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TECHNICAL REPORT NO. LWL-CR-21F69

REMOTELY INITIATED ILLUMINATING PERIMETER ROCKET (RIPER)

Final Report
Contract No. DAAD05-70-C-0024

By
Thiokol Chemical Corporation
Wasatch Division
Brigham City, Utah

October 1971

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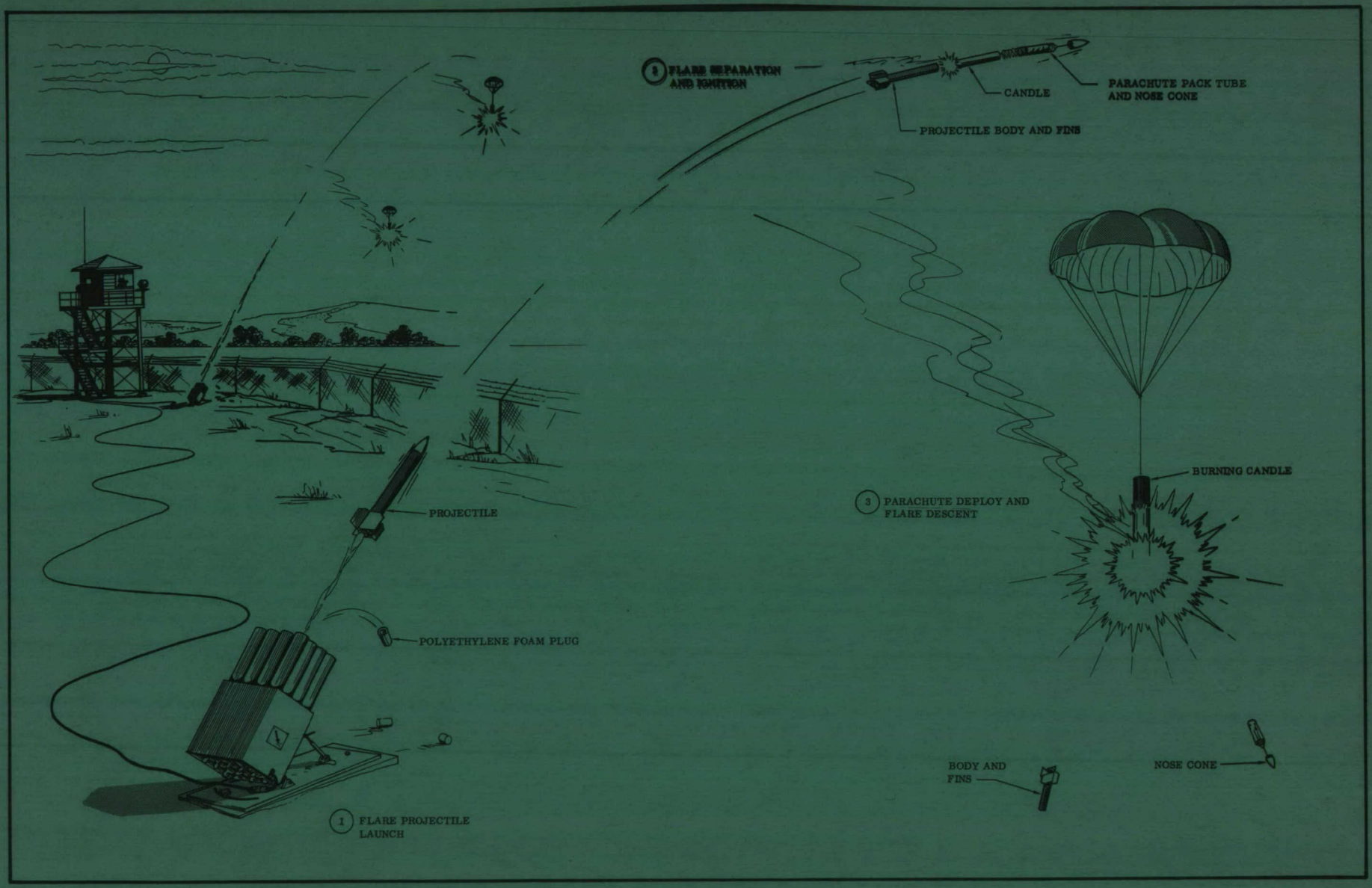

RIPER Functional Sequence

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By

R. T. Minert
J. V. Ferrara

THIOKOL CHEMICAL CORPORATION
WASATCH DIVISION
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ABSTRACT

The Remotely Initiated Illuminating Perimeter Rocket (RIPER) program, conducted under Contract DAADO 5-70-C-0024, consisted of the development, flight testing, and environmental testing of the RIPER projectile and launcher.

This report discusses the design details and fabrication of the component parts, the environmental exposures, and test results.

Three hundred and fifty projectiles and five launchers were fabricated and tested. Projectiles and launchers were exposed to environments including: (1) transportation vibration, (2) high temperature, (3) low temperature, (4) humidity, (5) salt fog, (6) five foot drop, (7) forty foot drop, and (8) shock.

An overall success ratio of 81 percent was demonstrated. The units exposed to humidity and five foot drop tests exhibited the highest failure rates. With relatively minor changes which improve the projectile seals and give the launch tube better impact resistance, a reliability of above 90 percent can be achieved.

FOREWORD

This report was prepared by Thiokol Chemical Corporation, Wasatch Division, Brigham City, Utah, under Contract DAADO 5-70-C-0024 with the U. S. Army Land Warfare Laboratory, Aberdeen Proving Ground, Maryland. The report covers design approach and testing accomplished to develop a remotely and individually initiated flare system for perimeter illumination.

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I. INTRODUCTION AND SUMMARY

The Vietnam conflict has demonstrated the need for a quick reaction flare system that can be initiated by ground troops that are directly exposed to infiltration or hostile night attack. At the present time, numerous systems are currently available to provide illumination such as air dropped flares, artillery and mortar illuminating warheads, and hand initiated flare systems. While these flare systems apparently fulfill the mission requirements for which they were designed, they fall short in meeting quick reaction capability for base defense applications where sentry-flashlight-type operations are required. In response to this need, the U.S. Army Land Warfare Laboratory generated a design for the Remotely Initiated Illuminating Perimeter Rocket (RIPER). This design was provided Thiokol under contract for development, fabrication, and test.

The Thiokol program was structured into three phases of work with separate funding allocations. Phase I encompassed rocket motor and candle development, Phase II encompassed preliminary flight function testing of the projectile, and Phase III encompassed system integration and environmental testing. During Phase III of the program, 350 projectiles were fabricated, exposed to controlled environmental conditions, and flight function tested to establish design suitability of the system to meet operational requirements under simulated environmental conditions.

Test results of the Phase III systems demonstrated a success to test ratio of 81 percent, with the greater percentage of failures occurring in units exposed to humidity and 5 foot drop environmental conditions. Failures associated with humidity tests are attributed to inadequate hermetical sealing. Redesign action necessary to correct this deficiency is considered to be a relatively minor undertaking and should be implemented for follow-on units. Failures associated with 5 foot drop units were primarily experienced with horizontal drop conditions. Corrective action for this deficiency is the selection of an alternate shipping and launch tube material. Incorporation of these fixes would statistically allow reliability performance above the 90 percent level for similar test conditions.

Phase I and Phase II summary reports are presented as Appendixes A and B.

II. PROGRAM DESCRIPTION SUMMARY

A. WORK SCOPE

Program definition required development of an illumination system for close-in operations capable of remote initiation and providing continuous illumination for 16 minutes or selective firing of individual flares for 1 minute intervals.

The specific objectives of the program were to develop, fabricate, test, and complete prototype systems for Engineering Design Tests.

The development program was structured into three phases of work with funding allocations separate for each phase.

B. PERFORMANCE GOALS

Program requirements established the following performance goals for the operating illumination system.

Setup and firing	One man operations
Projectile initiation	Remote, wire controlled
Safety classification	Class B, special fireworks
Horizontal range	600 meters
Parachute deployment altitude	800 feet AGL
Minimum average candlepower	300,000 cd
Minimum candle burn time	1 minute
Burnout altitude	300 feet AGL
Mean descent rate	8 feet per second
Environmental requirements	Exposure simulating temperature, humidity, vibration, salt fog, shock, 40 foot drop, and 5 foot drop

III. PERFORMANCE SUMMARY

The corrected predicted performance of the RIPER System, when launched at sea level conditions, is presented in this section. The curves presented are based on the actual average data from the control group and quality assurance rounds tested in Phase III.

Figure 1 shows a plot of range vs altitude for four different launcher angle settings. Note that the target altitude and range (800 feet/1, 970 feet) are most nearly met using a launcher angle of 50. 5 degrees. This target is very near to apogee, which means that altitude does not vary significantly with small variations of time but range does.

Figure 2 shows a plot of altitude vs time. For the 50. 5 degree launcher angle, altitude varies from 750 to 790 feet in the time between 5. 8 and 9. 0 seconds.

Figure 3 shows a plot of range vs time. For the same time variation, range varies from 1, 450 to 2, 250 feet.

With target deployment near the trajectory apogee, velocity is also near minimum. Figure 4 shows velocity is below 250 feet/second from 7. 0 to 11. 5 seconds.

Figure 5 is a plot of ground illumination of the RIPER flare based on candle light output of 340, 000 cd. Various illumination levels are plotted for comparison. For deployment at target altitude (800 feet), the area lighted at a level of 0. 05 foot candles or more is 7, 660, 000 square feet (825, 000 square meters).

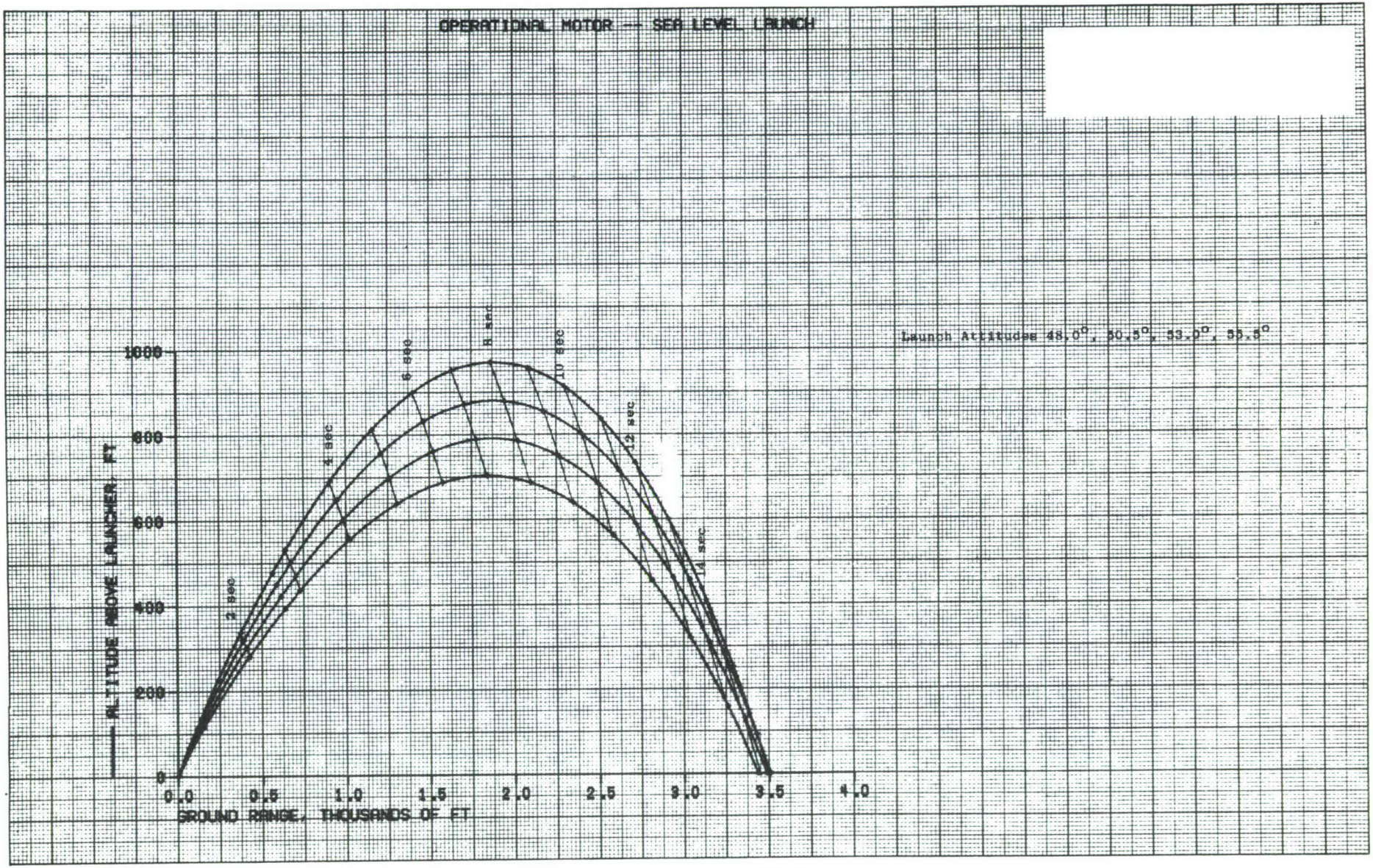


Figure 1. Range vs Altitude

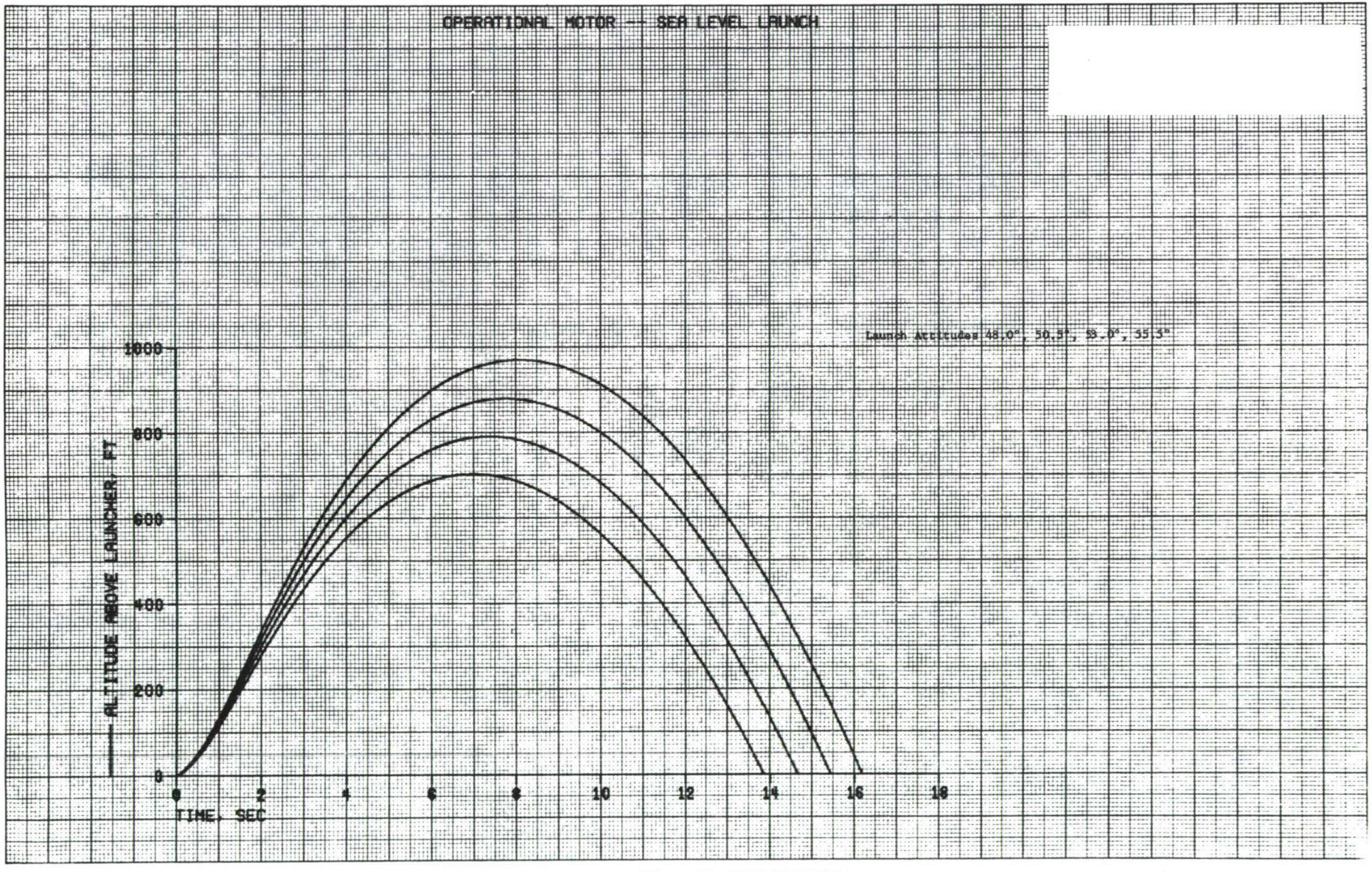


Figure 2. Altitude vs Time

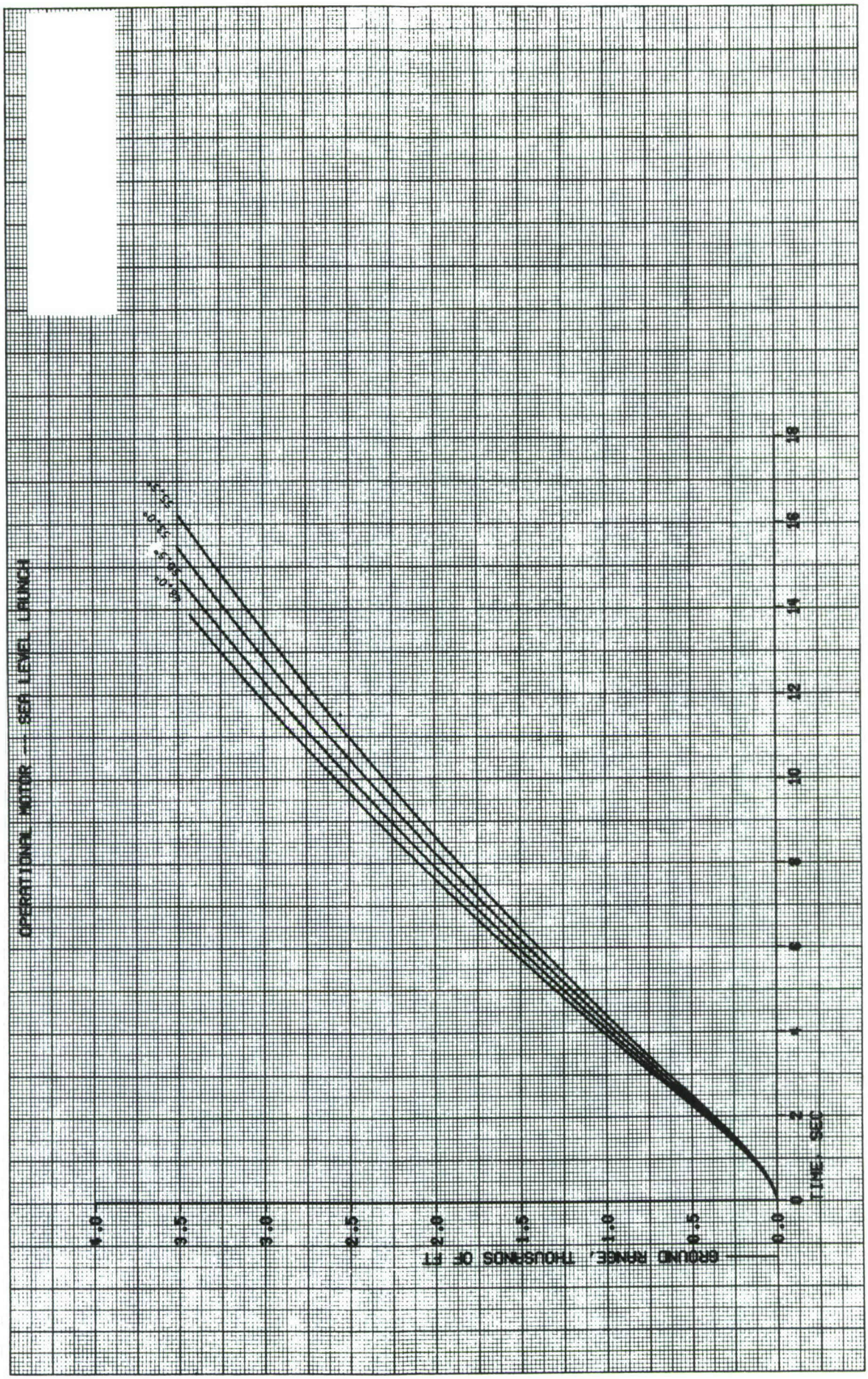


Figure 3. Range vs Time

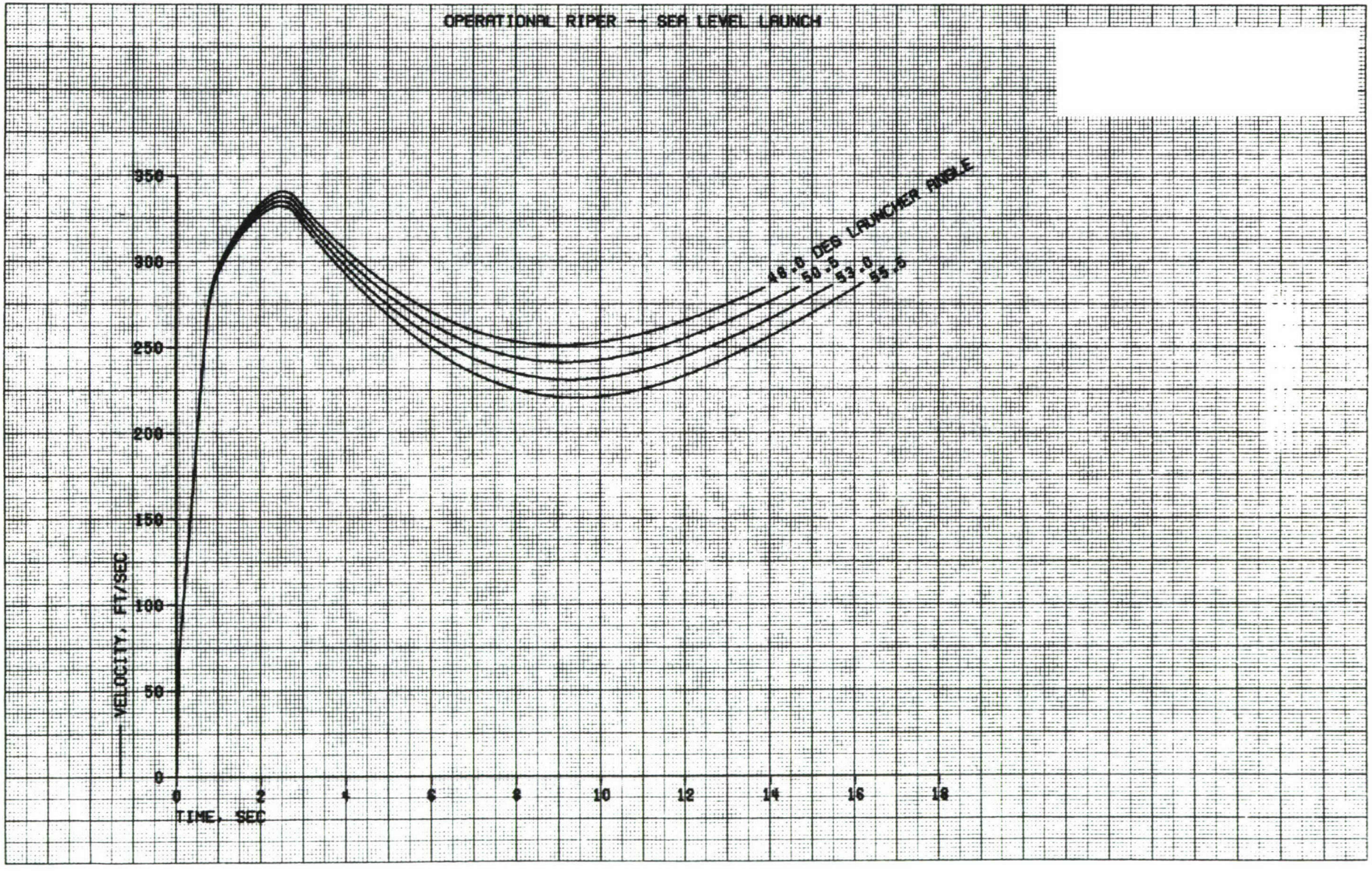


Figure 4. Velocity vs Time

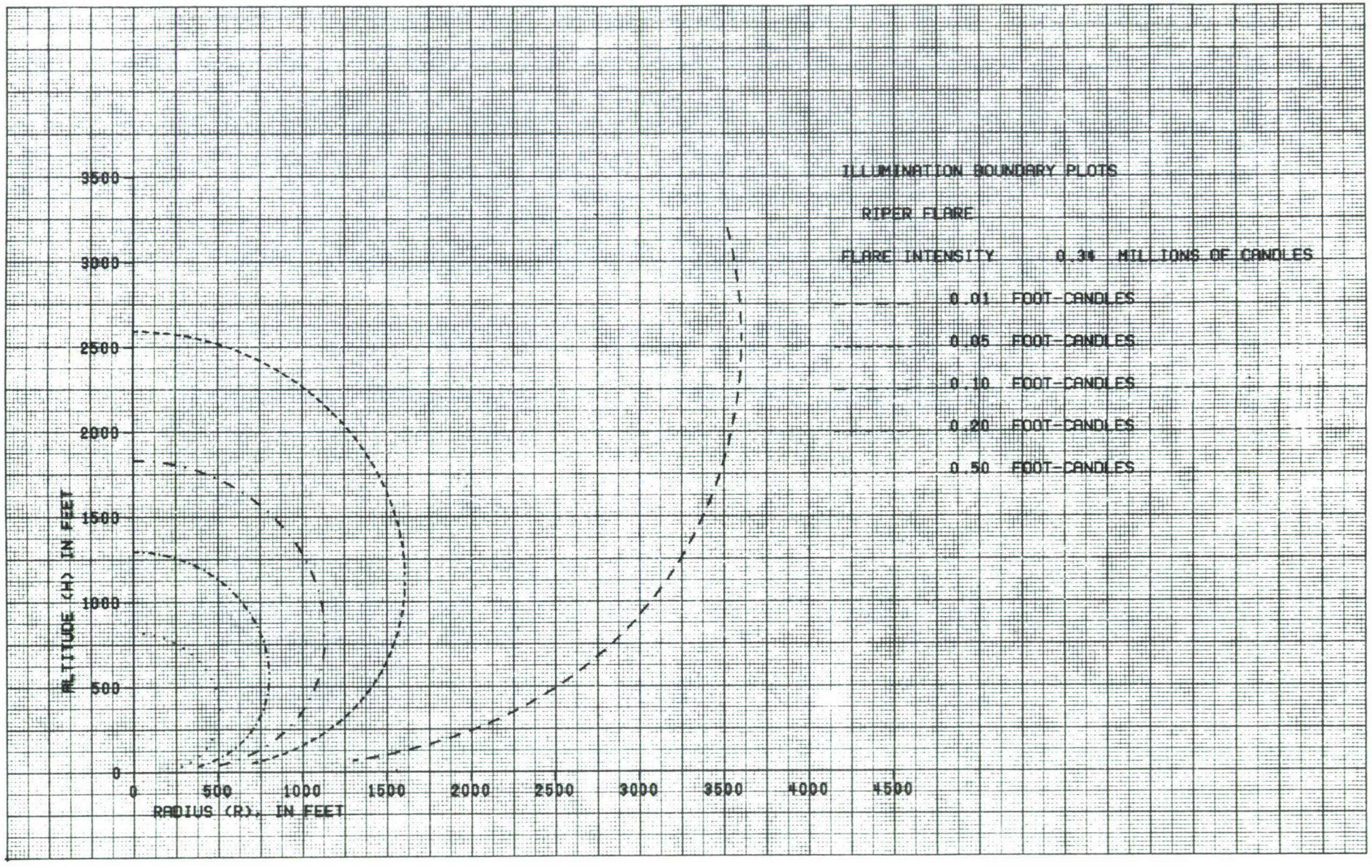


Figure 5. Ground Illumination

IV. DESIGN AND FABRICATION

The RIPER System is a ground launched, rocket boosted, parachute deployed, illuminating flare. It has an effective illuminating pattern of 1,000 meters in diameter for a 1 minute time period.

The RIPER System consists of two basic units: (1) the projectile, and (2) the launcher.

A. PROJECTILE DESIGN

A cutaway drawing of the RIPER projectile in its shipping and launch configuration is shown in Figure 6. The projectile consists of the following major components:

1. Rocket Motor
2. Flare
3. Parachute
4. Ogive Nose Cone
5. Projectile Body
6. Folding Fin Assembly
7. Squib and Holder
8. Shipping and Launch Tube Assembly

1. Rocket Motor

The rocket motor case is injection molded Celcon GR 20, a 20 percent glass-filled acetal copolymer thermoplastic. The case is molded with Class 2 threads for mating with the threaded nozzle.

The rocket motor nozzle is also injection molded of Celcon GR 20. A throat insert is machined of HLM 85 Graphite and is molded into the nozzle.

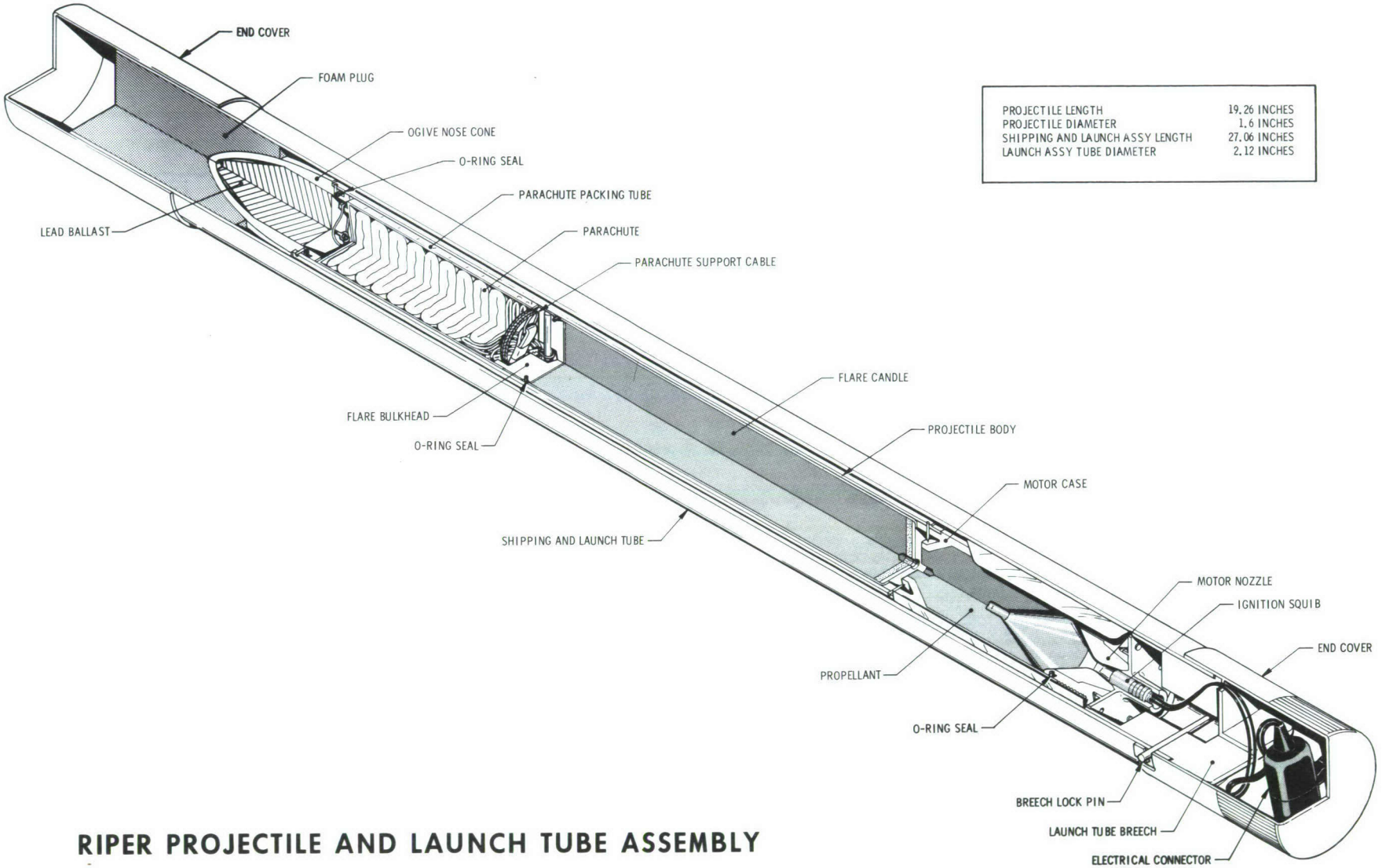


Figure 6. RIPER Projectile and Launch Tube Assembly (Cutaway)

The rocket motor is cleaned and the head end is lightly abraded before it is lined with TL-L-305 liner. The liner is applied by the fill-and-drain method. The TPL-3014C propellant is pressure cast into the case from the head end to the desired level. The propellant core is then pushed into place and the propellant is cured. After cure, the core is removed and the delay cavity is machined into the cured propellant.

A first fire composition is applied to the conical propellant surface to provide positive motor ignition.

2. Flare

The flare case is made from 6061-T6 aluminum thin-wall extruded tubing. A paper liner is bonded into the case and a mastic liner applied to the inside diameter of the paper. The candle is then loaded with THIOLITE® B-8 illuminant and cured. The flare bulkhead is roll-crimped into the case. The flare igniter is made up of a wafer of solid rocket propellant bonded to a thin fiberglass disc. This igniter is placed in the end of the candle, and the candle case is crimped over the disc.

3. Parachute

The parachute is made from a single piece of 1.1 ounce per yard nylon cloth cut into an octagonal shape 35 inches across corners. The edges of the nylon cloth are pinked and otherwise unfinished. The nylon cord shroud lines are attached at each vertex by a bartack stitch 1 inch in length along the line and two bartacks across the line. A center shroud line is used in this design and is attached in the same manner as the skirt shroud lines, except that additional reinforcement is needed at this point. The reinforcement consists of a 5 inch piece of 1/2 inch wide nylon tape.

The parachute is packed into a closed end plastic tube to aid in handling, assembly, and deployment of the parachute.

4. Ogive Nose Cone

The nose cone is a 1.6 to 1 ogive for low aerodynamic drag and is injection molded from Celcon M-90 unfilled acetal copolymer. The nose cone is filled by a molded lead slug for ballast. The lead slug contains an eye to which the parachute pack is attached. One of the functions of the nose cone is to pull the plastic packing tube off of the parachute during the deployment sequence.

5. Projectile Body

The projectile body is an extruded plastic tube machined at each end to meet the required configuration. It is extruded from Lexan 121, a clear polycarbonate.

6. Folding Fin Assembly

The fin assembly is fabricated from thin stainless steel sheet and consists of a support tube with four tangential fins. The fins are fabricated from 0.0085 inch thick stock and spot welded to the support tube through a doubler strip. The fins fold in order to allow the projectile to be inserted into its shipping and launch tube.

7. Squib and Holder

The rocket motor is initiated by a 1 watt, 1 amp, no-fire, end flashing squib. The squib is enclosed in a molded polyethylene holder which is heat staked to the nozzle assembly.

8. Shipping and Launch Tube Assembly

The projectile shipping and launch tube assembly consists of the following components:

1. Shipping and Launch Tube
2. Breech and Lock Pin
3. Foam Spacer
4. End Covers

The shipping and launch tube is fabricated from paper phenolic and is 2.00 inches in outside diameter, has a wall thickness of 0.06 inch, and is 23.00 inches long. After the projectile is inserted into the tube, a molded plastic (Lexan) breech is inserted into the aft end and held in place by a steel pin which protrudes from both sides and performs the dual function of attaching the breech to the launch tube and locking the assembly into the launcher. The electrical lead wires from the squib pass through a slot in the plastic breech, leaving the electrical connector outside the tube.

An expanded polyethylene foam plug is inserted into the muzzle end of the tube and pushed into contact with the ogive nose cone.

A molded polyethylene cover is placed on both ends of the tube, completing the assembly. Figure 6 shows a cutaway of the projectile and launch tube assembly.

B. LAUNCHER DESIGN

The RIPER Launcher consists of the following components:

1. Launcher Base

2. Tube Assembly

3. Electrical Chassis

4. Support Arm

5. Launch Angle Indicator

1. Launcher Base

The launcher base is an aluminum plate 0.375 inch thick by 13.00 inches wide and 28.25 inches long.

2. Tube Assembly

The launcher tube assembly consists of 2 bulkheads, 16 tubes, and a wrap-around cover. The tubes are bonded into the bulkheads, and the cover is riveted in place. The cavity around the tubes is filled with urethane foam. All components are aluminum alloy.

3. Electrical Chassis

The electrical chassis is a formed aluminum plate with cutouts to match the tube assembly, 16 electrical connectors for the individual projectiles, a wiring harness, and a 17 pin electrical connector.

4. Support Arm

The launcher support arm provides for rapid adjustment of the launch angle and is a simple turnbuckle design. Launch angles from 45 to 55 degrees may be selected.

5. Launch Angle Indicator

The launch angle indicator is located on the right side of the launch tube assembly. The assembly consists of a pivoted heavy needle and a scale. As the support arm is adjusted, the needle remains vertical, and the desired launch angle is set by bringing the scale in line with the needle.

C. WEIGHT AND BALANCE DATA

Actual weight data were taken during the fabrication portion of Phase III and are presented in Table I. In most cases, the weights are an average of 10 units.

TABLE I

RIPER WEIGHT DATA

Description	Weight (pounds)
Nose Cone Ogive	0.073
Nose Cone Ballast	0.613
Nose Cone-Ballast Assembly (with O-ring)	0.687
Projectile Body	0.211
Flare Case, Lined	0.081
Loaded Flare Case	0.713
Illuminant (calculated)	0.633
Bulkhead	0.070
Pin	0.003
Parachute with Packing Tube and Cord	0.120
Cable	0.012
Parachute Pack, Cable, and Bulkhead Assembly	0.206
Parachute and Candle Assembly	0.912
Rocket Motor Case	0.126
Lined Motor Case	0.145
Loaded Motor Case	0.298
Rocket Motor Propellant (calculated)	0.153
Rocket Motor Nozzle	0.068
Squib, Squib Holder, and Electrical Connector	0.058
Nozzle and Squib Assembly	0.126
Folding Fin Assembly	0.185
Complete Projectile Assembly	2.423
Shipping and Launch Tube	0.359
Breech	0.175
Lock Pin	0.021
Spacer	0.012
End Cover	0.050
Complete Shipping Configuration	3.076

The overall weight of the projectile as it is shipped in its shipping and launch tube is 3.00 pounds.

The projectile alone weighs 2.42 pounds, and its center of gravity is 9.955 inches forward of the nozzle exit plane.

The RIPER Launcher weighs 28.3 pounds empty and 76.3 pounds loaded with 16 projectiles.

V. ENVIRONMENTAL TESTING

The RIPER Projectile and Launcher were exposed to various environmental conditions in order to determine the ability of the design to withstand handling, storage, and transportation environments to which it is likely to be exposed as a military inventory item. Table II shows the environments selected and the quantity of projectiles and launchers exposed to each test.

A. TRANSPORTATION VIBRATION TEST

Forty-eight RIPER Projectiles, packaged in three shipping boxes and one launcher packed individually in its shipping box, were subjected to the Transportation Vibration Test.

A resonant search was conducted on each test setup, and the three most severe resonant frequencies were determined. Table III shows the frequencies and amplitudes at which the items were vibrated in each of the three axes. Total vibration time in each axis was at least 1.5 hours. Figure 7 shows one box of projectiles mounted on the vibration table for vibration in the horizontal plane, perpendicular to the projectile axis. Figure 8 shows the boxed launcher setup on the vibrator for test in the vertical direction.

Post-test examination of the projectiles and the launcher showed no indications of damage to projectiles, launcher, or shipping boxes.

B. FORTY FOOT DROP TEST

Ten RIPER Projectiles were subjected to the forty foot drop test. The projectiles were packed into shipping boxes, two live projectiles and 14 dummy units per box. The dummy units consisted of a 16.9 inch length of 3/4 inch diameter galvanized iron pipe placed into used launch tubes with foam spacers and end covers. This arrangement very closely simulated live projectile weight and center of gravity. Placement of live projectiles within the box is shown in Figure 9.

