The residue analysis suggest a potassium chlorate composition containing an organic material with the possible inclusion of elemental carbon. It is possible hexachloroethane (HC) was an ingredient, however, metals such as zinc (or zinc oxide) aluminum or magnesium are usually used in conjunction with HC but none of these are detected in the analysis.

Multi-Band Screening (MBS) Grenade. These units randomly dispensed several small charges that burned producing high quality white smoke. Most of the charges (3 to 4) burned quickly, however one or two of the charges would burn for an extended period (30 seconds or longer).

High Intensity Pyrotechnic Source (HIPS) Jr. Units produced bright flame with white smoke, burn times were about fifty seconds. Unit B69 may not have been quite as bright as B70 and B71 as indicated by the Inframetrics 600.

HIP. This is the large unit that essentially aerosols powdered aluminum with oxygen and is ignited. The writer observed units B73 and B74 which did not produce a sustained burn. Reports by other personnel on a successful test performed the week before arrival of the writer indicated a great amount of heat and light were produced.

APPENDIX A

1. COMMENTS ON VIDEO COVERAGE
2. ANALYTICAL DATA

COMMENTS ON VIDEO COVERAGE

Test of August 23, 1991. This was the line charge of Mg/Teflon/ Pb_3O_4 /fluorel pressed pellets with a hole near one side and FITCO down the holes for ignition. The unit properly demonstrated the feasibility.

Test of September 13, 1991. This was supposed to be the walking charge at a burn rate of 2-5 ft/sec. The composition was molybdenum/potassium/perchlorate/tungsten/barium chromate/superfloss. The small charge that was tested all burned as one rapid puff with considerable smoke. The smoke was primarily beyond the video coverage. The pyrotechnic charge is not satisfactory for the intended use.

Test of September 14, 1991. This test is not part of the contract but was on the video film and was not edited out.

Test of September 16, 1991. This was the walking charge. The composition was Mg/Teflon/ Pb_3O_4 /fluorel as discussed in the text. The charge broke up into many segments as can be seen from the video. This breakup was due to the way the unit was assembled and the test results were not satisfactory.

A later properly assembled unit was assembled and tested with satisfactory results. A separate video was made of this later test and the video sent to WSMR without making copies.

SEM/TEO Laboratories, Inc.

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Desert Analytics
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Analysis Report

TO: John Fronabarger
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P.O. Box 46100
Phoenix, AZ 85063-6100

Report Date: 01/10/92
Date Received: 01/09/92

Sample ID	%C	%H	%N
B47	59.22	0.22	0.00
Duplicate	59.87	0.23	0.13

Notes:

Initial analysis was carried out under normal combustion conditions. Duplicate was done with maximum extended combustion. We carried out two other determinations where carbon turned out higher (64 - 66%) but these variations seem more due to variation in sample (presence of light colored material) than the possibility of incomplete combustion.

END

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