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FINAL REPORT

DEVELOPMENT OF THE TX346-1 INITIATOR AND QUALIFICATION TESTING OF TX346 AND TX346-1 INITIATORS

(Contract NAS8-5448 --- Project 408)

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HUNTSVILLE DIVISION
HUNTSVILLE, ALABAMA

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Huntsville Division
Huntsville, Alabama

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DEVELOPMENT OF THE TX346-1 INITIATOR AND QUALIFICATION TESTING OF TX346 AND TX346-1 INITIATORS

(Contract NAS8-5448--Project 408)

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SUMMARY

This report describes the successful development of an exploding bridgewire initiator to match the ordnance output of the NASA-MSFC furnished AGX2008 initiator. Further, the new initiator, designated the TX346-1, was required to meet the electrical safety, environmental, functional, and physical requirements of NASA-MSFC specification S-1-PS(A). This initiator is intended for use in the ignition system of the motor employed on the Saturn S-I stage for retro control. This report also describes the qualification testing of this initiator and the previously developed TX346 initiator.

Basically, a pyrotechnic charge was developed to yield the desired performance, when contained within the fixed envelope dimensions of the initiator body, as dictated by NASA-MSFC. This necessitated pyrotechnic formulation research and development directed towards a specific pressure-time profile, a specific minimum calorific output, and a specific flame pattern. These parameters comprise the ordnance output. The limits of these parameters were established by testing AGX2008 initiators using the same equipment and techniques to be utilized in the development program in conjunction with the specifications supplied by NASA-MSFC.

The spark gap and "stand-off" concepts were incorporated in the initiator to prevent inadvertent initiation by spurious electrical signals. The spark gap prevents current flow in the bridgewire circuit below its voltage breakdown level, thereby giving assurance that neither safety nor functional capability is compromised by direct application of power sources such as 250 volts, alternating current. Furthermore, the TX346-1 initiator was found to be safe and have functional capability after individual or sequential exposure to electrostatic discharge, alternating current, direct current, high temperature (250°F), low temperature (-65°F) and other extreme conditions within the limits of the NASA requirement. The "stand-off" concept involves the isolation of the bridgewire from the main pyrotechnic charges by imposing a small air gap between the pyrotechnic charges and the bridgewire. The charges are supported by a thin metal diaphragm. The "stand-off" concept precludes inadvertent firing from high electrostatic energy discharges into the bridgewire or case-to-connector pins, as well as when the bridgewire is electrically heated to incandescence or to its fusion temperature. The above concepts are the same as those utilized in the TX346 initiator.

Three-hundred and twenty-one each of the TX346-1 and TX346 initiators were subjected to the same qualification program phases, simultaneously (see Appendix A for Program Plan). All of the TX346 initiators passed the qualification tests. All but six TX346-1 initiators passed. The latter failed to function, after certain exposures, on application of the firing pulse. A failure analysis report on the six units is included as Appendix B.

FINAL REPORT

DEVELOPMENT OF THE TX346-1 INITIATOR AND QUALIFICATION

TESTING OF TX346 AND TX346-1 INITIATORS

INTRODUCTION

Thiokol Chemical Corporation, Huntsville Division, under contract to NASA-MSFC (ORD 1274 Mods. 1, 2, 3, and 4), developed and qualified a solid propellant rocket motor, designated TX280, for use as the ullage motor of the Saturn I S-IV stage. The ignition system for this motor consists of a perforated, fiberglass tube filled with boron-potassium nitrate igniter pellets and removable exploding bridgewire initiators.

Initial igniter development was performed with an initiator furnished by NASA-MSFC. The pressure output of this initiator, however, was too high, resulting in rupture of the igniter tubes. Development was continued and qualification completed using the Thiokol TX255 (XM6) exploding bridgewire squib, even though this squib did not meet all of NASA's safety requirements.[1,2] Concurrent with the motor qualification, Thiokol was requested, under ORD 1274, Mod. 3, to modify and improve the XM6 design to meet the requirements of NASA specification S-1-PS(A). Subsequent to development of the improved design, designated the TX346, spark gap type initiator[3], NASA-MSFC funded the qualification of this initiator as well as the development and qualification of another initiator, designated the TX346-1. The latter is intended for use in the ignition system of the retro motor for the Saturn S-I stage. The two initiators differ only in internal volume for main charge as well as weight and composition of this charge. Plans to use the same initiator for both the ullage and retro

[1] Exploding Bridgewire Initiator Development, Samuel Zeman, Thiokol Chemical Corporation, Huntsville Alabama, Report Number 5-62, 9 February 1962.

[2] Development of Exploding Bridgewire Igniter for M5 JATO Motor, G. E. Webb, Thiokol Chemical Corporation, Huntsville, Alabama, Report Number 6-62, 7 February 1962.

[3] Initiator-Igniter Compatibility Testing for the TX280 Rocket Motor and Development of the TX346 Initiator, Thiokol Chemical Corporation, Huntsville Division, Huntsville, Alabama, Report Number 81-63, 30 December 1963.

motors proved unfeasible when it was determined that a greater initiator ordnance output was required for the ignition system of the retro motor than for the ullage motor. The TX346-1 initiator was required to match three major parameters as exhibited by the Aerojet AGX2008 initiator; namely, pressure versus time in a 22 cm.^{3} closed volume, calorific output, and flame pattern. Subsequent to successful matching of these parameters via design demonstration or configuration tests, a lot of each type of initiator was fabricated for exposure to the various environmental, safety, and functioning conditions per NASA specification S-1-PS(A).

This report consists of two major sections. The first deals with the TX346-1 development and the qualification program. The second portion contains the appendices which relate the details of the qualification program relative to plan, data, instrumentation, failure analysis, etc.

TX346-1 INITIATOR DEVELOPMENT

Technical Description

No major hardware modification was involved in the TX346 initiator body to make it compatible with the TX346-1 design. The metal retainer and one plastic spacer were changed to permit more vent area and internal volume, respectively. A discussion of these modifications follows.

Retainer Design

Initial testing of the TX346-1 initiator with the TX346 retainer resulted in some retainers being expelled from the body. Further testing revealed that the larger and faster burning charge of the TX346-1 compared to the TX346 required more vent area in order to avoid excessive pressure drop across the retainer. Abnormally high pressure drop over-stressed the crimp lip and caused the retainer to be expelled. Enlarging the inside diameter of the retainer, however, proved to be an adequate solution to this problem.

Spacer Configuration

In order to achieve maximum volume in the main charge cavity of the TX346-1 initiator, the spacer common to that cavity in the TX346 initiator was significantly reduced in volume without sacrificing its functional integrity. A large cavity volume was necessary to attain the charge weight needed to generate sufficient pressure and heat for ordnance output matching.

The connector configuration, spark gap, bridgewire, etc., remained unchanged. A cross-section of the TX346-1 initiator is shown on Figure 1. The TX346-1 is hermetically sealed and contains the spark gap internally. The body is a gold plated, threaded metal shell. The contact pins are insulated from the body with a glass insert which is fused to the pins and the internal diameter of the shell. The unit is designed to function with a 2000-volt short duration pulse from either a 0.75 or 1.0 microfarad capacitor discharged through a low impedance transmission cable. The ordnance output of this unit is capable of igniting boron-potassium nitrate or "Alclo" pellets over a wide range of temperature and pressure.