Post-test examination of the test units revealed the following conditions:

1. The shipping boxes were severely damaged.

TABLE II
RIPER EVALUATION TEST SUMMARY

Test	Test Quantity Projectiles	Test Quantity Launchers	Specification Reference	Flight Function Test
1. Baseline Flight Function Test	29		Mil Std 810, para 3.2.1	52
2. Transportation Vibration (Crated)	48 32	1 S/N 1	Mil Std 810, Method 514 Procedure X, Equipt Category (g)	48
3. Forty Foot Drop Test (Crated)	10 9		Mil Std 331, Test 103	0
4. High Temp (+160°F) (Uncrated)	32 8	1 S/N 1	Mil Std 810, Method 501 Procedure II	32
5. Low Temp (-65°F) (Uncrated)	32 36	1 S/N 2	Mil Std 810, Method 502 Procedure I	32
6. Humidity (Uncrated)	32 8	1 S/N 3	Mil Std 810, Method 507 Procedure I	32
7. Salt Fog (Uncrated)	32 8	1 S/N 3	Mil Std 810, Method 509 Procedure I	32
8. Five Foot Drop Test (Uncrated)	30 20		Mil Std 331, Test III	30
9. Shock Test (Crated)		1 S/N 2	Mil Std 810, Method 516 Procedure II	

Table III. Transportation Vibration Test Data

Projectiles, Box No. 1

X AXIS		Y AXIS		Z AXIS	
Frequency HZ	Amplitude G's	Frequency HZ	Amplitude G's	Frequency HZ	Amplitude G's
120	18.75	290	12	94	13.1
328	42.75	410	11.25	109	18.75
419	86.25	988	11.25	320	8.25

Projectiles, Box No. 2

X AXIS		Y AXIS		Z AXIS	
Frequency HZ	Amplitude G's	Frequency HZ	Amplitude G's	Frequency HZ	Amplitude G's
95	12.75	114	8.25	62	29.25
350	55.5	270	15.75	105	13.87
390	75	430	9	309	11.25

Projectiles, Box No. 3

X AXIS		Y AXIS		Z AXIS	
Frequency HZ	Amplitude G's	Frequency HZ	Amplitude G's	Frequency HZ	Amplitude G's
120	15	103	9	81	13.1
350	90.75	270	14.62	100	12.75
380	45.37	425	7.5	335	12.37

Launcher

X AXIS		Y AXIS		Z AXIS	
Frequency HZ	Amplitude G's	Frequency HZ	Amplitude G's	Frequency HZ	Amplitude G's
120	41.25	60	21	80	27.75
260	45.75	304	12.75	223	24
492	28.5	487	15	428	22.5

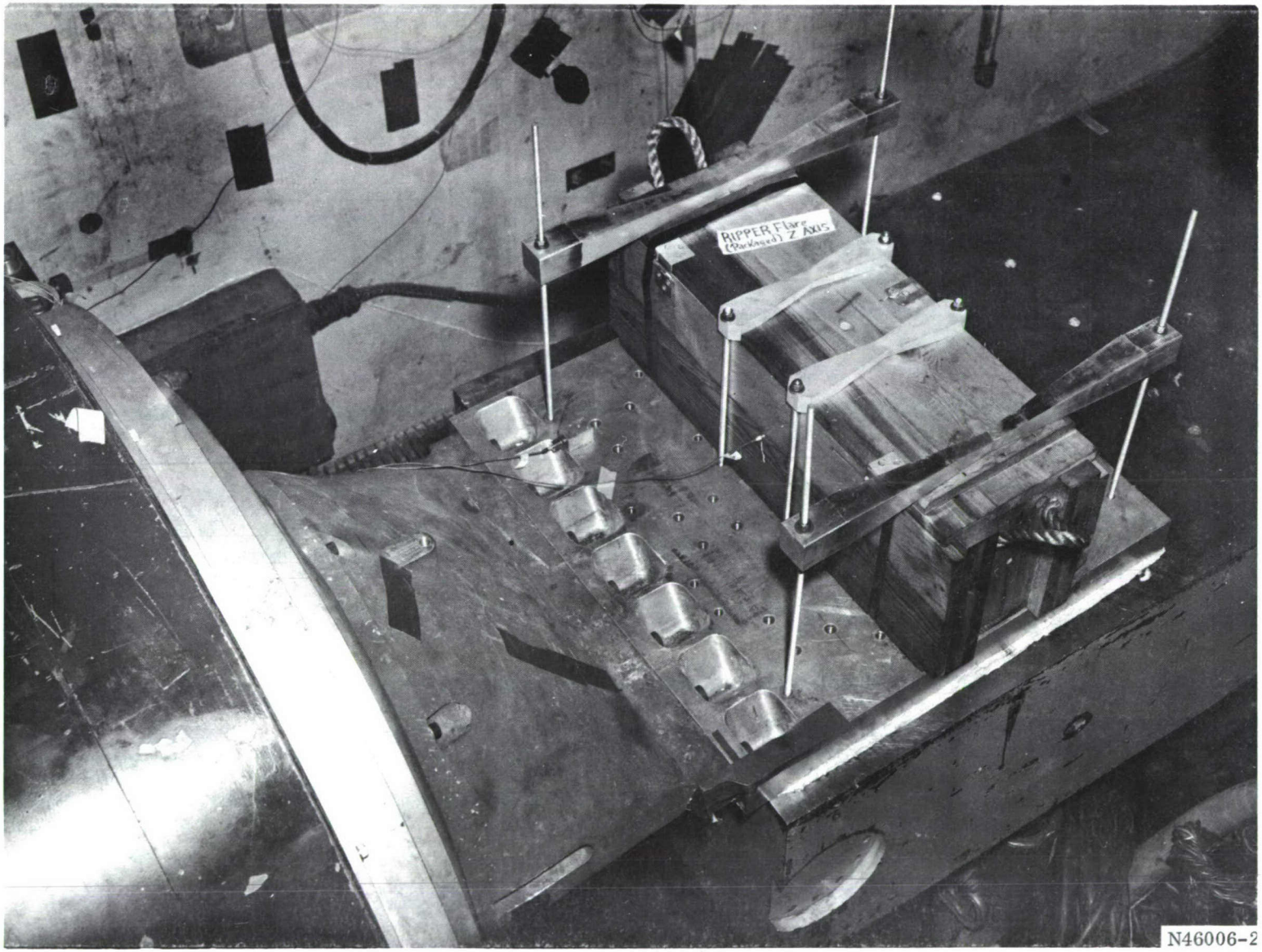


Figure 7. RIPER Projectile Transportation Vibration, Typical Test Setup

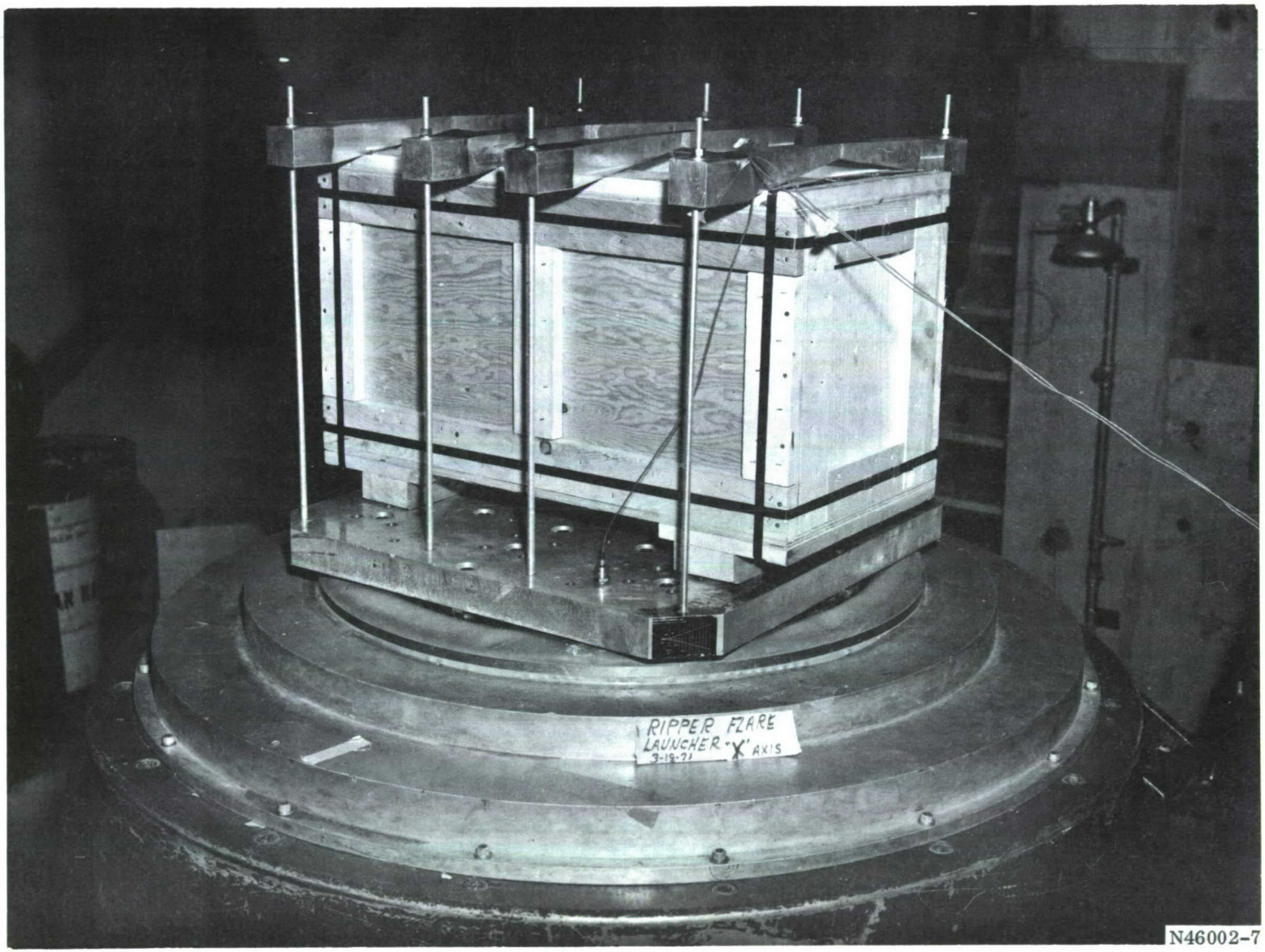
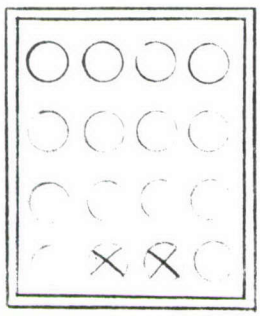
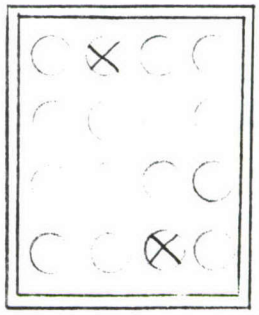


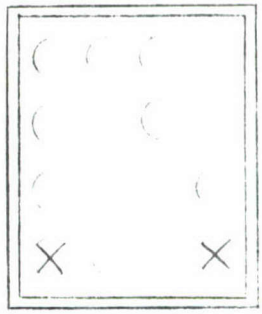
Figure 8. RIPER Launcher Transportation Vibration Test Setup



No. 1



No. 2 & 3



No. 4 & 5

Box No. 1 Flat drop on bottom

Box No. 2 End drop

Box No. 3 End drop

Box No. 4 45° drop on bottom corner

Box No. 5 45° drop on bottom corner

⊗ indicates live RIPER Projectile

⌒ indicates dummy unit simulating weight and C.G.

Figure 9. RIPER Forty Foot Drop Test Packing Diagram

2. Approximately 50 percent of the live projectiles were damaged.

3. No hazardous conditions were found which would prevent safe handling and disposal of the projectiles.

Figures 10, 11, and 12 show the condition of the shipping boxes after the test. Figures 13 and 14 show the projectiles after the test, removed from the boxes for closer examination. Damage to the launch tubes is evident on five projectiles (Figure 13). Of these, one projectile had the nose cone knocked loose. The remaining five projectiles, shown in Figure 14, showed evidence of slight damage to the plastic end covers and indications show that the projectile has shifted position in the tube.

C. HIGH TEMPERATURE TEST

Thirty-two RIPER Projectiles and one launcher were subjected to high temperature exposure. The items were placed in a conditioning chamber as shown in Figure 15. The temperature of the chamber was raised to +120° F and maintained for 6 hours, then raised to +165° F and maintained for 4 hours. This cycle was repeated three times for a total exposure of 30 hours.

Examination of the test items after the test showed no significant damage had been sustained by the units. One component did show a change, however. The foam plugs, which cushion the projectile in the launch tube, shrink when exposed to high temperature and were all loose in the launch tube. The diameter of the plug was approximately 1/8 inch smaller than the launch tube inside diameter. Figure 16 shows a comparison of the foam plug in the tube before and after high temperature test.

D. LOW TEMPERATURE TEST

Thirty-two RIPER Projectiles and one launcher were subjected to low temperature exposure. The items were placed into the conditioning chamber and the temperature reduced to -65° F. The temperature was held at -65° F for 48 hours. Four units were kept at the low temperature until ready for testing. The remaining 28 units were allowed to warm up to ambient temperature.

Examination of hardware revealed no damage or change due to the low temperature exposure.

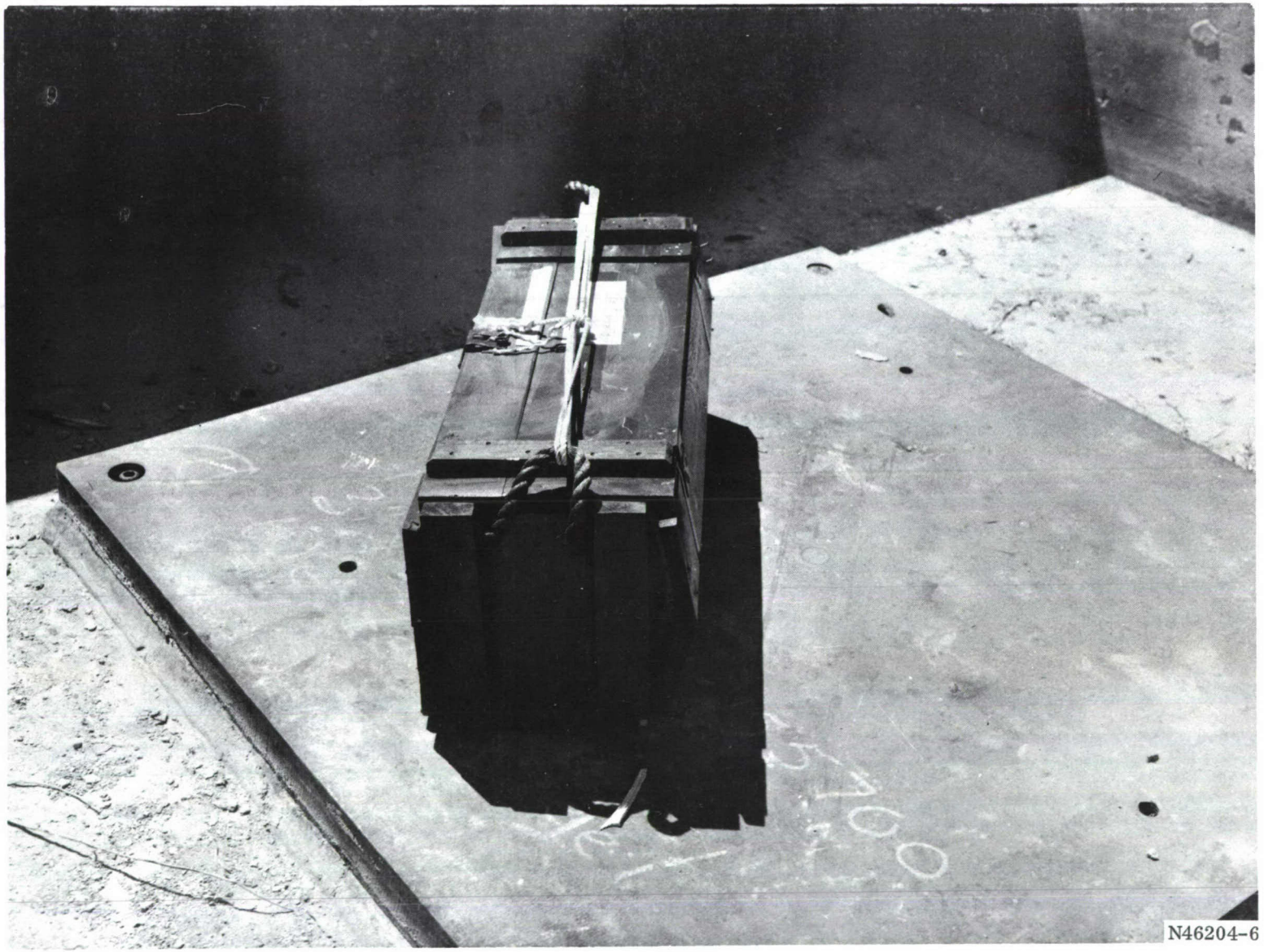


Figure 10. RIPER Projectiles in Shipping Box Following 40 Foot Drop Test, Dropped Flat on the Bottom

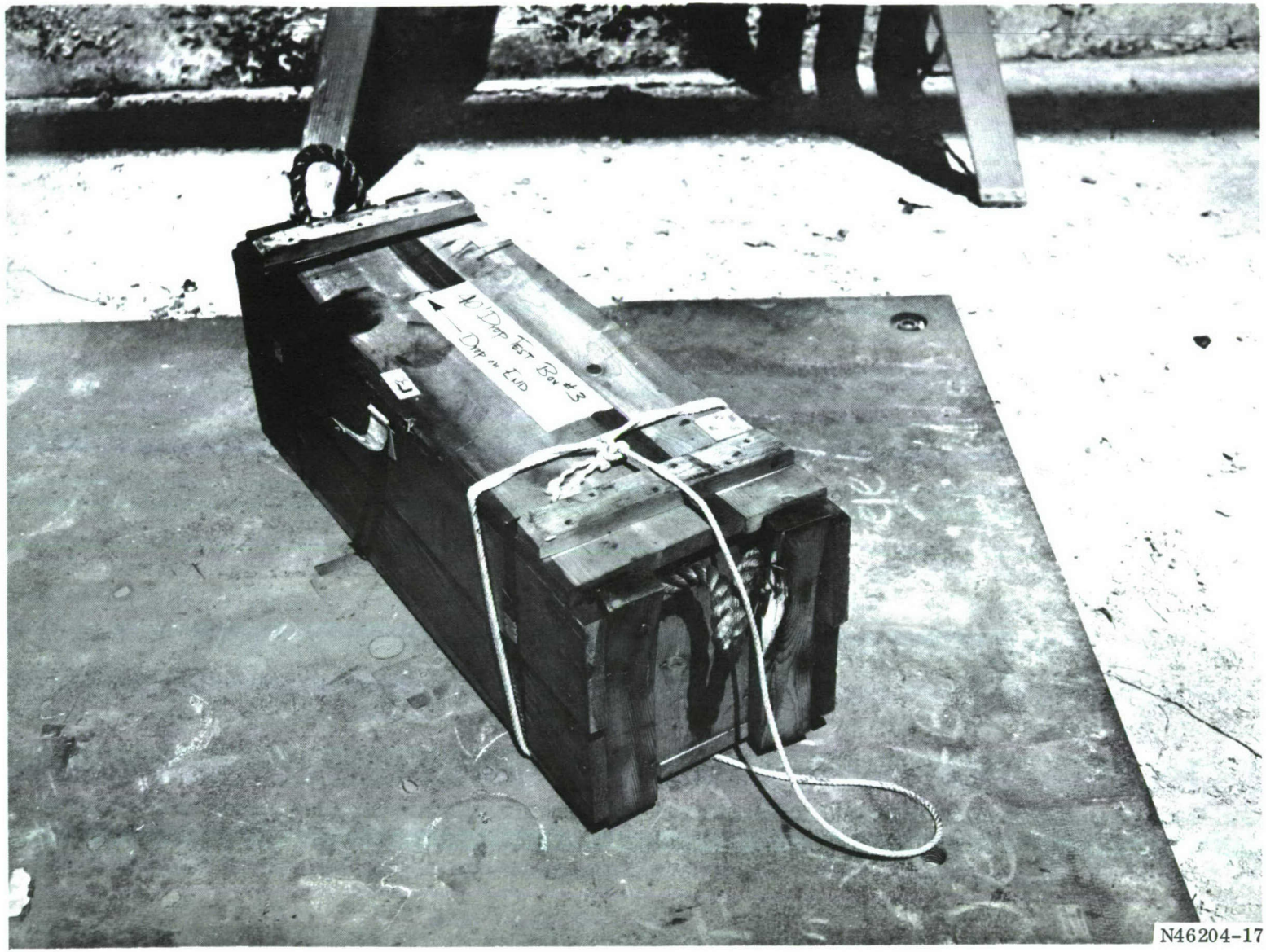


Figure 11. RIPER Projectiles in Shipping Box Following 40 Foot Drop Test, Dropped on End

Figure 12. RIPER Projectiles in Shipping Box Following 40 Foot Drop Test, Dropped 45 Deg on Bottom-End Edge

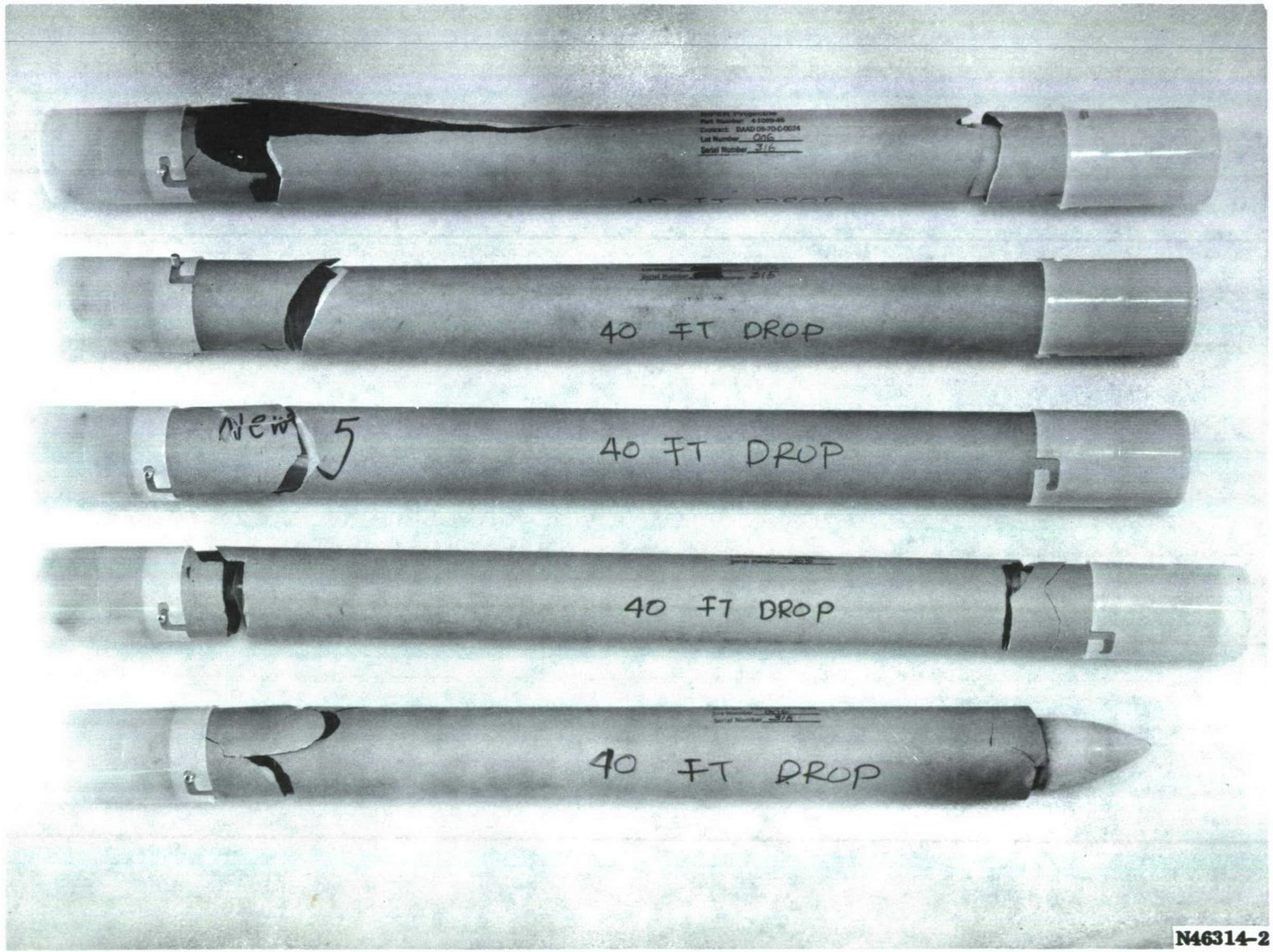


Figure 13. **Projectiles Damaged by 40 Foot Drop Test**

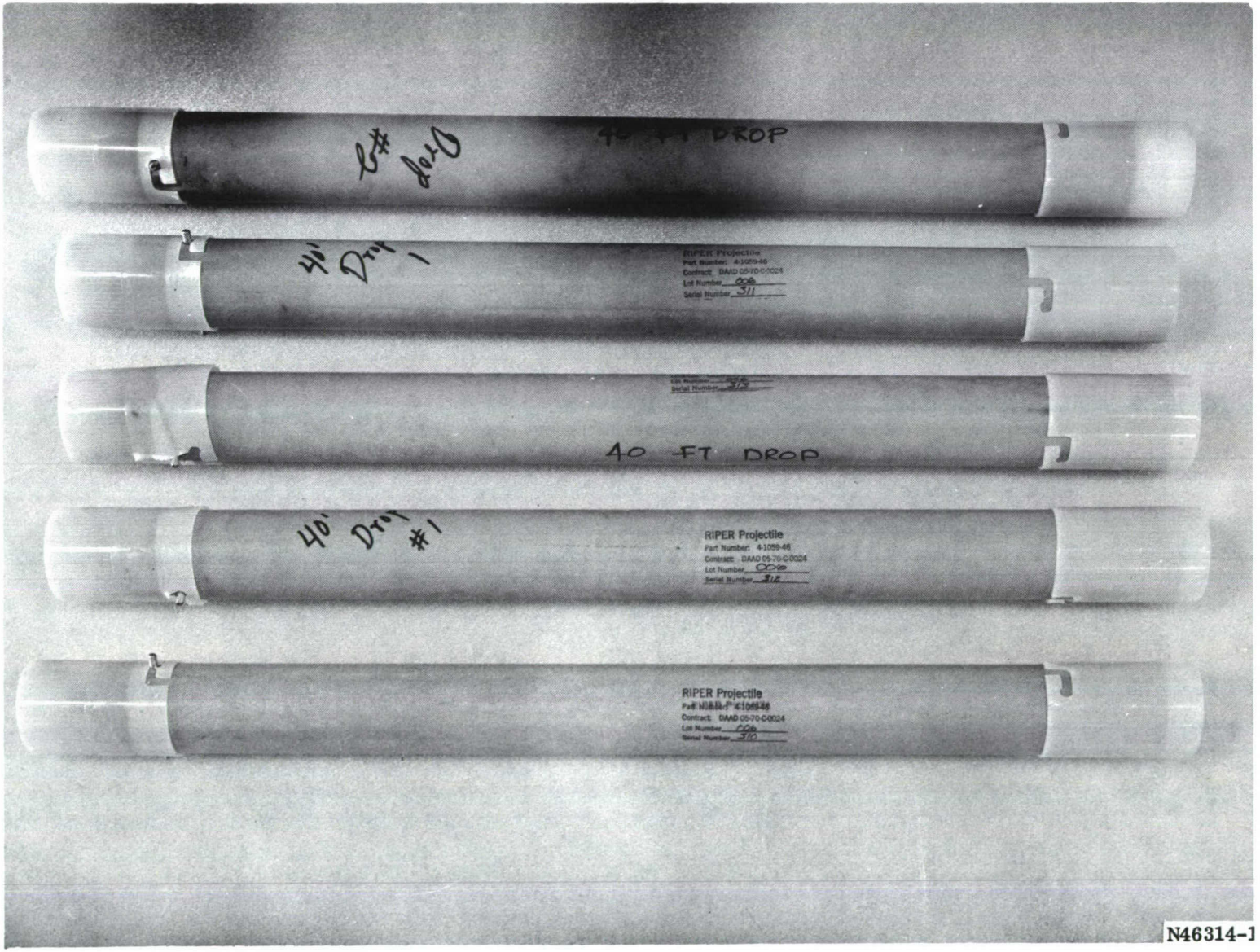


Figure 14. Projectiles Undamaged by 40 Foot Drop Test

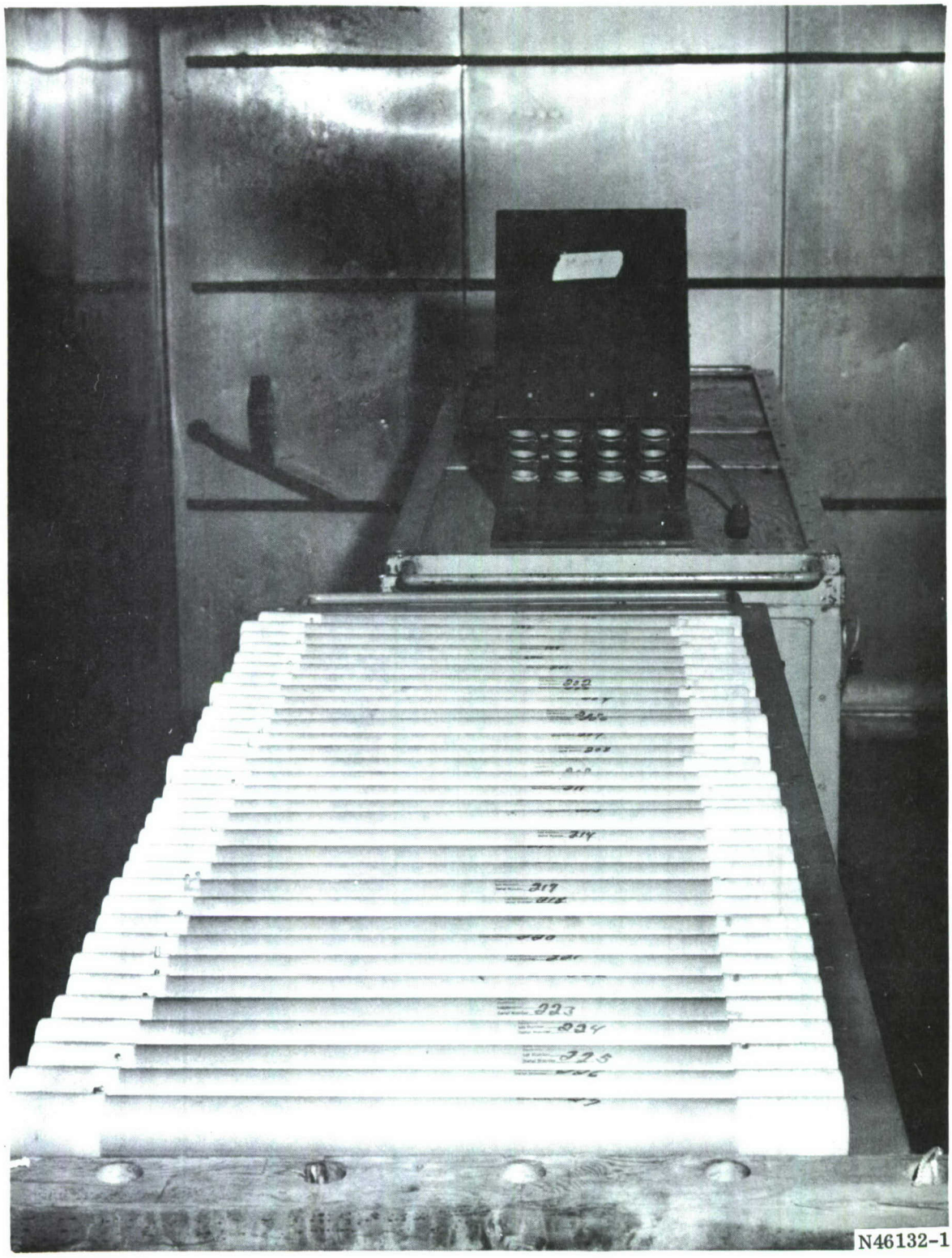


Figure 15. RIPER Projectiles and Launcher in High Temperature Test Chamber

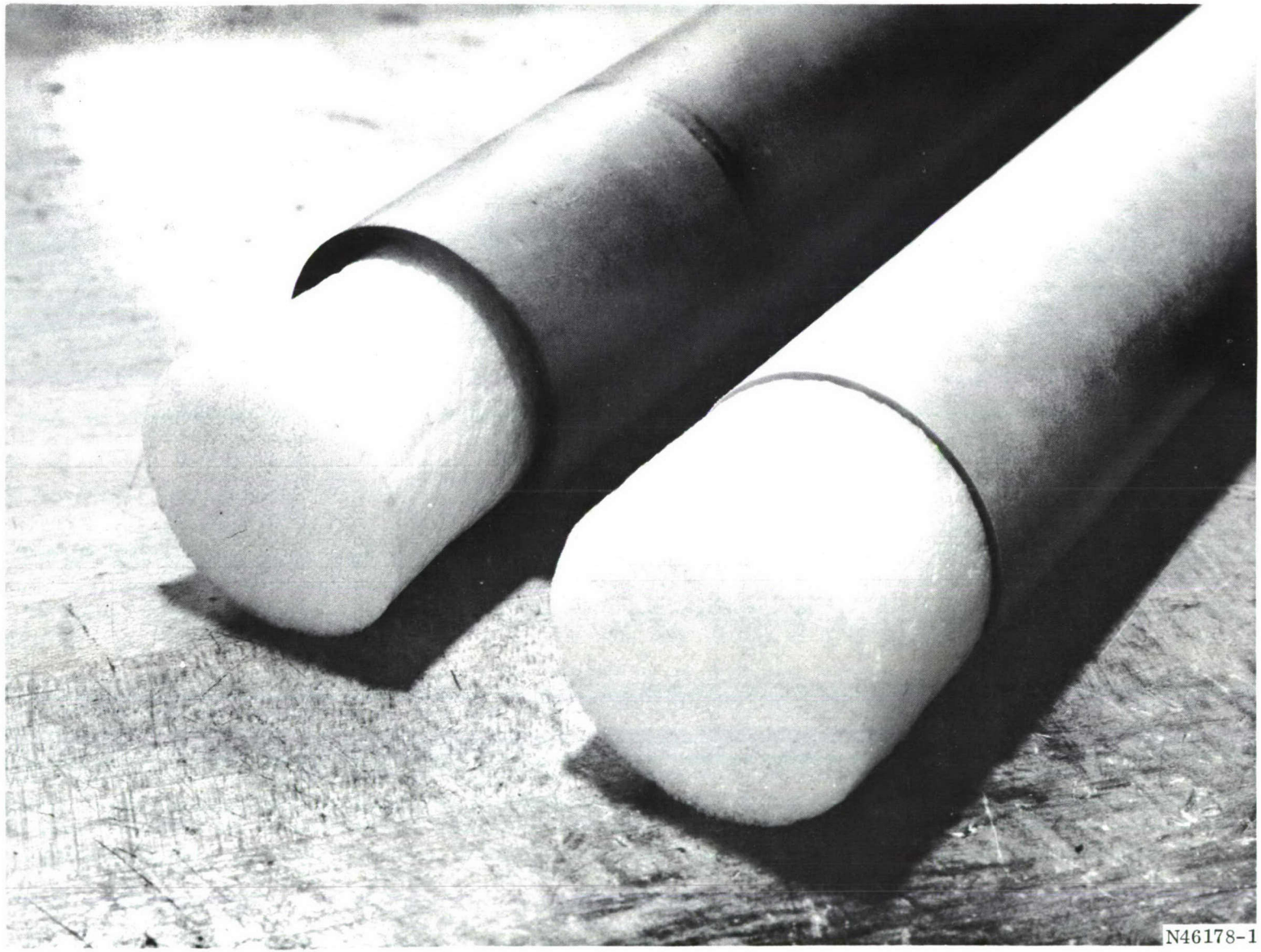


Figure 16. Foam Plug Before and After High Temperature Test

E. HUMIDITY TEST

Thirty-two RIPER Projectiles and one launcher were subjected to the humidity test. The items were placed into the conditioning chamber as shown in Figure 17. The conditioning cycle was: 6 hours at +160° F with 95 percent relative humidity, 16 hours at +82° F with a 85 percent relative humidity, repeated for 10 complete cycles in not less than 240 hours (10 days).

Examination of the projectiles after the test showed the launch tubes to be quite discolored and the foam plug to be shrunk, similarly to that shown in Figure 16. Several projectiles were removed from the launch tubes and examined. Discolorations were noticed in the parachute pack and around the ignition end of the flare candle.

Subsequent flight function testing of eight projectiles indicated that the test had seriously affected the candle ignition system. A design change was made and incorporated into the remaining 24 projectiles.

The 24 reworked projectiles were again subjected to a humidity test with a slightly different cycle as follows:

a 16 hours at +165° F and 95 percent RH

b 8 hours at 75° F and uncontrolled RH

a 16 hours at +165° F and 95 percent RH

b 8 hours at 75° F and uncontrolled RH

a 16 hours at +165° F and 95 percent RH

b 8 hours at 75° F and uncontrolled RH

a 64 hours at +165° F and 95 percent RH

b 8 hours at 75° F and uncontrolled RH

a 16 hours at +165° F and 95 percent RH

b 8 hours at 75° F and uncontrolled RH

a 16 hours at +165° F and 95 percent RH

b 8 hours at 75° F and uncontrolled RH

Figure 17. RIPER Projectiles and Launcher in Humidity Test Chamber

a 16 hours at +165° F and 95 percent RH

b 8 hours at 75° F uncontrolled RH

a 16 hours at 165° F and 95 percent RH

The total cycle covered 10 days.

Post-test examination of the projectiles showed the same discoloration of the launch tube as before. Disassembly of several of the units showed an even greater humidity effect than before, with actual droplets of water between the flare candle and the projectile body as shown in Figure 18. Also observed on several projectiles were cracks in the extruded Lexan projectile body. One of the most severely cracked units is shown in Figure 19. This type of cracking frequently occurs in Lexan after exposure to high temperature/humidity conditions in contact with some O-ring materials when under stress conditions.

F. SALT FOG TEST

Thirty-two RIPER Projectiles and one launcher were subjected to the Salt Fog Test. The items were placed into the chamber as shown in Figure 20. The temperature of the chamber was raised to 95° F, and the salt fog atomization system started. Three quarts of salt solution per 10 cubic feet of chamber volume were atomized per 24 hour period. The test duration was 48 hours.

At completion of the test, some salt crystal buildup was seen on the projectiles and considerable buildup was seen on the launcher. Figure 21 shows the projectiles and the launcher after completion of the test. Figures 22 and 23 show the launcher from the breech and muzzle end. All test items were then flushed with clean water and dried.

No effect was noted on the projectiles. The launcher showed a slight corrosion on the adjustment arm but no other effect.

G. FIVE FOOT DROP TEST

Thirty RIPER Projectiles were subjected to a Five Foot Drop Test as follows.