Technical Requirements

Physical

The external dimensions of the TX346-1 were specified by NASA-MSFC to assure compatibility with mating components. The mo.ınting thread for mating with the igniter boss is 9/16-18 UNF-3A. The initiator connector mates with a Bendix RB type plug, No. 10-42612-3S.

Functional

The TX346-1 initiator must function satisfactorily from the discharge of a 0.75 microfarad capacitor charged to 2000 volts, at any altitude up to 300,000 feet, and over a temperature range of -10 to 150°F. The initiator must remain functional after exposure to various electrical pulses and temperature cycling, as described in Appendix C. The ordnance output must be unaffected by the range of temperatures and pressures given above and be comparable to the AGX2008 initiator.

Nonfunctional (No Fire--May Dud)

The initiators must not fire, but may be rendered inoperative (dud), when s ıbjected to the following:

1. One watt for 5 minutes through the bridgewire[1]
2. One ampere for 5 minutes through the bridgewire[1]
3. One microfarad, 500 volts discharged through the bridgewire
4. Progressive application of current from zero at the rate of 0.5 ampere per second until bridgewire burns out
5. 320°F for 3.3 hours
6. 500°F for 2 hours.

The reference cited in 1 and 2 above deals with exposure of the XM6 and XM8 squibs to RF energy. The XM6 squib, as well as the TX346

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[1] The Effects of RF Energy on the XM6 and XM8 Squibs, D. L. Thompson, J. W. Vall, W. L. Strickland, U.S. Army Missile Command Redstone Arsenal, Alabama, Report Number RK-TR-63-1, 15 January 1963.

and TX346-1 initiators, utilize the "stand-off" concept, as pointed out in the Summary of this report. This concept permits high RF energy tolerance limits. The "one amp - one watt" tests are intended to simulate heating of the bridgewire resulting from RF-induced current flow in the initiator bridgewire circuit. The reference, therefore, presents information concerning the behavior of this concept relative to RF energy.

Technical Approach

Main Charge Development

Prerequisite to matching the ordnance output of the AGX2008 initiator, it was necessary to establish its ordnance parameters. A group of these initiators was procured and tested for (1) pressure versus time in a 22 cm.^{3} closed bomb, (2) calorific output with a Parr calorimeter, and (3) the flame pattern by photography. Tables I and II present the closed bomb and calorific data on the AGX2008 initiators. It can be noted from the calorific output data presented in Table II that the AGX2008 initiator did not develop the minimum acceptable heat output (810 calories) when tested in inert gas at 25 atmospheres, as shown by S/N's AJD-5-1-8 and AJD-5-1-15. When tested in air at ambient pressure, however, the initiators liberated the expected number of calories (~900), as indicated by the last three units in Table II. Figures 2 through 6 show the flame patterns obtained. The data obtained were examined in conjunction with NASA-MSFC specification S-1-PS(A), Figure 1, and Aerojet specification AGC-54048. A summary of the limits of these values follows:

<u>Pressure Versus Time</u> — Minimum 425 psig
Maximum 853 psig
Pressure developed within 5.5 msec.

<u>Calorific Output per Initiator</u> — Minimum 810 Calories
Maximum N/A

<u>Flame Pattern</u> — See Figures 2 through 6. The grid lines on these photographs are 6 inches apart.

Experimental Program

Initial work on the pyrotechnic charge development for the TX346-1 was confined to a metal-oxidant type composition. This type of composition has been used successfully by Thiokol in other exploding bridgewire initiators. These compositions exhibit good storage stability, high heat of reaction, and favorable flame gas properties. Therefore, Thiokol drew heavily from past experience for pyrotechnic composition development. Computations were made on various candidate pyrotechnics to determine similarity of calorific output before proceeding to experimental determination of these characteristics. Aluminum, as a fuel, has been used extensively in exploding bridgewire pyrotechnics along with oxidizers such as CuO, $KClO_4$, PbO, etc. Consideration of these and other compounds were based on the following reactions:

$$Pb_3O_4 + 8CuO + 8Al \rightarrow 4Al_2O_3 + 8Cu + 3Pb \quad (1)$$

$$PbO_2 + CuO + 2Al \rightarrow Al_2O_3 + Cu + Pb \quad (2)$$

$$Ba(NO_3)_2 + 7CuO + 8Al \rightarrow 4Al_2O_3 + 7Cu + BaO + N_2 \quad (3)$$

$$2Ti + KClO_4 \rightarrow 2TiO_2 + KCl \quad (4)$$

$$2Al + 3CuO \rightarrow Al_2O_3 + 3Cu \quad (5)$$

$$8Al + 3KClO_4 \rightarrow 4Al_2O_3 + 3KCl \quad (6)$$

$$6C_2F_4 + 8Al + 3KClO_4 \rightarrow 8AlF_3 + 3KCl + 12CO \quad (7)$$

Theoretical heat calculations on a typical formulation such as aluminum-cupric oxide are presented below.

Assumption No. 1 – All reaction products are crystalline solids.

Assumption No. 2 – The Al_2O_3 produced is the alpha form.

The reaction is as follows:

$$2Al(s) + 3CuO(s) \rightarrow Al_2O_3(s) + 3Cu(s)$$

Substance	Molecular Weight[1]		Number of Moles	
Aluminum	26.98	X	2	53.96
Cupric Oxide (CuO)	79.54	X	3	238.62
			Formula Weight =	292.58

[1] Handbook of Chemistry and Physics, 1959, Chemical Rubber Publishing Co.

Substance	Form	Heat of Formation (ΔHf°) KCal/Mole @ 25°C[1]
Aluminum	(Crystalline)	0.0
Aluminum Oxide (Al_2O_3)	(Crystalline)	-399.09
Copper	(Crystalline)	0.0
Cupric Oxide (CuO)	(Crystalline)	-37.1

$$\Delta H \text{ reaction} = \Delta Hf^\circ \text{ products} - \Delta Hf^\circ \text{ reactants}$$

$$\Delta H = -399.09 - 3(-37.1)$$

$$= \frac{-287.79}{292.58 \text{ (formula wt.)}} = 0.9836 \text{ KCal/gm}$$

or 983.6 cal/gm.

The reactions presented above embody a number of characteristics. For instance, (1) and (2) have a high bulk density and produce considerable slag, while (3) through (7) vary in bulk density and react to form a variety of slag/gas ratios.

Preliminary Testing

Testing was begun using compositions having theoretical properties nearest to those desired. Calorific output tests were performed with a Paar calorimeter as a screening tool. The calorific values of initial compositions were below the desired output (target) per initiator. Nevertheless, some formulations were sufficiently promising to warrant further experimentation. Additional testing, however, revealed unfavorable ignition characteristics, particularly with aluminum-cupric oxide mixtures (See Table III, TXB87 and TXB88). The high calorific output required in combination with the limited space available in the TX346-1 charge cavity dictated the use of high density pyrotechnic materials. High density materials usually do not ignite as readily as other pyrotechnic compositions. Furthermore, while high density materials produce a higher calorific output per unit of volume, the output per unit of weight is lower than the calorific output of less dense materials. For these reasons, achieving the optimum combination of pyrotechnic materials required extensive experimentation. Additional constituents were added to enhance ignition, however, the loading density dropped prohibitively low (See Table III, TXB89, TXB90, TXB91, and TXB92), so this approach was abandoned.

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[1] Handbook of Chemistry and Physics, 1959, Chemical Rubber Publishing Co.