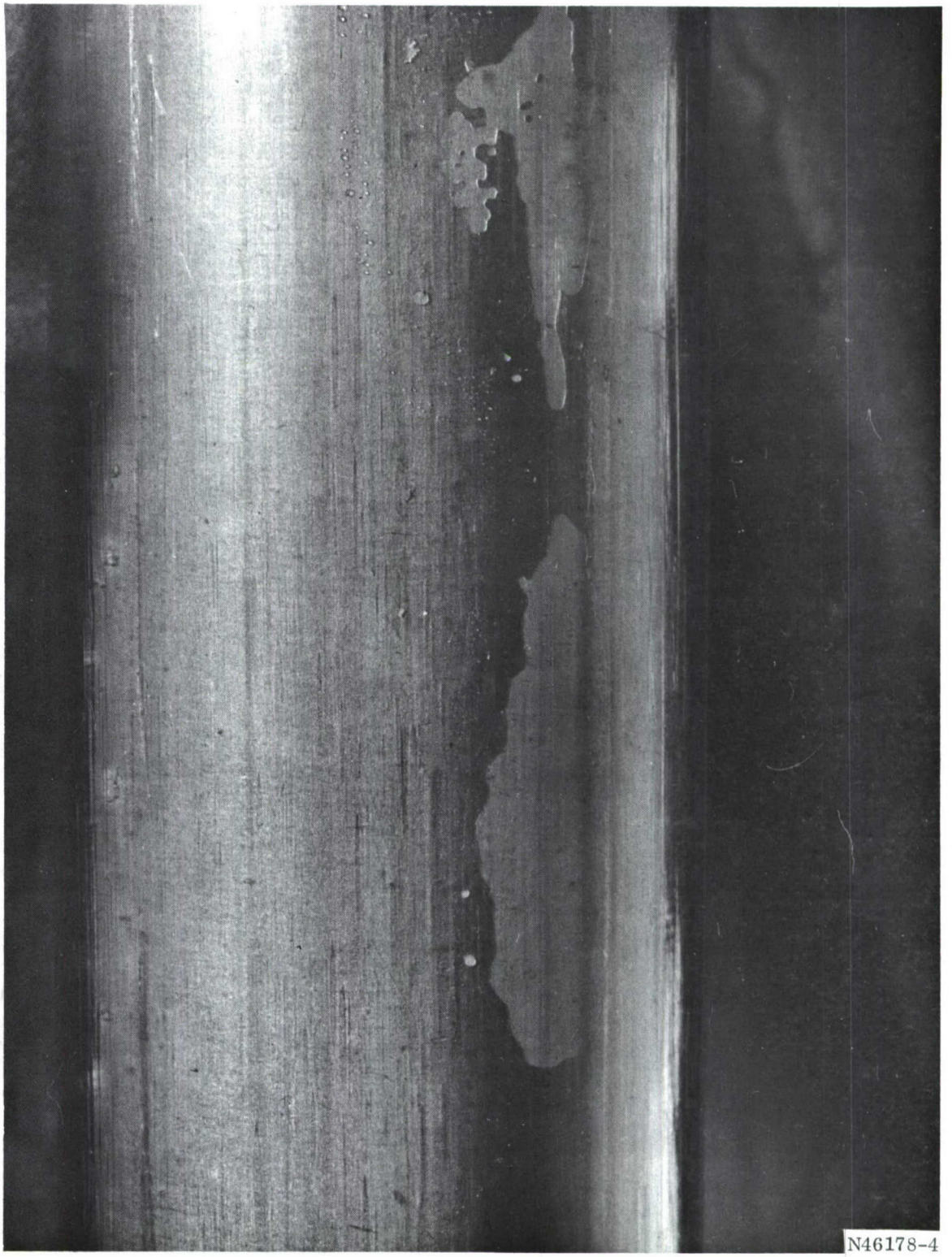


Figure 18. Water Drops Between Candle and Projectile Body

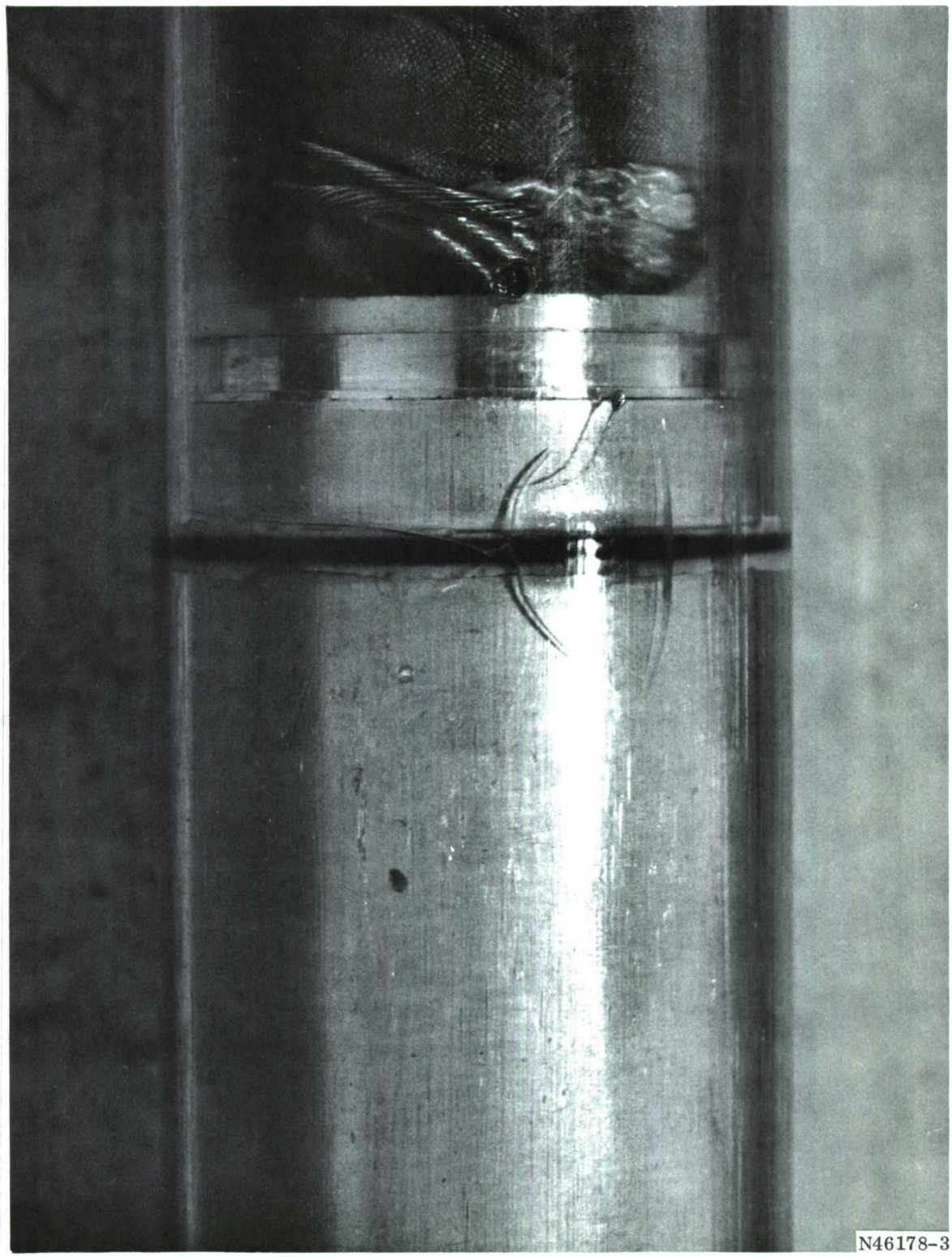


Figure 19. Cracks in Projectile Body After Humidity Test

Figure 20. RIPER Projectiles and Launcher Prepared for Salt Fog Test

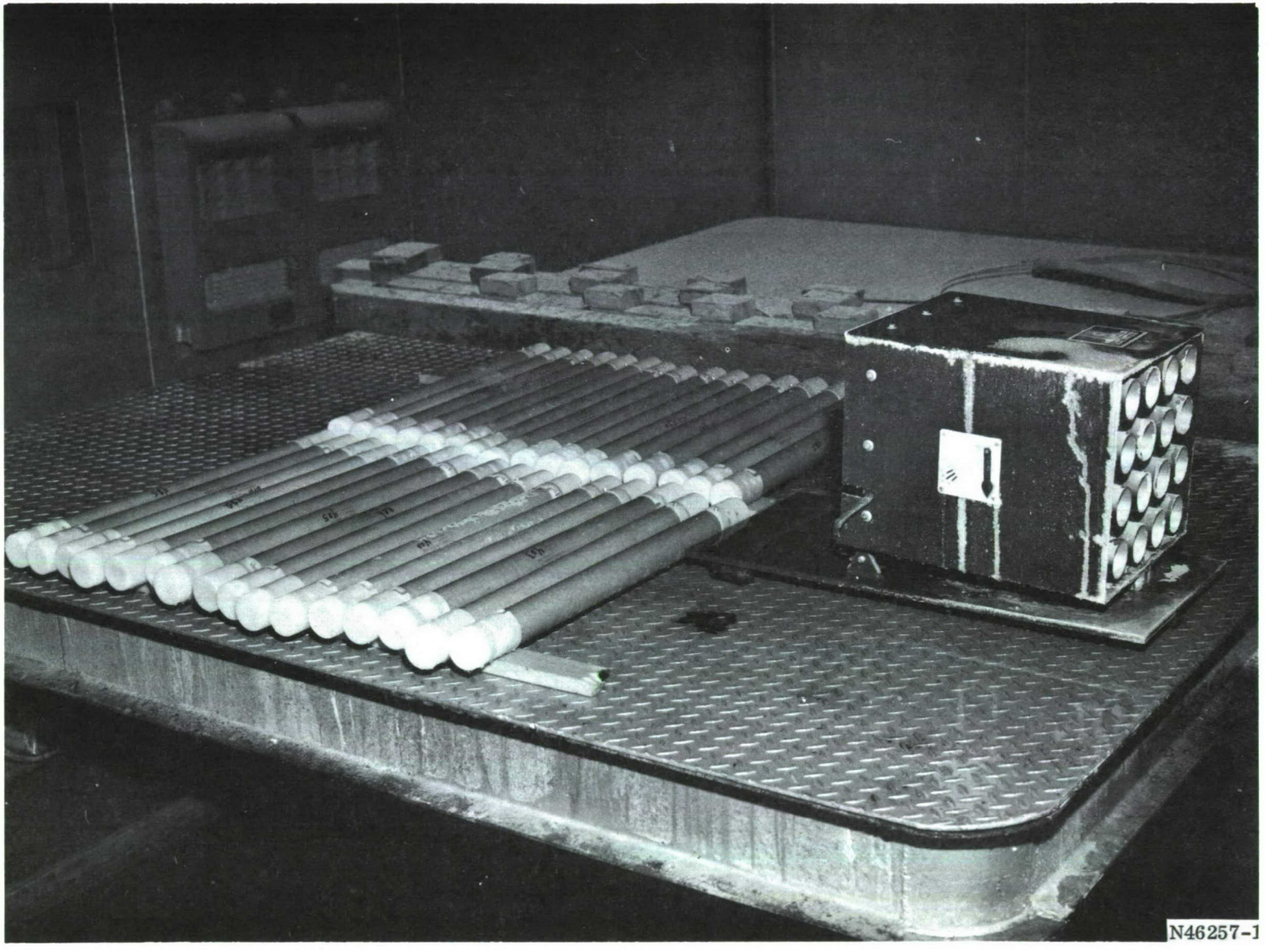


Figure 21. RIPER Projectiles and Launcher Following Salt Fog Test

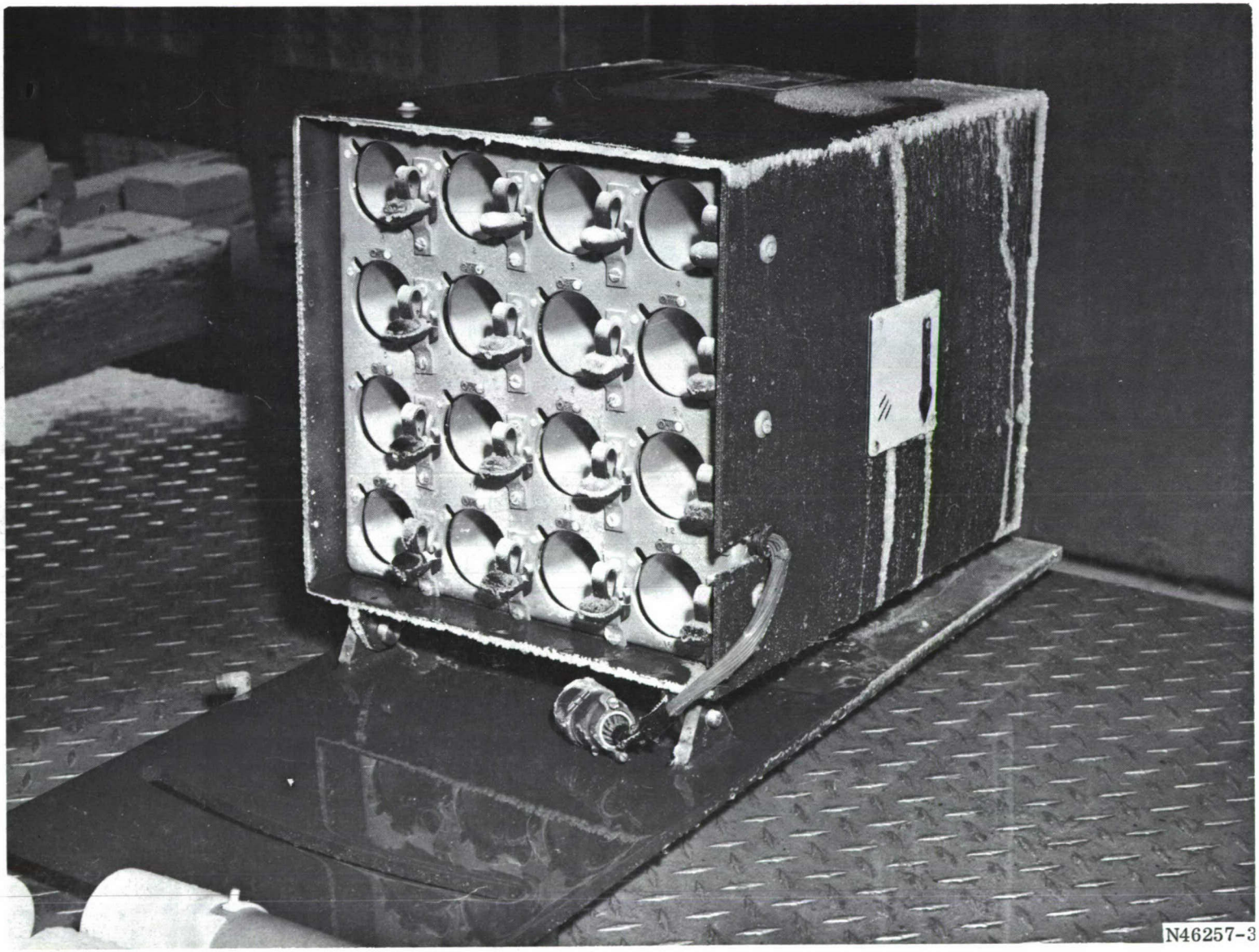


Figure 22. RIPER Launcher Breech After Salt Fog Test

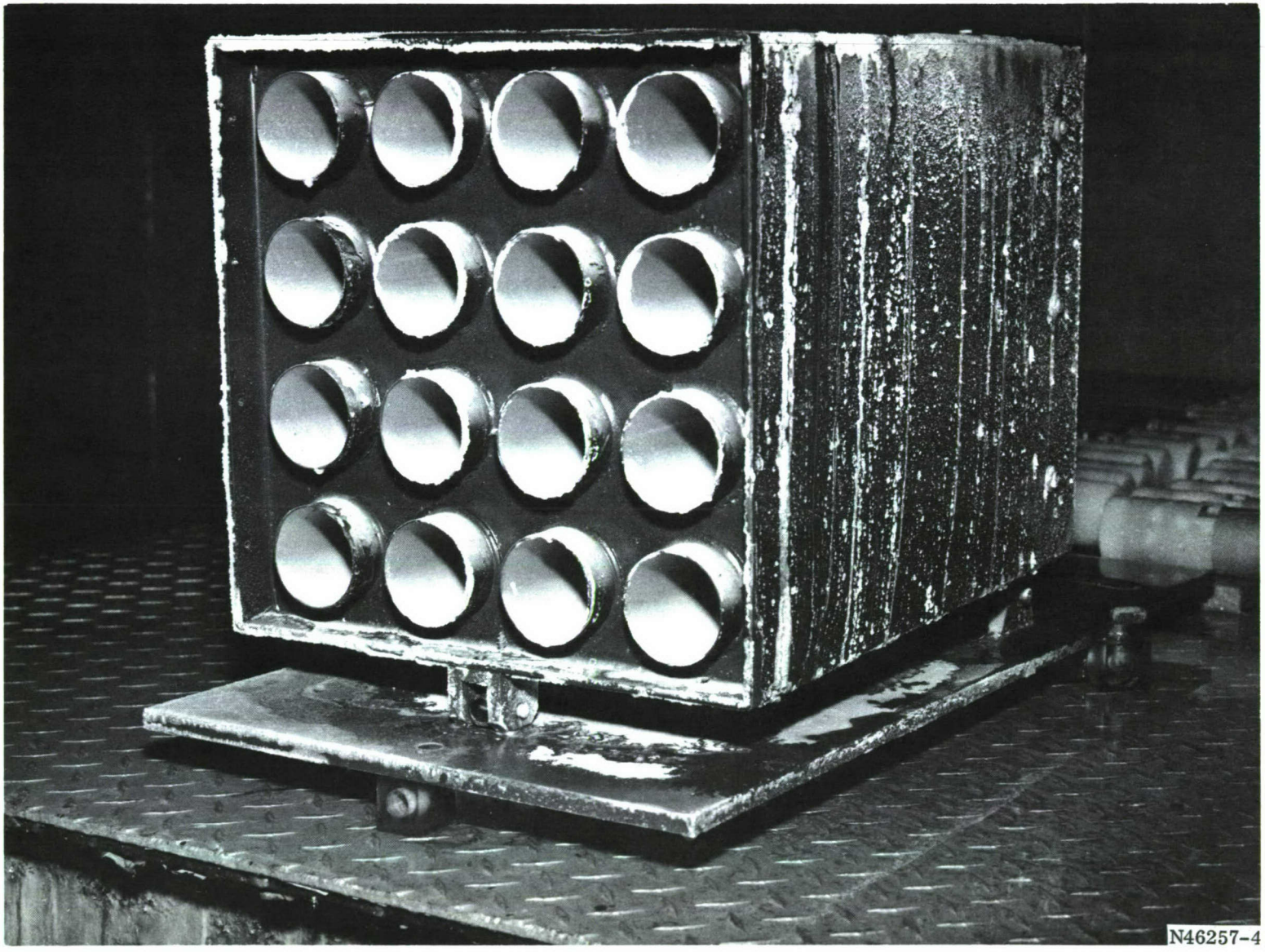


Figure 23. RIPER Launcher (Muzzle End) Following Salt Fog Test

Condition	Units Dropped	Units Damaged	Drop Orientation
1	6	5	Horizontally
2	6	1	45 deg, base down
3	6	1	45 deg, nose down
4	6	0	Vertically, base down
5	6	0	Vertically, nose down

The projectiles impacted on a flat steel plate.

Figure 24 shows the projectiles which were dropped horizontally. Damage was sustained by five of the six units sufficient to prevent launching the projectile. The damage consisted of cracked and broken launch tubes and, in some cases, loose nose cones.

Figure 25 shows the projectiles which were dropped at 45 deg base down. Damage was sustained by one of the six units, again consisting of a broken launch tube.

Figure 26 shows the projectiles which were dropped 45 deg nose down. One projectile sustained a broken launch tube.

Figure 27 shows the projectiles which were dropped vertically, base down. All six projectiles were operable following the test. The protective end cover was very slightly damaged on these units but was easily removable.

Figure 28 shows the projectiles which were dropped vertically, nose down. All six projectiles were operable following the test. The protective end cover was pushed onto the launch tube in all cases and required a greater than normal force to remove.

H. SHOCK TEST

One RIPER Launcher, packed in its shipping box, was subjected to the shock test. Shock loads were induced by dropping the package from a four foot height onto a steel plate. The box was dropped a total of 26 times; once on each face, edge, and corner.

Figure 29 shows the box after the testing prior to removing the launcher. The launcher was removed and was undamaged.

Figure 24. RIPER Projectiles After Five Foot Drop Test (Horizontal Drop)

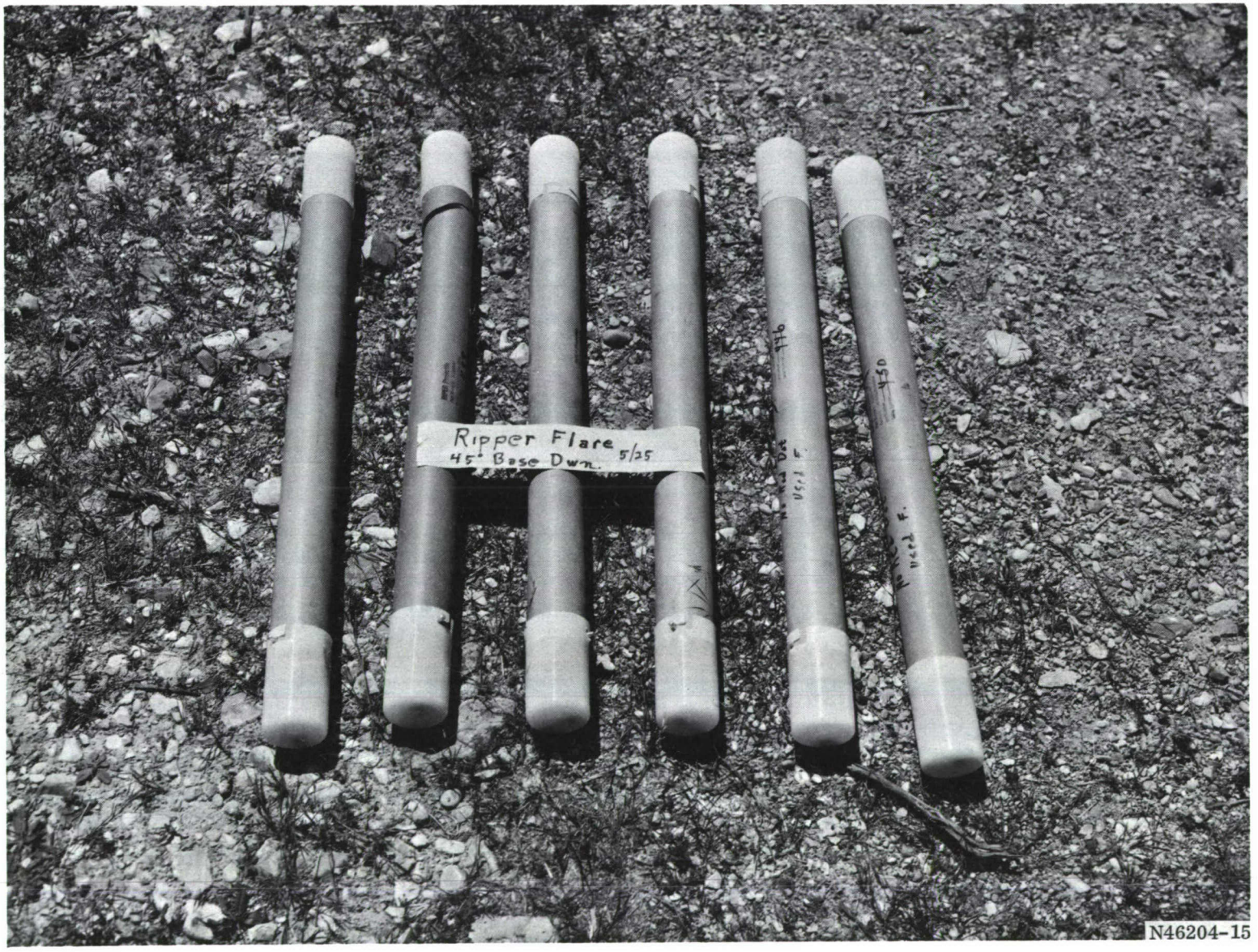


Figure 25. RIPER Projectiles After Five Foot Drop Test (45 Deg, Base Down)

Figure 26. RIPER Projectiles After Five Foot Drop Test (45 Deg, Nose Down)

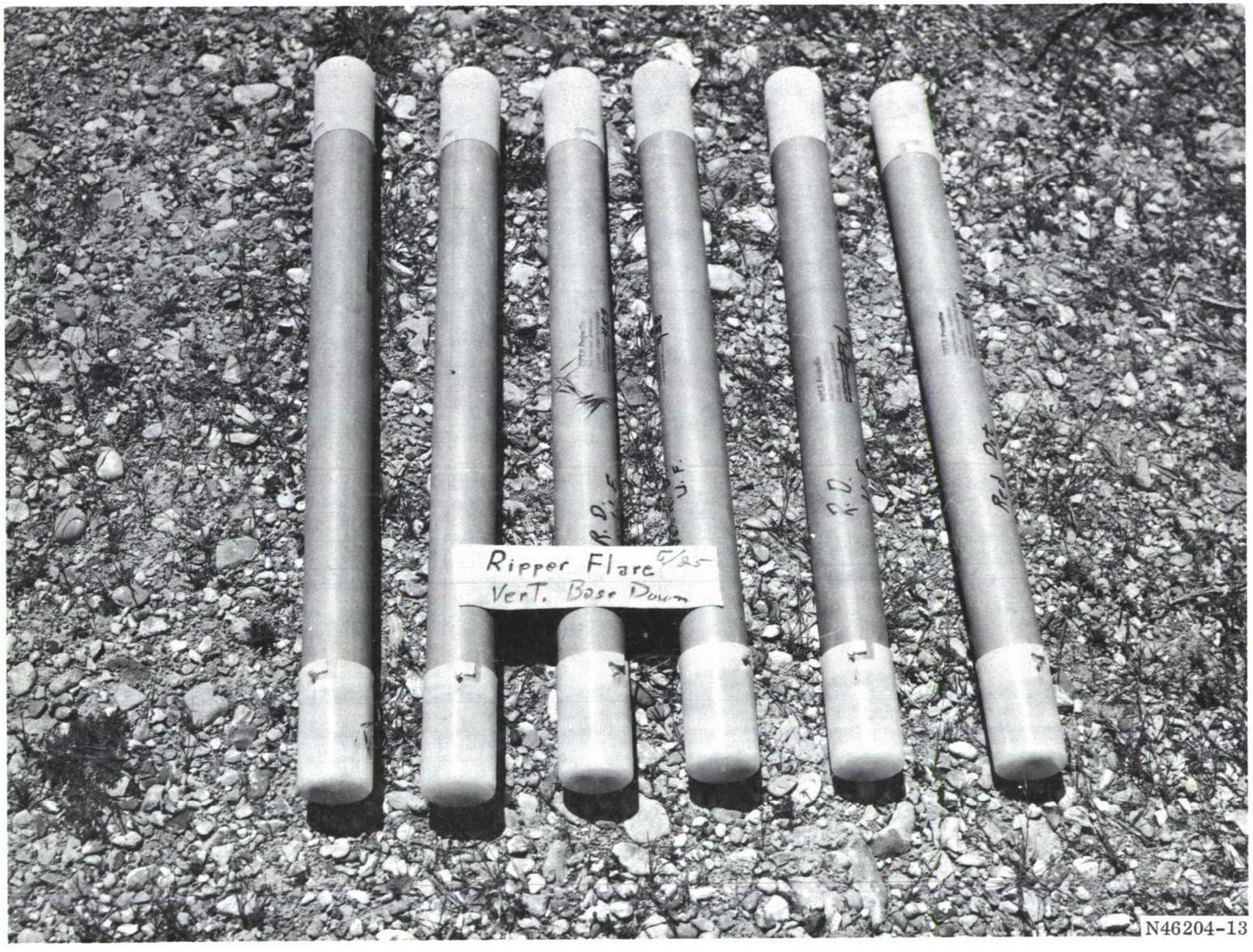


Figure 27. RIPER Projectiles After Five Foot Drop Test (Vertically, Base Down)

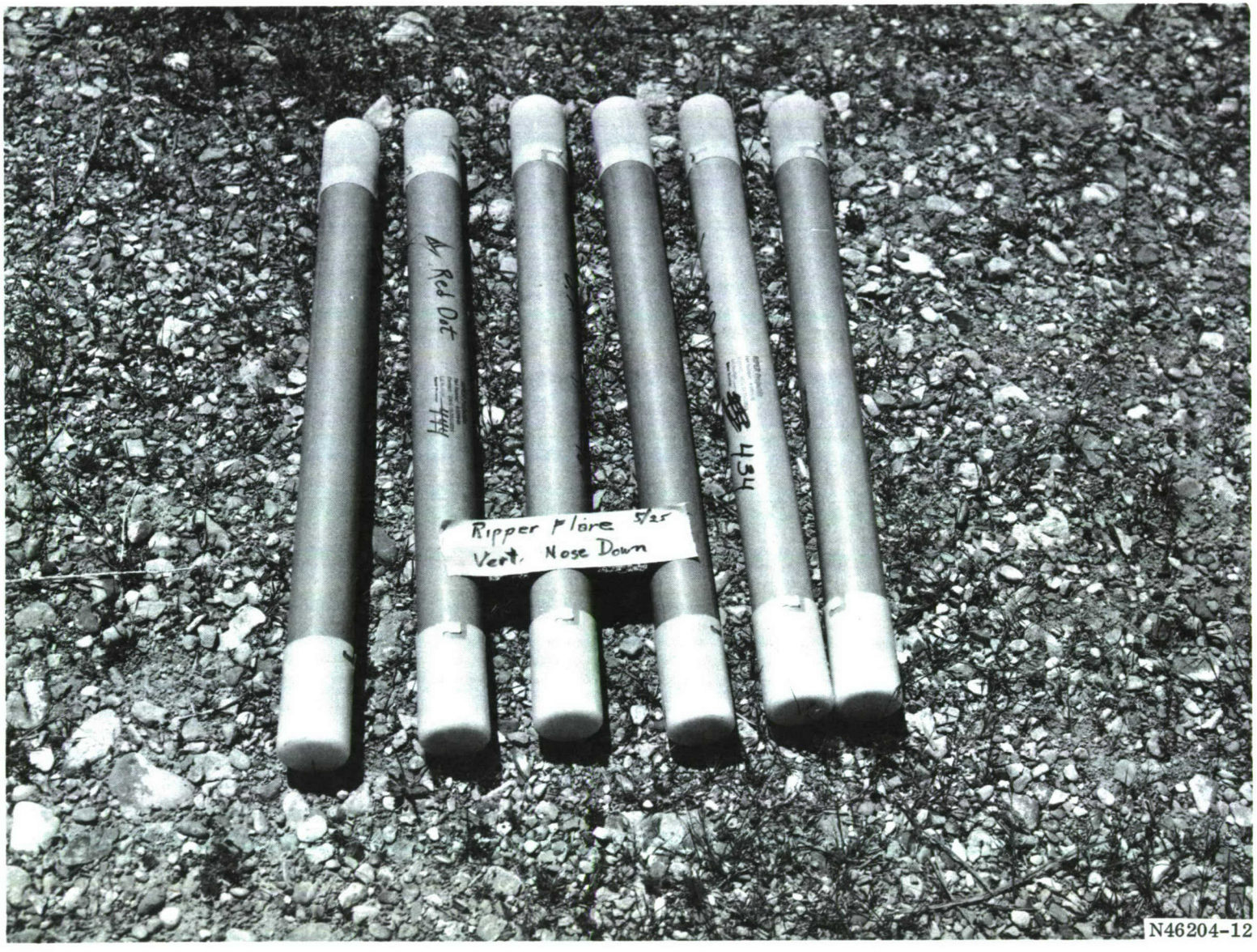


Figure 28. RIPER Projectiles After Five Foot Drop Test (Vertically, Nose Down)

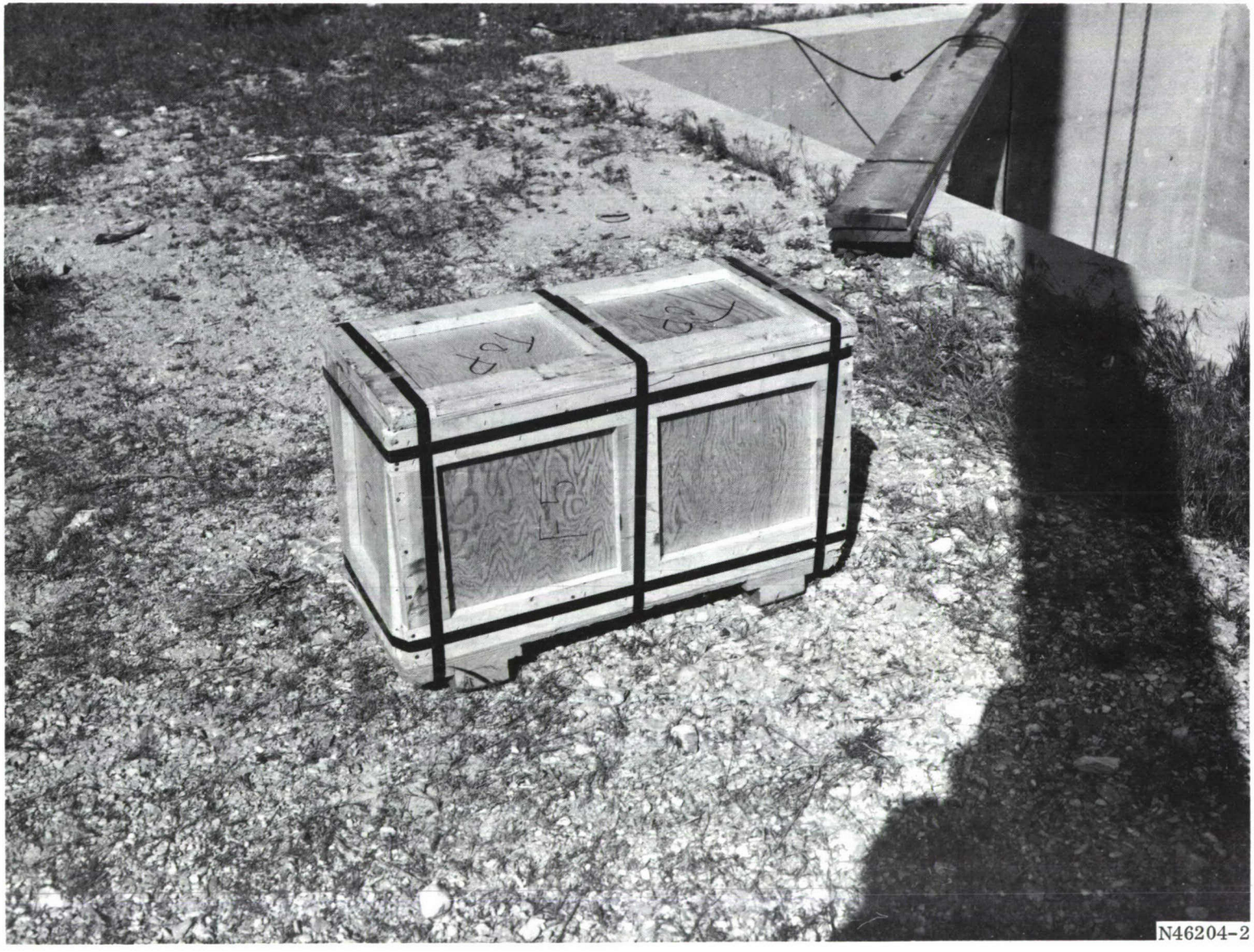


Figure 29. RIPER Launcher Following Shock Test

VI. FLIGHT FUNCTION TESTING

During Phase III, a total of 317 RIPER projectiles were flight function tested. Of these, 50 units were quality assurance rounds, 52 were control group rounds, and the remainder were units which had been exposed to environmental tests. Table IV is a summary of the flight function tests and results.

Flight function tests were conducted using the five launchers procured in Phase III. Launchers were used before and after environmental exposure, and all functioned properly.

A comparison of flight test results is tabulated and presented as Table V. Data presented are the averages for the groups tested. Table VI presents a test result summary for QA and baseline units.

Individual flight test data are presented in Tables VII thru XIV. The data are grouped by environmental exposure groups, as are Tables IV and V. The columnar headings in Table VII are further defined as follows:

1. Range (m) = horizontal distance from launcher in meters at flare deployment (FL) and at flare burnout (BO).

2. Range (ft) same as above except in feet.

3. Down Range (ft) = horizontal distance from launcher toward theoretical target in feet.

4. Cross Range (ft) = horizontal distance from theoretical flight path in feet, negative indicates to the right and positive indicates to the left.

5. Altitude (ft) = vertical height above launcher at flare deployment (FL) and at flare burnout (BO) in feet.

6. Descent and Drift (ft) = the upper number is the descent in feet of the candle during burn time, the lower number is drift in feet during candle burn time.

TABLE IV

RIPER PHASE III

FLIGHT FUNCTION TEST SUMMARY

Test Group	Total Units	Units Flight Tested	Number Successful	Number of Failures			
				Rocket Motor	Parachute	Flare Candle	Other
Baseline and QA Units	102	101	87	2	5	5	2
Transportation Vibration Units	48	48	45	2	0	1	0
High Temperature	32						
Units Tested Hot (+120° F)		10	5	3	0	0	0
Tested at Ambient (+70° F)		22	20	1	0	1	1
Low Temperature	32						
Units Tested Cold (-50° F)		11	(3)	(3)	(3)	0	1
Tested at Ambient (+70° F)		21	21	0	0	0	0
Humidity Units	32	32	9	6	1	14	2
Salt Fog Units	32	32	31	0	1	0	0
Five Foot Drop Units	30	23	17	3	3	0	0

TABLE V - RIPER PHASE III

COMPARISON OF FLIGHT FUNCTION TEST AVERAGE RESULTS

	Time To Deployment (seconds)	Range (feet)	Range (meters)	Altitude (Deployment) (feet)	Altitude (Burnout) (feet)	Candle Burn Time (seconds)	Parachute Descent Rate (feet/sec)	Parachute Drift Rate (feet/sec)
Baseline & QA Units (Average of 88)	6.8	1802	549	814	384	58.4	7.53	13.68
Transportation Vibration Units (Average of 45)	7.0	1787	545	796	311	60.8	7.88	15.05
High Temperature Units								
Tested Hot (Average of 4)	6.7	1579	481	1120	643	60.3	7.92	15.70
Tested at Ambient (Average of 18)	8.1	2029	619	796	336	58.3	8.32	19.66
Low Temperature Units								
Tested Cold (Average of 4)	7.2	1686	514	754	282	60.7	7.78	15.16
Tested at Ambient (Average of 21)	6.9	1793	547	752	311	58.7	7.53	16.91
Humidity Units (Average of 7)	8.6	2141	653	834	272	60.6	9.02	20.33
Salt Fog Units (Average of 31)	6.2	1655	504	769	343	59.5	7.25	13.46
5 Foot Drop Units (16 Average)	6.4	1655	504	829	483	58.6	6.96	12.98
Design Target	7.3	1969	600	800	300	60.00	8.20	--

TABLE VI

TEST RESULTS SUMMARY

Test Date	Units Tested	Successes	Failures			
			Motor	Parachute	Candle	Other
3/3/71	9 QA	4	0	1	3*	1
3/9/71	16 QA	15	0	0	0	1
3/12/71	16 QA	15	1	0	0	0
4/14/71	8 QA	6	0	2	0	0
4/15/71	16 BL	15	0	0	1*	0
4/20/71	36 BL	32	1	2	1*	0
	101	87	2	5	5	2

*WRONG IGNITION PROPELLANT

DISCOUNT 5 CANDLE FAILURES

87 OUT OF 96 = 90%

7. Descent and Drift Rate (ft/sec) = the upper number is parachute descent rate, average during candle burn time in feet per second; the lower number is the drift rate of the parachute, average during candle burn time in feet per second.

8. Candle Burn (sec) = candle burn time in seconds.

9. First Light (sec) = time from launch to flare deployment in seconds.

10. Radius Illum (ft) = the theoretical radius of the circle on the ground which would be illuminated with an intensity of 0.05 foot candles by the flare candle at first light (FL) and at burnout (BO). This calculation assumes a flare candle output of 337,000 cd.

The range vs altitude of each test and the range vs cross range of each test have been plotted by test groups.

A. BASELINE AND QUALITY ASSURANCE UNITS

During the fabrication process, 50 RIPER units were selected as quality assurance units and flight function tested. In addition to these QA units, 52 RIPER units were selected as baseline units and flight function tested. Table VI showed the test groups and summarized the results.

The units tested on 9 March were preselected QA units and the first units completed in Phase III. The candle ignition failures were traced to a misidentified lot of propellant which was used as the candle ignition wafer. The correct propellant, TP-H1016, was used in all subsequent tests. The 9 March failure listed as "other" in Table VI was a projectile which failed and burned in the launcher, resulting in local damage to the launcher. Figure 30 shows the damaged launcher. One live projectile was in a launch tube adjacent to the projectile which burned and sustained some damage to its launch tube but was otherwise undamaged. This projectile and launch tube are shown in Figure 31.

As shown in Table V, the average range of this test group was 550 meters (50 meters short of target), and the average altitude was 811 feet (11 feet above target). Candle burn times averaged 58.4 seconds (1.6 seconds short of target) and parachute descent rates averaged 7.53 feet per second (0.67 feet per second less than target).

Flight test data for the QA and control group units are presented in Table VII and on Figures 32 and 33.

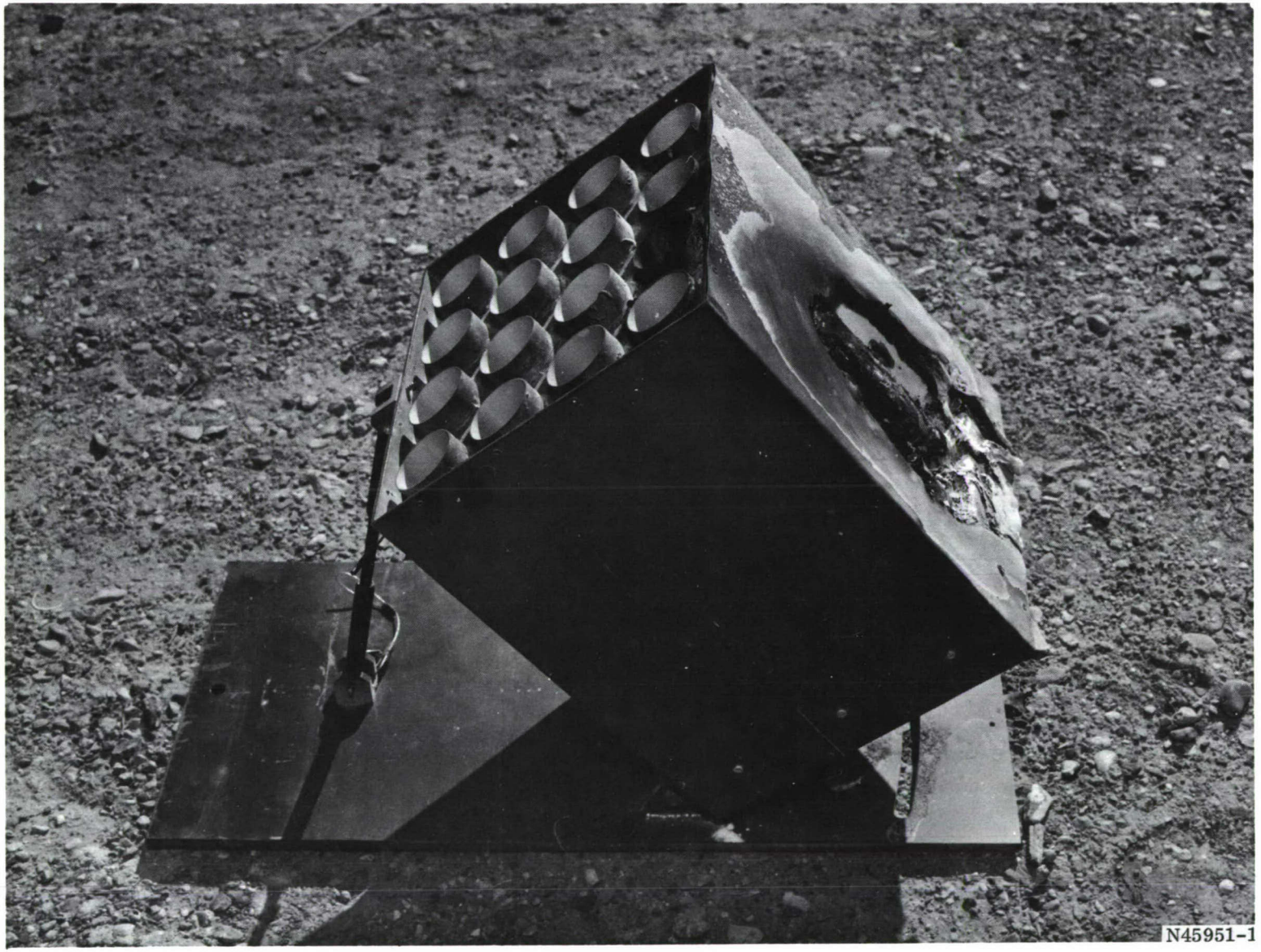


Figure 30. RIPER Launcher Damaged by Projectile Failure

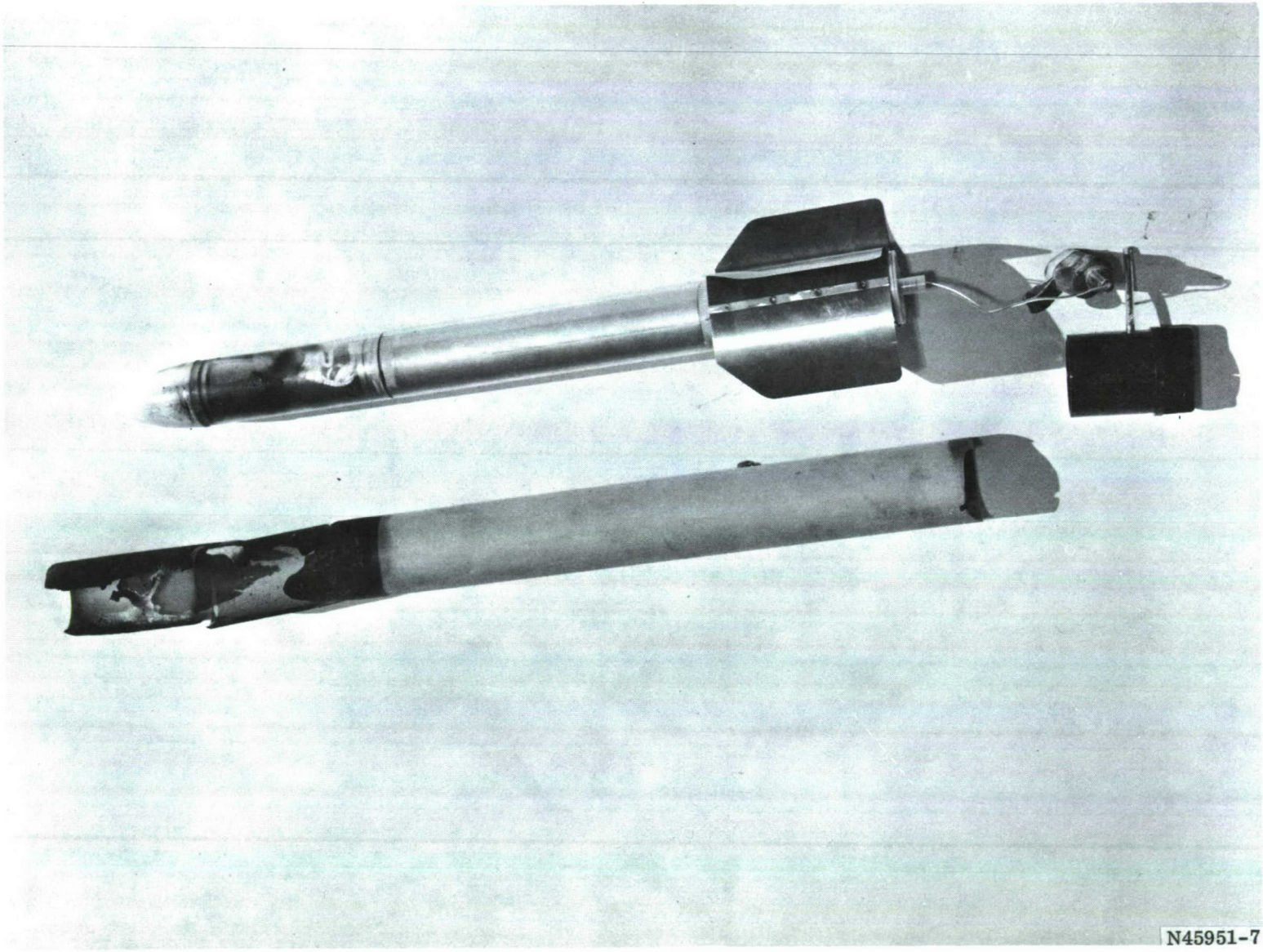


Figure 31. Damaged Projectiles and Launch Tube

Table VII
Flight Function Test Data
Quality Control and Control Group

DAY	MONTH	YEAR
3	3	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
1	FL	438.	1436.	1436.	-9.	557.	0.	0.0	0.0	0.0	1451.
	BO	0.	0.	0.	0.	0.	0.	0.0			0.
		NO CANDLE IGNITION									
2	FL	491.	1613.	1613.	6.	563.	305.	4.85	63.00	6.25	1454.
	BO	191.	627.	558.	-284.	257.	1093.	17.36			1174.
3	FL	504.	1655.	1647.	158.	535.	517.	8.23	62.80	6.35	1437.
	BO	122.	401.	398.	-48.	18.	1266.	20.15			494.
4	FL	545.	1789.	1746.	392.	309.	0.	0.0	0.0	6.05	1239.
	BO	0.	0.	0.	0.	0.	0.	0.0			0.
		18 SECOND GROUND BURNOUT									

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table VII (Continued)
Flight Function Test Data
Quality Control and Control Group

DAY	MONTH	YEAR
3	3	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
5	FL	440.	1443.	1422.	246.	631.	631.	0.0	0.0	6.30	1492.
	BO	429.	1407.	940.	-1047.	0.	1380.	0.0			0.
		NO CANDLE IGNITION									
8	FL	564.	1851.	1843.	-180.	823.	0.	0.0	0.0	7.35	1567.
	BO	0.	0.	0.	0.	0.	0.	0.0			0.
		CABLE BROKE ON CHUTE DEPLOYMENT									
1	FL	567.	1860.	1859.	76.	778.	608.	0.0	0.0	0.0	1553.
	BO	317.	1040.	971.	-372.	170.	995.	0.0			1033.
2	FL	565.	1854.	1848.	147.	792.	477.	7.78	61.30	0.0	1558.
	BO	288.	945.	841.	-432.	316.	1162.	18.95			1247.

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table VII (Continued)
Flight Function Test Data
Quality Control and Control Group

DAY	MONTH	YEAR
9	3	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
3	FL	591.	1940.	1916.	304.	685.	302.	5.30	57.00	6.85	1518.
	BO	317.	1039.	1029.	-140.	383.	992.	17.41			1317.
4	FL	639.	2096.	2087.	194.	535.	401.	6.98	57.40	7.75	1437.
	BO	374.	1226.	1226.	-2.	134.	883.	15.38			958.
5	FL	563.	1848.	1803.	406.	761.	250.	5.16	48.50	7.10	1548.
	BO	311.	1021.	1020.	39.	511.	865.	17.83			1421.
6	FL	595.	1951.	1942.	187.	682.	501.	7.97	62.90	7.25	1516.
	BO	256.	841.	782.	-311.	180.	1263.	20.07			1052.

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table VII (Continued)
Flight Function Test Data
Quality Control and Control Group

DAY	MONTH	YEAR
9	3	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
7	FL	583.	1911.	1907.	121.	721.	469.	7.89	59.50	7.05	1533.
	BO	290.	952.	923.	-235.	252.	1047.	17.60			1166.
8	FL	600.	1968.	1955.	221.	494.	493.	7.88	62.50	7.00	1409.
	BO	293.	962.	961.	-40.	1.	1028.	16.45			201.
9	FL	589.	1933.	1932.	-49.	714.	401.	6.62	60.60	7.10	1530.
	BO	319.	1046.	978.	-372.	313.	1007.	16.62			1244.
10	FL	604.	1982.	1978.	-121.	403.	0.	0.0	0.0	7.50	1336.
	BO	0.	0.	0.	0.	0.	0.	0.0			0.