Another method explored to improve ignition and combustion characteristics of high density pyrotechnic charges was the use of a finer fuel (aluminum powder). Two other atomized aluminum powders were obtained for use in the experimental main charge compositions. These powders had average particle diameters of 4.9 and 8.6 microns, compared to 20.4 microns for the aluminum powder used previously. Ignition characteristics were improved, as were the calorific outputs and loading densities (See Table III, TXB93 and TXB94). The pressure-time characteristics, however, were unacceptable. Experimentation was then continued by substituting constituents and additives and adjusting ratios to obtain the proper balance of output parameters (See Table III, TXB95 through TXB103).

Development Testing

A charge, designated TXB104, was developed that exhibited the features necessary to match the AGX2008 performance. The basic TXB104 composition at this stage of development contained only fuel and oxidizer. In order to prevent charge stratification under conditions of shock and vibration, an appropriate binder had to be added. A compatible binder was selected and incorporated in two ratios into the basic TXB104 composition. These compositions were designated TXB105 and TXB106. Prototype TX346-1 initiators were then assembled and tested for pressure-time performance. See Table IV for a tabulation of the data.

Although all initiators performed satisfactorily except two (S/N's 174 and 114), the variation in maximum pressure, from initiator to initiator, was greater than desired. An investigation indicated the variation was caused by failure to obtain a uniform consistency during mixing of the pyrotechnic charge. To test this theory, two mixes of formulation TXB106 were manufactured and tested. Nine initiators were loaded from Mix 1, which was mixed according to standard procedures. The mixing technique for Mix 2 was changed to obtain a more uniform dispersal of the binder. Seven initiators were loaded from this mix.

Delay time and pressure performance was within specification limits for all 16 initiators tested. Results of the tests are shown in Table V. The range of maximum pressure for initiators loaded from Mix 1 was 430 to 720 psig. Mix 2 initiators performed more consistently, with maximum pressures ranging from 630 to 740 psig. The test results indicate that the change in mixing technique solved the problem of excessive pressure variation.

Forty-four additional TX346-1 initiators were tested: 19 in a 22 cm^3 closed bomb to determine pressure-time characteristics, 15 in a modified adiabatic calorimeter to determine calorific output, and 10 to determine the flame pattern. The procedures used during assembly and testing of these initiators were also used during the qualification test program for both the

TX346 and TX346-1 initiators.

Calorimeter tests were conducted in two groups of seven and eight units each. Test results are shown in Table VI. Calorific output for the first five initiators in Group I was below the minimum requirement of 900 calories per initiator. The charge weight was increased for the reminaing two units in this group, and calorific outputs of 944 and 960 calories were recorded for these initiators. All initiators in Group II performed satisfactorily, with calorific outputs ranging from 935 to 1,027 calories.

The closed bomb tests were conducted in two groups of fourteen and five units each. Test results are shown in Table VII. Thirteen initiators in Group I functioned within the required time and pressure ranges. Performance was not affected by temperature extremes of -10 and 150°F. The fourteenth unit fired normally, but no record was obtained because of an instrumentation failure. All initiators in Group II performed satisfactorily except Initiator No. 210, which produced pressure exceeding calibration.

Maximum pressures for Group II initiators were higher than for Group I because of an increase in the pyrotechnic charge weight. Nevertheless, the values were well within the acceptable range.

Results of the 10 flame pattern tests were satisfactory. Photographs showing the flame patterns produced by the TX346-1 are presented as Figures 7 through 16. For comparison, refer back to Figures 2 through 6 for typical flame patterns produced by the AGX2008 initiator.

Confirmation Testing

TX346

A group of TX346 initiators were assembled as prototypes for testing using assembly and test procedures intended for the qualification program. Subsequent to assembly, the initiators were tested in a 22 $cm.^3$ closed bomb. The test data are shown in Table IX. These data were normal relative to functioning time and maximum pressures. Since no specification values existed on the TX346 initiator relative to functioning times and pressures, these results along with those obtained in the qualification program were used to establish the appropriate range of values.

TX346-1

The data obtained from the prototype testing were very close to the design goals, so an additional group of initiators was assembled to confirm that the TX346-1 did match the AGX2008 output. Thirty TX346-1 initiators were assembled and tested in a 22 $cm.^3$ closed bomb. Test results are shown in Table VIII. The performance of the initiators was within specified limits.

QUALIFICATION PROGRAM

At the successful completion of the TX346-1 development program and design demonstration testing of both the TX346 and TX346-1 initiators, fabrication of the required quantity of each initiator was begun. Throughout the assembly and acceptance of the initiator lots, the applicable NASA and Thiokol quality control procedures were applied. When the initiators were assembled, they were subjected to (1) "Preliminary Measurements," (2) Lot Acceptance Tests, and (3) the Qualification Program. Items (1) and (2) are described in Appendix A, and item (3) in Figure A-1 of the same appendix. Data, circuitry, and procedures are given in Appendices D and E, respectively.

Under the "Preliminary Measurements" leak test phase, a total of 665 initiators were subjected to the "Radiflo" technique. The initiators were required to have a leak rate of not more than 1×10^{-8} cc./sec. Krypton 85. The initiators were exposed 3.4 hours to this gas at 30 psia then checked with a Geiger Counter (Ratemeter) to determine if any gas had penetrated the unit. There were 18 (2.7% of the total) "leakers." The distribution of these is as follows:

Type	Number Checked	Leakers
TX346-1	352	12
TX346	313	6

Some leakers were set aside and replaced with spares (See Appendix F). A point to be emphasized here, however, is that the yield of approximately 97.3% acceptable units is above the industry average of around 94% or less.

During some phases of the qualification program testing, scheduled exposure limits were exceeded--such is the case with shock and vibration. The shock pulse, as defined in Appendix A, was a 100 g peak half-sine pulse with a duration of 11 milliseconds. The acceleration vector was defined as parallel to the axis of the initiator and positive in the direction of the mounting end of the initiator. Samples of the recorded data were checked and indicated that the peak values ranged from 95 to 110 g's with durations ranging from 10.8 to 12.6 milliseconds. The test sequence and remarks are shown on Table D-XI. In the remarks, it will be noted that during some of the tests the test table "shocked twice." The inertia catch, built into the shock machine, failed to work in these instances and allowed the table to drop a second time, resulting in a second shock pulse. The duration of the second pulse was approximately the same, but the peak value was approximately 70 g. In one instance, the table "shocked three times." The third shock was about 50 g.

The vibration schedule, as defined in Appendix A and deviation in Appendix F, was exceeded for some initiators as regards "g" loading. These exceptions are noted in Tables D-IX and D-X. The remainder of the tests were run per Appendix A except for deviations listed in Appendix F.

DISCUSSION

An examination of the test results shows that both initiators exhibited exceptional mechanical integrity in that no faults were noted on any initiators visually, none on six (6) (see Appendix B, Table B-III) units that were X-rayed and none showed up during functional testing. Further, the integrity of the glass-to-metal bond and hermetic sealing technique is substantiated by the low number of leakers resulting from subjection to the "Radiflo" test using the stringent leak rate requirement of less than 1×10^{-8} cc/sec. Krypton 85.

The electrical characteristics of the initiators met or exceeded requirements. Specifically, the connector met stringent altitude and temperature requirements, thus demonstrating an adequate design. The insulation resistance data show less than 1 microampere current flow at 1000 n.d.c. (20 microamps allowable) for all initiators. The spark gaps exhibited the desired characteristics. The combined effects of temperature cycling, vibration, shock and electrostatic pulses did not cause a significant shift in the breakdown voltage. The changes noted from one reading to another following the above exposures were comparable to the normal scatter obtained when several readings are taken on the same unit under the same condition.