11 SECOND GROUND BURNOUT

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table VII (Continued)
Flight Function Test Data
Quality Control and Control Group

DAY	MONTH	YEAR
9	3	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
11	FL	679.	2228.	2222.	168.	668.	506.	9.58	52.80	7.10	1510.
	BO	345.	1131.	1062.	-390.	162.	1287.	24.38			1017.
12	FL	590.	1937.	1919.	262.	709.	313.	6.07	51.50	7.00	1528.
	BO	349.	1146.	1116.	-261.	397.	959.	18.61			1330.
13	FL	571.	1874.	1861.	220.	646.	516.	8.66	59.50	6.75	1500.
	BO	299.	982.	938.	-288.	131.	1053.	17.69			950.
14	FL	624.	2046.	1982.	509.	459.	411.	6.91	59.50	6.80	1383.
	BO	359.	1178.	1098.	427.	47.	888.	14.92			681.

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table VII (Continued)
Flight Function Test Data
Quality Control and Control Group

DAY	MONTH	YEAR
9	3	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
15	FL	550.	1805.	1804.	23.	621.	457.	7.75	59.00	7.20	1487.
	BO	318.	1042.	876.	-564.	164.	1099.	18.62			1021.
16	FL	716.	2350.	2340.	216.	865.	0.	0.0	0.0	7.65	1578.
	BO	0.	0.	0.	0.	0.	0.	0.0			0.
		CHUTE BROKE FREE FROM FLARE -- PIN MISSING									
1	FL	503.	1651.	1621.	314.	833.	0.	0.0	58.90	6.85	1570.
	BO	0.	0.	0.	0.	0.	0.	0.0			0.
	12										
2	FL	614.	2014.	1982.	355.	770.	0.	0.0	62.55	7.90	1551.
	BO	0.	0.	0.	0.	0.	0.	0.0			0.
	11										

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table VII (Continued)
Flight Function Test Data
Quality Control and Control Group

DAY	MONTH	YEAR
12	3	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
3	FL	652.	2139.	2126.	233.	1038.	794.	14.31	55.50	7.20	1606.
	BO	298.	976.	758.	-615.	244.	1609.	28.99			1155.
	66										
4	FL	635.	2083.	2043.	407.	605.	496.	8.64	57.35	7.40	1478.
	BO	398.	1306.	1111.	-687.	109.	1437.	25.06			896.
	89										
5	FL	602.	1976.	1923.	456.	783.	525.	8.57	61.25	7.65	1555.
	BO	342.	1122.	794.	-792.	258.	1682.	27.47			1175.
	60										
6	FL	520.	1705.	1684.	266.	851.	0.	0.0	59.60	6.75	1575.
	BO	0.	0.	0.	0.	0.	0.	0.0			0.
	53										

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FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table VII (Continued)
Flight Function Test Data
Quality Control and Control Group

DAY 12 MONTH 3 YEAR 1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
8	FL	550.	1805.	1785.	266.	817.	0.	0.0	0.0	6.70	1566.
	BO	0.	0.	0.	0.	0.	0.	0.0			0.
	46										
9	FL	591.	1938.	1848.	584.	617.	0.	0.0	58.85	7.00	1485.
	BO	0.	0.	0.	0.	0.	0.	0.0			0.
	41										
10	FL	596.	1955.	1942.	232.	733.	0.	0.0	62.90	7.10	1537.
	BO	0.	0.	0.	0.	0.	0.	0.0			0.
	74										
11	FL	527.	1727.	1700.	308.	1009.	0.	0.0	58.30	7.55	1604.
	BO	0.	0.	0.	0.	0.	0.	0.0			0.
	97										

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FL = CANDLE FIRST LIGHT
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Table VII (Continued)
Flight Function Test Data
Quality Control and Control Group

DAY 12 MONTH 3 YEAR 1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
12	FL	549.	1802.	1774.	316.	955.	0.	0.0	58.40	7.00	1596.
	BO	0.	0.	0.	0.	0.	0.	0.0			0.
	MOTOR S/N 29										
12	FL	0.	0.	0.	0.	0.	0.	0.0	0.0	0.0	0.
	BO	0.	0.	0.	0.	0.	0.	0.0			0.
	29										
13	FL	609.	1999.	1923.	544.	530.	394.	6.46	61.00	6.90	1434.
	BO	208.	684.	576.	-369.	136.	1628.	26.68			961.
	28										
14	FL	623.	2046.	2030.	252.	768.	0.	0.0	60.20	7.40	1550.
	BO	0.	0.	0.	0.	0.	0.	0.0			0.
	20										

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FL = CANDLE FIRST LIGHT
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Table VII (Continued)
Flight Function Test Data
Quality Control and Control Group

DAY	MONTH	YEAR
12	3	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
16	FL	517.	1697.	1654.	378.	772.	0.	0.0	62.95	9.25	1551.
	BO	0.	0.	0.	0.	0.	0.	0.0			0.
	61										
1	FL	278.	913.	904.	-132.	582.	452.	8.22	55.00	5.00	1466.
	BO	272.	893.	893.	25.	130.	157.	2.86			948.
	141										
2	FL	530.	1739.	1716.	-285.	756.	463.	8.33	55.60	6.35	1546.
	BO	489.	1604.	1597.	-153.	293.	178.	3.20			1220.
	137										
3	FL	609.	1998.	1959.	-389.	873.	547.	9.25	59.20	7.30	1580.
	BO	569.	1867.	1844.	-292.	325.	150.	2.54			1258.
	138										

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FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table VII (Continued)
Flight Function Test Data
Quality Control and Control Group

DAY	MONTH	YEAR
14	4	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
4	FL	619.	2031.	2021.	202.	591.	542.	9.09	59.60	6.75	1471.
	BO	611.	2006.	1977.	336.	49.	140.	2.36			688.
	139	45 DEG LAUNCH									
5	FL	725.	2379.	2299.	610.	443.	379.	7.41	51.10	7.50	1370.
	BO	668.	2191.	2074.	704.	65.	244.	4.77			756.
	140	45 DEG LAUNCH									
8	FL	586.	1923.	1604.	1062.	1129.	516.	9.28	55.60	7.50	1611.
	BO	580.	1903.	1537.	1122.	613.	91.	1.63			1483.
	144	45 DEG LAUNCH									
1	FL	637.	2091.	2059.	-362.	859.	262.	5.04	52.00	7.40	1577.
	BO	563.	1849.	1847.	-83.	597.	351.	6.75			1474.
	145										

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FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table VII (Continued)
Flight Function Test Data
Quality Control and Control Group

DAY	MONTH	YEAR
15	4	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
2	FL	422.	1385.	1383.	78.	1447.	15.	0.24	61.00	7.00	1572.
	BO	463.	1519.	1351.	694.	1432.	616.	10.10			1576.
	146										
3	FL	560.	1838.	1838.	-56.	1066.	0.	0.0	0.0	7.40	1608.
	BO	0.	0.	0.	0.	0.	0.	0.0			0.
	147	NO CANDLE IGNITION									
4	FL	478.	1567.	1565.	-86.	1100.	142.	2.44	58.10	6.50	1610.
	BO	551.	1809.	1742.	489.	958.	601.	10.34			1597.
	148										
5	FL	476.	1562.	1534.	-297.	951.	426.	7.36	57.80	5.90	1596.
	BO	566.	1858.	1784.	517.	526.	852.	14.74			1431.
	149										

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FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table VII (Continued)
Flight Function Test Data
Quality Control and Control Group

DAY	MONTH	YEAR
15	4	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
6	FL	491.	1611.	1579.	321.	1084.	374.	6.23	60.00	6.60	1609.
	BO	527.	1728.	1471.	907.	711.	596.	9.93			1529.
	150										
7	FL	530.	1738.	1716.	275.	907.	352.	5.88	59.80	6.80	1588.
	BO	552.	1810.	1701.	618.	556.	344.	5.75			1450.
	151										
8	FL	563.	1847.	1823.	-293.	885.	97.	1.66	58.40	6.60	1583.
	BO	786.	2577.	2478.	710.	788.	1197.	20.50			1557.
	152										
9	FL	506.	1659.	1658.	-71.	892.	536.	9.92	54.00	6.00	1584.
	BO	540.	1773.	1510.	928.	356.	1010.	18.71			1291.
	153										

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Table VII (Continued)
Flight Function Test Data
Quality Control and Control Group

DAY	MONTH	YEAR
15	4	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
10	FL	562.	1843.	1778.	-483.	994.	361.	6.21	58.20	6.60	1602.
	BO	710.	2329.	2192.	789.	633.	1337.	22.98			1493.
	154										
11	FL	505.	1658.	1658.	3.	1141.	640.	11.94	53.60	6.80	1611.
	BO	626.	2053.	1737.	1095.	501.	1094.	20.42			1414.
	155										
12	FL	543.	1780.	1766.	-225.	1024.	47.	0.77	60.80	6.80	1605.
	BO	711.	2333.	1926.	1317.	977.	1550.	25.50			1600.
	156										
13	FL	548.	1798.	1781.	-250.	1001.	878.	15.62	56.20	6.80	1603.
	BO	613.	2012.	1931.	565.	123.	829.	14.74			931.
	157										

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FL = CANDLE FIRST LIGHT
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Table VII (Continued)
Flight Function Test Data
Quality Control and Control Group

DAY	MONTH	YEAR
15	4	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
14	FL	492.	1615.	1604.	186.	1068.	460.	8.22	56.00	6.40	1609.
	BO	545.	1788.	1598.	802.	608.	616.	11.00			1480.
	158										
15	FL	534.	1750.	1750.	22.	847.	448.	7.72	58.10	6.30	1574.
	BO	692.	2270.	2134.	772.	399.	843.	14.51			1332.
	159										
16	FL	653.	2143.	2124.	-283.	883.	409.	7.35	55.70	7.30	1582.
	BO	750.	2460.	2361.	690.	473.	1002.	17.99			1394.
	160										
1	FL	531.	1744.	1744.	4.	928.	418.	6.72	62.20	6.90	1592.
	BO	392.	1287.	1269.	211.	510.	517.	8.32			1420.
	161										

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FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table VII (Continued)
Flight Function Test Data
Quality Control and Control Group

DAY	MONTH	YEAR
20	4	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
2	FL	517.	1695.	1693.	71.	1017.	404.	6.61	61.10	6.90	1604.
	BO	346.	1137.	1094.	307.	612.	644.	10.54			1483.
	162										
3	FL	447.	1466.	1463.	96.	925.	545.	8.94	61.00	6.00	1591.
	BO	170.	556.	488.	268.	379.	990.	16.23			1313.
	163										
4	FL	571.	1872.	1865.	167.	946.	502.	8.11	61.90	7.20	1595.
	BO	397.	1303.	1096.	704.	444.	938.	15.15			1371.
	164										
5	FL	500.	1642.	1642.	20.	840.	530.	9.24	57.30	6.20	1572.
	BO	292.	959.	914.	289.	310.	776.	13.54			1241.
	165										

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Table VII (Continued)
Flight Function Test Data
Quality Control and Control Group

DAY	MONTH	YEAR
20	4	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
6	FL	589.	1932.	1888.	410.	869.	439.	7.12	61.60	7.10	1579.
	BO	411.	1349.	1345.	104.	430.	623.	10.12			1359.
	166										
7	FL	545.	1787.	1715.	504.	909.	411.	6.80	60.40	6.70	1588.
	BO	429.	1406.	1071.	911.	499.	761.	12.60			1412.
	167										
8	FL	603.	1980.	1948.	352.	847.	560.	9.47	59.20	7.10	1574.
	BO	446.	1462.	1270.	725.	286.	775.	13.08			1212.
	168										
9	FL	543.	1781.	1781.	18.	883.	399.	6.84	58.40	6.70	1583.
	BO	412.	1351.	1350.	40.	484.	431.	7.39			1402.
	169										

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Table VII (Continued)
Flight Function Test Data
Quality Control and Control Group

DAY	MONTH	YEAR
20	4	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
10	FL	205.	674.	666.	102.	623.	0.	0.0	53.30	4.30	1488.
	BO	0.	0.	0.	0.	0.	0.	0.0			0.
	170										
11	FL	518.	1700.	1677.	278.	1104.	418.	7.10	58.90	6.60	1610.
	BO	326.	1071.	1070.	46.	685.	650.	11.03			1518.
	171										
12	FL	632.	2072.	2043.	349.	826.	358.	6.49	55.10	7.80	1568.
	BO	439.	1441.	1438.	91.	469.	658.	11.94			1391.
	172										
13	FL	603.	1977.	1977.	10.	624.	484.	8.10	59.70	6.67	1489.
	BO	440.	1443.	1406.	326.	140.	653.	10.93			971.

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Table VII (Continued)
Flight Function Test Data
Quality Control and Control Group

DAY	MONTH	YEAR
20	4	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
14	FL	619.	2030.	2030.	57.	661.	0.	0.0	0.0	6.10	1507.
	BO	0.	0.	0.	0.	0.	0.	0.0			0.
		PARACHUTE SEPARATED FROM FLARE									
15	FL	599.	1965.	1960.	130.	405.	395.	0.0	0.0	6.30	1337.
	BO	540.	1773.	1689.	540.	10.	491.	0.0			407.
		10 SECOND GROUND BURNOUT									
17	FL	488.	1600.	1592.	159.	974.	435.	7.85	55.40	6.60	1599.
	BO	305.	1000.	1000.	7.	540.	611.	11.03			1440.
	177										
18	FL	493.	1618.	1614.	123.	961.	400.	6.66	60.00	6.80	1597.
	BO	273.	895.	872.	203.	562.	747.	12.44			1454.
	178										

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Table VII (Continued)
Flight Function Test Data
Quality Control and Control Group

DAY	MONTH	YEAR
20	4	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
19	FL	556.	1826.	1825.	32.	1152.	470.	8.47	55.50	7.50	1611.
	BO	306.	1003.	982.	205.	682.	861.	15.51			1516.
	179										
20	FL	550.	1806.	1803.	102.	1115.	454.	8.41	54.00	7.00	1610.
	BO	375.	1229.	1227.	64.	661.	577.	10.68			1507.
	180										
21	FL	506.	1659.	1657.	65.	1084.	518.	9.09	57.00	7.00	1609.
	BO	315.	1033.	1014.	199.	566.	657.	11.53			1456.
	181										
22	FL	486.	1596.	1593.	97.	1134.	437.	7.43	58.80	7.20	1611.
	BO	262.	860.	860.	7.	697.	739.	12.56			1523.
	182										

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Table VII (Continued)
Flight Function Test Data
Quality Control and Control Group

DAY	MONTH	YEAR
20	4	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
23	FL	496.	1628.	1584.	377.	882.	358.	6.12	58.50	6.50	1582.
	BO	300.	985.	822.	543.	524.	780.	13.34			1430.
	183										
24	FL	578.	1897.	1895.	99.	708.	542.	9.02	60.10	6.90	1527.
	BO	437.	1435.	1383.	383.	166.	585.	9.74			1024.
	184										
25	FL	545.	1789.	1785.	108.	777.	534.	9.09	58.70	6.80	1553.
	BO	355.	1163.	1111.	346.	244.	715.	12.19			1154.
	185										
26	FL	540.	1773.	1681.	562.	892.	483.	8.57	56.40	6.90	1584.
	BO	404.	1326.	1271.	381.	408.	449.	7.96			1341.
	186										

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table VII (Continued)
Flight Function Test Data
Quality Control and Control Group

DAY 20 MONTH 4 YEAR 1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
27	FL	688.	2259.	2232.	347.	522.	508.	8.36	60.80	7.80	1428.
	BO	543.	1782.	1696.	549.	14.	573.	9.42			451.
	187										
28	FL	558.	1829.	1829.	-6.	695.	417.	6.93	60.20	6.50	1522.
	BO	377.	1238.	1231.	135.	278.	615.	10.22			1201.
	188										
29	FL	406.	1333.	1329.	105.	758.	538.	9.22	58.30	5.10	1547.
	BO	249.	817.	811.	100.	221.	518.	8.89			1120.
	188A										
31	FL	479.	1571.	1555.	225.	934.	448.	7.47	60.00	6.40	1593.
	BO	362.	1186.	1161.	246.	486.	395.	6.58			1403.
	190										

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table VII (Continued)
Flight Function Test Data
Quality Control and Control Group

DAY	MONTH	YEAR
20	4	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
32	FL	489.	1604.	1591.	202.	843.	833.	0.0	0.0	6.50	1573.
	BO	148.	487.	104.	476.	10.	1512.	0.0			407.

NO CANDLE IGNITION

RIPER CONTROL AND QUALITY ASSURANCE TESTS

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

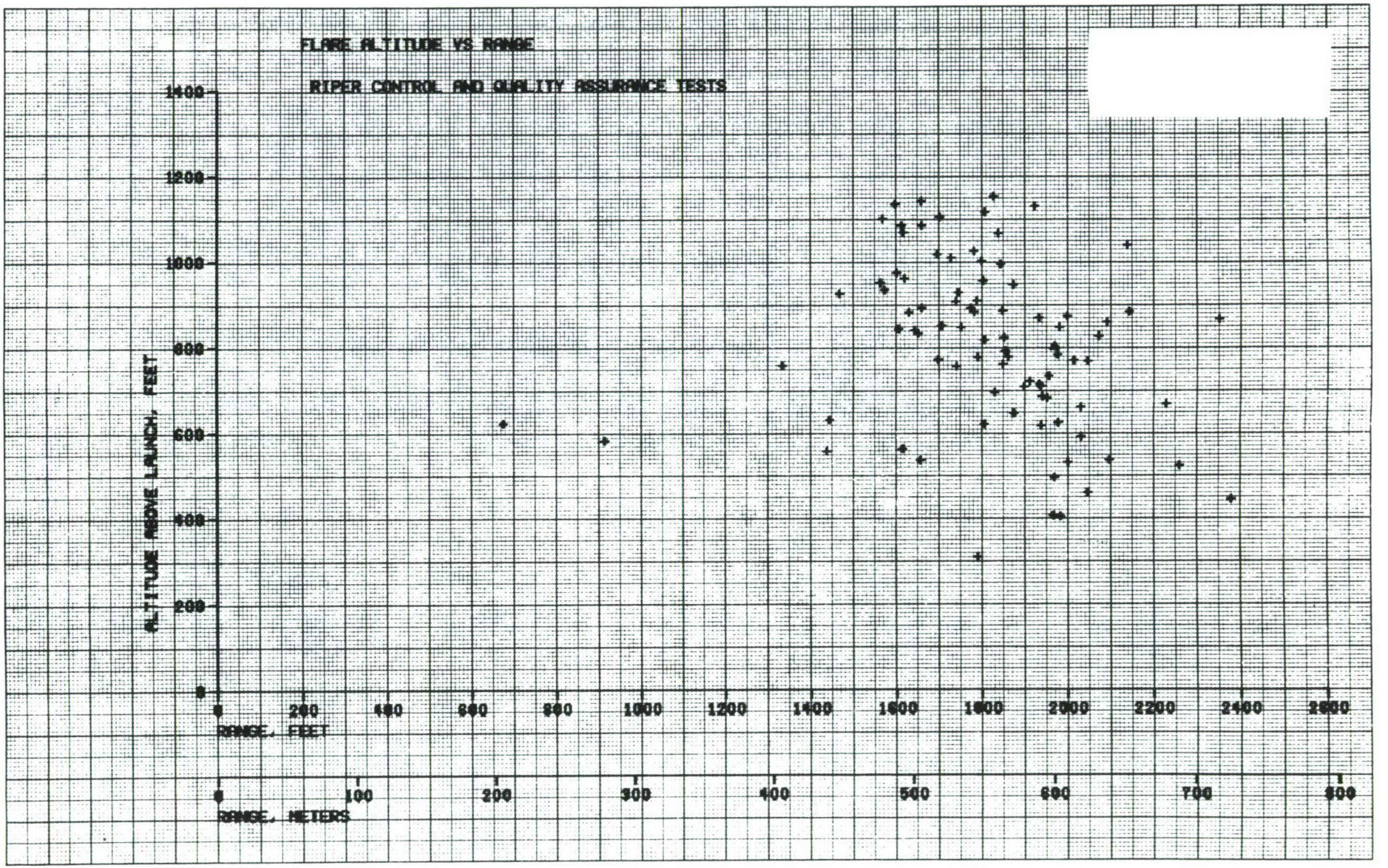

Figure 32. Flare Altitude Versus Range RIPER Control and Quality Assurance Tests

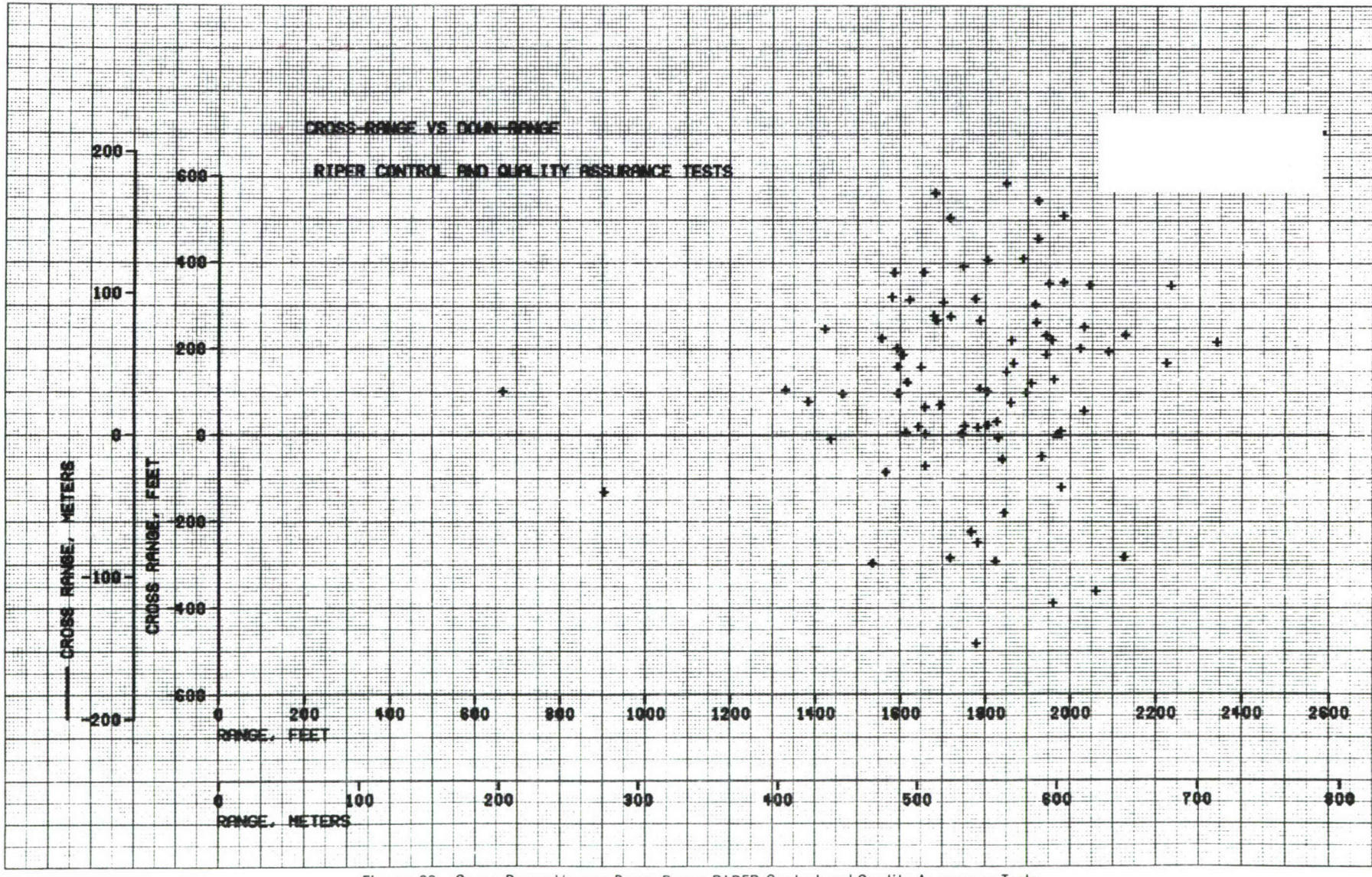

Figure 33. Cross-Range Versus Down-Range RIPER Control and Quality Assurance Tests

B. TRANSPORTATION VIBRATION UNITS

Transportation vibration testing was completed on 23 March 1971. The following table shows the flight function test groups and summarizes the test results:

Test Date	Units Tested	Successes	Failures			
			Motor	Parachute	Candle	Other
4/5/71	16	14	1	0	1	0
4/20/71	32 / 48	31 / 45	1 / 2	0	0 / 1	0

93.6% REL.

From Table V, we see that average range and altitude for these units is very close to the control group. Flare candle burn time was better than control group, averaging 60.8 seconds. Average parachute descent rate was 7.88 feet/second, slightly higher than control group but still less than target.

The transportation vibration test apparently had no adverse effect upon function or performance of the RIPER System.

Flight test data for the transportation - vibration units are presented in Table VIII and Figures 34 and 35.

C. HIGH TEMPERATURE UNITS

High temperature exposure was completed on 29 April 1971, and the units were flight function tested on that day. Ten of the units were allowed to cool to +140° F, then placed into insulated boxes and kept hot until tested. Twenty-two units were allowed to cool to ambient temperature and tested at ambient. The listing below is a summary of the test results:

Temperature	Units Tested	Successes	Failures			
			Motor	Parachute	Flare	Other
+140° F	10	7 5	3	0	0	0
Ambient	20 2 / 32	20 / 25	1	0	1	1

70% REL.

One squib failure "other" was experienced on this test group. The squib fired but did not ignite the motor. Examination of the squib showed that the squib case had burst on the side and did not fire into the motor chamber. Figure 36 shows the failed squib (sidewall rupture) and a squib which functioned normally (end rupture). The squib was replaced with a new squib and the unit functioned properly.

Table VIII
Flight Function Test Results
Transportation Vibration Units

DAY 5 MONTH 3 YEAR 1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
1	FL	540.	1771.	1755.	-237.	887.	435.	6.90	63.00	6.70	1584.
	BO	385.	1261.	1131.	-560.	453.	703.	11.15			1378.
	031										
2	FL	484.	1589.	1579.	183.	928.	0.	0.0	0.0	6.90	1592.
	BO	0.	0.	0.	0.	0.	0.	0.0			0.
	032										
3	FL	544.	1786.	1777.	-183.	857.	345.	5.47	63.00	7.00	1576.
	BO	393.	1290.	1249.	-321.	512.	546.	8.66			1422.
	033										
5	FL	451.	1481.	1477.	104.	1165.	518.	7.51	69.00	8.50	1610.
	BO	356.	1169.	1162.	-128.	647.	391.	5.67			1500.
	035	IGNITION DELAY									

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table VIII (Continued)
Flight Function Test Results
Transportation Vibration Units

DAY	MONTH	YEAR
5	3	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
6	FL	556.	1823.	1823.	-35.	745.	521.	8.90	58.50	6.80	1542.
	BO	347.	1140.	1106.	-275.	225.	756.	12.93			1126.
	036										
7	FL	504.	1655.	1653.	76.	939.	466.	7.72	60.30	6.50	1594.
	BO	354.	1160.	1153.	-122.	473.	537.	8.91			1394.
	037										
8	FL	567.	1859.	1847.	-206.	801.	408.	6.80	60.00	7.50	1561.
	BO	458.	1503.	1470.	-314.	393.	392.	6.53			1327.
	038										
9	FL	570.	1870.	1865.	139.	719.	546.	8.95	61.00	6.60	1532.
	BO	340.	1115.	1112.	-82.	173.	784.	12.86			1038.
	044										

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table VIII (Continued)
Flight Function Test Results
Transportation Vibration Units

DAY	MONTH	YEAR
5	3	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
10	FL	547.	1794.	1758.	355.	680.	530.	8.47	62.60	6.60	1516.
	BO	301.	988.	916.	368.	150.	842.	13.45			992.
	045										
11	FL	557.	1826.	1801.	-302.	797.	636.	10.59	60.00	7.00	1560.
	BO	369.	1211.	1095.	-518.	162.	739.	12.31			1017.
	039										
12	FL	619.	2031.	2019.	227.	860.	536.	8.89	60.30	7.90	1577.
	BO	400.	1311.	1311.	11.	324.	740.	12.28			1256.
	040										
13	FL	557.	1828.	1828.	33.	924.	553.	9.17	60.30	7.20	1591.
	BO	366.	1201.	1190.	-163.	371.	668.	11.07			1306.
	042										

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table VIII (Continued)
Flight Function Test Results
Transportation Vibration Units

DAY 5 MONTH 3 YEAR 1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
14	FL	553.	1814.	1779.	356.	980.	448.	7.30	61.40	7.00	1600.
	BO	380.	1247.	1215.	282.	532.	568.	9.26			1435.
	043										
15	FL	559.	1835.	1835.	11.	911.	529.	8.53	62.00	6.70	1589.
	BO	348.	1141.	1133.	137.	382.	713.	11.50			1316.
	108										
16	FL	553.	1815.	1813.	-80.	789.	530.	9.07	58.40	6.80	1557.
	BO	286.	940.	926.	163.	259.	921.	15.76			1176.
	109										
33	FL	544.	1785.	1783.	86.	899.	160.	2.67	59.90	6.70	1586.
	BO	243.	798.	796.	54.	739.	987.	16.48			1540.
	064										

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table VIII (Continued)
Flight Function Test Results
Transportation Vibration Units

DAY	MONTH	YEAR
20	4	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
34	FL	575.	1888.	1874.	226.	805.	537.	8.46	63.50	6.60	1562.
	BO	318.	1044.	1041.	73.	268.	847.	13.34			1188.
	065										
35	FL	507.	1664.	1664.	13.	972.	0.	0.0	62.80	7.00	1599.
	BO	0.	0.	0.	0.	0.	0.	0.0			0.
	067										
36	FL	553.	1814.	1814.	-7.	944.	333.	6.12	54.30	7.20	1595.
	BO	319.	1048.	1039.	136.	612.	788.	14.51			1482.
	068										
37	FL	645.	2115.	2063.	467.	511.	478.	8.83	54.10	7.40	1421.
	BO	390.	1280.	1203.	438.	34.	861.	15.91			609.
	069										

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table VIII (Continued)
Flight Function Test Results
Transportation Vibration Units

DAY 20 MONTH 4 YEAR 1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS ILLUM (FT) *
38	FL	571.	1872.	1871.	63.	906.	545.	8.58	63.60	7.40	1587.
	BO	240.	787.	786.	39.	361.	1085.	17.06			1295.
	071										
39	FL	537.	1762.	1748.	224.	828.	583.	9.55	61.10	6.90	1569.
	BO	233.	765.	751.	143.	244.	1000.	16.36			1155.
	071										
40	FL	568.	1864.	1864.	-6.	774.	0.	0.0	62.40	6.80	1552.
	BO	0.	0.	0.	0.	0.	0.	0.0			0.
	072										
41	FL	569.	1866.	1837.	327.	925.	359.	6.84	52.50	7.40	1591.
	BO	373.	1225.	1158.	399.	566.	683.	13.00			1456.
	073										

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table VIII (Continued)
Flight Function Test Results
Transportation Vibration Units

DAY	MONTH	YEAR
20	4	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
42	FL	560.	1837.	1810.	311.	665.	326.	5.17	63.00	8.50	1509.
	BO	323.	1060.	951.	469.	339.	873.	13.86			1273.
	075 IGNITION DELAY										
43	FL	583.	1914.	1898.	249.	586.	587.	0.0	0.0	6.90	1468.
	BO	379.	1242.	1198.	328.	-1.	704.	0.0			0.
	077										
44	FL	623.	2042.	2042.	18.	661.	556.	9.27	60.00	7.60	1507.
	BO	360.	1181.	1181.	10.	105.	861.	14.36			885.
	076										
45	FL	570.	1870.	1870.	-11.	972.	0.	0.0	62.30	7.70	1599.
	BO	0.	0.	0.	0.	0.	0.	0.0			0.
	078										

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table VIII (Continued)
Flight Function Test Results
Transportation Vibration Units

DAY 20 MONTH 4 YEAR 1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
46	FL	562.	1845.	1844.	49.	812.	403.	6.10	66.10	7.40	1564.
	BO	232.	761.	742.	167.	409.	1108.	16.76			1341.
	79										
47	FL	378.	1239.	1239.	29.	613.	612.	9.83	62.30	5.40	1483.
	BO	68.	224.	224.	1.	1.	1015.	16.29			202.
	111	1 SEC GROUND BURN									
48	FL	600.	1969.	1969.	6.	799.	600.	9.52	63.00	6.90	1560.
	BO	219.	718.	701.	159.	200.	1278.	20.28			1086.
	110										
49	FL	314.	1031.	1000.	250.	726.	543.	9.05	60.00	4.50	1535.
	BO	113.	369.	204.	308.	183.	798.	13.30			1057.
	047										

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table VIII (Continued)
Flight Function Test Results
Transportation Vibration Units

DAY	MONTH	YEAR
20	4	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
50	FL	496.	1628.	1624.	109.	602.	445.	8.64	51.50	6.50	1477.
	BO	213.	698.	696.	48.	157.	930.	18.06			1007.
	048										
51	FL	621.	2037.	2025.	217.	530.	0.	0.0	0.0	7.40	1434.
	BO	0.	0.	0.	0.	0.	0.	0.0			0.
	049	15 SEC BURN OUT GROUND									
52	FL	618.	2028.	2017.	214.	614.	417.	7.19	58.00	7.00	1484.
	BO	317.	1041.	976.	362.	197.	1052.	18.13			1082.
	050										
53	FL	576.	1891.	1886.	139.	758.	412.	6.75	61.10	6.90	1546.
	BO	226.	741.	738.	59.	345.	1151.	18.83			1280.
	051										

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table VIII (Continued)
Flight Function Test Results
Transportation Vibration Units

DAY	MONTH	YEAR
20	4	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
54	FL	570.	1870.	1863.	161.	581.	489.	8.17	59.80	0.0	1465.
	BO	199.	653.	635.	154.	92.	1228.	20.54			848.
	054 IGNITION DELAY										
55	FL	588.	1929.	1920.	178.	666.	508.	8.13	62.50	7.00	1509.
	BO	615.	2018.	1061.	1716.	158.	1762.	28.19			1008.
	053										
56	FL	653.	2142.	2141.	65.	785.	487.	7.89	61.70	8.80	1556.
	BO	279.	916.	902.	158.	298.	1242.	20.14			1226.
	052										
57	FL	540.	1772.	1758.	227.	613.	564.	9.22	61.20	7.00	1483.
	BO	246.	808.	807.	47.	49.	968.	15.81			688.
	056										

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table VIII (Continued)
Flight Function Test Results
Transportation Vibration Units

DAY	MONTH	YEAR
20	4	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
58	FL	319.	1046.	1020.	233.	661.	411.	6.65	61.80	4.70	1507.
	BO	83.	272.	54.	267.	250.	966.	15.63			1163.
	057										
60	FL	549.	1802.	1801.	62.	833.	256.	4.44	57.50	7.00	1570.
	BO	250.	821.	806.	159.	578.	1000.	17.39			1463.
	059										
61	FL	518.	1699.	1694.	134.	984.	523.	8.16	64.10	7.40	1601.
	BO	162.	530.	529.	39.	461.	1169.	18.24			1384.
	062										
62	FL	510.	1674.	1674.	32.	932.	581.	9.47	61.30	7.20	1592.
	BO	101.	330.	329.	32.	351.	1346.	21.95			1286.
	063										

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table VIII (Continued)
Flight Function Test Results
Transportation Vibration Units

DAY 20 MONTH 4 YEAR 1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
63	FL	524.	1720.	1720.	31.	891.	523.	8.37	62.50	7.00	1584.
	BO	154.	504.	474.	169.	368.	1253.	20.05			1303.

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RIPER TRANSPORTATION - VIBRATION

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

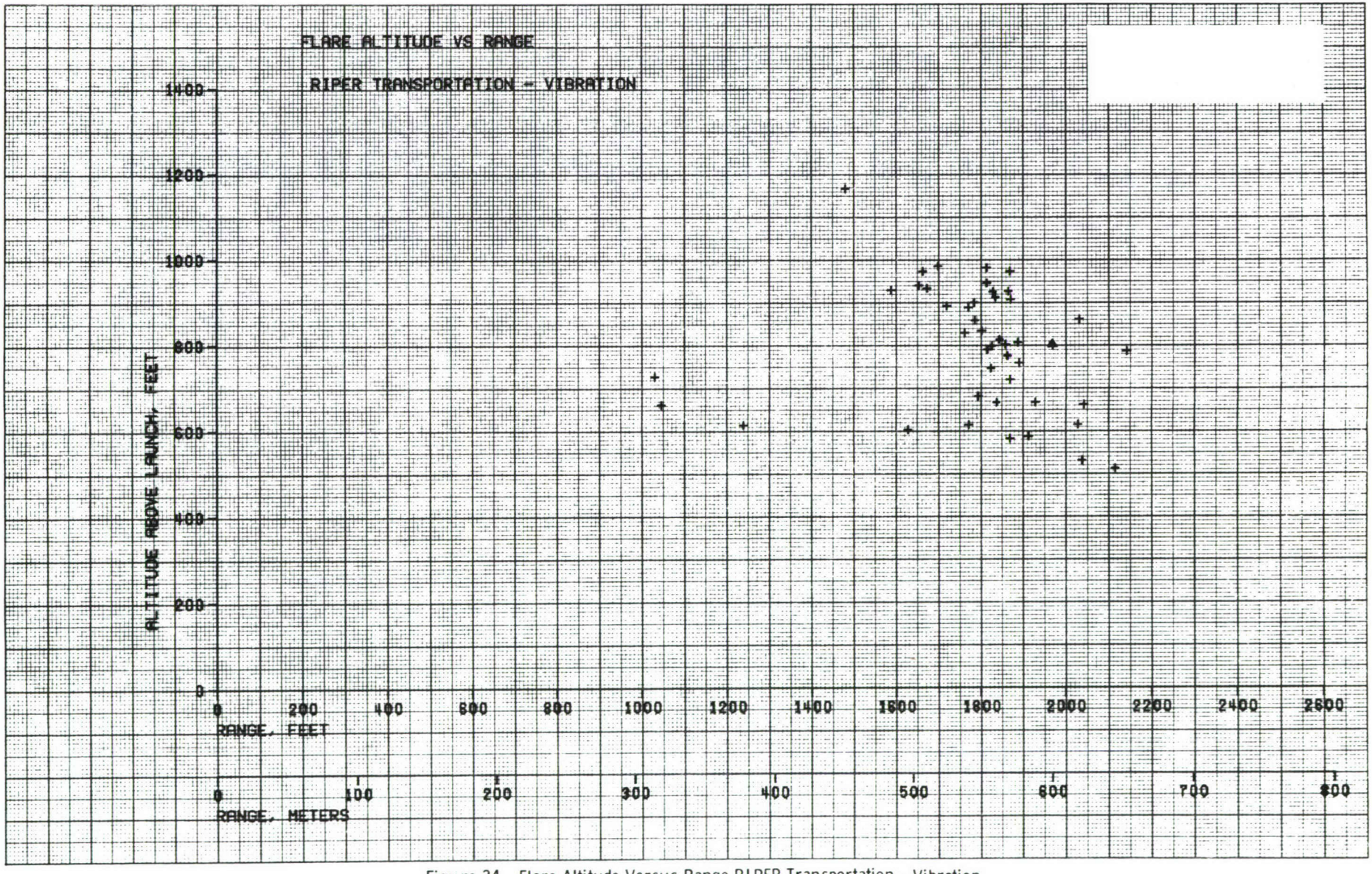

Figure 34. Flare Altitude Versus Range RIPER Transportation - Vibration

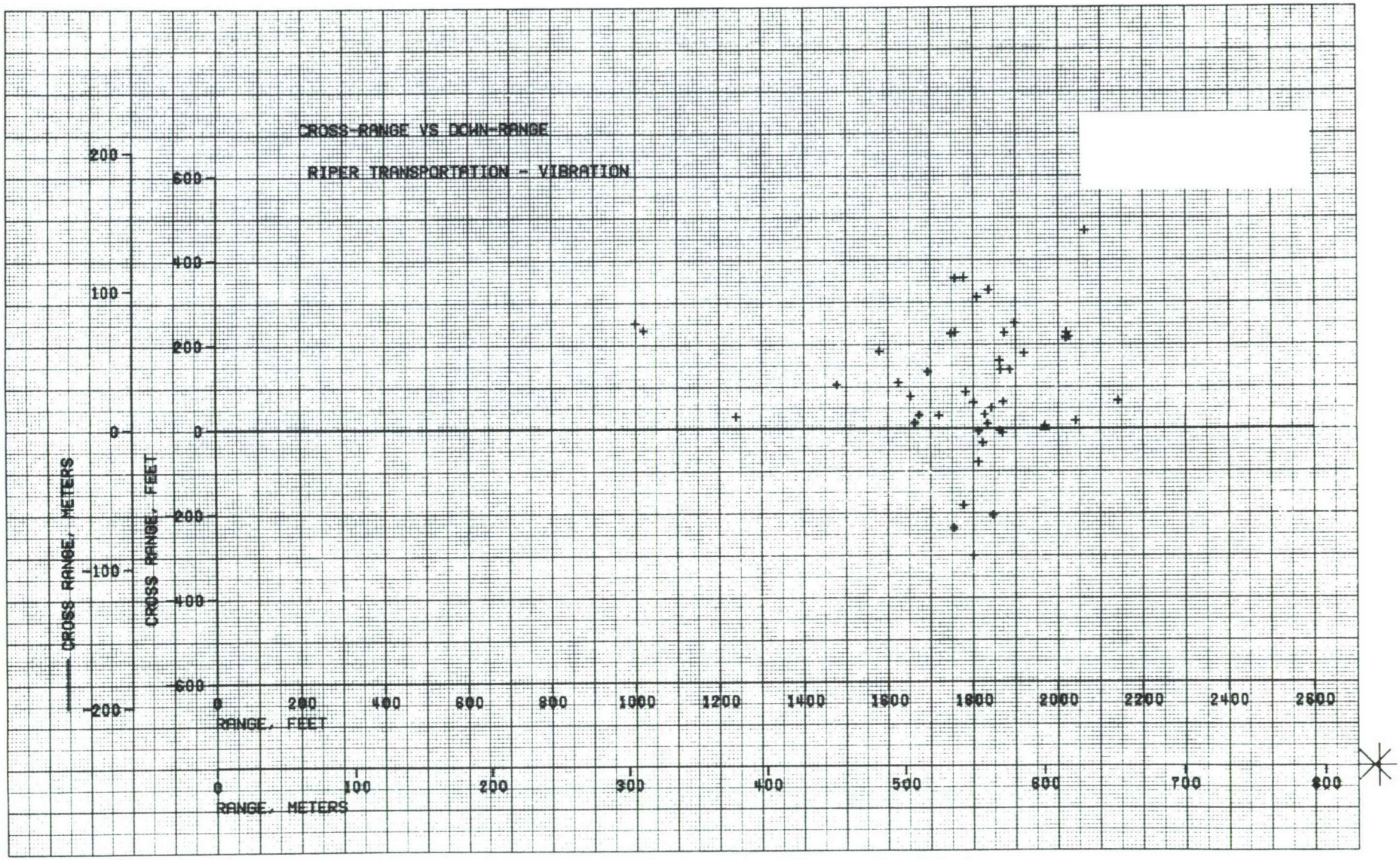

Figure 35. Cross-Range Versus Down-Range RIPER Transportation - Vibration

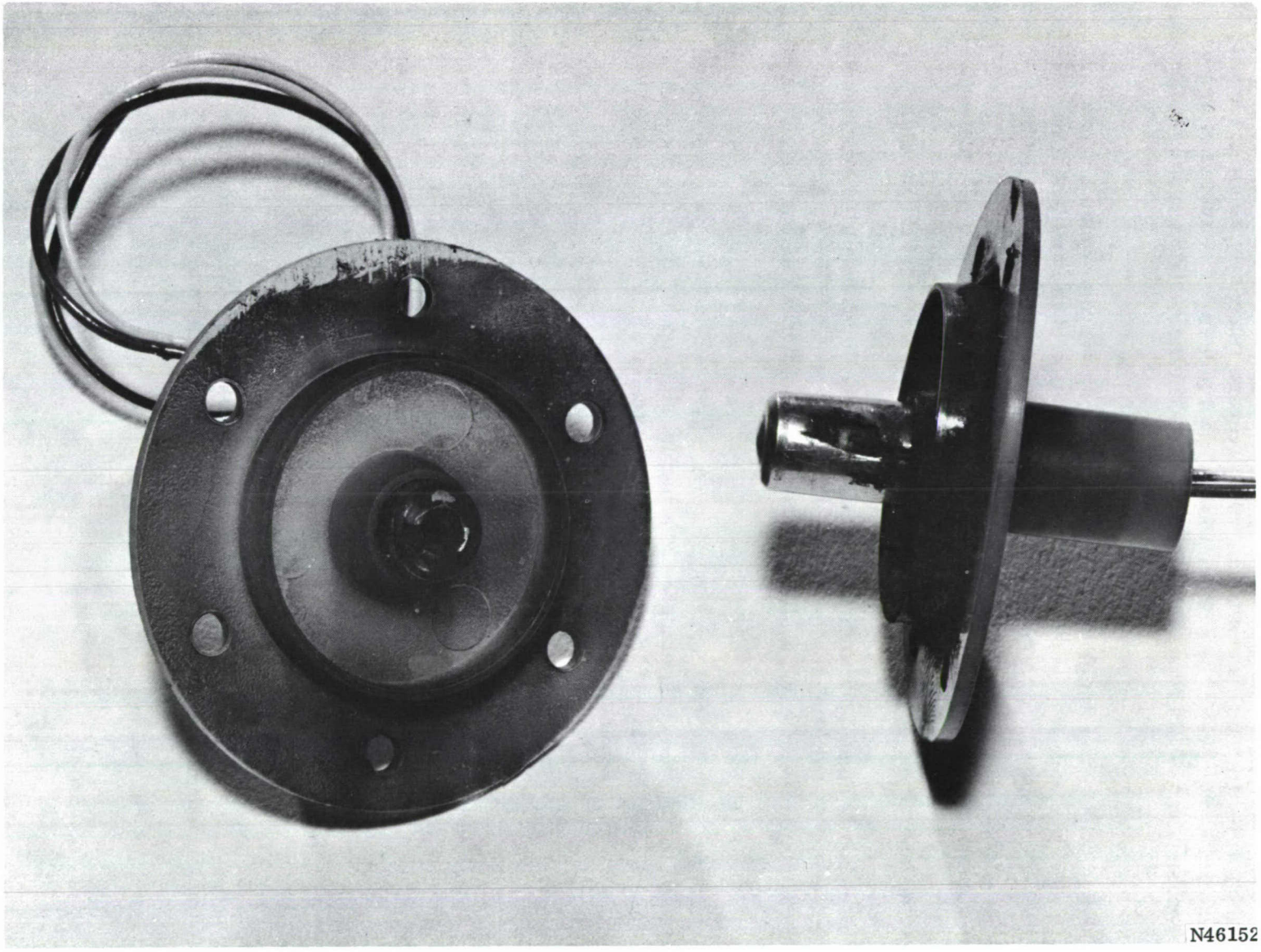

Figure 36. Failed Squib (Sidewall Rupture) and Normal Squib (End Rupture)

The test results as shown in Table V indicate that testing at high temperature affects projectile range and altitude. The average range was 61 meters shorter than the control group, while the altitude was 309 feet higher. The average flare candle burn time was 60.3 seconds, slightly longer than the control group average of 58.4.

The units tested at ambient temperature show an average range increase of 66 meters over the control group. However, examination of the ambient test results data presented on page 98 shows that the average range is greatly influenced by three tests (10, 20, and 22). These three units had abnormally long times to deployment (14.9, 14.1, and 13.6 seconds) and ranges of 880, 797, and 770 meters, respectively. The high temperature exposure seems to have affected the flare ignition characteristics on these units and on one unit which failed to ignite and eject the candle.

A relatively higher proportion of rocket motor failures was also experienced on the projectiles tested at high temperature. This is probably due to an increase in motor chamber pressure and a slight decrease in motor case strength at elevated temperature.

Flight test data for the high temperature units are divided in two groups; units tested hot and units tested at ambient. Data for units tested hot are presented in Table IX and Figures 37 and 38. Data for the units tested at ambient are presented as Table X and Figures 39 and 40.

D. LOW TEMPERATURE UNITS

Low temperature exposure was completed on 22 March 1971. Ten units were placed into an insulated container while still at -65° F and transported to the test site. Seven of these units were tested under these conditions, and five were failures. Testing was held up for evaluation.

On 3 April, three units which had been conditioned for 48 hours at -65° F were tested. Of these, two were failures.

On 5 April, 17 cold temperature units (16 of which had been allowed to warm to ambient conditions) were tested. All 17 were successful.

On 7 June, the remaining five units were tested at ambient temperature. All were successful. The test results are summarized in the listing on page 105.

Table IX
Flight Function Test Results
High Temperature Units
(Tested Hot)

DAY	MONTH	YEAR
29	4	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
1	FL	501.	1643.	1642.	16.	900.	516.	8.18	63.00	6.20	1586.
	BO	250.	820.	765.	293.	385.	920.	14.60			1319.
	196										
2	FL	521.	1709.	1660.	405.	1061.	435.	7.11	61.20	6.60	1608.
	BO	275.	904.	895.	126.	626.	814.	13.31			1490.
	197										
3	FL	544.	1785.	1779.	144.	1356.	529.	9.12	58.00	8.00	1591.
	BO	229.	751.	678.	323.	827.	1115.	19.22			1568.
	198										
4	FL	359.	1179.	1173.	122.	1161.	428.	7.27	58.90	6.00	1610.
	BO	110.	360.	260.	249.	733.	922.	15.65			1537.
	199										

RIPER HIGH TEMPERATURE - FIRED HOT

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

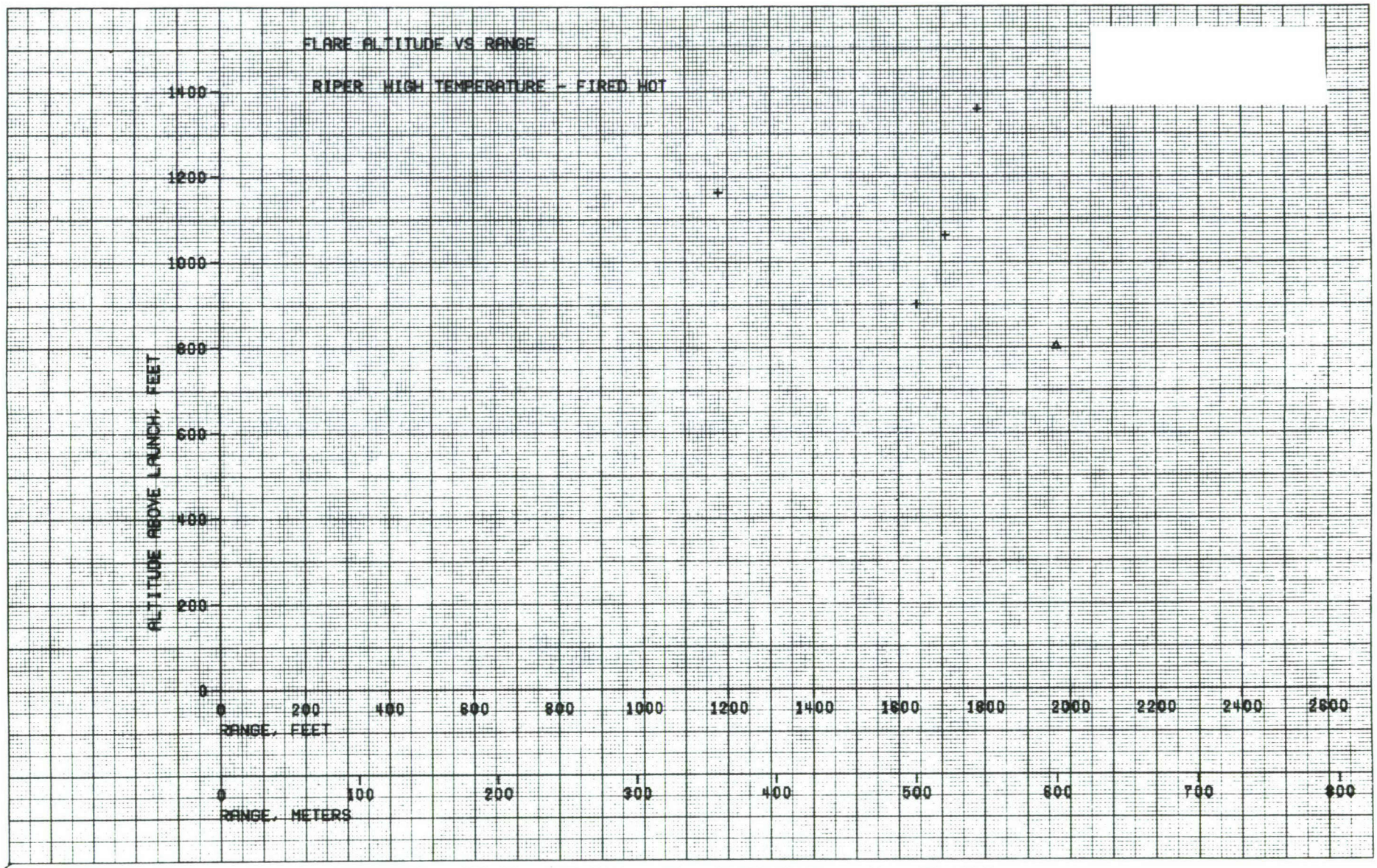

Figure 37. Flare Altitude Versus Range RIPER High Temperature - Fired Hot

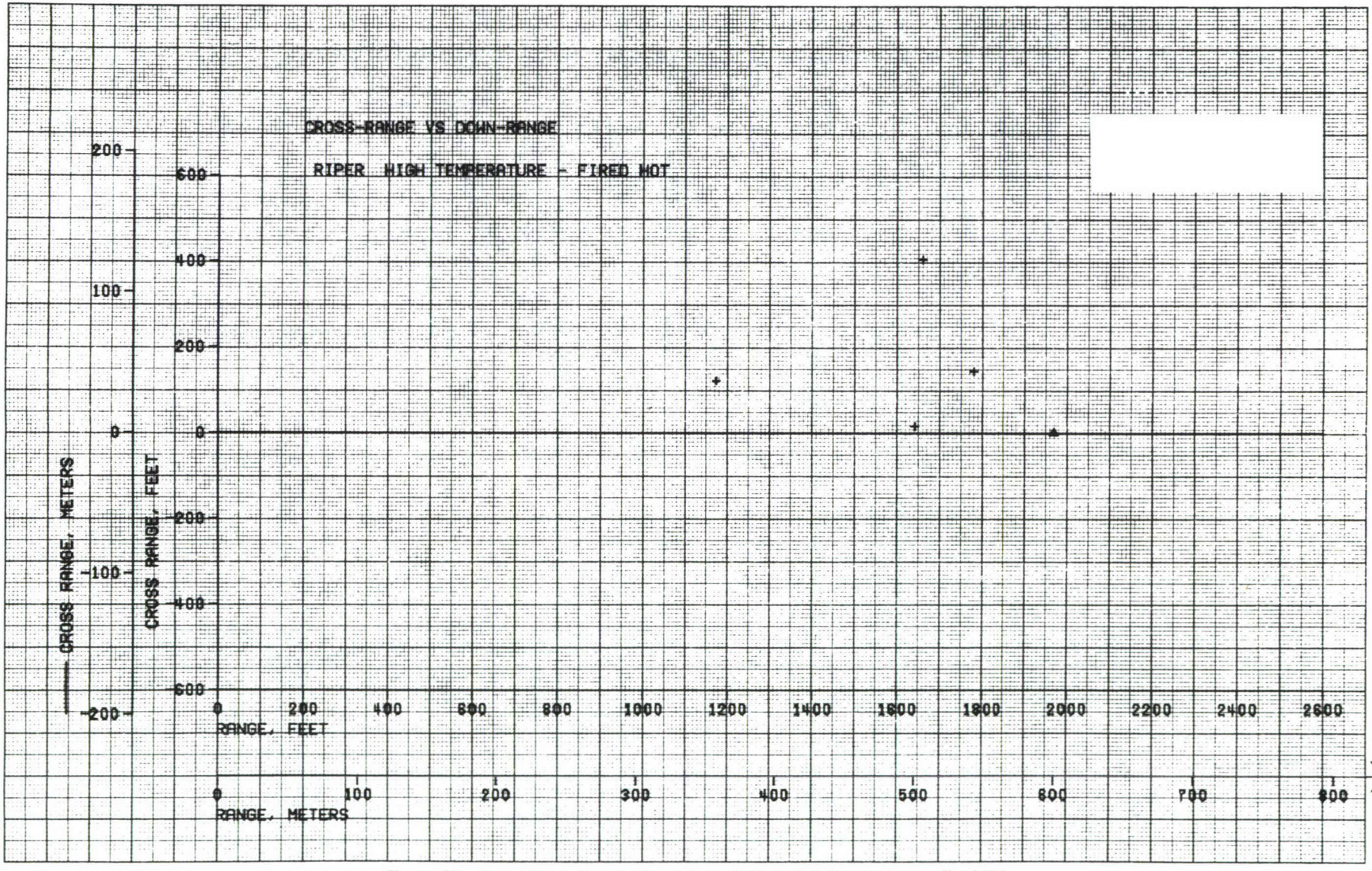

Figure 38. Cross-Range Versus Down-Range RIPER High Temperature - Fired Hot

Table X
Flight Function Test Results
High Temperature Units
(Tested at Ambient)

DAY	MONTH	YEAR
29	4	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
6	FL	518.	1699.	1658.	373.	843.	493.	8.74	56.40	6.20	1573.
	BO	262.	861.	854.	107.	350.	846.	15.01			1285.
	212										
7	FL	527.	1729.	1725.	123.	1133.	508.	8.47	59.90	7.30	1611.
	BO	321.	1055.	994.	352.	626.	766.	12.78			1490.
	213										
10	FL	1149.	3771.	3771.	70.	354.	0.	0.0	0.0	15.00	1288.
	BO	0.	0.	0.	0.	0.	0.	0.0			0.
	218	30 SECOND GROUND BURNOUT									
11	FL	599.	1965.	1962.	102.	832.	480.	8.19	58.60	7.30	1570.
	BO	289.	947.	916.	239.	352.	1055.	18.00			1286.
	217										

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table X (Continued)
Flight Function Test Results
High Temperature Units
(Tested at Ambient)

DAY	MONTH	YEAR
29	4	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
12	FL	449.	1475.	1466.	163.	726.	454.	7.55	60.20	5.40	1535.
	BO	138.	453.	423.	161.	271.	1042.	17.32			1193.
	216										
13	FL	538.	1764.	1763.	57.	879.	467.	7.52	62.10	6.60	1582.
	BO	201.	661.	657.	72.	412.	1106.	17.81			1344.
	221										
14	FL	546.	1792.	1792.	-1.	1034.	340.	6.11	55.60	6.80	1606.
	BO	258.	846.	835.	138.	694.	967.	17.39			1522.
	222										
15	FL	472.	1549.	1526.	266.	1150.	460.	7.68	59.90	7.70	1611.
	BO	81.	267.	246.	103.	690.	1291.	21.55			1520.
	223										

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table X (Continued)
Flight Function Test Results
High Temperature Units
(Tested at Ambient)

DAY	MONTH	YEAR
29	4	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
16	FL	550.	1806.	1804.	80.	592.	576.	9.53	60.40	6.50	1472.
	BO	195.	639.	232.	596.	17.	1655.	27.40			483.
	220										
17	FL	581.	1906.	1884.	288.	731.	539.	9.78	55.10	9.80	1537.
	BO	205.	673.	615.	273.	193.	1270.	23.04			1074.
	227										
18	FL	486.	1594.	1594.	12.	583.	506.	9.00	56.20	6.80	1467.
	BO	201.	660.	438.	493.	78.	1252.	22.28			802.
	226										
19	FL	527.	1730.	1728.	99.	964.	535.	9.15	58.50	6.90	1398.
	BO	270.	887.	624.	630.	428.	1225.	20.94			1358.
	225										

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table X (Continued)
Flight Function Test Results
High Temperature Units
(Tested at Ambient)

DAY	MONTH	YEAR
29	4	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
20	FL	1053.	3456.	3424.	471.	472.	459.	8.14	56.40	14.10	1393.
	BO	758.	2487.	2484.	118.	12.	1004.	17.80			435.
	224										
22	FL	1019.	3345.	3335.	251.	768.	423.	7.30	57.90	13.60	1550.
	BO	625.	2051.	2051.	-3.	345.	1309.	22.61			1279.
	202										
23	FL	487.	1596.	1594.	91.	989.	463.	8.47	54.60	6.30	1601.
	BO	207.	679.	635.	241.	526.	971.	17.78			1432.
	201										
24	FL	643.	2109.	2106.	109.	680.	444.	7.84	56.70	7.30	1516.
	BO	296.	973.	970.	63.	236.	1136.	20.04			1143.
	200										

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table X (Continued)
Flight Function Test Results
High Temperature Units
(Tested at Ambient)

DAY 29 MONTH 4 YEAR 1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
25	FL	476.	1562.	1561.	50.	929.	520.	8.67	60.00	6.40	1592.
	BO	147.	483.	202.	439.	409.	1414.	23.56			1341.
	207										
26	FL	512.	1680.	1674.	134.	663.	582.	9.25	62.90	6.30	1508.
	BO	158.	518.	487.	177.	81.	1188.	18.89			814.
	206										

RIPER HIGH TEMPERATURE - FIRED AT AMBIENT

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

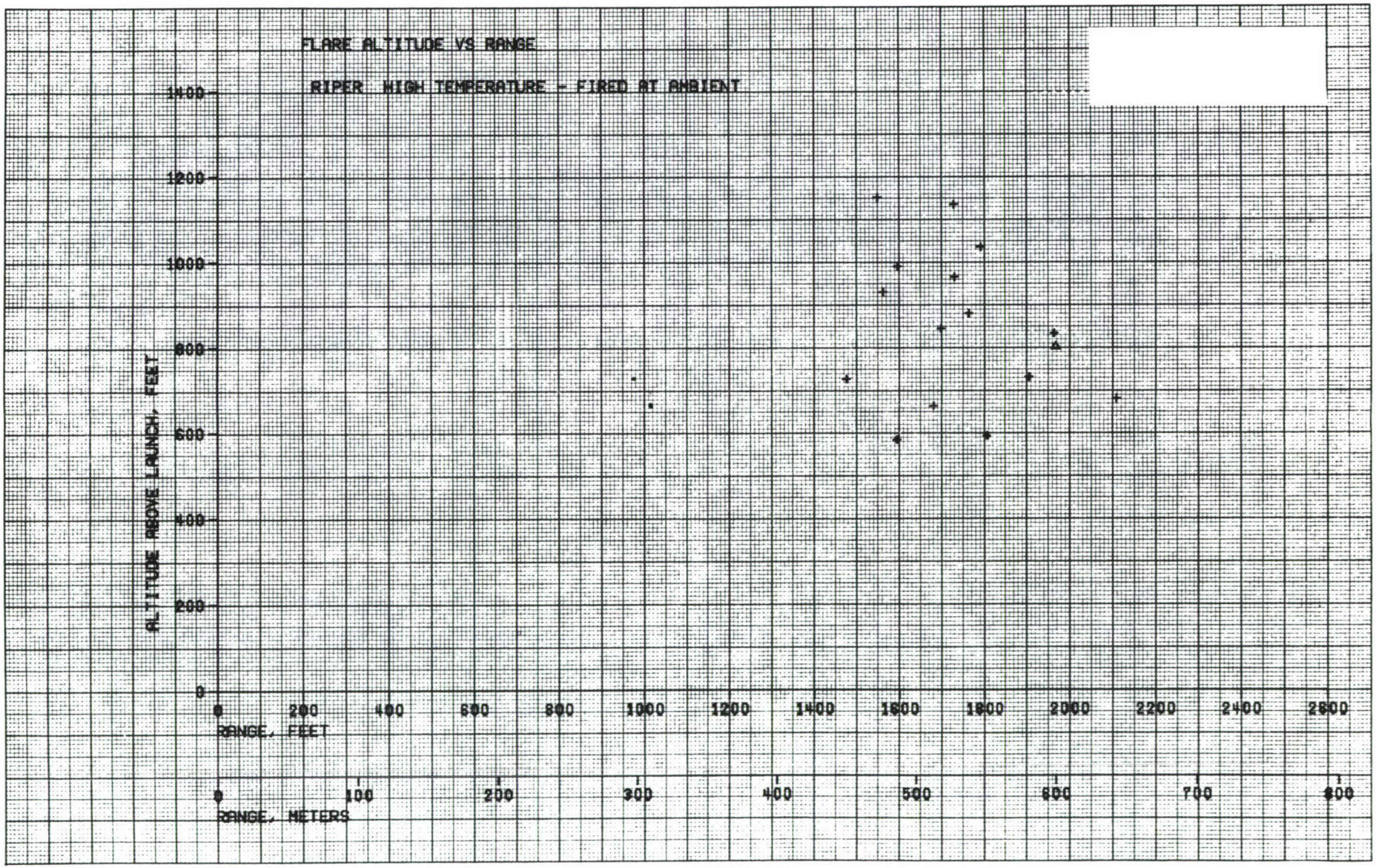

Figure 39. Flare Altitude Versus Range RIPER High Temperature - Fired at Ambient

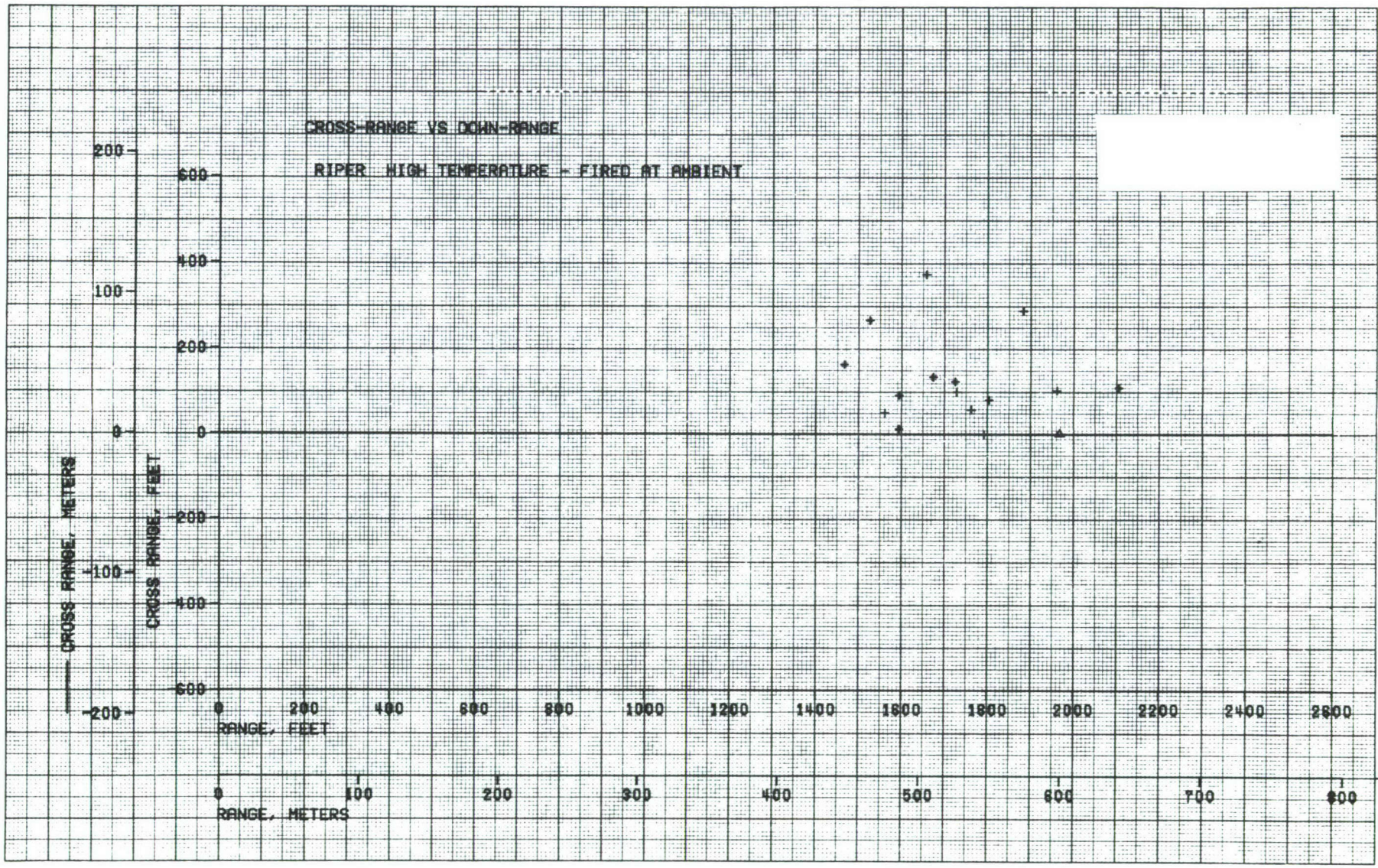

Figure 40. Cross-Range Versus Down-Range RIPER High Temperature - Fired at Ambient

Test Date	Test Temperature		Successes	Failures			
	Cold	Ambient		Motors	Parachutes	Candles	Other
3/22/71	7		2	3	1	0	1
4/3/71	3		1	0	2	0	0
4/5/71	1	16	17	0	0	0	0
6/7/71		5	5	0	0	0	0

From the data in Table V, it appears that the units tested cold showed an average range loss of 36 meters and an altitude loss of 57 feet from the control group. Candle burn time, however, was increased by 2.3 seconds.

The units tested at ambient temperature show almost identical performance with the control group except for an altitude loss of 59 feet.

Data for the low temperature units are divided into two groups: units tested cold and units tested at ambient. Data for units tested cold are presented in Table XI and Figures 41 and 42. Data for the units tested at ambient are presented in Table XII and Figures 43 and 44.

E. HUMIDITY UNITS

The 32 units exposed to the humidity cycle were removed from the chamber on 29 March 1971. Eight units were tested on 5 April 1971. The flare candle failed to ignite on four of the eight tests, one rocket motor failed, and one parachute failed to deploy. Testing was suspended pending analysis of the problem.

Disassembly of projectiles revealed that moisture had penetrated the projectile joints and affected the flare candle illuminant and ignition wafer. The remaining 24 projectiles were disassembled and reassembled with special emphasis on sealing all possible leak paths. These 24 units were then subjected to the humidity cycle described in Section V-D. Examination of several projectiles after humidity test indicated that moisture was again inside the projectile as noted in Section V-D.

The 24 units were flight function tested on 19 May 1971. The following table summarizes the test results:

Test Date	Units Tested	Successes	Failures			
			Motor	Parachute	Candle	Other
4/5/71	8	2	1	1	4	0
4/19/71	24	7	5	0	10	2

Table XI
Flight Function Test Results
Low Temperature Units
(Tested Cold)

DAY 22 MONTH 3 YEAR 1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
3	FL	592.	1941.	1937.	113.	712.	459.	7.53	61.00	7.80	1529.
	BO	394.	1291.	1233.	386.	253.	756.	12.39			1167.
		118									
6	FL	587.	1926.	1920.	151.	647.	431.	7.19	60.00	7.20	1500.
	BO	514.	1685.	1656.	311.	216.	309.	5.14			1113.
		119									
2	FL	590.	1937.	1663.	-993.	748.	458.	7.70	59.50	8.30	1543.
	BO	952.	3124.	3083.	505.	290.	2064.	34.69			1216.
17	FL	286.	939.	921.	182.	909.	542.	8.72	62.10	5.50	1588.
	BO	152.	497.	410.	282.	368.	521.	8.39			1302.
		089									

RIPER LOW TEMPERATURE MOTORS-FIRED COLD

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

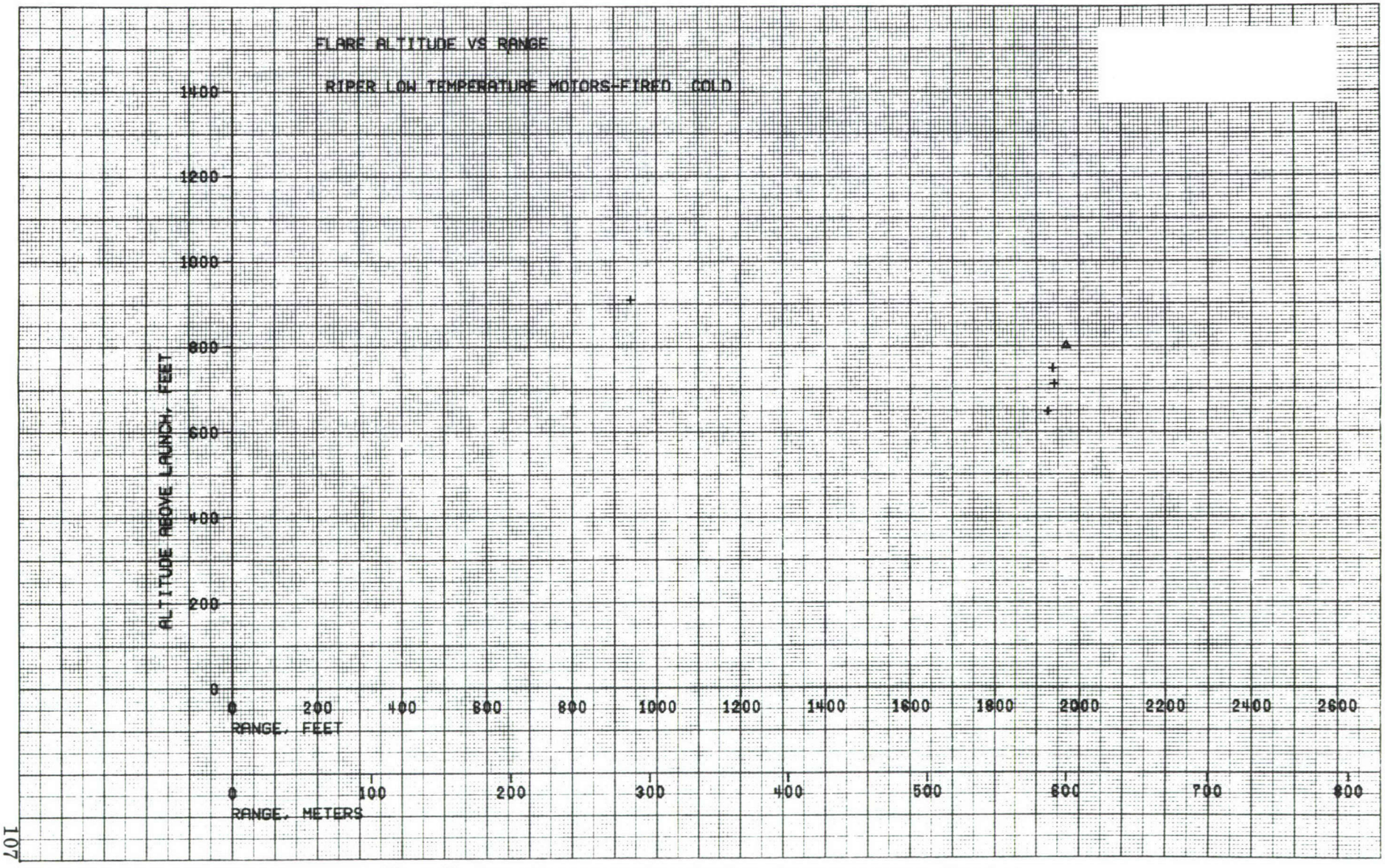

Figure 41. Flare Altitude Versus Range RIPER Low Temperature Motors - Fired Cold

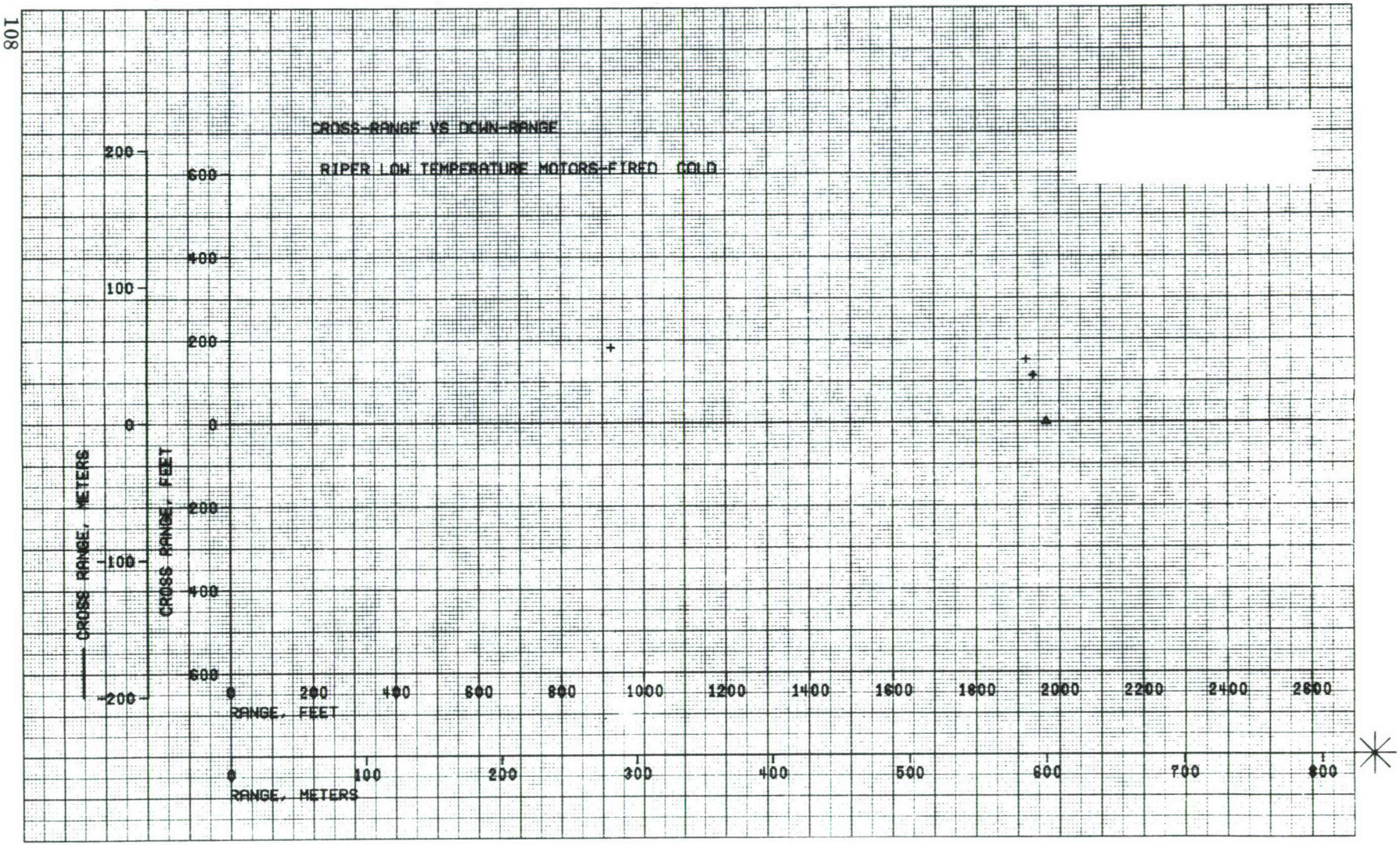

Figure 42. Cross-Range Versus Down-Range RIPER Low Temperature Motors - Fired Cold

Table XII
Flight Function Test Results
Low Temperature Units
(Tested at Ambient)

DAY 5 MONTH 3 YEAR 1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
26	FL	554.	1818.	1809.	182.	999.	530.	8.62	61.50	7.30	1602.
	BO	247.	809.	809.	25.	469.	1012.	16.46			1391.
	081										
27	FL	565.	1853.	1850.	108.	712.	494.	8.44	58.50	7.20	1529.
	BO	262.	860.	860.	-1.	218.	997.	17.04			1116.
	082										
28	FL	615.	2019.	2013.	155.	641.	302.	5.55	54.40	7.80	1497.
	BO	306.	1005.	1004.	-50.	339.	1030.	18.94			1273.
	083										
29	FL	523.	1717.	1688.	-312.	830.	475.	8.09	58.70	6.95	1569.
	BO	266.	872.	812.	-320.	355.	876.	14.93			1290.
	085										

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table XII (Continued)
Flight Function Test Results
Low Temperature Units
(Tested at Ambient)

DAY 5 MONTH 3 YEAR 1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
30	FL	581.	1905.	1904.	76.	672.	0.	0.0	60.00	7.60	1512.
	BO	0.	0.	0.	0.	0.	0.	0.0			0.
	086										
31	FL	512.	1680.	1650.	-315.	891.	497.	8.55	58.10	7.05	1584.
	BO	218.	717.	599.	-394.	394.	1054.	18.14			1328.
	088										
32	FL	571.	1873.	1860.	-224.	762.	454.	8.78	51.70	7.25	1548.
	BO	294.	964.	935.	-235.	308.	925.	17.89			1238.
	092										
33	FL	485.	1592.	1585.	154.	689.	423.	6.80	62.30	6.20	1519.
	BO	163.	534.	529.	72.	265.	1059.	17.00			1184.
	094										

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table XII (Continued)
Flight Function Test Results
Low Temperature Units
(Tested at Ambient)

DAY 5 MONTH 3 YEAR 1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
34	FL	596.	1956.	1948.	-176.	456.	456.	7.61	60.00	7.20	1381.
	80	287.	942.	941.	-44.	0.	1016.	16.93			0.
	098	9 SEC BURN ON GROUND									
35	FL	548.	1799.	1798.	-67.	814.	436.	7.74	56.30	6.95	1565.
	80	256.	841.	795.	-273.	378.	1024.	18.19			1312.
	122										
36	FL	544.	1784.	1775.	179.	826.	484.	8.38	57.80	6.90	1568.
	80	212.	694.	694.	-18.	342.	1098.	19.00			1276.
	123										
37	FL	530.	1740.	1737.	-103.	695.	450.	7.77	57.90	6.30	1522.
	80	196.	641.	569.	-296.	245.	1184.	20.45			1156.
	124										

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
80 = CANDLE BURNOUT

Table XII (Continued)
Flight Function Test Results
Low Temperature Units
(Tested at Ambient)

DAY	MONTH	YEAR
5	4	71

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
38	FL	624.	2046.	2046.	27.	452.	408.	7.21	56.60	6.70	1377.
	BO	274.	900.	898.	58.	44.	1149.	20.30			664.
	125										
39	FL	598.	1963.	1960.	116.	627.	177.	2.94	60.00	6.95	1490.
	BO	267.	875.	872.	74.	451.	1089.	18.14			1376.
	127										
40	FL	593.	1947.	1918.	335.	614.	587.	9.72	60.40	6.30	1484.
	BO	233.	763.	739.	192.	27.	1188.	19.66			568.
	128										
41	FL	545.	1790.	1789.	50.	888.	576.	9.40	61.30	7.60	1584.
	BO	234.	769.	741.	-203.	312.	1078.	17.59			1243.
	129										

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table XII (Continued)
Flight Function Test Results
Low Temperature Units
(Tested at Ambient)

DAY 7 MONTH 6 YEAR 1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
56	FL	560.	1838.	1834.	121.	1109.	363.	6.23	58.30	7.50	1610.
	BO	378.	1241.	1240.	56.	745.	597.	10.24			1542.
	463										
57	FL	470.	1541.	1539.	66.	840.	370.	6.33	58.40	5.90	1572.
	BO	247.	809.	765.	264.	470.	799.	13.68			1392.
	464										
58	FL	526.	1727.	1727.	44.	387.	377.	0.0	0.0	0.0	1321.
	BO	427.	1400.	237.	1380.	10.	2002.	0.0			407.
	465	11 SECOND GROUND BURNOUT									
59	FL	412.	1351.	1343.	143.	836.	464.	7.45	62.30	5.60	1571.
	BO	232.	762.	739.	187.	372.	605.	9.72			1307.
	466										

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table XII (Continued)
Flight Function Test Results
Low Temperature Units
(Tested at Ambient)

DAY 7 MONTH 6 YEAR 1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
60	FL	525.	1723.	1704.	256.	1059.	581.	0.0	0.0	6.00	1608.
	BO	401.	1315.	1314.	48.	478.	442.	0.0			1398.
	467										

RIPER LOW TEMPERATURE MOTORS-FIRED AMBIENT

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

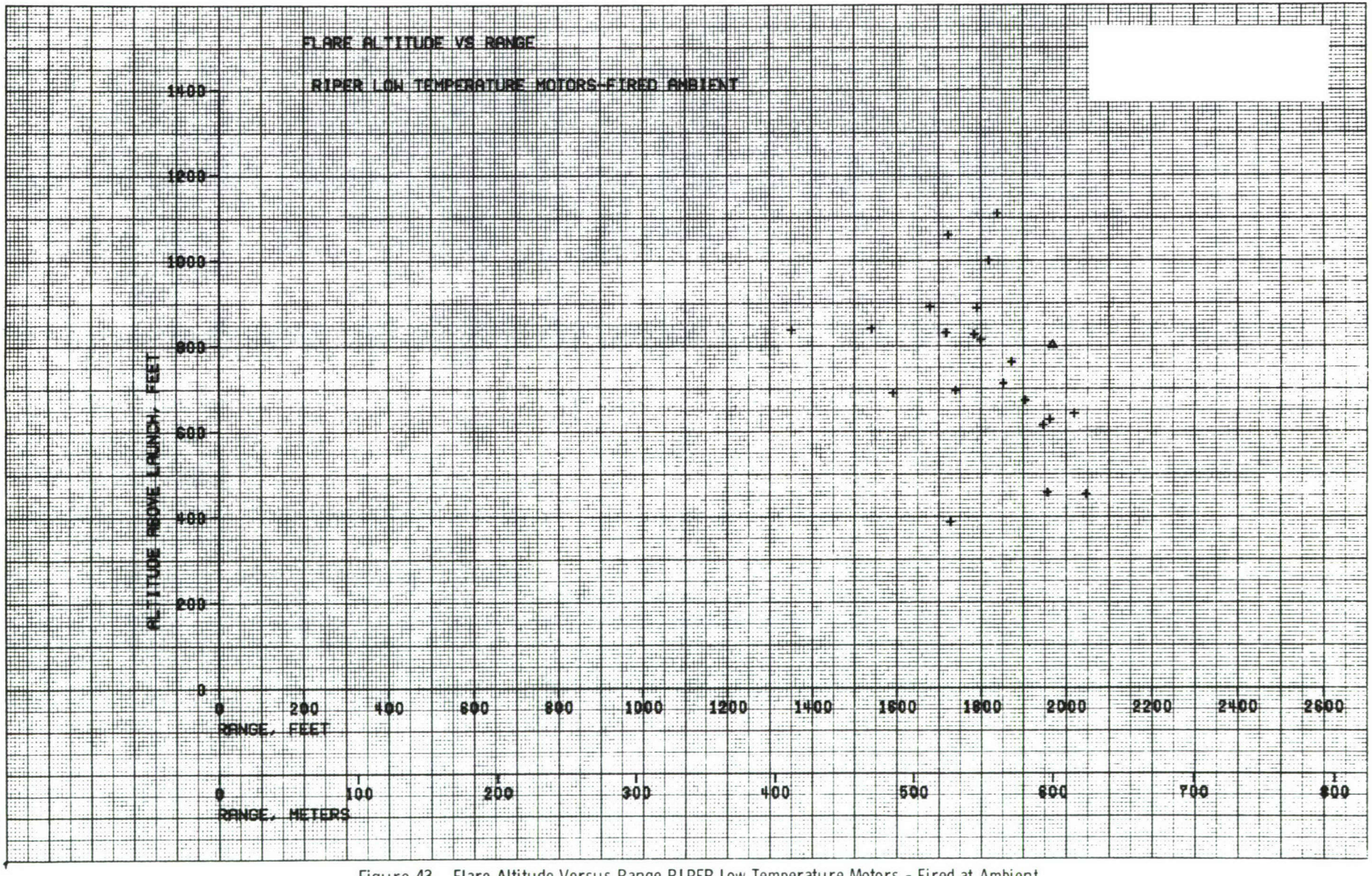

Figure 43. Flare Altitude Versus Range RIPER Low Temperature Motors - Fired at Ambient

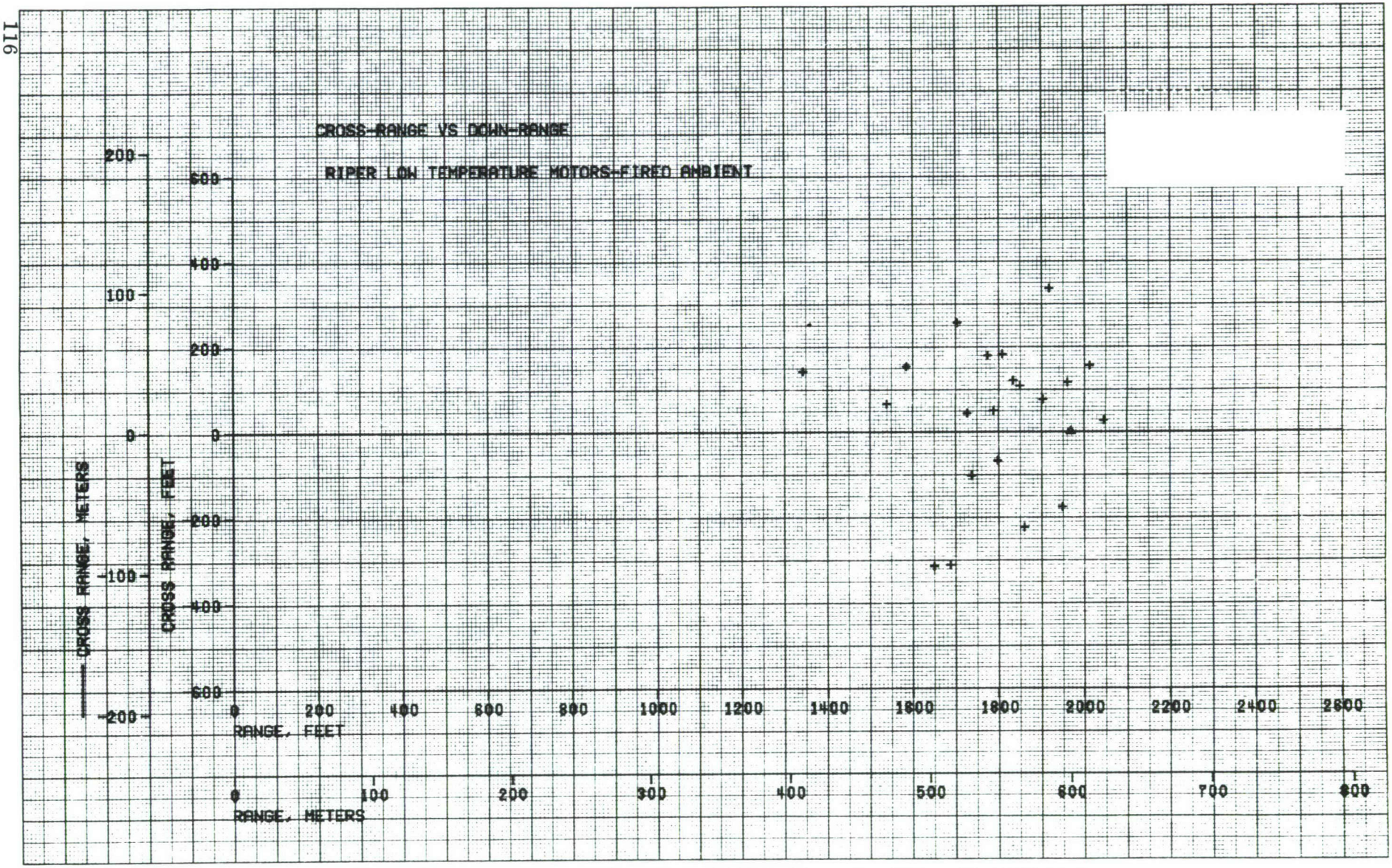

Figure 44. Cross-Range Versus Down-Range RIPER Low Temperature Motors - Fired at Ambient

Of the two "other" failures, one motor ignition squib failed to fire due to a broken lead wire, and one projectile followed a very erratic trajectory because the nose cone came loose as it emerged from the launch tube.