The pyrotechnic compositions did not undergo any perceptible changes on exposure to adverse conditions during the qualification program. Temperature extremes did not affect the Ordnance output. In those cases where the closed bomb was evacuated to simulate altitude the maximum pressures dropped about 33%, as anticipated. The maximum pressure developed and the functioning times exhibited by the TX346-1 initiator were comparable to the customer furnished AGX2008. The same parameters of the TX346 initiator were comparable to those of the XM6 (TX255) squib.

CONCLUSIONS

The TX346-1 initiator developed under this program matched the Ordnance output of the NASA-MSFC furnished AGX2008 initiator and met all of the requirements called out in NASA-MSFC specification S-1-PS(A) except for six initiators which did not function, when required, during the qualification program. Nevertheless, this initiator demonstrated96% reliability at 95% confidence level. NASA-MSFC has not issued a disposition on this initiator as yet, therefore, its qualification status is pending.

The previously developed TX346 initiator met all safety, environmental and functioning requirements of NASA-MSFC specification S-1-PS(A) without a single failure. The Ordnance output of the TX346 is comparable to that of the TX255 (XM6) squib and is completely qualified under the requirements of this contract.

TABLE I

AGX2008 INITIATOR CLOSED BOMB TEST DATA

Initiator Serial Number	Test Conditions[a]	Functioning Delay Times (Milliseconds)[b] t_1	t_2	Maximum Pressure (psig)
AJD-5-1-43	1, 3	2.4	6.0	640
AJD-5-1-45	1, 3	2.4	5.4	550
AJD-5-1-25	1, 3	2.4	5.4	610[c]
AJD-5-1-1	2, 3	2.0	3.0	460
AJD-5-1-11	2, 3	2.2	1.6	560
AJD-5-1-18	2, 3	2.5	3.3	540
AJD-5-1-30	2, 3	2.3	3.3	600
AJD-5-1-31	2, 3	2.3	3.3	480
AJD-5-1-19	2, 3	2.2	3.5	510
AJD-5-1-32	2, 4	2.2	2.9	490
AJD-5-1-16	2, 4	2.1	5.0	520
AJD-5-1-9	2, 4	2.4	4.0	580
AJD-5-1-4	2, 4	2.1	3.3	700
Unknown	2, 4	2.2	3.9	540
AJD-5-1-26	No record--gap switch in power supply failed.			

Notes: a. Legend:

1. Fired in 22.36 cc. closed bomb with 2000-volt direct current firing pulse applied from 1.0 Mfd. capacitor.
2. Fired in 22 cc. closed bomb with 2300-volt direct current firing pulse applied from 0.75 Mfd. capacitor.
3. Pressure output measured with Kintel-CEC pressure measuring system.
4. Pressure output measured with a Photocon-Dynagage pressure measuring system.

b. Functioning delay time definitions:

t_1 Time from triggering of firing pulse to first pressure rise.

t_2 Time from first pressure rise to maximum pressure.

c. Initiator retainer was blown out during firing of this initiator.

TABLE II

AGX2008 INITIATOR CALORIFIC TEST DATA

S/N	Environment	Pressure (Atmospheres)	Output per Initiator (Total Calories)
AJD-5-1-8	Helium	25	687
AJD-5-1-15	Helium	25	674
AJD-5-1-17	Air	1	988
AJD-5-1-2	Air	1	1001
AJD-5-1-35	Air	1	960

Note: Tests were conducted in a Parr adiabatic calorimeter which was modified to accommodate full scale initiators.

TABLE III

PERFORMANCE OF TX346-1 CANDIDATE COMPOSITIONS

Composition Designation	Test Initiator S/N	Loading Density (g. /0.4 cc.)	Calorific Output Per Initiator (Total Calories)	Pressure Vs. Time: Delay Time (Milliseconds)[a] t_1	t_2	P_{max} (psig)
TXB87	N/A	0.985	940c			
TXB88	N/A	0.949	895c			
TXB89	N/A	0.399	533c			
TXB90	N/A	0.569	477c			
TXB91	N/A	0.384	314c			
TXB92	N/A	0.419	503c			
TXB93	N/A	0.835	773c			
TXB94	28	0.864	825c	1.0	5.0	120
TXB94	49			1.2	No Data	b
TXB94	52			2.5	No Data	b
TXB95	112	0.790	785c	0.7	1.3	400
TXB95	54			0.7	1.3	350
TXB95	169			0.8	1.5	340
TXB96	N/A	0.591	676c			
TXB97	N/A	0.602	421c			
TXB98	90	0.718		0.6	1.3	510
TXB98	8	0.718		2.7	3.7	470
TXB98	35	0.718		0.9	1.9	530
TXB98	72	0.718		0.7	1.9	460
TXB98	42	0.718	880c			
TXB98	65	0.718	990d			
TXB98	63	0.718	999d			
TXB98	109	0.718	863c			
TXB99	152	0.620	724d	2.1	3.1	460
TXB99	170			1.9	2.8	470
TXB102	45	0.627	950d			
TXB102	174	0.612	918d			
TXB102	20	0.608		0.6	1.6	460
TXB102	97	0.614		0.6	1.7	490
TXB103	77	0.653	1003d			
TXB103	123	0.658	1031d			
TXB103	86	0.645		0.8	1.6	550
TXB103	98	0.645		0.6	1.6	520
TXB104	100	0.624	1009d			
TXB104	140	0.629	1034d			

TABLE III

(CONTINUED)

Legend: a. Function delay time definitions:

t_1 Time from firing pulse to initial pressure rise.

t_2 Time from initial pressure rise to maximum pressure.

b. No pressure--crimp lip burn-through.

c. Tested in helium at 25 atm.

d. Tested in air at 1 atm.

TABLE IV

PROTOTYPE TX346-1 INITIATOR TEST DATA[a]

Serial Number	Charge Designation	Functioning Delay Times (Milliseconds)[b] t_1	t_2	Maximum Pressure (psig)
17	TXB104	0.6	c	d
42	TXB104	0.6	0.7	790
149	TXB104	0.6	0.7	760
173	TXB104	0.5	0.8	750
97	TXB105	0.7	0.6	720
104	TXB105	0.6	0.7	700
98	TXB105	0.7	0.6	680
146	TXB105	0.7	0.8	580
55	TXB106	0.6	0.6	740
150	TXB106	0.8	0.8	530
169	TXB106	0.6	0.8	610
174	TXB106	0.7	0.8	420
135	TXB106	0.6	0.8	610
117	TXB106	0.7	0.7	620
114	TXB106	1.1	3.8	380
33	TXB106	0.6	1.0	540

Legend:

a. Tested in a 22-$cm.^3$ closed bomb with a Photocon-Dynagage pressure measuring system. The firing pulse consisted of 2300 volts d.c. discharged from a 1.0 Mfd. capacitor.

b. Functioning delay time definitions:

t_1 Time from current input to initial pressure rise.

t_2 Time from initial pressure rise to maximum pressure.

c. An approximate value of 0.8 millisecond was obtained; the value is in doubt because of incomplete pressure measurements. (See note d.)

d. Pressure exceeded 800 psig, the maximum pressure to which the measuring equipment was calibrated; consequently, the exact value was not obtained.