The effect of the humidity test upon projectile performance can be seen by comparing the data in Table V. Due to slower flare candle ignition, the time to flare deployment is 1.8 seconds longer than the control group. This time difference is reflected in a 104 meter increase in range. Flare candle burn time was 2.2 seconds longer than control group flares.

The humidity test apparently affected both the rocket motor and flare candle, resulting in a high rate of rocket motor failures and a very high rate of candle ignition failures.

Flight test data for the humidity test units are presented in Table XIII and Figures 45 and 46.

F. SALT FOG UNITS

Thirty-two units which were exposed to the salt fog test were removed from the chamber on 3 June 1971.

The units were flight function tested on 7 June 1971. The following table summarizes the test results.

Units Tested	Successes	Failures			
		Motors	Parachute	Candle	Other
32	31	0	1	0	0

The average time to flare deployment was 0.6 seconds less than the control group average, resulting in a 45 meter shorter range. Average deployment altitude was 45 feet lower than control group.

The salt fog test shows no effect upon RIPER System performance.

Flight test data for the salt fog test units are presented in Table XIV and Figures 47 and 48.

G. FIVE FOOT DROP TEST UNITS

The 23 units which survived the five foot drop test were flight function tested on 7 June 1971. The listing on page 132 summarizes the test results.

Table XIII
Flight Function Test Results
Humidity Units

DAY 5 MONTH 3 YEAR 1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
19	FL	595.	1953.	1951.	-91.	512.	512.	8.54	60.00	7.00	1422.
	BO	255.	835.	810.	-201.	0.	1146.	19.10			0.
		BURNED 2 SEC ON GROUND									
23	FL	508.	1666.	1657.	-176.	899.	453.	7.55	60.00	6.80	1586.
	BO	218.	715.	603.	-384.	446.	1074.	17.90			1373.
		025									
7	FL	558.	1830.	1822.	164.	964.	442.	7.08	62.50	8.10	1598.
	BO	230.	754.	743.	125.	522.	1080.	17.27			1428.
		010									
8	FL	891.	2924.	2924.	21.	589.	586.	0.0	0.0	12.80	1470.
	BO	582.	1909.	1899.	198.	3.	1040.	0.0			281.
		002									

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table XIII (Continued)
Flight Function Test Results
Humidity Units

DAY	MONTH	YEAR
19	5	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
9	FL	679.	2228.	2226.	110.	1264.	605.	9.93	60.90	9.60	1604.
	BO	307.	1007.	903.	446.	659.	1365.	22.41			1506.
	004										
15	FL	859.	2819.	2806.	261.	627.	622.	0.0	0.0	0.0	1490.
	BO	592.	1942.	1892.	440.	5.	932.	0.0			324.
	093	IGNITION DELAY									
24	FL	478.	1568.	1565.	95.	984.	717.	12.03	59.60	7.40	1600.
	BO	92.	303.	90.	289.	267.	1488.	24.97			1186.
	102										

RIPER HUMIDITY MOTORS

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

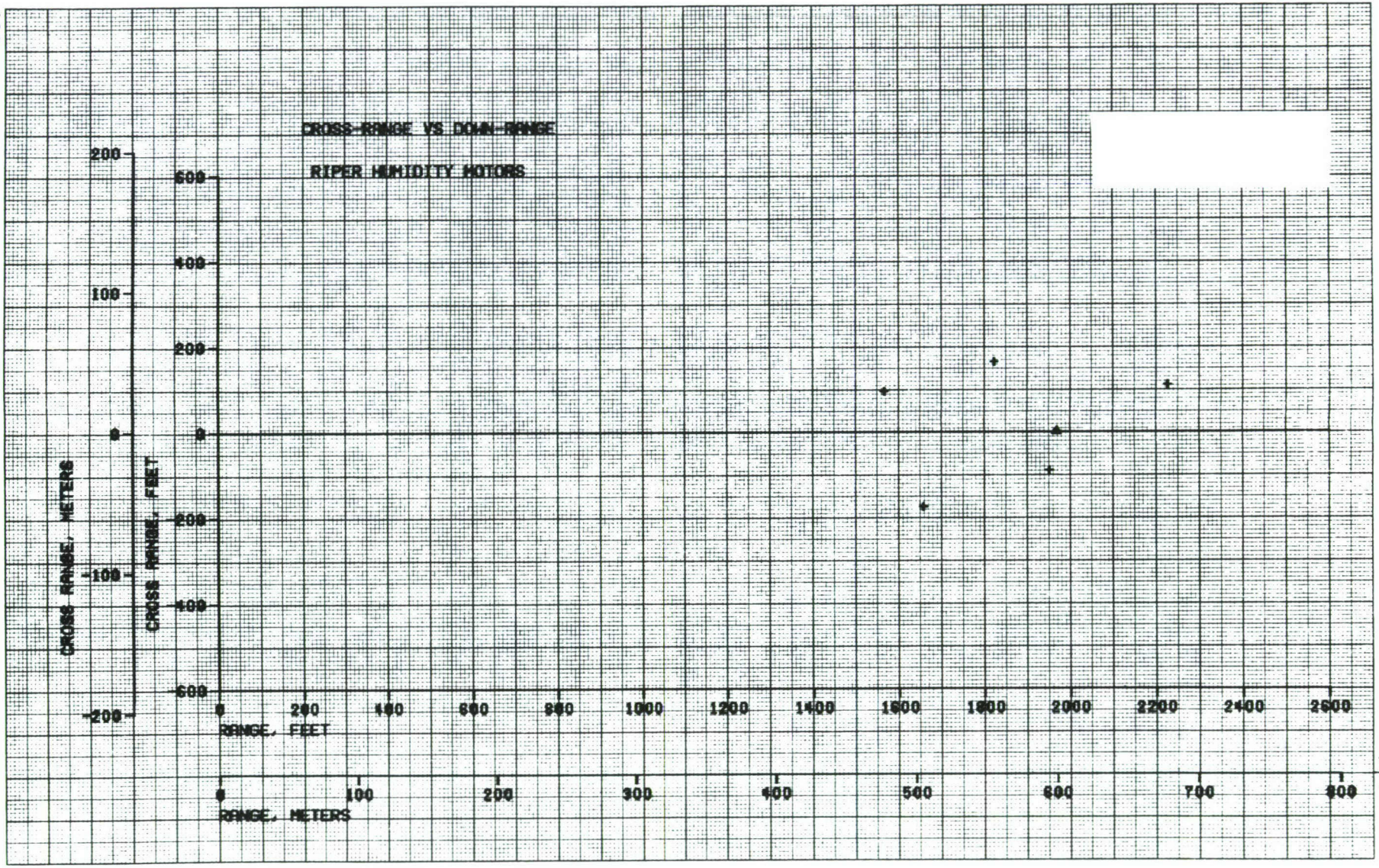

Figure 45. Cross-Range Versus Down-Range RIPER Humidity Motors

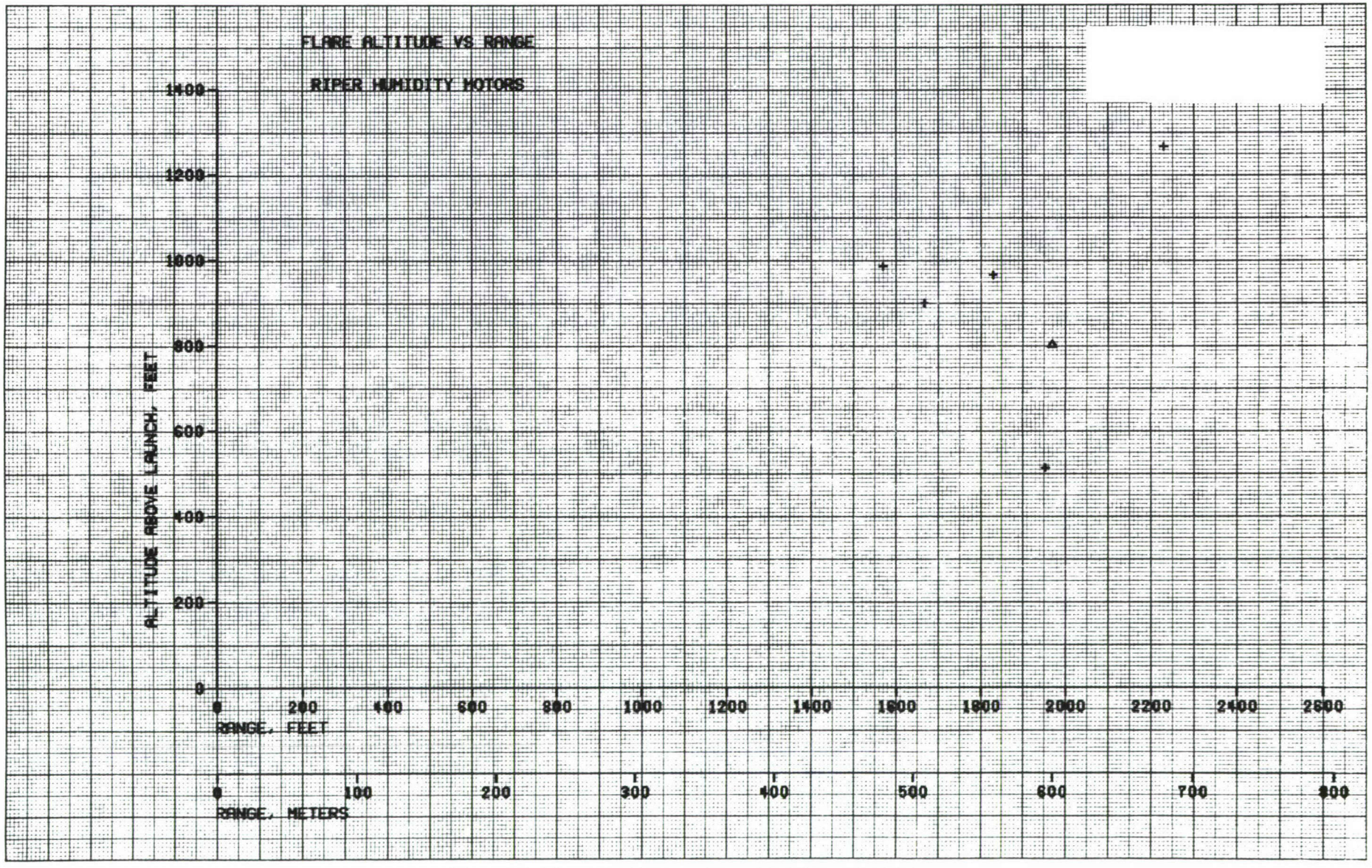

Figure 46. Flare Altitude Versus Range RIPER Humidity Motors

Table XIV
Flight Function Test Results
Salt Fog Units

DAY 7 MONTH 6 YEAR 1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
1	FL	542.	1778.	1772.	149.	636.	395.	6.36	62.10	6.60	1495.
	BO	318.	1044.	989.	335.	241.	804.	12.95			1151.
	432										
2	FL	456.	1495.	1485.	173.	654.	571.	9.94	57.50	6.40	1504.
	BO	220.	720.	720.	22.	83.	780.	13.56			818.
	411										
3	FL	409.	1343.	1341.	81.	927.	594.	9.66	61.50	5.40	1592.
	BO	227.	744.	715.	206.	333.	639.	10.38			1266.
	412										
4	FL	504.	1655.	1652.	92.	988.	526.	7.79	67.60	6.10	1601.
	BO	328.	1075.	993.	411.	462.	732.	10.82			1385.
	403										

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table XIV (Continued)

Flight Function Test Results
Salt Fog Units

DAY 7 MONTH 6 YEAR 1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
5	FL	559.	1834.	1771.	475.	901.	400.	6.77	59.10	6.30	1586.
	BO	434.	1423.	1148.	841.	500.	723.	12.24			1414.
	402										
6	FL	463.	1519.	1486.	315.	937.	487.	7.49	65.00	6.10	1593.
	BO	236.	775.	745.	214.	451.	748.	11.50			1376.
	415										
7	FL	534.	1752.	1751.	66.	854.	0.	0.0	0.0	6.00	1576.
	BO	0.	0.	0.	0.	0.	0.	0.0			0.
	413	PARACHUTE BROKE AWAY FROM FLARE									
8	FL	551.	1809.	1801.	162.	477.	283.	5.55	51.10	6.50	1397.
	BO	356.	1167.	1042.	524.	193.	841.	16.45			1075.
	414										

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table XIV (Continued)
Flight Function Test Results
Salt Fog Units

DAY 7 MONTH 6 YEAR 1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
9	FL	528.	1733.	1703.	320.	1113.	515.	8.46	60.90	7.40	1610.
	80	414.	1359.	1210.	617.	598.	576.	9.45			1475.
	423										
10	FL	484.	1587.	1586.	54.	531.	412.	6.72	61.40	5.80	1435.
	80	224.	734.	634.	369.	119.	1002.	16.33			921.
	431										
12	FL	491.	1611.	1604.	147.	632.	272.	4.68	58.20	5.90	1493.
	80	260.	855.	807.	282.	360.	809.	13.90			1294.
	427										
13	FL	515.	1688.	1687.	63.	680.	373.	6.40	58.30	6.20	1516.
	80	284.	932.	905.	222.	307.	798.	13.69			1237.
	430										

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
80 = CANDLE BURNOUT

Table XIV (Continued)
Flight Function Test Results
Salt Fog Units

DAY	MONTH	YEAR
7	6	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
14	FL	569.	1866.	1861.	128.	807.	360.	7.42	48.60	6.70	1563.
	BO	382.	1253.	1169.	453.	447.	765.	15.74			1373.
	416										
15	FL	404.	1327.	1327.	12.	906.	343.	0.0	0.0	5.90	1587.
	BO	238.	782.	741.	249.	563.	632.	0.0			1455.
	420										
16	FL	586.	1923.	1909.	238.	593.	455.	7.41	61.40	6.70	1472.
	BO	476.	1562.	1340.	801.	138.	800.	13.03			966.
	429										
17	FL	471.	1546.	1538.	163.	380.	0.	0.0	0.0	5.00	1315.
	BO	0.	0.	0.	0.	0.	0.	0.0			0.
	418	15 SEC GROUND BURNOUT									

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table XIV (Continued)
Flight Function Test Results
Salt Fog Units

DAY	MONTH	YEAR
7	6	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
18	FL	460.	1509.	1500.	167.	833.	514.	8.69	59.20	5.00	1570.
	BO	289.	948.	871.	374.	319.	663.	11.19			1251.
	425										
19	FL	499.	1636.	1636.	-4.	964.	151.	2.41	62.90	6.40	1598.
	BO	252.	827.	769.	305.	813.	921.	14.63			1564.
	417										
20	FL	555.	1821.	1821.	6.	545.	469.	7.96	59.00	6.10	1444.
	BO	274.	898.	878.	189.	76.	960.	16.28			796.
	421										
21	FL	411.	1348.	1330.	222.	871.	293.	4.89	60.00	5.40	1580.
	BO	155.	510.	497.	115.	578.	840.	13.99			1463.
	422										

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table XIV (Continued)
Flight Function Test Results
Salt Fog Units

DAY	MONTH	YEAR
7	6	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
22	FL	547.	1793.	1706.	550.	1024.	0.	0.0	0.0	6.80	1605.
	BO	0.	0.	0.	0.	0.	0.	0.0			0.
	401 CHUTE OUT NOT FULLY DEPLOYED GROUND BURNOUT										
23	FL	458.	1504.	1478.	276.	701.	174.	2.95	58.80	5.40	1524.
	BO	181.	595.	552.	221.	527.	928.	15.78			1432.
	409										
24	FL	515.	1688.	1663.	288.	755.	517.	8.12	63.70	6.90	1546.
	BO	334.	1095.	1085.	148.	238.	595.	9.34			1146.
	427										
25	FL	608.	1994.	1993.	59.	893.	565.	9.42	60.00	6.50	1585.
	BO	346.	1135.	1116.	205.	327.	890.	14.83			1260.
	405										

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table XIV (Continued)
Flight Function Test Results
Salt Fog Units

DAY 7 MONTH 6 YEAR 1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
26	FL	438.	1436.	1430.	130.	867.	549.	9.18	59.80	5.80	1579.
	BO	187.	615.	609.	81.	318.	822.	13.75			1250.
	407										
27	FL	501.	1644.	1644.	28.	765.	498.	9.06	55.00	6.00	1549.
	BO	267.	876.	786.	388.	267.	931.	16.92			1186.
	408										
28	FL	607.	1991.	1991.	27.	685.	539.	9.63	56.00	7.00	1518.
	BO	425.	1396.	1342.	383.	146.	740.	13.21			983.
	400										
29	FL	495.	1625.	1610.	218.	679.	547.	8.85	61.80	5.80	1515.
	BO	199.	652.	639.	128.	132.	975.	15.78			952.
	410										

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table XIV (Continued)
Flight Function Test Results
Salt Fog Units

DAY 7 MONTH 6 YEAR 1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
30	FL	493.	1618.	1618.	46.	672.	407.	6.89	59.10	5.90	1512.
	BO	273.	895.	843.	300.	265.	815.	13.79			1184.
	426										
31	FL	422.	1385.	1350.	309.	711.	165.	2.78	59.30	6.70	1529.
	BO	292.	956.	710.	640.	546.	721.	12.15			1444.
	419										
32	FL	561.	1841.	1740.	601.	867.	620.	10.30	60.20	7.00	1579.
	BO	467.	1531.	1161.	998.	246.	703.	11.68			1158.
	406										

RIPER SALT FOG

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

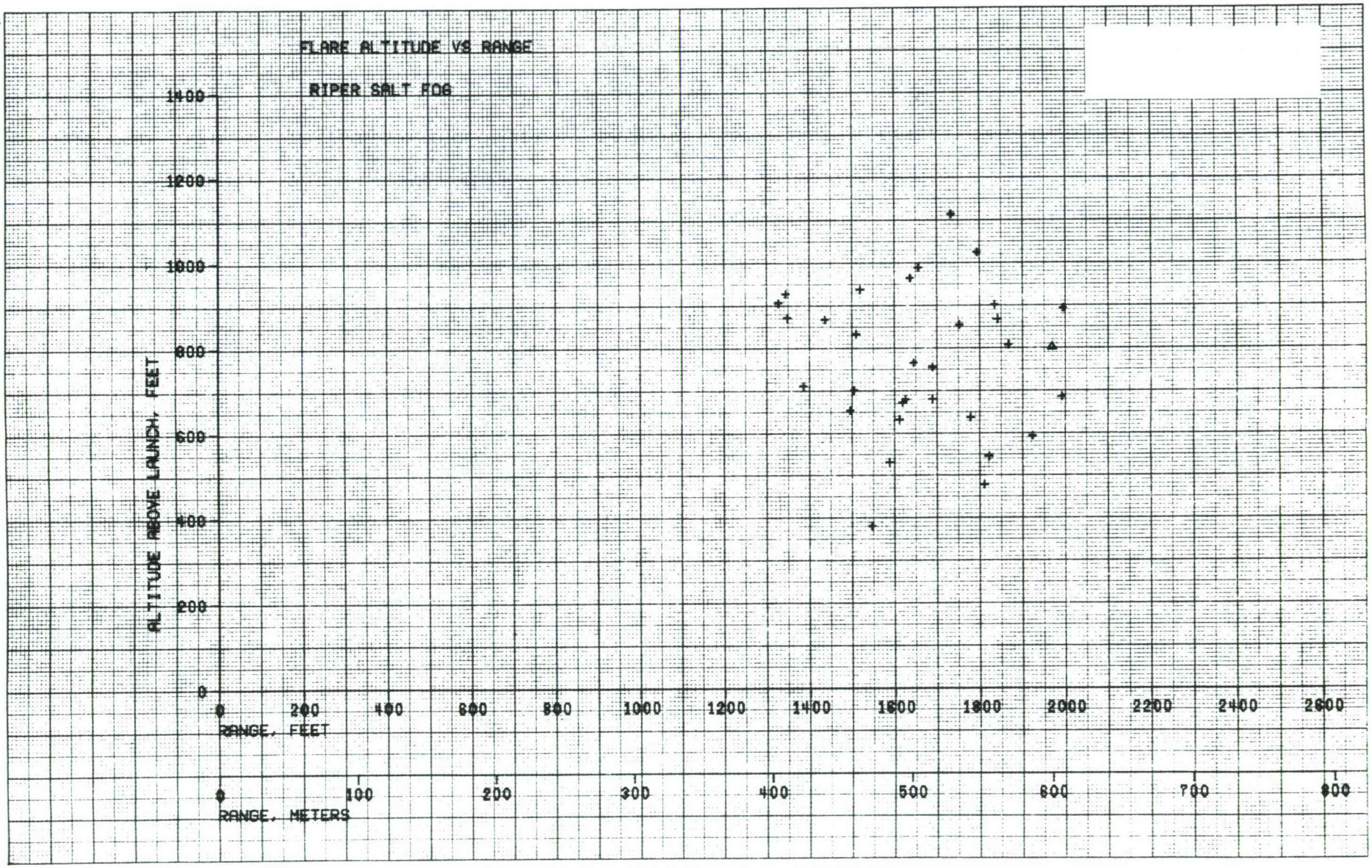

Figure 47. Flare Altitude Versus Range RIPER Salt Fog

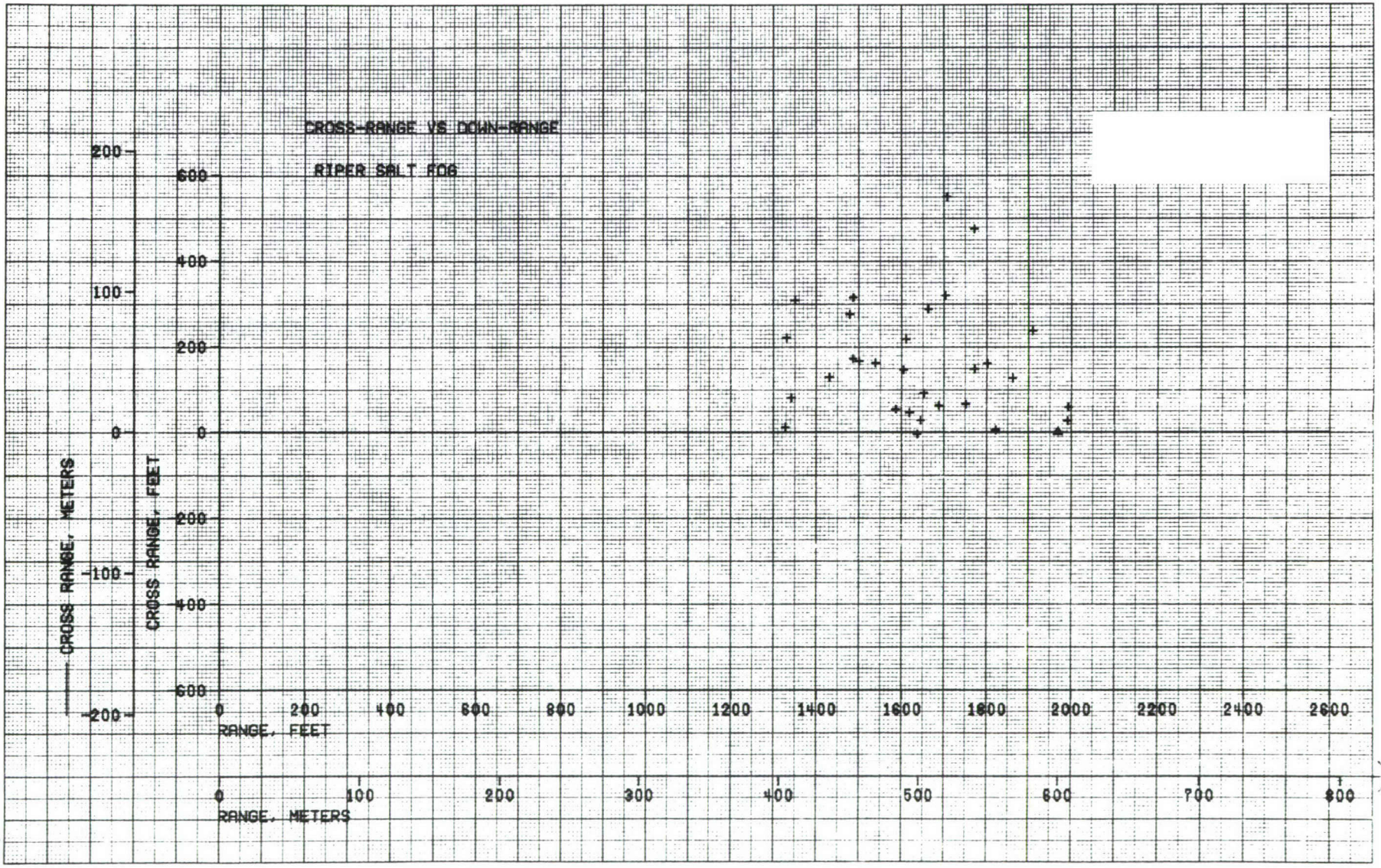

Figure 48. Cross-Range Versus Down-Range RIPER Salt Fog

Units Tested	Successes	Failures			
		Motor	Parachute	Candle	Other
23	17	3	3	0	0

The 0.4 second shorter time to flare deployment resulted in a 45 meter shorter range. The deployment altitude averaged 15 feet higher than control group (see Table V).

RIPER Projectiles which survived the five foot drop test appear to have been affected by the test and experienced a rather high rate of rocket motor failures and parachute deployment failures.

Flight test data for the five foot drop test units are presented in Table XV and Figures 49 and 50.

H. GROUND ILLUMINATION

Included in Tables VII thru XV is a calculated radius of illumination for each test. This radius has been plotted around the candle position at initial deployment for all tests and is presented as Figure 51. This figure shows that in the 258 tests, only three candles failed to provide target illumination at a level of 0.05 foot-candles at initial deployment. On most of the tests, the theoretical target is well within the illuminated circle. The three candles which did not illuminate the target were all humidity test units which experienced excessively long times to candle deployment and, therefore, excessively long ranges and low altitudes.

Table XV
Flight Function Test Results
Five Foot Drop Units

DAY	MONTH	YEAR
7	6	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
33	FL	420.	1377.	1367.	166.	962.	425.	7.39	57.60	6.20	1597.
	BO	264.	867.	827.	258.	537.	548.	9.51			1438.
	444										
34	FL	461.	1513.	1495.	235.	807.	448.	7.29	61.40	5.80	1563.
	BO	278.	912.	709.	574.	360.	857.	13.95			1295.
	447										
35	FL	578.	1897.	1879.	258.	741.	0.	0.0	0.0	7.40	1540.
	BO	0.	0.	0.	0.	0.	0.	0.0			0.
	481	CHUTE STREAMERED									
36	FL	519.	1702.	1643.	444.	936.	426.	6.80	62.60	6.80	1593.
	BO	215.	704.	668.	223.	510.	1000.	15.97			1421.
	450										

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table XV (Continued)
Flight Function Test Results
Five Foot Drop Units

DAY	MONTH	YEAR
7	6	1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
37	FL	443.	1452.	1402.	376.	1001.	451.	7.51	60.00	5.80	1603.
	BO	263.	864.	863.	28.	550.	642.	10.69			1447.
	445										
38	FL	474.	1556.	1548.	151.	841.	221.	4.34	51.00	6.20	1572.
	BO	394.	1294.	1288.	124.	620.	261.	5.13			1486.
	449										
39	FL	606.	1988.	1970.	273.	550.	414.	7.56	54.70	7.30	1446.
	BO	411.	1350.	1098.	785.	136.	1011.	18.48			962.
	458										
40	FL	399.	1307.	1306.	52.	1013.	392.	6.38	61.50	5.80	1604.
	BO	202.	661.	515.	415.	621.	871.	14.16			1487.
	455										

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table XV (Continued)
Flight Function Test Results
Five Foot Drop Units

DAY 7 MONTH 6 YEAR 1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
41	FL	515.	1688.	1687.	56.	698.	405.	6.41	63.20	6.30	1523.
	BO	299.	982.	639.	746.	293.	1255.	19.86			1220.
	454										
42	FL	628.	2060.	2054.	157.	382.	0.	0.0	0.0	7.20	1316.
	BO	0.	0.	0.	0.	0.	0.	0.0			0.
	441	20 SECOND GROUND BURNOUT									
45	FL	541.	1776.	1775.	49.	513.	0.	0.0	0.0	6.30	1423.
	BO	0.	0.	0.	0.	0.	0.	0.0			0.
	434	CHUTE BROKE AWAY FROM CANDLE									
47	FL	470.	1542.	1542.	-2.	906.	506.	8.18	61.80	6.40	1587.
	BO	258.	845.	705.	465.	401.	958.	15.51			1334.
	452										

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

Table XV (Continued)
Flight Function Test Results
Five Foot Drop Units

DAY 7 MONTH 6 YEAR 1971

FLIGHT		RANGE (M)	RANGE (FT)	DOWN RANGE (FT)	CROSS RANGE (FT)	ALTITUDE (FT)	DESCENT & DRIFT (FT)	DESCENT & DRIFT RATE (FT/SEC)	CANDLE BURN (SEC)	FIRST LIGHT (SEC)	RADIUS * ILLUM (FT)
50	FL	608.	1993.	1993.	-11.	1011.	565.	9.62	58.80	6.60	1604.
	BO	494.	1620.	1580.	360.	445.	556.	9.45			1372.
		457									
51	FL	481.	1577.	1576.	78.	917.	246.	4.45	55.40	6.30	1590.
	BO	321.	1053.	951.	451.	671.	728.	13.13			1511.
		442									
52	FL	452.	1485.	1484.	41.	1149.	615.	10.31	59.70	6.80	1611.
	BO	360.	1180.	1141.	298.	534.	428.	7.18			1436.
		438									
55	FL	475.	1557.	1549.	159.	835.	230.	4.21	54.50	6.00	1570.
	BO	253.	829.	725.	401.	605.	859.	15.75			1479.
		456									

RIPER FIVE FOOT DROP TESTS

* RADIUS OF CIRCLE ILLUMINATED TO 0.050 FOOT-CANDLES WITH CANDLE INTENSITY OF 0.337 MILLION CANDLES

FL = CANDLE FIRST LIGHT
BO = CANDLE BURNOUT

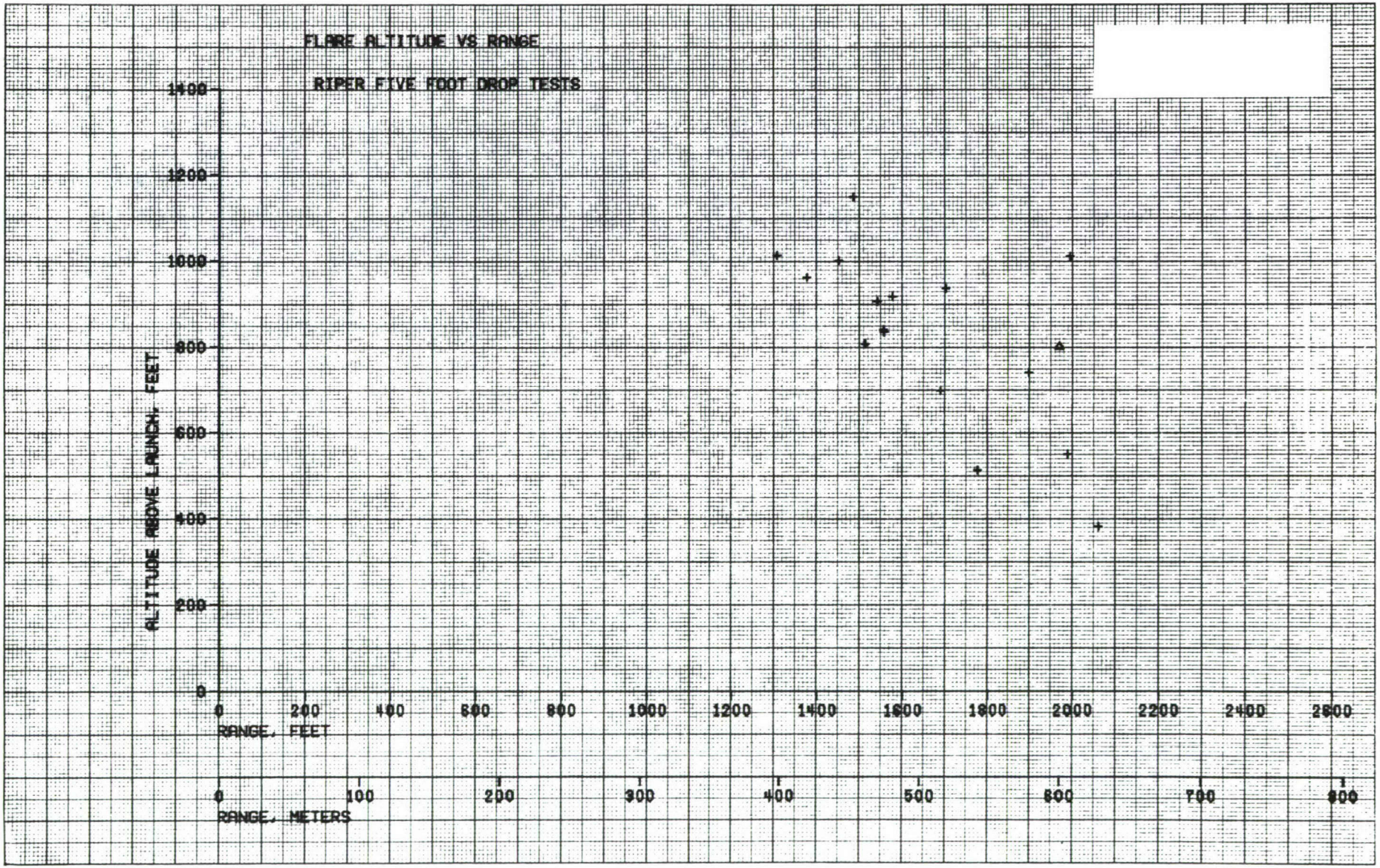

Figure 49. Flare Altitude Versus Range RIPER 5 Foot Drop Tests

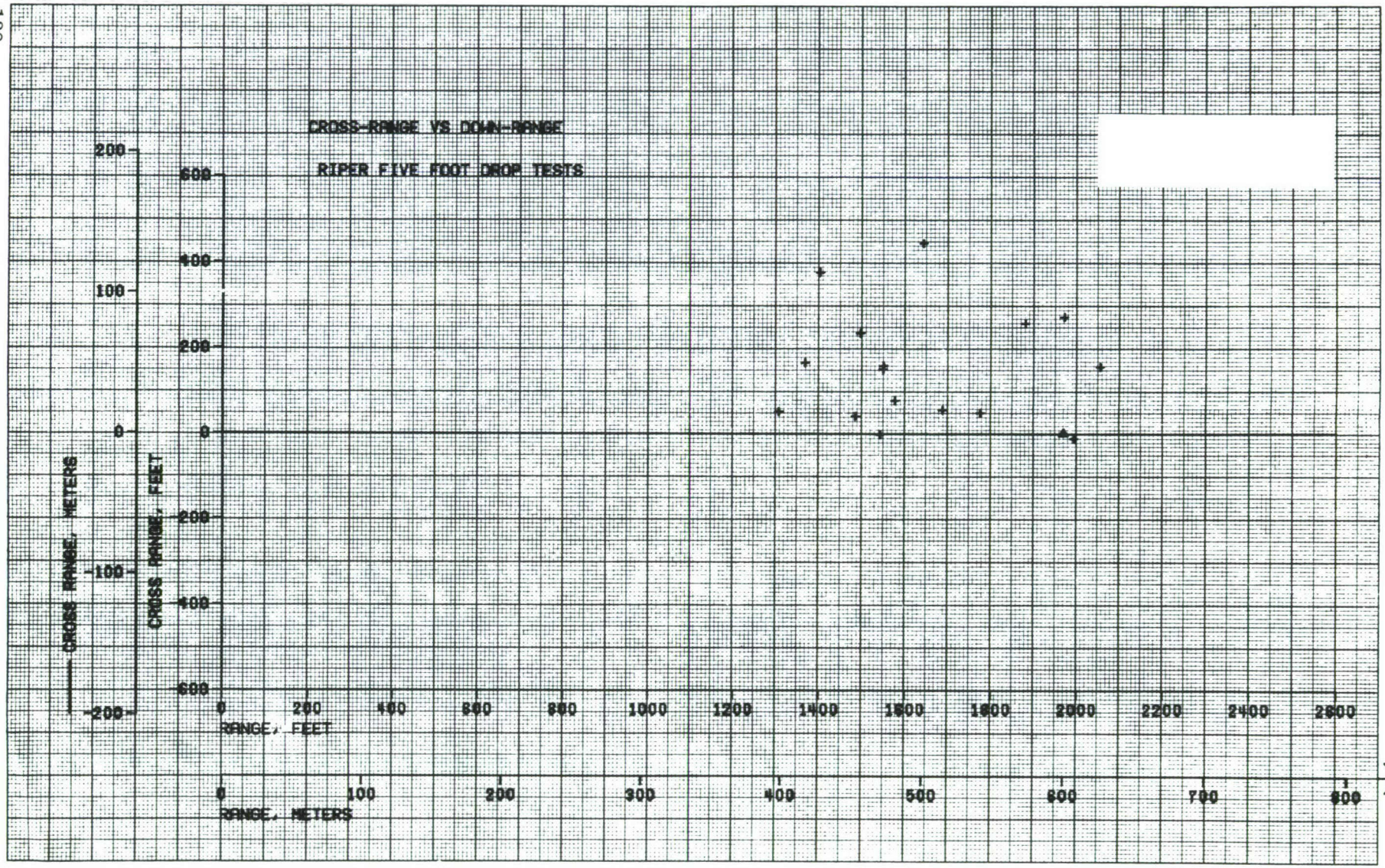

Figure 50. Cross-Range Versus Down-Range RIPER 5 Foot Drop Tests

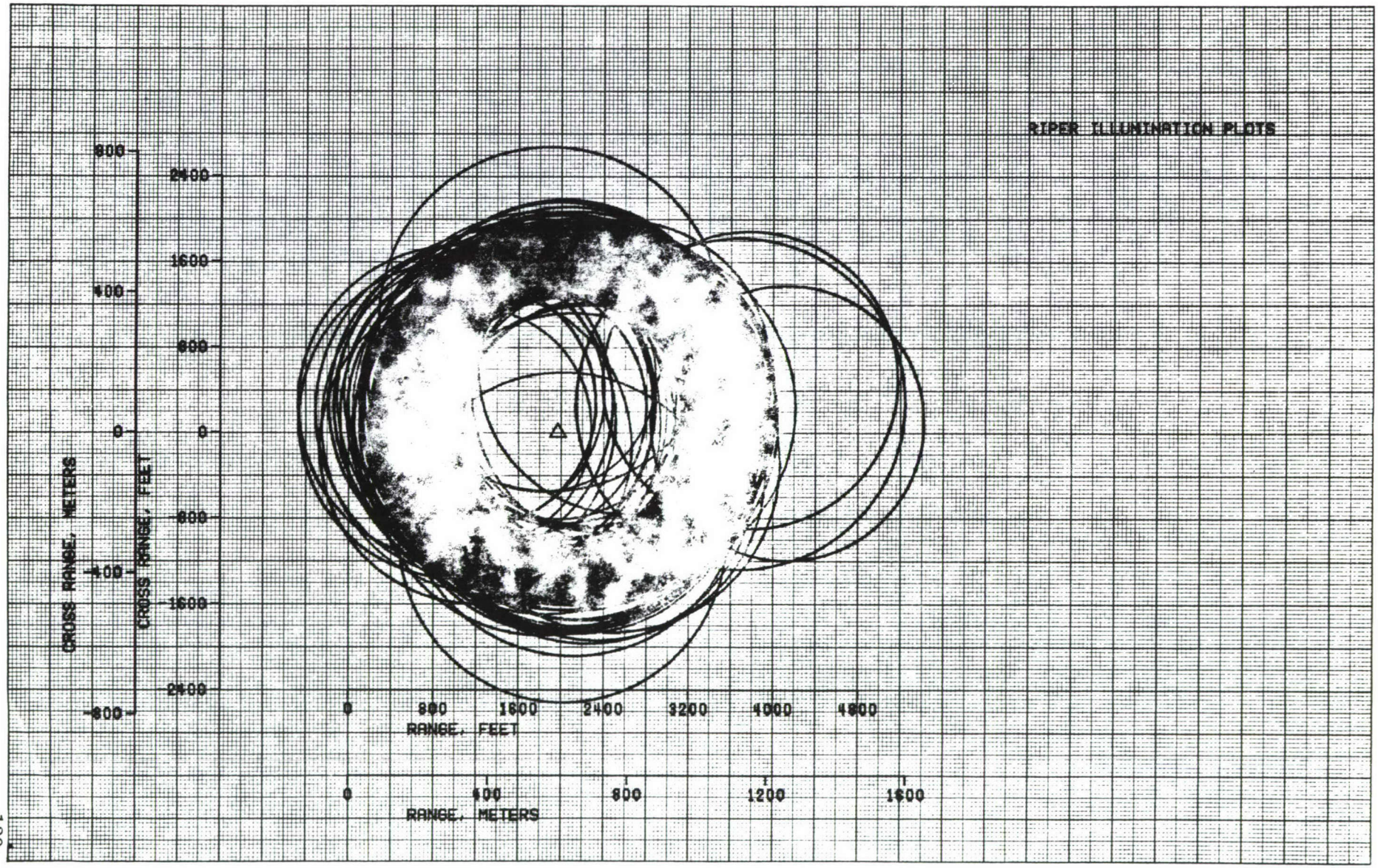

Figure 51. RIPER Illumination Plots

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APPENDIX A

REMOTELY INITIATED ILLUMINATING PERIMETER ROCKET (RIPER)

Contract No. DAADO-5-70-C-0024

PHASE I FINAL REPORT

21 May 1970

Submitted to
U. S. ARMY LIMITED WAR LABORATORY
(CRDLWL-6B)
Aberdeen Proving Ground, Maryland

By
THIOKOL CHEMICAL CORPORATION
WASATCH DIVISION
Brigham City, Utah

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of the U. S. Army Limited War Laboratory
Aberdeen Proving Ground, Maryland
Attn: CRDLWL-6B

SECTION I

SUMMARY

The rocket motor design has been modified and tested to verify that performance meets predicted values. Trajectories have been simulated based on actual "nominal" motor performance. Flare candle ignition and ejection has been demonstrated and the candle ignition configuration has been defined.