TABLE V

TX346-1 INITIATOR TEST DATA, SHOWING EFFECT OF

CHANGE IN MIXING TECHNIQUE[a]

Serial Number	Mix Number[b]	Functioning Delay Times (Milliseconds)[c] t_1[d]	t_2	Maximum Pressure (psig)
95	1	0.8	0.8	695
3	1	1.2	0.8	485
106	1	1.4	0.7	430
136	1	3.0	0.8	720
7	1	1.5	0.6	670
108	1	1.2	1.0	625
43	1	1.2	1.0	690
129	1	1.6	0.8	590
173	1	1.4	0.8	610
76	2	1.2	0.8	680
82	2	1.6	0.8	740
91	2	1.0	0.6	660
101	2	2.6	0.8	650
131	2	2.6	0.8	650
142	2	0.9	0.8	630
151	2	0.7	0.7	640

Legend:

a. TXB106 charge composition was used in all initiators in this group of tests. The tests were conducted in a 22-cm.^{3} closed bomb fitted with a Photocon-Dynagage pressure measuring system. The firing pulse consisted of 2300 volts d.c. applied from a 1.0 Mfd. capacitor. A flight firing unit was used.

b. Mix No. 1 was manufactured using standard procedures. Changes in the mixing technique were made to obtain a more uniform dispersal of the binder in Mix No. 2.

c. Functioning delay time definitions:

t_1 Time from current input to initial pressure rise.

t_2 Time from initial pressure rise to maximum pressure.

d. Values for t_1 were adjusted to compensate for a characteristic delay of 4.0 ± 1.0 milliseconds in the flight firing unit.

TABLE VI

CALORIFIC OUTPUT OF PROTOTYPE TX346-1 INITIATORS

	Initiator Number	Calorific Output[b] (Total Calories)
Group I:		
	177	820
	220	894
	200	813
	222	798
	235	826
	88	960
	139	944
Group II:		
	22	969
	6	962
	39	1001
	16	988
	78	935
	134	1027
	246	976
	13	965

Legend: a. Tested in a modified Parr adiabatic calorimeter charged with air at one atmosphere.

b. Minimum output of 810 calories per initiator is required.

TABLE VII

PRESSURE-TIME CHARACTERISTICS OF PROTOTYPE TX346-1 INITIATORS[a]

	Initiator Number	Temperature (°F)	Functioning Time (Milliseconds)[b]	Maximum Pressure[c] (psig)
Group I:				
	183	70	2.4	725
	199	70	1.8	730
	212	70	1.6	680
	214	70	1.4	660
	215	70	2.6	660
	224	70	Fired normally--No record obtained	
	227	70	1.6	630
	236	70	1.7	650
	256	70	1.5	670
	244	70	2.9	630
	189	-10	2.2	720
	226	-10	2.5	650
	187	150	2.2	620
	238	150	2.7	640
Group II.				
	210	70	1.6[d]	800[d]
	229	70	1.7	770
	237	70	1.5	700
	239	70	3.2	710
	253	70	1.6	680

Legend:

a. Tested in a 22-cm.^{3} closed bomb equipped with a Photocon-Dynagage pressure measuring system.

b. Functioning time is time from application of firing pulse to maximum pressure; maximum of 5 milliseconds permitted.

c. Specification limits for maximum pressure are 425 to 775 psig.

d. Pressure exceeded 800 psig instrumentation calibration.

TABLE VIII

RESULTS OF TX346-1 INITIATOR CONFIRMATION TESTS[a]

Initiator Number	Functioning Time (Millisecond)[b] t_1	t_2	Maximum Pressure (psig)
182	0.4	0.7	690
190	0.4	0.7	645
209	0.3	0.8	625
221	0.4	0.8	640
266	0.3	0.7	650
289	0.4	0.8	645
291	0.4	0.7	650
330	1.0	0.8	600
335	0.4	0.6	670
380	0.4	0.7	625
405	0.4	0.8	605
439	0.4	0.9	610
444	0.6	0.9	640
447	0.4	0.7	640
448	0.4	0.6	650
502	0.4	0.7	655
526	0.4	0.7	650
533	0.4	0.6	675
602	0.4	0.7	675
604	0.4	0.5	705
639	0.5	0.8	690
643	0.4	0.6	710
670	0.4	0.8	680
753	0.4	0.6	680
784	0.4	0.8	695
798	0.4	0.6	650
819	0.5	0.7	670
832	0.4	0.6	675
833	0.4	0.6	675
834	0.5	0.6	635

Specification Limits: $(t_1 + t_2 = < 5.5$ msecs.) 425 to 853 psig.

TABLE VIII

(CONTINUED)

Legend: a. Tested in a 22-cm.[3] closed bomb equipped with a Photocon-Dynagage pressure measuring system. The firing pulse consisted of 2000 volts d. c. discharged from a 0. 75 Mfd. capacitor; a NASA-supplied Bench Model firing unit, Change "C," Serial No. 004, was used. Pyrotechnic charge composition TXB106 was used for all initiators.

b. Functioning time is defined as follows:

t_1 Time from application of the firing pulse to the first pressure rise.

t_2 Time from the first pressure rise to maximum pressure.

TABLE IX

PROTOTYPE TX346 INITIATOR CLOSED BOMB DATA

Serial Number	Temperature (°F)	Functioning Time (Milliseconds)[a]	Maximum Pressure[b]
176	70	2.5	360
179	70	2.5	315
185	70	3.2	340
193	70	3.0	320
195	70	1.8	350
197	70	1.6	320
206	70	1.8	360
191	-10	1.7	330
205	-10	1.6	320
223	-10	2.6	320

Legend: a. Time from application of firing pulse to maximum pressure in milliseconds.

b. Maximum Pressure expressed in psig
Closed Bomb Volume — 22 cc.
Photocon — Dynagage Pressure Measuring System