Twenty-eight motors were static tested during Phase I design development. Of these motors, twelve were cast from propellant standardization mixes. Test data from these motors provided data for ballistic design. Twelve motors were vacuum cast to check a propellant processing technique. Eight motors tested were GFP propellant and were tested for preliminary performance data and for materials testing.

Twenty-five rocket motors were fabricated and static tested to verify motor performance reproducibility. All of these motors were X-Rayed prior to static test and most were found to contain voids in the propellant. The size of the voids which were detected ranged from 1/16 inch in diameter to 3/8 inch in diameter. The effect of void size and location upon motor performance has been determined.

Propellant casting studies have been conducted. Casting tooling has been modified and sample propellant grains have been cast. The results of this study have provided evidence of acceptable propellant grains capable of meeting ballistic performance requirements.

SECTION II

CONCLUSIONS

The rocket motor design as shown on the following drawings will produce the performance required.

Drawing No.	Revision	Title
4-1059-7	A	Case Loaded
4-1059-8	C	Case
4-1059-9	A	Nozzle
4-1059-10	B	Insert-Nozzle
4-1059-11	A	Nozzle Body

Flare candle ignition and ejection can be reliably obtained by using a wafer of propellant as shown on Drawing 4-1059-4, Rev. A Candle Assy. An average light output of 270,000 candlepower can be delivered as evidenced by Phase I test data by the configuration noted above for a minimum of 60 seconds.

Motor performance is affected somewhat by voids in the propellant. However, delay time is seriously affected by propellant voids, particularly when the voids are in the delay area or along the motor centerline. In order to control the range and altitude of flare deployment, only small voids may be accepted in limited locations.

Motor ignition delay can be minimized by the application of a first fire to the propellant surface. Ignition delay has little effect upon motor performance under static test conditions.

SECTION III

RECOMMENDATIONS

1. Motor and flare design should be frozen for Phase II procurement.
2. Phase II effort should include some additional Quality Assurance effort. Motor propellant grains should be X-Rayed for acceptance and a Quality Assurance sampling plan established for selecting motors to be static tested to verify acceptance.
3. Phase II effort should include additional design effort required to finalize weight and center of gravity location for the latest design. Also, the new, one-piece ogive design should be tested to establish attachment method and blow-out pressures. This new design results in a better seal in the parachute-candle compartments, simplified ogive tooling and assembly procedures more adaptable to high quantity production.
4. A flare candle bulkhead should be redesigned to simplify construction and to eliminate the protrusion into the candle composition.
5. Although propellant casting techniques have been improved to enhance motor grain processing, further investigations should be conducted to increase the probability of void free motor grains and low processing cost.

6. The effect of motor ignition delay time upon system performance should be investigated. If the effect is significant, changes in the squib and/or in the mounting method should be incorporated.

7. Molded plastic protectors should be procured to protect the motor case during lining and casting operations.

SECTION IV

DESIGN

The design of RIPER and a complete set of detail drawings were furnished by the customer at the beginning of the program. Design work has been limited to that required to assure that system performance would meet specification requirements, and to changes required to facilitate economical fabrication.

The initial design review and performance analysis indicated that the required range and altitude could not be achieved with the original design. The propellant grain was redesigned to produce the necessary increase in performance and was presented as "Motor Redesign #1".

Static test data from motors fabricated to "Motor Redesign #1" confirmed the adequacy of the design.

The initial design review also raised a question as to the adequacy of the nozzle throat insert material. A change from ceramic to graphite was recommended and approved. The nozzle body was redesigned to accept the graphite insert and also to compensate for the lengthened motor case without an increase in the overall length of the projectile.

Static tests of the new nozzle design showed it to be acceptable. Exit cone erosion was quite severe but was not considered to be detrimental to motor performance.

Fabrication of the nozzle body produced voids in the area of most severe erosion and was felt to be unacceptable. An additional change was made, extending the graphite insert all the way to the exit plane. The graphite shows no measurable erosion so voids in the nozzle body will not be exposed by erosion. Static test of the final nozzle design verified its adequacy.

Initial tests for candle ignition and ejection showed that the original design (a propellant wafer bonded to the end of the candle) produced flare ejection but not flare ignition. The propellant wafer ignited, provided adequate pressure to eject the candle but burned out without igniting the flare illuminant. A modification of this design was made by drilling a small hole through the propellant into the illuminant and, in addition, coating part of the exposed propellant surface to inhibit burning. This design has provided flare ignition on 22 of 25 tests.

Motor ignition delays of from 4 to 8 seconds were experienced on the first motors tested with the 4-1059-14 squib. Three "first fire" materials were investigated for application to the propellant grain to provide consistent ignition. The material selected consisted of 27% Elemental Boron Powder, 64% Potassium Perchlorate and 9% VYLF Binder. On the final 25 motors tested in Phase I, ignition delays were again experienced even with the use of the selected "first fire."

It is not known what effect motor ignition delay will have on flight test motor performance. The motor ignition delay experienced during motor static test is probably the result of locating the squib outside the pressure chamber. When the squib is initiated, a high

pressure is generated which blows the squib-squib holder away from the nozzle. The rapid depressurization which results tends to extinguish any ignition which may have taken place. This condition may be overcome when the projectile-launcher combination is used because the fire arm (4-1059-20) will hold the squib holder against the nozzle until the complete projectile moves away. Movement of the larger mass will require more pressure or thrust and may sustain ignition much better than does the static test arrangement. The effects of motor ignition delay on flight test performance characteristics will be further investigated during the flight test evaluation portion of Phase II.

SECTION V

FABRICATION AND TEST

During Phase I, forty-nine rocket motors have been fabricated and fifty-three static tests have been conducted. Table I shows the configurations tested and summarizes the test results.

Two motor cases and nozzle bodies machined from Celcon GR-20 bar stock were fabricated, loaded and static tested (Test #17 & 18). The case was rough machined, then annealed prior to final machining. Both static tests were successful and demonstrated the feasibility of the plastic case-nozzle design.

Ten aluminum motor cases and five aluminum nozzle bodies were fabricated and can be loaded and static tested many times. All ten were loaded and tested once, six have been reloaded and two retested. One aluminum case, S/N 008 (Test #13) was damaged during the test when the flare ignited but was not ejected from the fixture. The burning flare, exhausting through the motor, caused the motor case to overheat and melt through on one side.

Two problem areas were encountered during Phase I fabrication effort. These were: (1) Difficulty in molding the motor case and nozzle due to the high shrinkage factors of the Celcon GR-20 material and (2) Developing casting techniques which will produce void-free grains.

A considerable effort and multiple mold changes were required in order to produce molded motor cases and nozzles. The primary

RIPER PHASE I TEST SUMMARY SHEET

Design Development Tests

Test No.	Motor No.	Test Date	Test Configuration	Test Purpose	Remarks and Test Results
1	---	27 Aug 69	Test stand measure motor chamber pressure and thrust.		
2	---	3 Sept 69	Elkton built GFF Hardware Machined Propellant Grain Break-wire was used to measure delay time.	To measure motor performance for comparison with predicted perf.	High speed movie camera coverage. Good data was recorded.
3	---	3 Sept 69	Same as Test #2.	Same as Test #2.	Pressure and thrust data are not reproducible (Test #1,2,3,4,5)
4	---	3 Sept 69	Same as Test #2.	Same as Test #2.	
5	---	3 Sept 69	Same as Test #2.	Same as Test #2.	
6	---	17 Sept 69	Alum. case, Celcon nozzle, graphite insert, Elkton machined grain. See Dwg. # SK43054 thru SK43057. Measured motor chamber pressure and thrust.	To test nozzle materials.	Graphite throat insert performed well, no measurable erosion. Exit cone erosion was excessive (celcon GR 20).
7	---	17 Sept 69	Same as Test #6 except nozzle throat insert was LCMC.	To test nozzle materials.	Nozzle throat insert broke up and ejected at .6 seconds. Motor extinguished.
8	---	30 Sept 69	Same as Test #6 except nozzle throat and exit cone were Asbestos TPD 150.	To test nozzle materials.	Asbestos phenolic throat eroded excessively, chamber pressure was affected and motor exhibited very long "tail off" (6 sec)
9	S/N 001	8 Jan 70	Machined Alum. case, Alum. nozzle, graphite throat. Cast propellant grain (Redesign #1) Stub Flare candle. Configuration #1. Measured motor chamber pressure, thrust, pressure and thrust integrals, and eject pressure. New RIPER Squib.	To measure motor performance, delay time to candle ignition and candle ejection pressures.	Lost chamber pressure instrumentation. Ignition delay of approx. 2 sec. Candle propellant wafer ignited, candle ejected, propellant wafer burned out but did not ignite candle.
10	003	9 Jan 70	Same as Test #9 except flare candle config. #2.	Same as Test #9.	Good pressure and thrust data. Ignition delay of 1 sec. Candle ejected and ignited.
11	005	9 Jan 70	Same as Test #10.	Same as Test #9.	Ignition delay of 5 sec. Candle and ignited.
12	007	9 Jan 70	Same as Test #9 except flare candle config. #2.	Same as Test #9.	Candle ejected but did not ignite. Ignition delay of
13	008	9 Jan 70	Same as Test #10.	Same as Test #9.	Candle ignited in test fixture - did not eject. Burning candle overheated motor case and damaged case. Ignition delay of approximately 7 sec.
14	009	9 Jan 70	Same as Test #9 except no flare candle.	Same as Test #9.	
15	010	9 Jan 70	Same as Test #10.	Same as Test #9.	Approx. 7 sec. ignition delay. Candle ignited & ejected.
16	C-002	9 Jan 70	Same as Test #9 except case and nozzle were machined Celcon GR 20.	Same as Test #9. Also to test the plastic case-nozzle design.	Approx. 5 sec. ignition delay. Candle ejected but did not ignite.
17	C-001	13 Feb 70	Same as Test #16.	Same as Test #16 except no candle or eject pressure.	
18	002	13 Feb 70	Same as Test #9 except "First Fire" applied to propellant surface.	Same as Test #9 except no candle. First Fire was applied to surface of propellant. Temp. cycle prior to test.	
19	004	13 Feb 70	Same as Test #18.	Same as Test #18.	
20	006	13 Feb 70	Same as Test #18.	Same as Test #18.	
21	0026	18 Mar 70	All up motor (molded celcon case and nozzle body short graphite throat) vacuum cast propellant. Same instrumentation as Test #9 except no eject pressure.	To determine the effect of void-free propellant upon delay time. Delay time measured with break-wire.	Instrumentation failed, no pressure, thrust or delay time recorded. Test appeared good in every respect.
22	001	18 Mar 70	Same as Test #9 (recycled Alum. case, vacuum case propellant)	Same as Test #21 (Instrumentation checkout)	Good test. Instrumentation functioned O.K.
23	0031	18 Mar 70	Same as Test #21.	Same as Test #21.	Good test.
24	0028	18 Mar 70	Same as Test #21.	Same as Test #21.	Good test.
25	0027	18 Mar 70	Same as Test #21.	Same as Test #21.	Approx. 1 sec. ignition delay. Good test.
26	0029	18 Mar 70	Same as Test #21.	Same as Test #21.	Good test.
27	0030	18 Mar 70	Same as Test #21.	Same as Test #21.	Good test.

RIPER PHASE I TEST SUMMARY SHEET

Design Confirmation Tests

Test No.	Serial No.	Test Date	TEST CONFIGURATION			PERFORMANCE DATA										Candle Test Results
			Motor	Squib	Candle	Ign. Delay	P Max.	High Press. Avg.	High Thrust Avg.	Burn Time	Ref to Amb. Time	Flare Ign.	Time Flare Eject	Eject Pres.	Test Temp.	
28	010	29 Apr 70	Alum Case Vac. Cast	RIPER	none	(7)										
29	0002	29 Apr 70	Phase I Final Design	RIPER	1" Stub with Wafer	0	790	725	28	2.8	4.8	11.9	3.4	165	Ambient	Ignited and ejected properly.
30	0013	29 Apr 70	Phase I Final Design	RIPER	1" Stub with Wafer	1.6	790	750	30	2.7	4.5	10.9	.25	4.0	Ambient	Ignition wafer ignited and partially ejected candle. Illuminant did not ignite.
31	0016	29 Apr 70	Phase I Final Design	RIPER	1" Stub with Wafer	0	(3)	-	--	-	-	--	-	-	Ambient	Ignited and ejected properly.
32	0019	29 Apr 70	Phase I Final Design	RIPER	1" Stub with Wafer	0	790	775	28	2.6	5.0	13.2	3.7	158	Ambient	Ignited and ejected properly.
33	0022	29 Apr 70	Phase I Final Design	RIPER	1" Stub with Wafer	1.6	750	700	24	2.6	4.0	17.0	1.0	90	Ambient	Ignited and ejected properly.
34	0021	29 Apr 70	Phase I Final Design	RIPER	1" Stub with Wafer	1.75	1020	820	26	2.3	4.5	9.05	0	NR	Ambient	Ignited and ejected properly.
35	0020	29 Apr 70	Phase I Final Design	RIPER	1" Stub with Wafer	2.5	1500	1000	35	Not Det.	4.0	5.30	0	NR	Ambient	Ignited and ejected properly.
36	0009	29 Apr 70	Phase I Final Design	RIPER	1" Stub with Wafer	4.1	715	650	20	2.7	3.6	3.60	.15	35	Ambient	Ignited and ejected properly.
37	0025	29 Apr 70	Phase I Final Design	RIPER	1" Stub with Wafer	7.5	680	650	17	-	4.0	7.90	.20	5	-40°F	Ignited and ejected properly.
38	0011	29 Apr 70	Phase I Final Design	RIPER	no candle	0	900(1)	-	27	2.2	4.0	12.3	-(4)	15	+120°F	No candle. Delay measured by and ignition wafer only.
39	0001	29 Apr 70	Phase I Final Design	RIPER	1" Stub with Wafer	.95	1000	900	33	2.1	4.0	9.75	.25	37	+120°F	Ignited and ejected properly.
40	0003	29 Apr 70	Phase I Final Design	RIPER	1" Stub with Wafer	.85	870	840	29	2.3	3.9	11.4	.5	60	+120°F	Ignited and ejected properly.
41	0008	29 Apr 70	Phase I Final Design	RIPER	1" Stub with Wafer	.75	900	850	27	2.1	4.0	11.75	2.7	90	+120°F	Ignited and ejected properly.
42	0015	30 Apr 70	Phase I Final Design	RIPER	1" Stub with Wafer	0	850	750	18	3.0	5.5	11.0	.8	75	-40°F	Ignited and ejected properly.
43	0017	30 Apr 70	Phase I Final Design	RIPER	1" Stub with Wafer	3.3	520	500	15	3.3	6.2	10.7	.9	66	-40°F	Ignited and ejected properly.
44	0018	30 Apr 70	Phase I Final Design	RIPER	1" Stub with Wafer	0	680	625	15	2.5	3.6	10.5	2.6	60	-40°F	Ignited and ejected properly.
45	0023	30 Apr 70	Phase I Final Design	RIPER	1" Stub with Wafer	2.55	880	800	--	3.1	5.5	13.5	1.7 to 2.35	103 to 110	-40°F	Ignited and ejected properly.
46	0005	30 Apr 70	Phase I Final Design	RIPER	1" Stub with Wafer	.95	935	750	25	2.4	3.8	9.00	.9	42	+120°F	Ignited and ejected properly.
47	0004	30 Apr 70	Phase I Final Design	RIPER(3) Exper.	no candle	-	1500(2)	-	--	-	-	--	-	-	+120°F	No candle.
48	0012	30 Apr 70	Phase I Final Design	Exper.	1" Stub with Wafer	0	1020(1)	-	28	2.4	3.1	11.8	.3	88	+120°F	Ignited and ejected properly.
49	0006	30 Apr 70	Phase I Final Design	Exper.	1" Stub with Wafer	3.5	1030	800	27	1.7	3.5	6.70	.2	90	+120°F	Illuminant did not ignite. Ignition wafer ignited and ejected candle.
50	0024	30 Apr 70	Phase I Final Design	Exper.	1" Stub with Wafer	1.45	900	850	27	2.3	4.5	11.2	2.25	75	Ambient	Ignited and ejected properly.
51	0014	30 Apr 70	Phase I Final Design	Exper.	1" Stub with Wafer	1.4	920	800	24	Not Det.	4.2	8.10	.2	77	Ambient(6)	Ignited and ejected properly.
52	0010	30 Apr 70	Phase I Final Design	Exper.	1" Stub with Wafer	7.5	730	625	18	2.7	5.0	11.3	(4)	Max 38	Ambient(6)	Ignition wafer ignited. Did not eject.
53	0007	30 Apr 70	Phase I Final Design	Exper.	1" Stub with Wafer	1.3	870	800	27	2.5	4.5	4.5	.2	150	Ambient(6)	Ignited and ejected properly.

NOTES:

1. Motors tested "Unrestrained" (without chamber pressure adapter). Chamber pressure estimated from thrust data.
2. Motor tested "Unrestrained." X-Ray of grain prior to test disclosed a large void. Case failed at .6 sec. Motor extinguished.
3. Experimental squib failed to ignite motor. RIPER squib ignited motor with noted ignition delay.
4. No candle was used for this test. Flare ignition and eject pressure were simulated by a propellant wafer only.
5. Data lost.
6. These motors were temperature conditioned for approx. 3½ hours at -40°F then warmed to ambient.
7. This motor was tested for instrumentation checkout.

problem area was found to be the threads where class 2 tolerances were very difficult to hold. Another problem area was roundness which is greatly affected by the gating method. Center gating and ring gating were required to produce round parts.

The problem of voids in the propellant grain was not identified until late in the Phase I effort. Large variations in motor chamber pressure, thrust, and delay (or candle ignition) time were evident for all of the first nineteen tests. Initially, these variations were attributed to varying motor ignition delay times but, as fabrication and testing proceeded, the propellant grain became suspect. When molded plastic cases were received, the first propellant cast was X-Rayed in the uncured condition and numerous large voids were found. The propellant was removed from the cases and they were re-cast using a vacuum casting method. X-Rays of the vacuum cast motors showed that most of the voids had been eliminated. Six motors were cured and only two had any detectable voids. Static testing of these six motors (Test #21, 23, 24, 25, 26 & 27) confirmed that reproducible performance could be obtained from void free grains and that performance was affected only slightly by small voids.

Several changes were made to the casting tooling to eliminate air entrapment. The final twenty-five motors were cast using this improved method. The motors were X-Rayed and many, and sometimes large, voids were found. The voids were analyzed and the effect upon motor performance was predicted. The motor judged to be most seriously affected was serial number 004. This motor was selected,

temperature conditioned at 120°F, and static tested unrestrained. The motor ignited and burned for .6 seconds at which time a large void was exposed which caused chamber pressure to rise to over 1500 psi. The motor case failed at the first thread root and the nozzle and case thread were ejected. The rapid depressurization, which took place when the case failed caused the propellant to extinguish. The burn pattern on the remaining grain confirmed that failure had occurred when the large void was exposed to flame.

Additional improvements in the casting arrangement have been made. Two items which have greatly improved grain integrity are: (1) Careful evacuation of the casting can when the pressure diaphragm is installed, and (2) The use of a formed casting tube which eliminates inversion of the casting can. Several motors have been cast using the new equipment and procedures and were virtually void free.

The motors were instrumented to monitor chamber pressure by venting the chamber gas through a small hole in the chamber wall into a closed structure capable of supporting the necessary instrumentation equipment. This instrumentation method resulted in a small ($\approx$ .75 inch) length of cylindrical motor case being structurally reinforced by the instrumentation equipment. The test arrangement is shown in Figure 1.

Flare delay was monitored by two methods. In the first five (5) tests, a breakwire was located such that contact would be lost when the flame front broke through into the flare candle chamber. On the last 25 motors, the pressure in the flare candle chamber was monitored and the ignition delay time was noted as the first pressurization of the candle chamber.

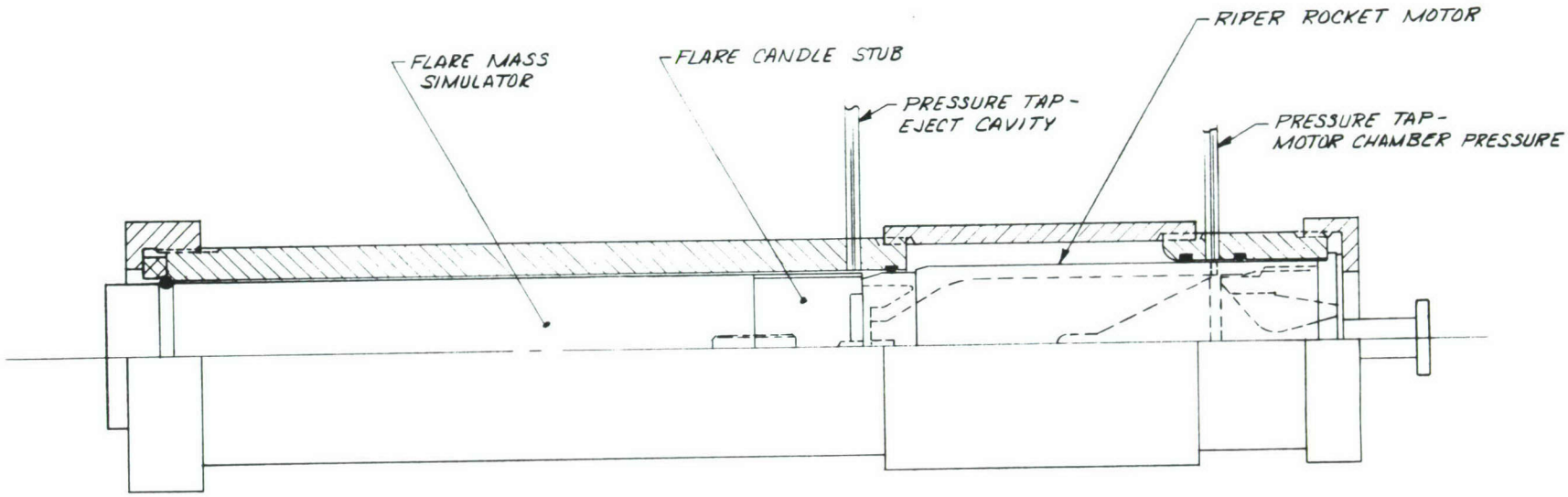


FIGURE 1. STATIC TEST ARRANGEMENT

Thrust measurements were made for all 30 tests on the same thrust stand, however, some slight modifications were made between the two (2) series of tests. Extreme thrust oscillations were recorded for the first series of motor tests, therefore, a damping dashpot was incorporated in the test structure to reduce normal stand vibration for the second series of tests.

SECTION VI

PERFORMANCE ANALYSIS

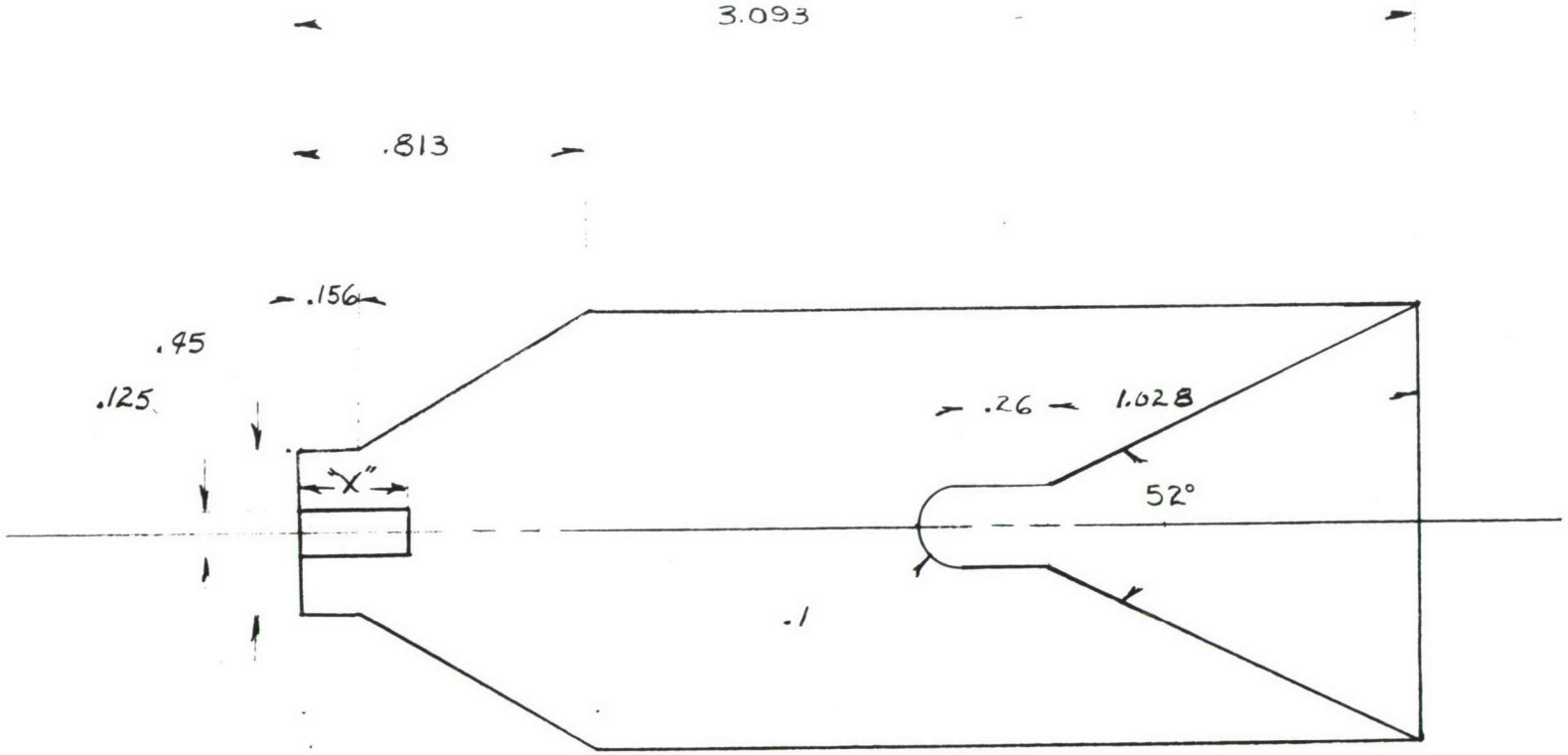
RIPER motor performance analysis is presented in four divisions; A. Predicted Performance, B. Vacuum Cast Motor Analysis, C. Pressure Cast Motor Analysis, and D. Design and Performance of Design for Phase II.

A. PREDICTED PERFORMANCE

The grain configuration and the burnout pattern for the rocket motor are shown in Figures 2 & 3. The predicted motor performance with pressure and thrust vs time curves are shown in Table II and Figure 4. The performance predicted for this motor was based upon propellant characterization data. During motor operation, a thrust plateau of approximately 26 lbf is maintained for .8 sec which then decreases rapidly to a subsequent plateau of approximately 5 lbf until 2.5 sec. The motor thrust is then regressive until motor pressure reaches ambient conditions. The motor continues to burn at ambient conditions until the flare ignition void at the forward end of the grain is reached. The original delay time for flare ignition was established by theoretical flight trajectory at 9.47 sec.

B. MOTOR ANALYSIS - VACUUM CAST MOTORS

The first five (5) motors were fabricated employing a vacuum casting technique. The castings as shown by pretest X-Ray were not entirely void free, but those few small voids which did exist were



NOTE:

Dimension "X" determines the length of delay time for flare ignition

Series of 5 motor X = .301

Series of 25 motors X = .138

Figure 2. Propellant Grain Design

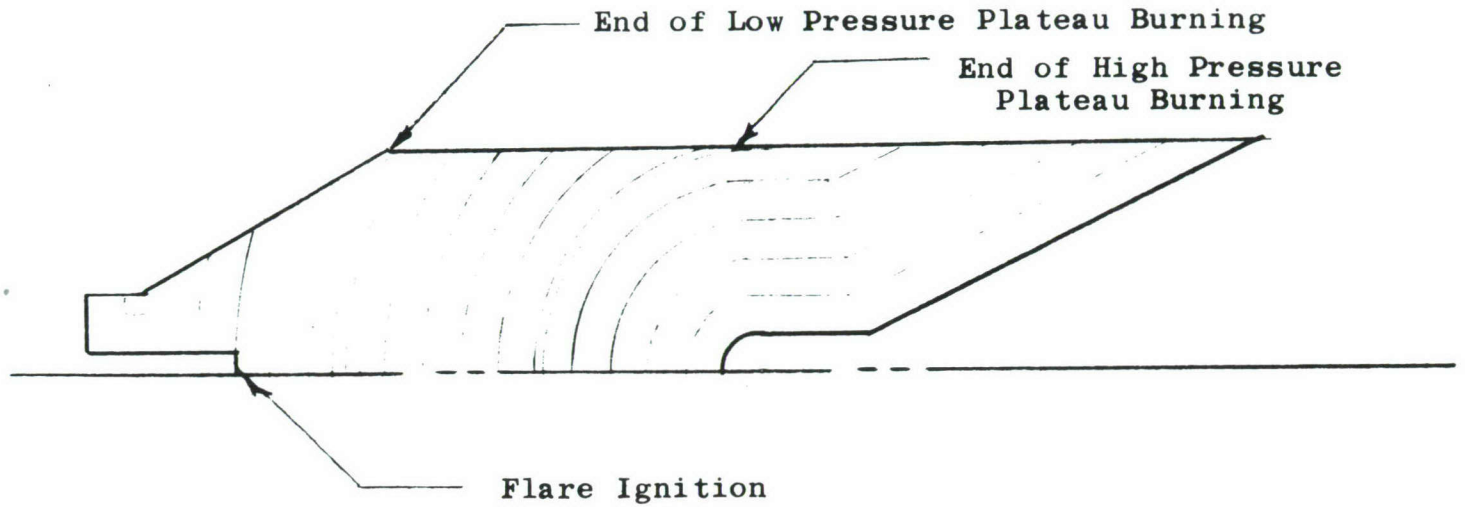


Figure 3. Propellant Grain Burn-Out Pattern

Table II

PREDICTION FOR BALLISTIC PERFORMANCE

RIPER PROPULSION SYSTEM

Burning Time Parameters[1]

Burning Time, sec	2.1
Average Pressure, psia	420
Maximum Pressure, psia	802
Average Thrust, lbf (Pa = 12.4)	13.2
Maximum Thrust, lbf (Pa = 12.4)	26.7
Delivered Impulse, lbf-sec (Pa = 12.4)	27.68
Delivered Specific Impulse, lbf-sec/lbm (pa = 12.4)	202.0
Propellant Expended, lbm	0.137
Distance Burned, in	1.048

Action Time Parameters[2]

Action Time, sec	9.47
Delivered Impulse, lbf-sec/lbm (Pa = 12.4)	28.7
Propellant Expended, lbm	0.149
Distance Burned, in	1.490

Nozzle Parameters

Throat Area, in^2	.0224
Throat Diameter, in	0.169
Exit Area, in^2	0.148
Exit Diameter, in	.434
Expansion Ratio	6.60

Theoretical Propellant Properties (1000 psia)

Chamber Temperature, ^oF	4513
Molecular Weight, g/mole	27.3
Effective Specific Heat Ratio	1.175
Characteristic Exhaust Velocity, ft/sec	4666
Theoretical Standard Specific Impulse, lbf-sec/lbm	233.6

[1]Burning time is defined beginning with fire switch closure and ending when the burning pattern progresses to the conical section of the case.

[2]Action time is defined beginning with fire switch closure and ending when the burning pattern progresses to the roof of the void area and initiates parachute deployment.

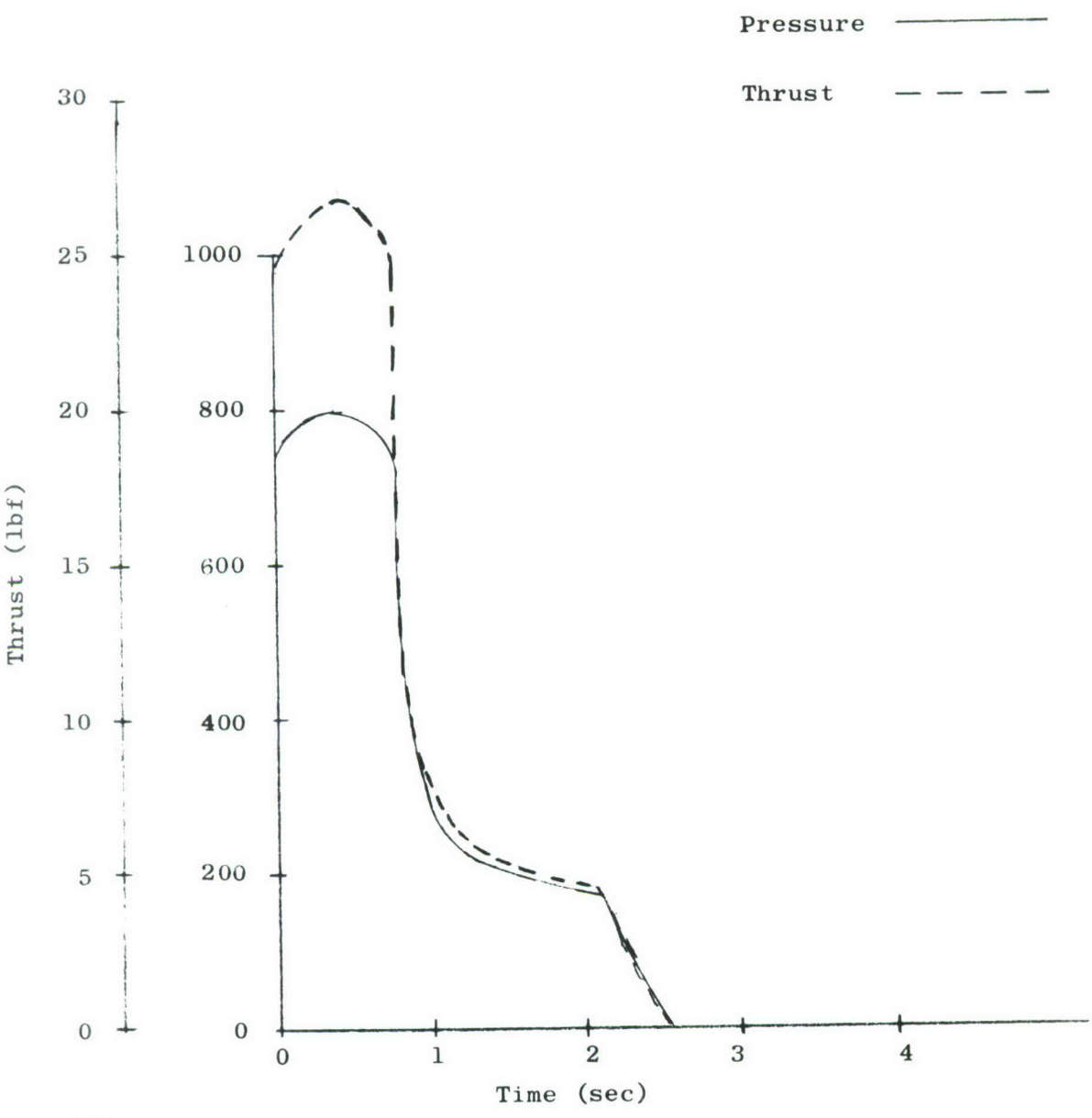


Figure 4. Predicted Motor Performance

predominantly in the region of the grain which would burn out in the first .8 second of firing. One casting, S/N 0031 had a small elongated void located at the end of the forward end hole which is used to control flare ignition delay.

The motors were conditioned at ambient temperature and tested on March 18, 1970. The results of those tests are summarized on Figure 5. The reproducibility of the pressure vs time performance and the noted burn time, pressure return to ambient time and the flare delay time indicate the consistency of these five motor tests. Motor S/N 0031 had a decreased flare ignition time resulting from a void in the extreme forward end of the motor. The average of the flare delay for the four motors was 7.3 with a range of $\pm$ .12 sec. The nominal thrust curve (Figure 5) for these motors is the result of extreme curve smoothing made necessary by thrust stand oscillation; however, evaluation of the data show that thrust requirements were met.

C. MOTOR ANALYSIS - PRESSURE CAST MOTORS

The second series of motors (25) were fabricated employing a pressure casting technique. The castings when examined by pre-test X-Ray showed considerably more and larger voids than those noted in the vacuum cast motors. The locations of the voids were also of greater concern because many were located in such a manner that would not only create pressure and thrust fluctuations, but would also decrease the designed ignition delay time. The motors were given a numerical ranking (1 to 25) based upon the void size and location and the estimated effect the void would have on flare

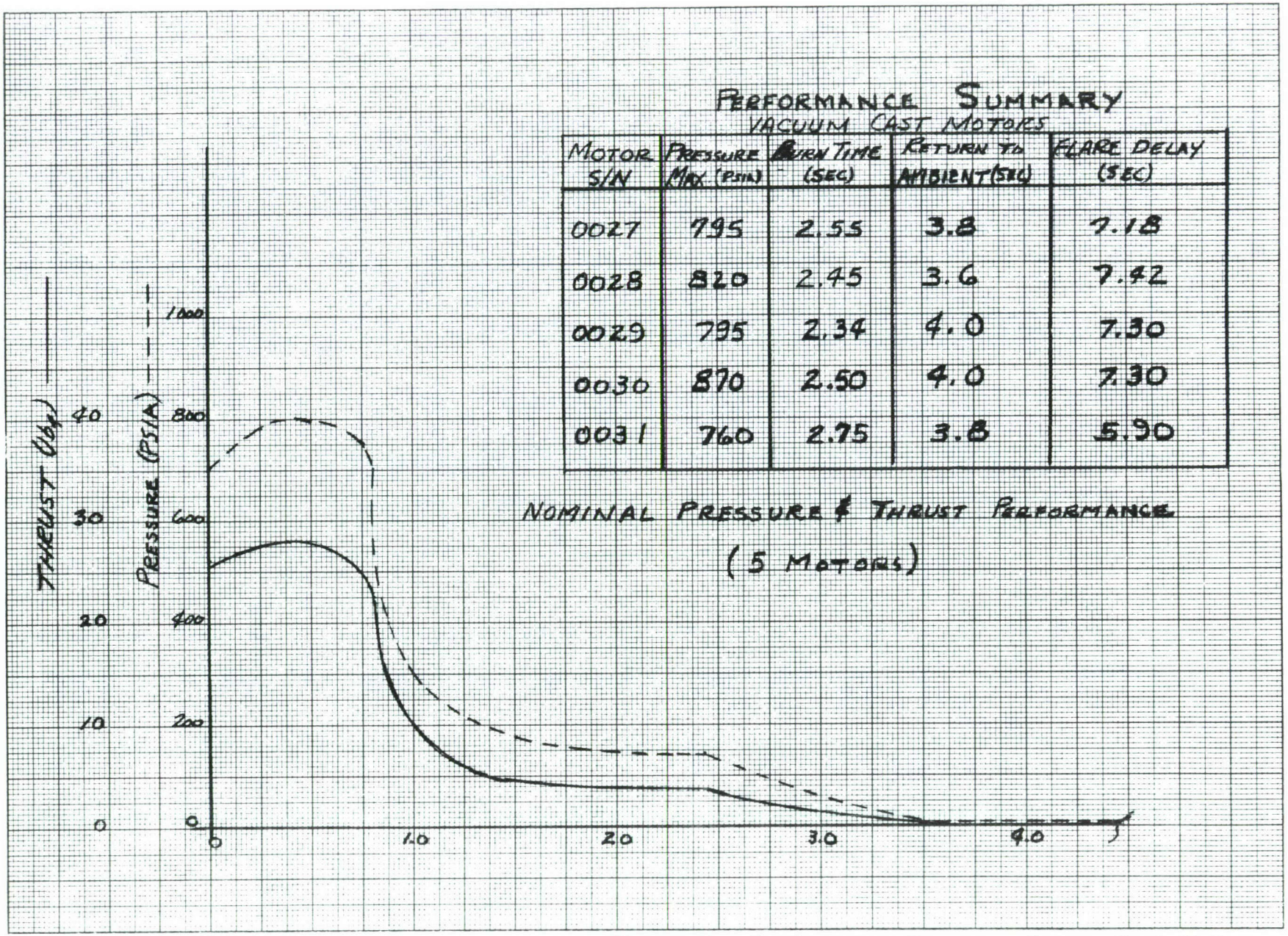


Figure 5 Performance Summary, Vacuum Cast Motors

ignition delay time. (Those motors with the smaller number having fewer and smaller voids which could have a direct effect on ignition delay time.)