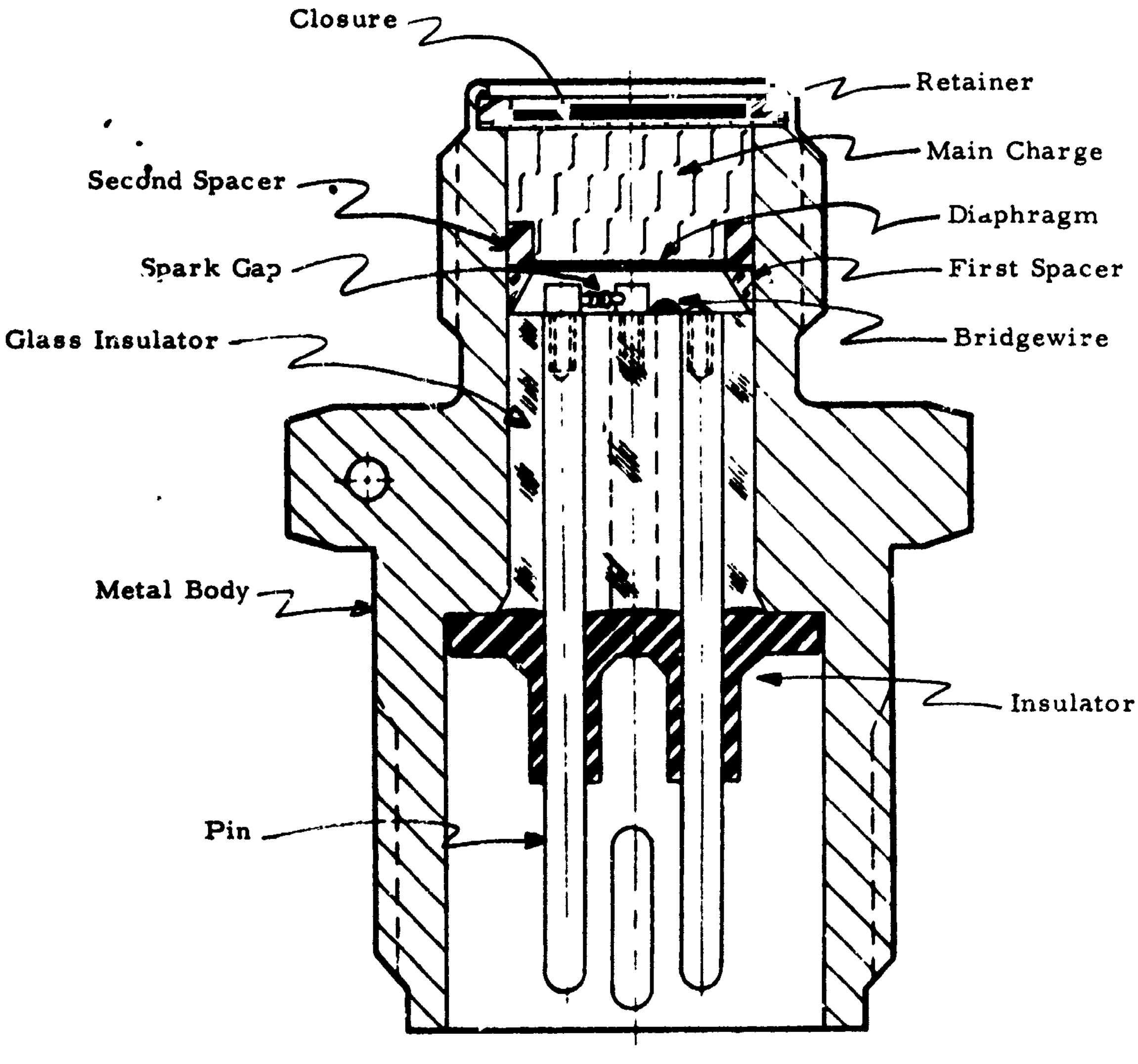


Figure 1. Cross Section of TX346-1 Initiator

Figure 2. AGX2008 Initiator Flame Pattern Test
(Grid lines spaced 6" apart)

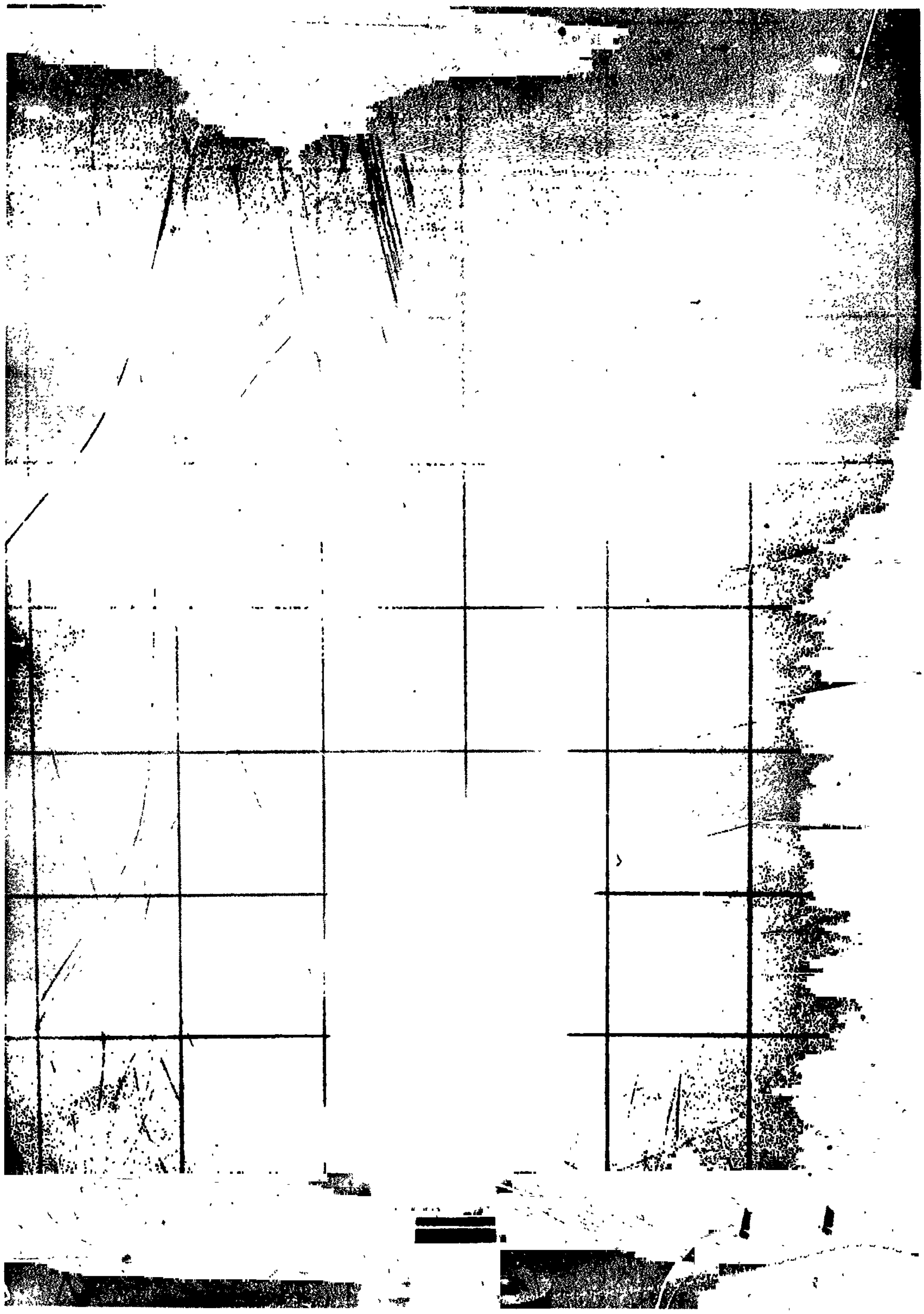


Figure 3. AGX2008 Initiator Flame Pattern Test
(Grid lines spaced 6" apart)