The scheduled test matrix was established to evaluate the effect of temperature conditioning (-40, 78, 128°F) as well as the effect of voids and their location on flare ignition delay time. The motors were tested on April 29 and 30. The results of those tests are summarized in Table III and Figures 6 and 7. Because of the large number of voids and their size, it was anticipated that the pressure-thrust fluctuations would be greater than those experienced in the first series of five (5) motors. As noted in Table III, the maximum pressure variation for any given conditioning temperature is greater than that noted for the previous ambient conditioned tests. A nominal pressure curve for each of the test conditioning temperatures is shown in Figure 6. The curves represent an average of those units tested at each conditioning temperature. Extreme pressure excursions have been smoothed and the performance generalized. It can be noted from the curves that the temperature conditioning had an effect on the operation time above ambient pressure. However, as noted on Figure 7, the measured flare ignition time show a dispersion which has no temperature effect. The data of Figure 7 are replotted as Figure 8, with the data arranged in the order of the assigned pre-test ranking. Again, the data dispersion does not establish a temperature dependency because of the wide overall dispersion of the data. Statistical evaluation of

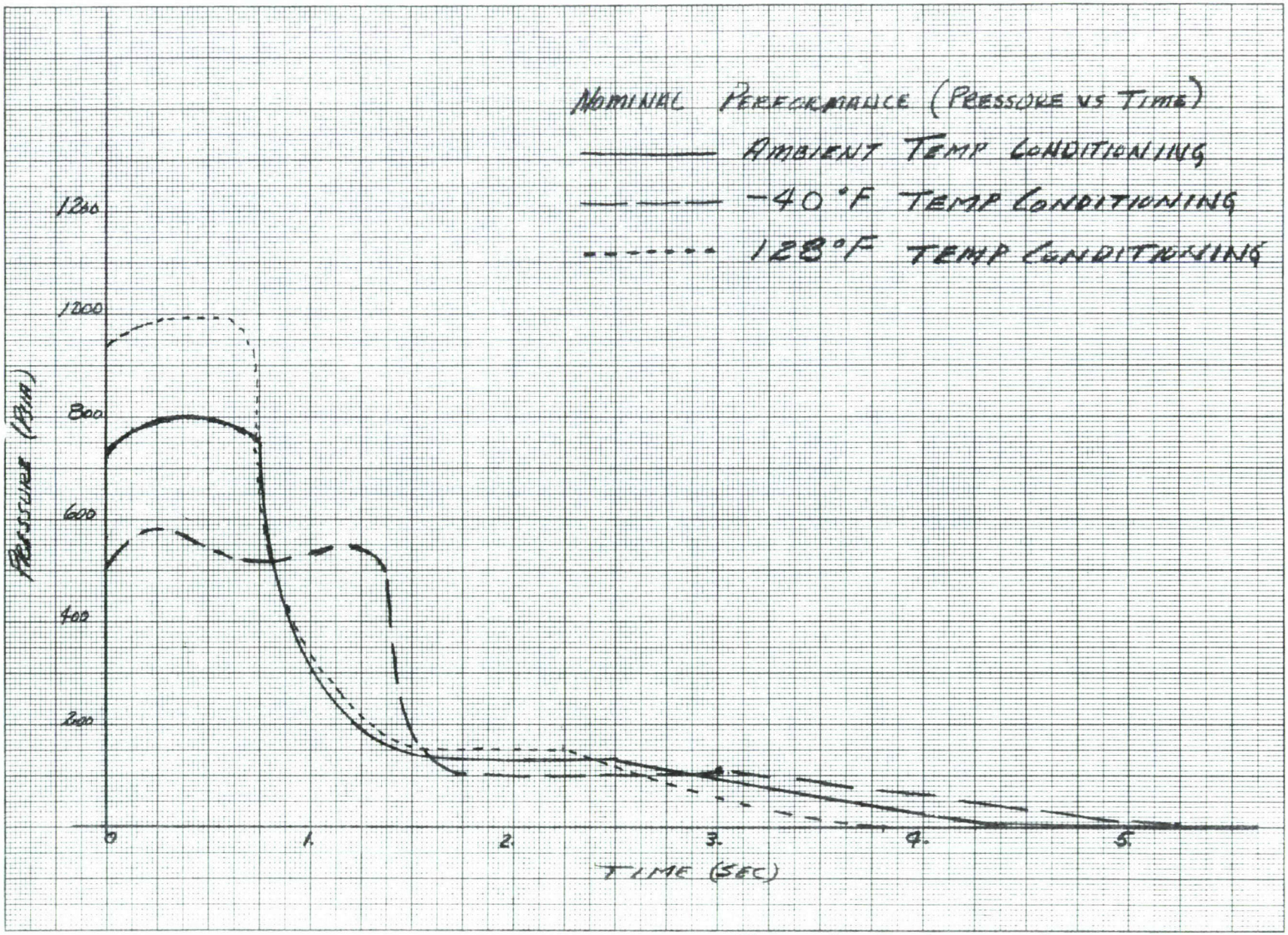


Figure 6. Performance Summary, Pressure Cast Motors

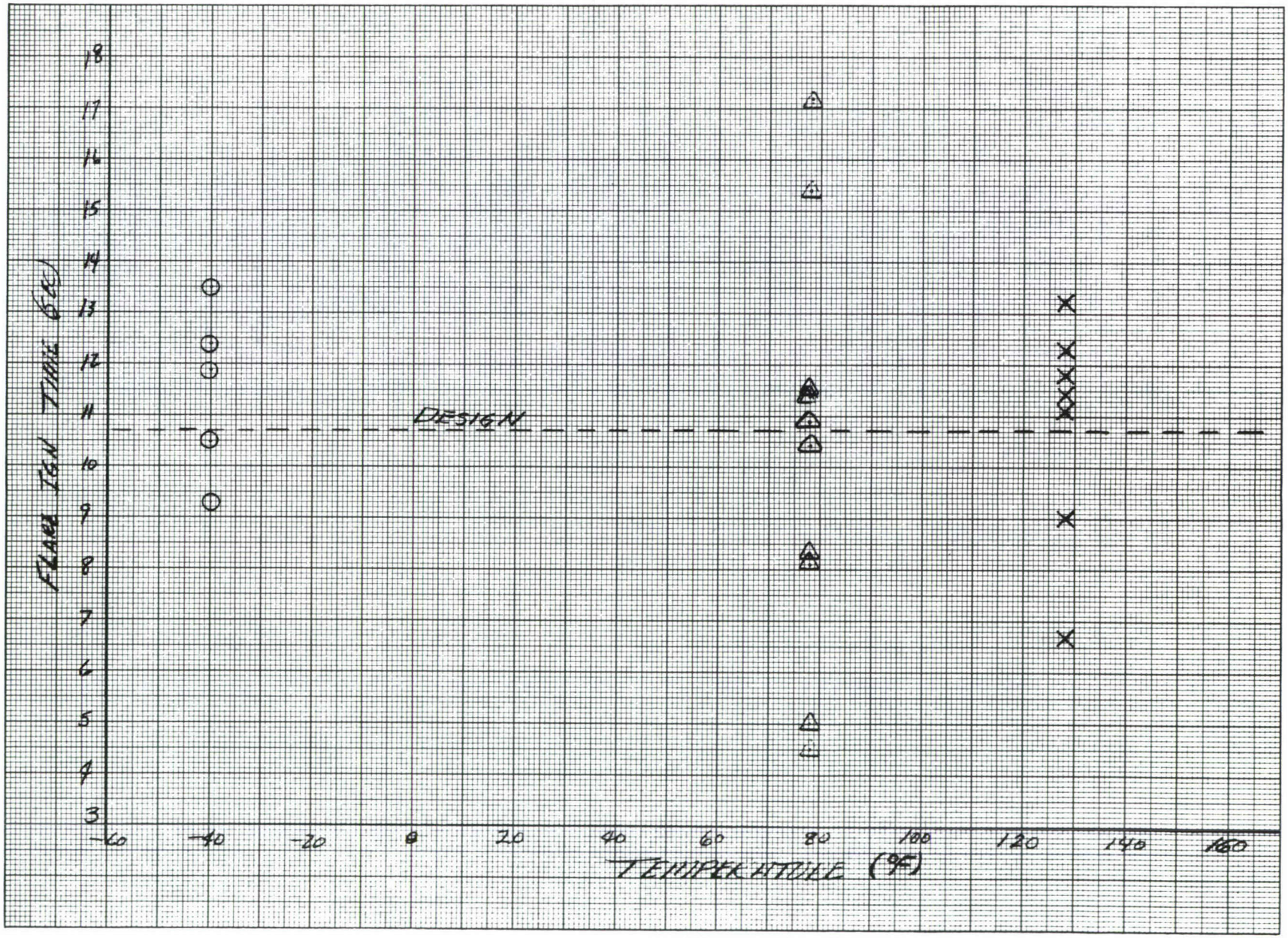


Figure 7. Effect of Motor Temperature on Delay Time

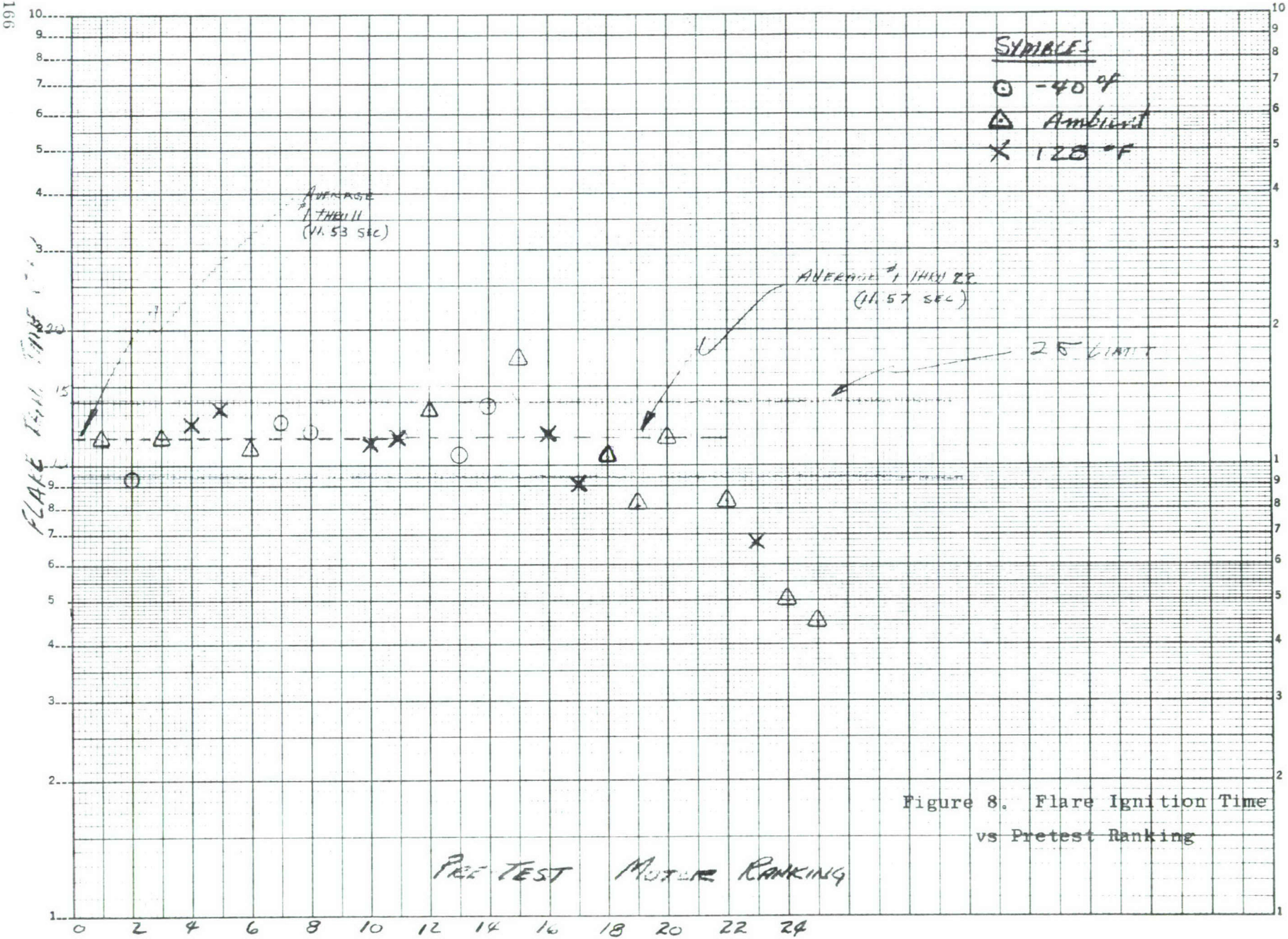


Figure 8. Flare Ignition Time vs Pretest Ranking

Table III

PERFORMANCE SUMMARY

Motor S/N	Pressure max (psia)	Burn Time (sec)	Return to Ambient (sec)	Flare Delay Time (sec) Conditioning -40	78	Temp °F 128	Ranking Pre-test Eval.
0024	900	2.3	4.5		°11.4		1
0025	660	**	4.0	°9.3			2
0002	790	2.6	4.3		°11.4		3
0011	**	2.2	4.0			12.3	4
0012	**	2.4	3.1			°13.2	5
0013	790	2.7	4.3		10.9		6
0015	850	3.0	5.5	°12.4			7
0017	520	3.3	6.2	°11.9			8
0016	*	*	*		*		9
0001	1000	2.1	4.0			°11.1	10
0003	870	2.3	3.9			11.4	11
0019	790	2.6	5.0		13.2		12
0018	680	2.5	3.6	10.5			13
0023	880	3.1	5.5	13.5			14
0022	760	2.6	4.0		°17.2		15
0008	900	2.1	4.0			11.8	16
0005	935	2.4	3.8			9.0	17
0021	1020	2.3	4.5		°10.45		18
0014	920	**	4.2		8.1		19
0010	730	2.7	5.0		°11.5		20
0004	Δ	Δ	Δ			Δ	21
0020	1500	**	4.0		8.3		22
0006	1090	1.7	3.8			6.7	23
0009	715	2.7	3.6		°5.0		24
0007	870	2.5	4.5		4.5		25

* Data Lost

** No Recorded Data

Δ Motor Case Failure

° Flare Delay Time Adjusted for Dimensional Variation (rate .048 in/sec)

the first 14 motors show an average ignition time of 11.5 sec with a 20% variation as the 2 sigma limit. This high variation results from the large number of voids and their location with the burning pattern. This is substantiated by the fact that the variation is considerably higher than that seen in the first series of five (5) tests in which the voids were known to have been less and to have been generally restricted to the area which would burn out in the first .8 second of burning time. The effectiveness of the pre-test void evaluation was demonstrated by the increased deviation from nominal of the higher ranked motors. The effect of temperature on the flare ignition time was not demonstrated by this series of tests.

The design ignition delay time was changed between the first series of five (5) motors and the second series of 25 motors. The "X" dimension of Figure I was changed from .301 to .138 inches. Based upon tests of open air ambient burning of the propellant, this should have accomplished a shift in delay time of 3.4 sec. Using the nominal times for the two series of tests, a 4.2 second shift in flare ignition was accomplished. This indicates an ambient pressure burning rate of .039 in/sec rather than the design value of .048 in/sec which was used. Although the flare ignition times varied considerably due to the propellant voids, the general shift to the longer delay times verifies the reduced ambient pressure burn rate.

Three motors (S/N 0011, 0012 and 0004) were tested in a modified test arrangement which did not measure pressure. This arrangement was designed to determine if the normal test setup,

in which pressure was measured, contributed to the structural capability of the motor case. Motor tests S/N 0011 and 0012 were tested successfully and a back calculation of the thrust measurement indicate a pressure of 950 and 1050 for these two motors. Motor test S/N 0004 failed the case at a calculated pressure of 1550 psi. Motor test S/N 0020, however, which was conducted in the normal test arrangement measured a pressure in excess of 1550 psi and did not fail the case. The mode of case failure in S/N 0004 was due to axial strain along with the stress concentrations developed at the base of the threaded portion of the case. The removal of the restraining influence of the pressure measuring equipment allowed flexure of the case wall at the base of the case threads and resulted in case failure.

D. DESIGN AND PERFORMANCE OF DESIGN FOR PHASE II.

The propellant grain as shown in Figure 2 will be used for Phase II with a delay cavity dimension (dimension X of Figure 2) of .250 inches. The predicted thrust is shown in Table IV. Trajectory plots based on the predicted thrust are shown as Figures 9, 10 and 11. A launch angle of $52\frac{1}{2}^{o}$ has been selected in order to achieve the desired range of 600 meters at an altitude of 800 feet. The flare ignition delay time will be 9.7 seconds and the velocity at flare ignition will be 206 feet per second.

FORM TC NO. 2074 PART III

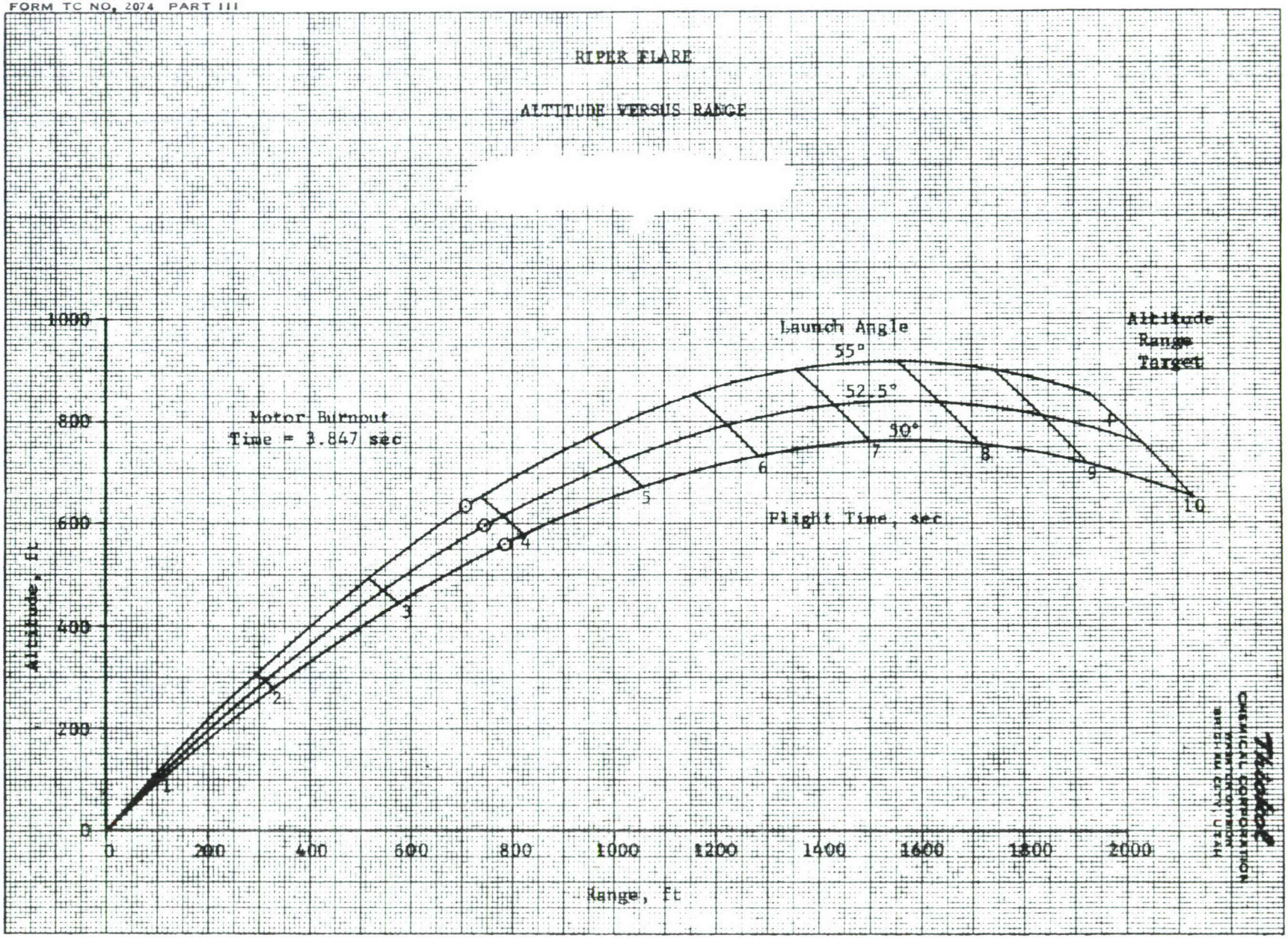


Figure 9. Phase II Design, Range vs Altitude

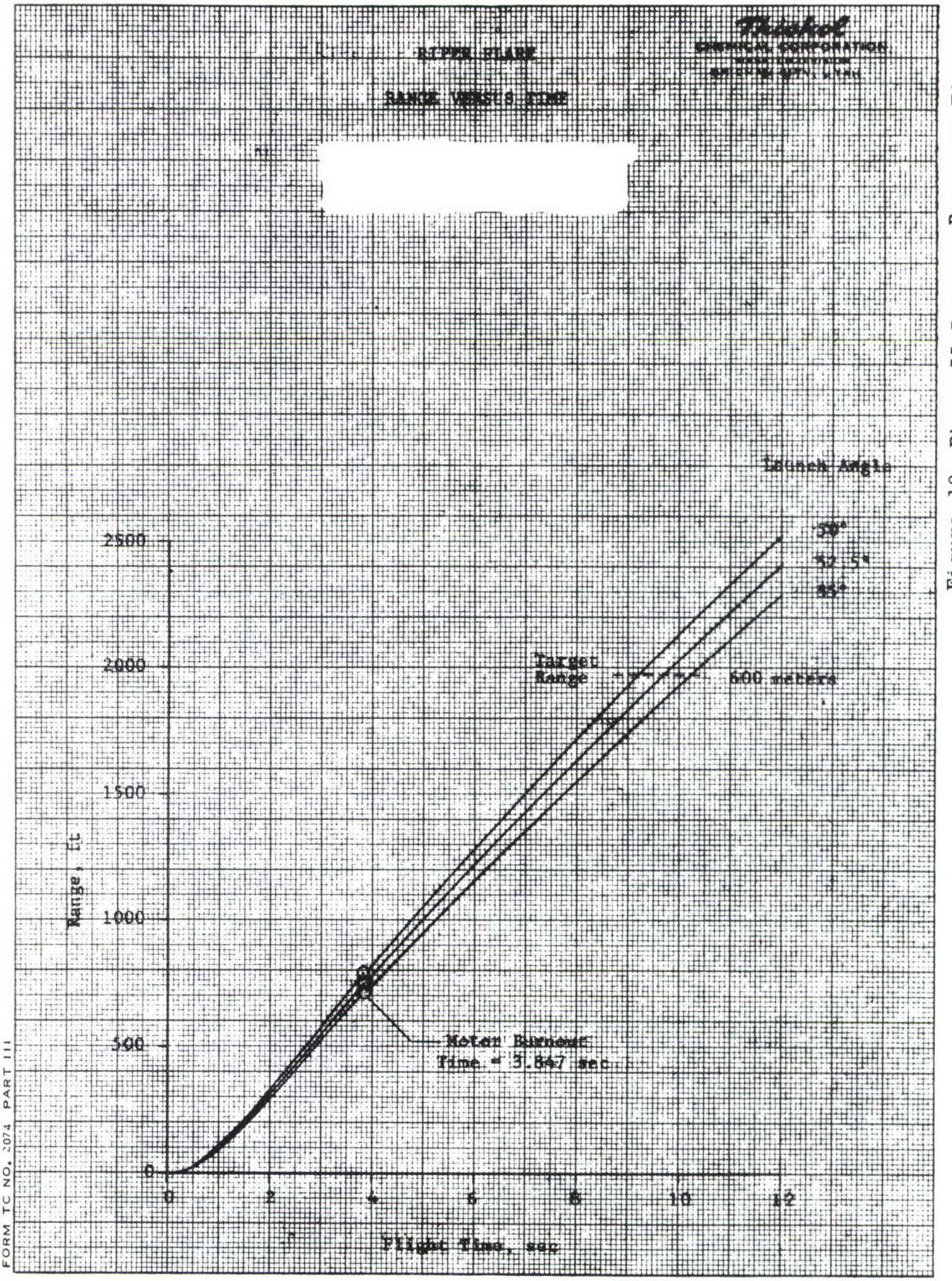


Figure 10. Phase II Design, Range vs Time

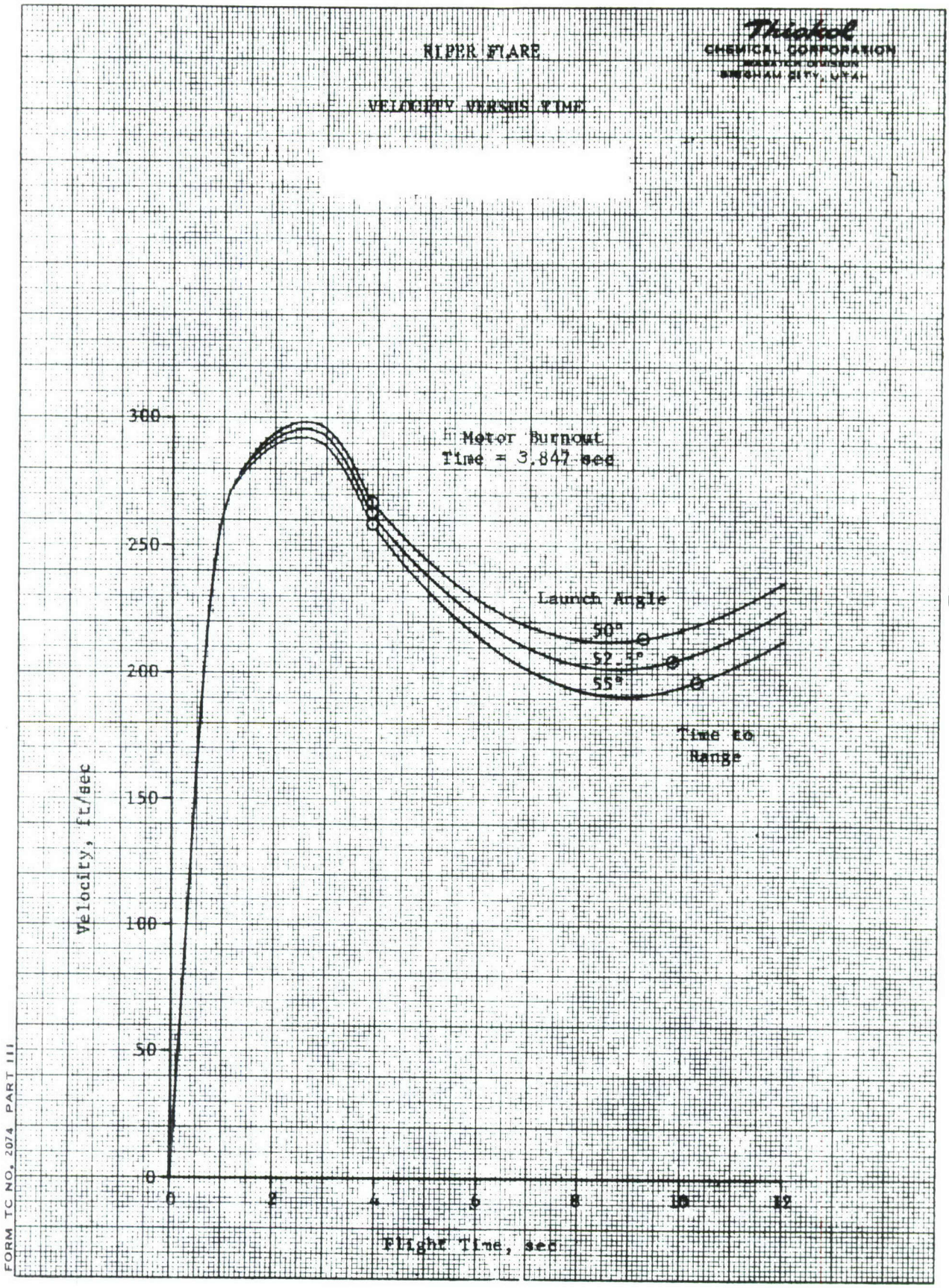


Figure 11. Phase II Design, Velocity vs Time

TABLE IV

RIPER FLARE

Motor Characteristics

Time	Thrust
0.0	0.0
0.05	27.06
0.1	26.37
0.2	25.35
0.3	24.92
0.4	24.24
0.5	23.21
0.6	22.36
0.7	20.65
0.8	18.09
0.9	9.55
1.0	7.42
1.1	6.14
1.2	5.03
1.3	4.60
1.4	4.17
1.5	4.00
1.6	4.00
1.7	3.75
1.8	3.57
1.9	3.32
2.0	3.15
2.5	2.46
3.0	1.27
3.847	0.0

Atmosphere Pressure (Utah Standard)

$P_a = 1794.1$

Delivered Impulse

$I_T = 27.68$ lb-sec

Delivered Specific Impulse

$I_{SP} = 178.58$ sec

Propellant Weight

$W_P = 0.155$ lb

Vehicle Burn Out Weight

(includes empty motor case)

$W_{BO} = 2.1753$ lb

SECTION VII

FLARE CANDLE TESTS

Fifty flare candles were fabricated and tested for burn time and light output. Forty candles were tested in the light tunnel and ten were tested on the tower. Table V contains detailed manufacturing and test data for these candles.

Four of the candles tested in the tunnel burned out in short times indicating defects in manufacturing such as torn paper liners. The average light output of the remaining 36 candles was 267,000 cd with an average burn time of 63.6 seconds.

The ten candles tested on the light tower averaged longer burn time and lower output. Average burn time was 65.2 seconds and average light output was 178,000 cd.

TABLE V

RIPER 1-3/8" Candle Manufacturing and Test Data

Candle No.	Tube and Paper Wt. (gms)	Tube + 1st liner coat (gms)	1st liner coat (gms)	Tube + 2nd liner coat (gms)	2nd liner coat (gms)	Loaded Case Wt. (gms)	Illuminant Wt. (gms)	Illuminant Length in	Illuminant Length cm	gm/cm^3	t_b sec.	r_b in/sec.	Cd x 10^{-3}	Eff. x 10^{-3} Cd-sec./gm	Test Facility Comments
R-01-1	33.0	36.1	3.1	39.8	3.7	313.0	273.2	7.120	18.08	1.730	64.0	.111	170	40.0	I-10 Tower
R-01-2	33.0	36.2	3.2	39.3	3.1	319.2	279.9	7.37	18.72	1.712	67.0	.110	162	38.8	"
R-01-3	33.0	36.1	3.1	39.3	3.2	314.7	275.4	7.16	18.19	1.734	67.0	.107	162	39.5	"
R-01-4	32.9	36.2	3.3	39.6	3.4	313.2	273.6	7.12	18.08	1.733	64.0	.111	182	42.5	"
R-01-5	32.9	36.4	3.5	40.1	3.7	343.4	303.3	7.75	19.69	1.764	70.0	.110	194	44.9	"
R-01-6	32.9	36.4	3.5	39.7	3.3	314.2	274.5	7.16	18.19	1.728	62.0	.115	183	41.5	"
R-01-7	33.0	36.4	3.4	39.9	3.5	308.7	268.8	7.020	17.83	1.726	64.0	.110	190	45.3	"
R-01-8	32.9	36.8	3.9	40.0	3.2	313.7	273.7	7.15	18.16	1.726	67.0	.107	178	43.7	"
R-01-9	32.9	36.3	3.4	39.4	3.1	310.9	271.5	7.06	17.93	1.734	63.0	.113	184	42.3	"
R-01-10	32.9	36.7	3.8	40.0	3.3	309.1	269.1	7.020	17.83	1.728	64.0	.091	175	41.7	"
7" Candles															
R-01-11	29.6	32.5	2.9	35.5	3.0	305.8	270.3	$7\frac{1}{32}$	17.86	1.733	63.6	.111	270	63.6	I-10 Tunnel
R-01-12	29.7	32.6	2.9	35.7	3.1	306.3	270.6	7.05	17.91	1.730	65.9	.107	270	65.1	"
R-01-13	29.6	32.5	2.9	35.6	3.1	307.0	271.4	$7\frac{1}{32}$	17.86	1.740	61.6	.114	279	62.8	"
R-01-14	29.8	32.9	2.9	36.1	3.2	306.4	270.3	$7\frac{1}{32}$	17.86	1.733	63.0	.112	268	62.6	"
R-01-15	29.7	32.5	2.8	35.7	3.2	307.2	271.5	7.030	17.86	1.741	67.5	.104	261	64.6	"
R-01-16	29.6	32.4	2.8	35.4	3.2	307.2	271.2	$7\frac{3}{32}$	17.93	1.734	63.0	.112	255	59.2	"
R-01-17	29.7	32.5	2.8	35.6	3.1	307.2	271.4	7.03	17.86	1.740	67.0	.105	261	64.4	"

* Tube Plus Insulation Paper

TABLE V (Cont)

RIPER 1-3/8" Candle Manufacturing and Test Data

Candle No.	Tube and Paper Wt (gms)	Tube + 1st liner coat (gms)	1st liner coat (gms)	Tube + 2nd liner coat (gms)	2nd liner coat (gms)	Loaded Case Wt. (gms)	Illuminant Wt. (gms)	Illuminant Length in	Illuminant Length cm	gm/cm^3	t_b sec.	r_b in/sec.	Cd x 10^{-3}	Eff. x 10^{-3} Cd-sec./gm	Test Facility Comments
R-01-18	29.7	32.5	2.8	35.8	3.3	307.8	272.0	7.0	17.78	1.752	64.0	.109	267	62.7	I-10 Tunnel
R-01-19	29.6	32.8	3.2	35.8	3.0	306.2	270.4	7.0	17.78	1.742	66.2	.106	257	62.9	"
R-01-20	29.6	32.5	2.9	35.7	3.2	307.2	271.5	7 1/16	17.93	1.734	63.6	.111	276	64.8	"
R-01-21	29.7	32.8	3.1	36.1	3.3	308.9	272.8	7 3/32	18.01	1.735	63.0	.112	264	60.8	"
R-01-22	29.7	32.4	2.7	35.2	2.8	308.4	273.2	7 1/32	17.86	1.752	66.2	.106	257	62.5	"
R-01-23	29.7	32.8	3.1	35.6	2.8	304.0	268.4	7 1/32	17.86	1.721	64.7	.109	260	62.7	"
R-01-24	29.7	32.6	2.9	35.4	2.8	308.4	273.0	7 1/32	17.86	1.750	65.2	.108	265	63.4	"
R-01-25	29.8	32.8	3.0	35.7	2.9	306.4	270.7	7 1/32	17.86	1.736	65.1	.108	268	64.4	"
R-01-26	29.7	32.6	2.9	35.7	3.1	309.3	273.6	7 1/16	17.93	1.743	67.8	.104	260	64.4	"
R-01-27	29.6	32.6	3.0	36.1	3.5	306.1	270.0	6.950	17.65	1.752	66.3	.105	270	66.3	"
R-01-28	29.5	32.4	2.9	35.2	2.8	305.6	270.4	6 15/16	17.63	1.756	46.1	.151	227	38.8	fell apart "
R-01-29	30.0	32.7	2.7	35.8	3.1	306.6	270.8	7.025	17.84	1.738	65.5	.107	272	65.7	"
R-01-30	29.7	33.0	3.3	36.0	3.0	306.2	270.2	7.0	17.78	1.740	66.3	.106	258	63.2	"
R-01-31	29.6	33.0	3.4	36.0	3.0	306.8	270.8	7.06	17.93	1.725	65.0	.108	265	63.5	"
R-01-32	30.0	32.7	2.7	35.5	2.8	312.5	277.0	7 1/32	17.86	1.776	66.7	.105	284	68.4	"
R-01-33	29.6	32.7	3.1	35.8	3.1	307.5	271.7	7 1/16	17.93	1.731	65.9	.107	253	61.7	"
R-01-34	29.6	32.3	2.7	35.1	2.8	298.1	263.0	6 13/16	17.32	1.739	59.4	.116	268	60.5	"
R-01-35	29.6	33.4	2.8	36.6	3.2	308.8	272.2	7 1/16	17.93	1.734	67.4	.105	265	65.7	"
R-01-36	29.6	32.6	3.0	35.5	2.9	305.2	269.7	7.0	17.78	1.737	61.0	.115	283	63.8	"

TABLE V (Cont)

RIPER 1-3/8" Candle Manufacturing and Test Data

Candle No.	Tube and Paper Wt. (gms)	Tube + 1st liner coat (gms)	1st liner coat (gms)	Tube + 2nd liner coat (gms)	2nd liner coat (gms)	Loaded Case Wt. (gms)	Illuminant Wt. (gms)	Illuminant Length in	Illuminant Length cm	gm/cm^3	t_b sec.	r_b in/sec.	Cd x 10^{-3}	Eff. x 10^{-3} Cd-sec./gm	Test Facility Comments
R-01-37	29.7	32.7	3.0	35.9	3.2	306.8	270.9	7.0	17.78	1.745	62.4	.112	265	61.2	I-10 Tunnel
R-01-38	29.7	32.5	2.8	35.2	2.7	306.8	271.6	$7\frac{1}{32}$	17.86	1.741	63.5	.111	276	64.4	"
R-01-39	30.0	32.7	2.7	35.8	3.1	308.2	272.4	$7\frac{1}{32}$	17.86	1.747	49.8	.141	275	50.3	"
R-01-40	29.8	32.6	2.8	35.5	2.9	307.5	272.0	7.07	17.96	1.734	65.2	.108	279	66.8	"
R-01-41	29.7	32.9	3.2	36.2	3.3	308.5	272.2	7.06	17.86	1.745	64.2	.110	274	64.6	"
R-01-42	29.6	32.7	3.1	35.7	3.0	308.4	272.7	7.080	17.98	1.737	43.0	.165	368	58.0	"
R-01-43	29.6	32.5	2.9	35.6	3.1	305.2	269.6	$6\frac{31}{32}$	17.70	1.745	62.5	.111	277	64.2	"
R-01-44	29.5	32.8	3.3	35.6	2.8	305.9	270.3	7.02	17.83	1.736	66.3	.106	262	64.2	"
R-01-45	29.7	32.6	2.9	35.6	3.0	306.5	270.9	$7\frac{1}{16}$	17.93	1.730	65.2	.108	270	65.1	"
R-01-46	29.6	32.8	3.2	35.8	3.0	307.0	271.2	$6\frac{15}{16}$	17.63	1.762	62.9	.105	271	62.9	"
R-01-47	29.7	32.6	2.9	35.6	3.0	307.1	271.5	$7\frac{1}{16}$	17.93	1.734	47.0	.150	338	58.6	"
R-01-48	29.7	32.5	2.8	35.7	3.2	306.8	271.1	$7\frac{1}{32}$	17.86	1.738	64.0	.110	271	64.0	"
R-01-49	29.7	32.7	3.0	35.9	3.2	307.3	271.4	7.04	17.88	1.738	65.5	.107	259	62.6	"
R-01-50	29.7	32.4	2.7	35.4	3.0	306.4	271.0	7.03	17.86	1.738	66.1	.106	255	62.2	"

Blank

APPENDIX B

SUMMARY OF PHASE II FLIGHT TESTS

The data gathered during the flight tests of Phase II are compiled on the charts attached as Table I.

All time data were measured using stop watches. The time listed as delay time is the measured time between the fire signal and first observed candle light. The accuracy of this measurement is approximately $\pm$ 1.0 seconds due to the difficulty in visually following the projectile and therefore some time is lost between actual first light and observed first light. Candle burn time is of about the same accuracy for the same reason.

Range and altitude data were measured using two hand operated theodolites. Accuracy of the measurements are approximately $\pm$ 100 feet because of the difficulty in visually following the projectile. Operator error also sometimes occurs in reading and recording the azimuth and elevation angles.

Projectile muzzle velocity was measured by use of high speed movie cameras (approximately 500 frames per second). Data were reduced by counting the number of frames between when the projectile nose is observed and when the fins clear the tube. Velocities are, therefore, average velocities during which the projectile moved through a distance equal to its own length.

Some of the problems encountered during the flight test program were:

1. Launch tube - fin friction.
2. Parachute to candle cable breakage.
3. Flare end plate (bulkhead) failure.
4. Projectile body to motor case joint failure.
5. Parachute deployment and projectile--parachute collision.
6. Parachute shroud line pull-out.
7. Wide dispersion of range and altitude at deployment.

1. Launch tube-fin friction. As soon as components were received on Phase II, launch tube friction tests were conducted in an attempt to evaluate the launch tube to projectile interface. The original 1 3/4 inch O.D. launch tube with the .008 inch thick fin assembly showed approximately 80 pounds friction force. This force exceeded rocket motor maximum thrust and was not acceptable. The .008 fin was tested in a 1 7/8 inch O.D. tube and forces of 30 pounds were measured. One test of this configuration was attempted (Test No. 1) but the projectile failed to clear the launch tube due to the high friction. Fins of a .006 thickness were fabricated and tested with the 1 7/8 inch O.D. tube where friction forces of 15 pounds were measured. Three successive launches from the same launch tube were attempted (Tests 4, 5, & 6). Test 4 was satisfactory, Test 5 was very slow coming out of the tube and Test 6 did not clear the tube.

A modification which removed the fin stub and added Teflon tape

to the fin edges reduced the friction force to under 5 pounds and is not apparently affected by repeated launches from the same tube. This configuration is satisfactory for launch from the 2" O.D. open tube.

2. Parachute to candle cable breakage and

3. Flare end plate (bulkhead) failure.

The Phase II baseline design called for 1/32 diameter stainless steel cable with a breaking strength of 110 lbs., a bulkhead with a breaking strength of 200 lbs., and a parachute opening shock load of 100 pounds maximum. The first two flight tests (Test No. 2 and 3) indicated that opening shock loads were exceeding the 100 lbs. because the cable broke on both tests. The cable strength was doubled for the next tests by using an .045 diameter nylon coated cable with breaking strength of 225 lbs. One cable of this configuration broke in flight test and one bulkhead failed.

An .051 diameter shock absorbing stainless steel cable was next tested and has been used on all successive tests and has never experienced a failure.

The bulkhead experienced several failures and near failures throughout the test series. A new design was prepared and is shown in the final drawing package. This new design has been tested in 12 tests and performs satisfactorily.

4. Projectile body to motor case joint failure. The bonded joint between the motor case and projectile body failed upon candle ignition on two tests (No. 19 and 21). To preclude this type of failure in subsequent

tests, four steel pins were added to the joint. This design change is also advantageous in the assembly sequence as it eliminates the necessity of holding the unit in a jig while the bonding material curves.

5. Parachute deployment and projectile-parachute collision. Several problems were encountered in parachute deployment during the flight test program. The first deployment system used a split cardboard tube to contain the parachute. As the ejection wafer ignited and pressurized the candle compartment, the parachute was also pressurized. When the nose cone separated from the projectile body, the pressure trapped in the parachute pack caused the parachute to blossom immediately, making it subject to being hit by the fins as the projectile body separated and overtook the deployed chute. An intermediate design employed an "O" ring around the flare candle at the bulkhead, a solid cardboard tube which was bonded to the candle case and a light breakline from the parachute apex to the nose cone. This configuration worked well on a number of tests (Test No. 21 thru 47) but failure of the breakline occurred on Tests No. 48 and 50. A heavier breakline was added but this resulted in the nose cone being retained in some tests, collapsing the parachute.

6. The final design retains the "O" ring around the candle, uses a solid tube to contain the parachute but the tube is not bonded to the candle. A line is attached from the nose cone to the deployment tube so that the nose cone pulls the deployment tube off the parachute and allows it to deploy. This method has proved successful and is shown on the design drawings.

7. Parachute shroud line pullout. In some tests, the parachute center shroud line tore away from the apex of the chute. Also a few of the edge shroud lines pulled out of the chute material. A reinforcement tape was added in the center of the chute to which the shroud line is sewn and the overlap distance of the edge shroud lines was increased. No further problems have been observed in this area.

8. Wide dispersion in range and altitude at candle deployment. A considerable spread in deployment range and altitude has been recorded during Phase II testing. Two major causes have been identified: 1. Thrust and projectile misalignment and, 2. Fin flutter. Satisfactory thrust alignment has been achieved by molding the nozzle insert in place with tooling designed to hold the insert in alignment. Projectile alignment has been improved by selecting straight projectile bodies and by using an alignment fixture when assembling the motor to the projectile body. Significant improvement has been the result of these changes. However, dispersion is still a problem.

High speed movies taken close to the muzzle of the launch tube show the flutter of the fins as they unfold leaving the launch tube. When flight path deviations occur, they always occur in approximately the first one hundred feet of flight. As the fins become steady and the projectile velocity increases, the flight path, which has been established in the initial hundred feet, is maintained and flight is very stable.

The solution to this problem is not simple but involves the fin and launch tube interface. Stiffer fins produce better results. However,

stiffer fins produce higher friction forces inside the launch tube. These higher friction forces can be overcome by increasing initial thrust. Increased thrust can be achieved in two ways: 1. Motor redesign and, 2. Closed tube launch.

A limited number of tests using stiff fins and the closed breech launch tube yielded very promising results. Muzzle velocities were comparable to similar tests with thin fins and range and altitude dispersions were reduced.

RECOMMENDATIONS

1. The design shown on the enclosed drawing package should be approved for Phase III fabrication and testing.

2. The closed tube launch concept should be adopted and incorporated into the Phase III testing.

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13. ABSTRACT

The RIPER program reported herein consisted of the development, flight testing, and environmental testing of the RIPER projectile and launcher. This report discusses the design details and fabrication of the component parts, the environmental exposures, and test results.

Three hundred and fifty projectiles and five launchers were fabricated and tested. Projectiles and launchers were exposed to environments including: (1) transportation vibration, (2) high temperature, (3) low temperature, (4) humidity, (5) salt fog, (6) five foot drop, (7) forty foot drop, and (8) shock.

An overall success ratio of 81 percent was demonstrated. The units exposed to humidity and five foot drop tests exhibited the highest failure rates. With relatively minor changes which improve the projectile seals and give the launch tube better impact resistance, a reliability above 90 percent can be achieved.

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