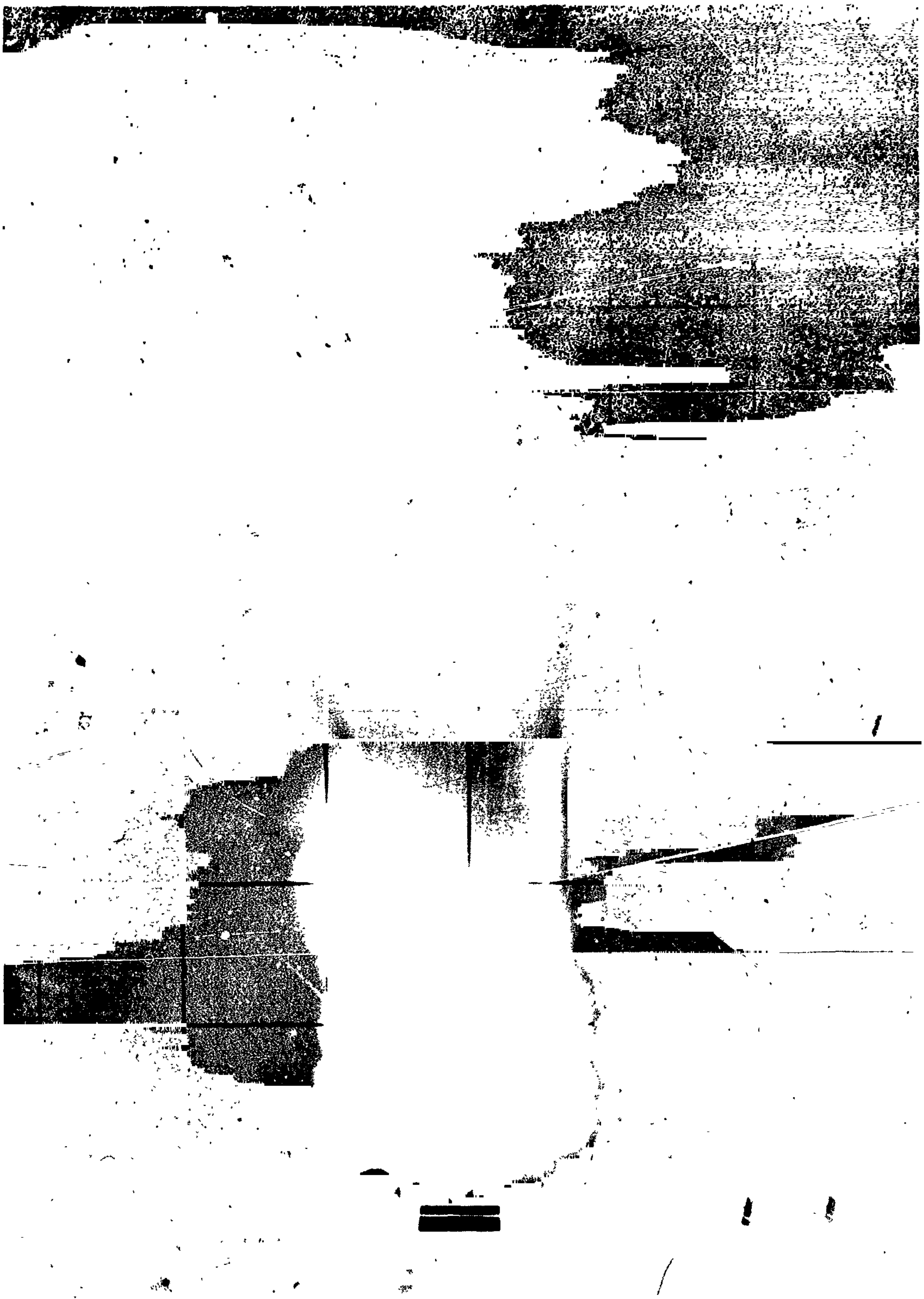


Figure 4. AGX2008 Initiator Flame Pattern Test
(Grid lines spaced 6" apart)

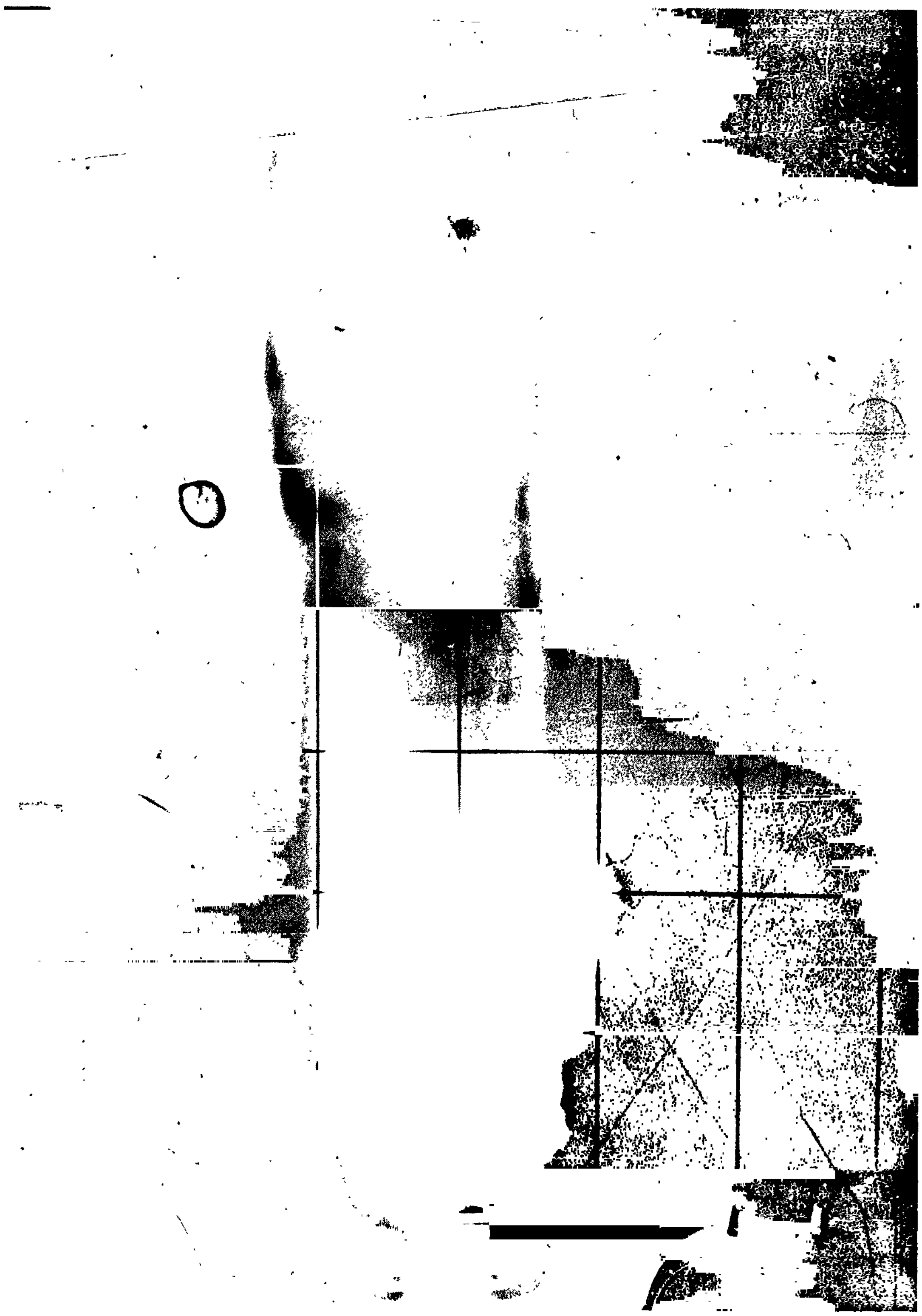


Figure 5. AGX2008 Initiator Flame Pattern Test (Grid lines spaced 6" apart)

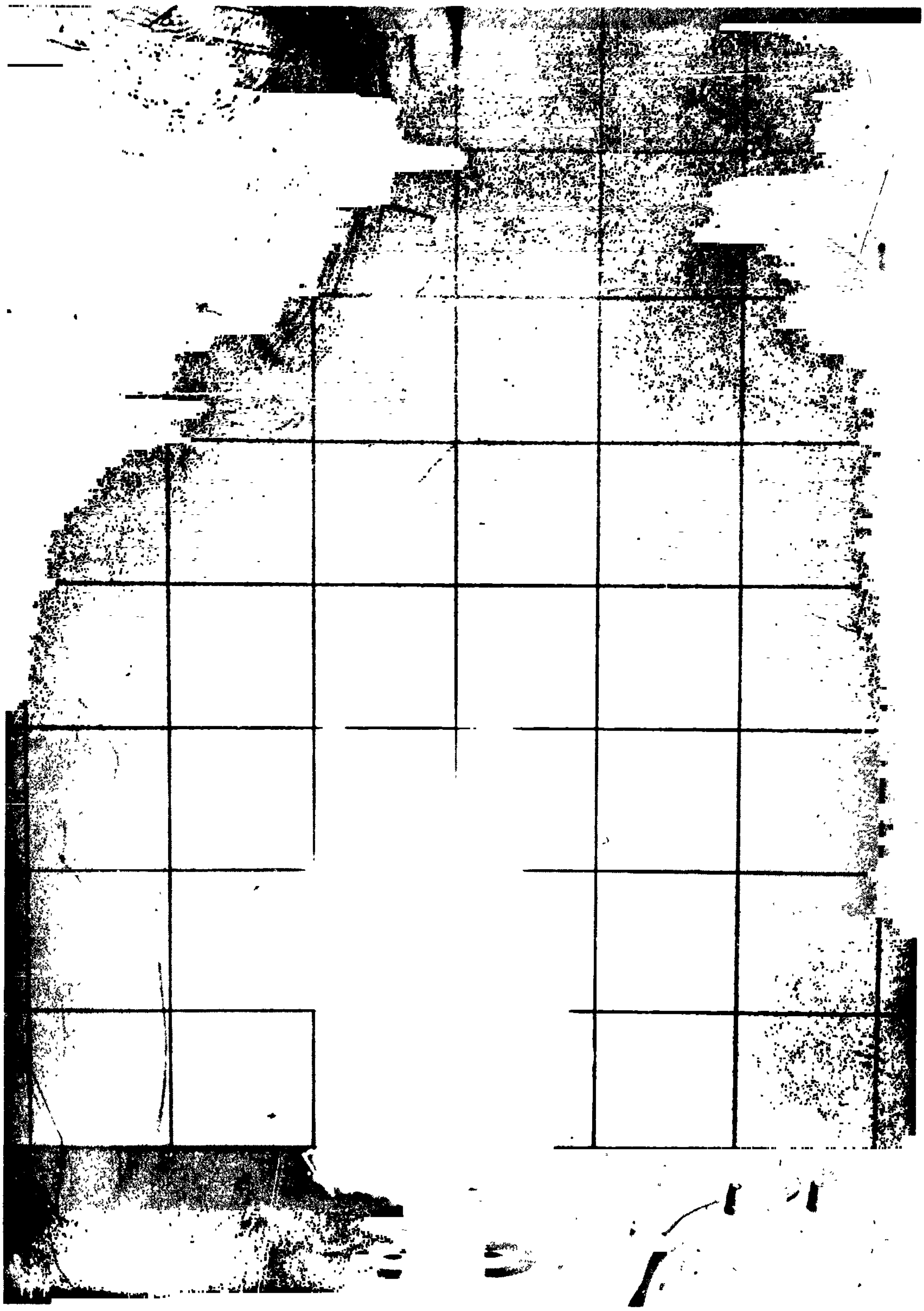


Figure 6. AGX2008 Initiator Flame Pattern Test
(Grid lines spaced 6" apart)

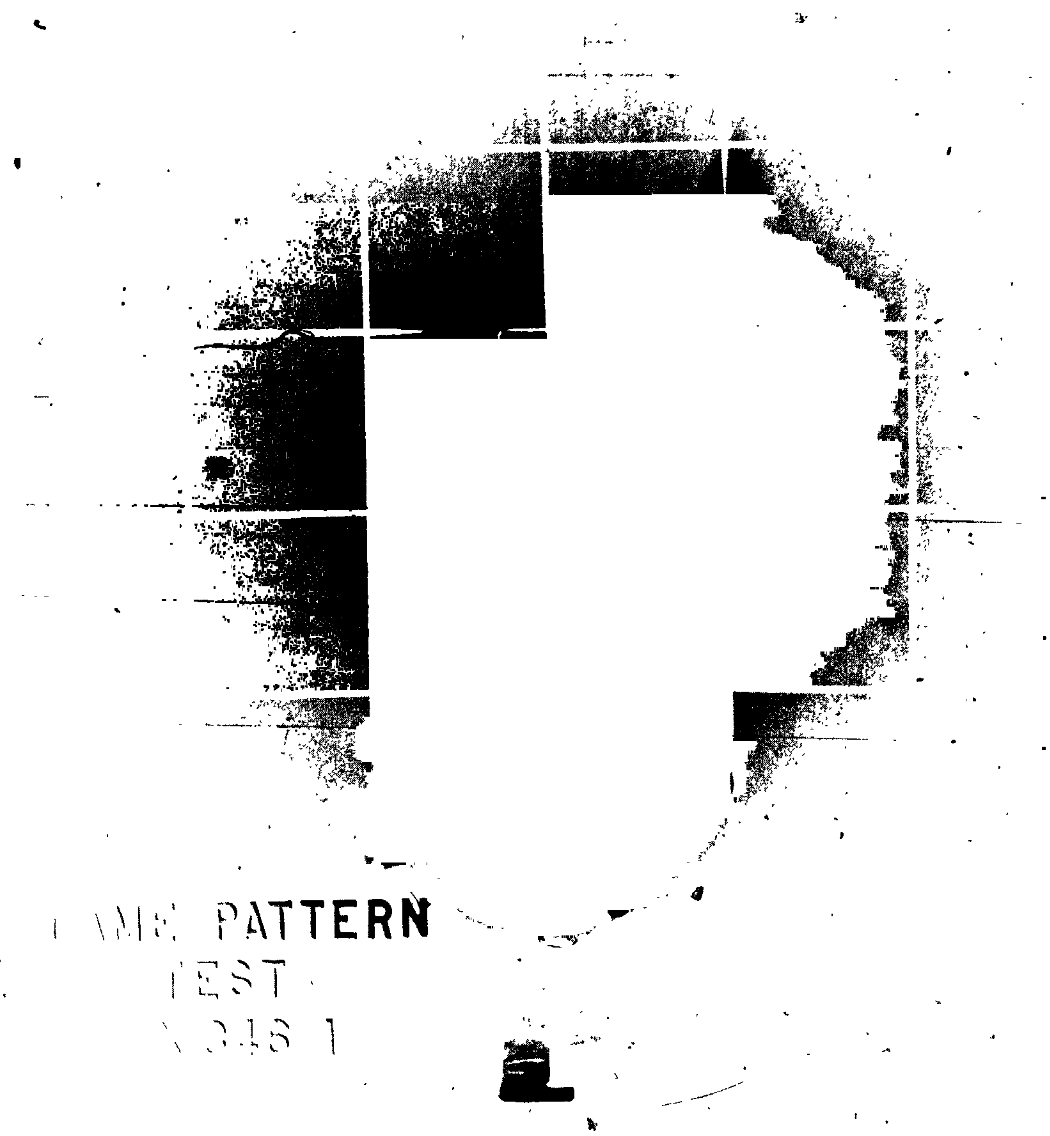


Figure 7. Flame Pattern Produced by TX346-1 Initiator (Grid lines spaced 6" apart)

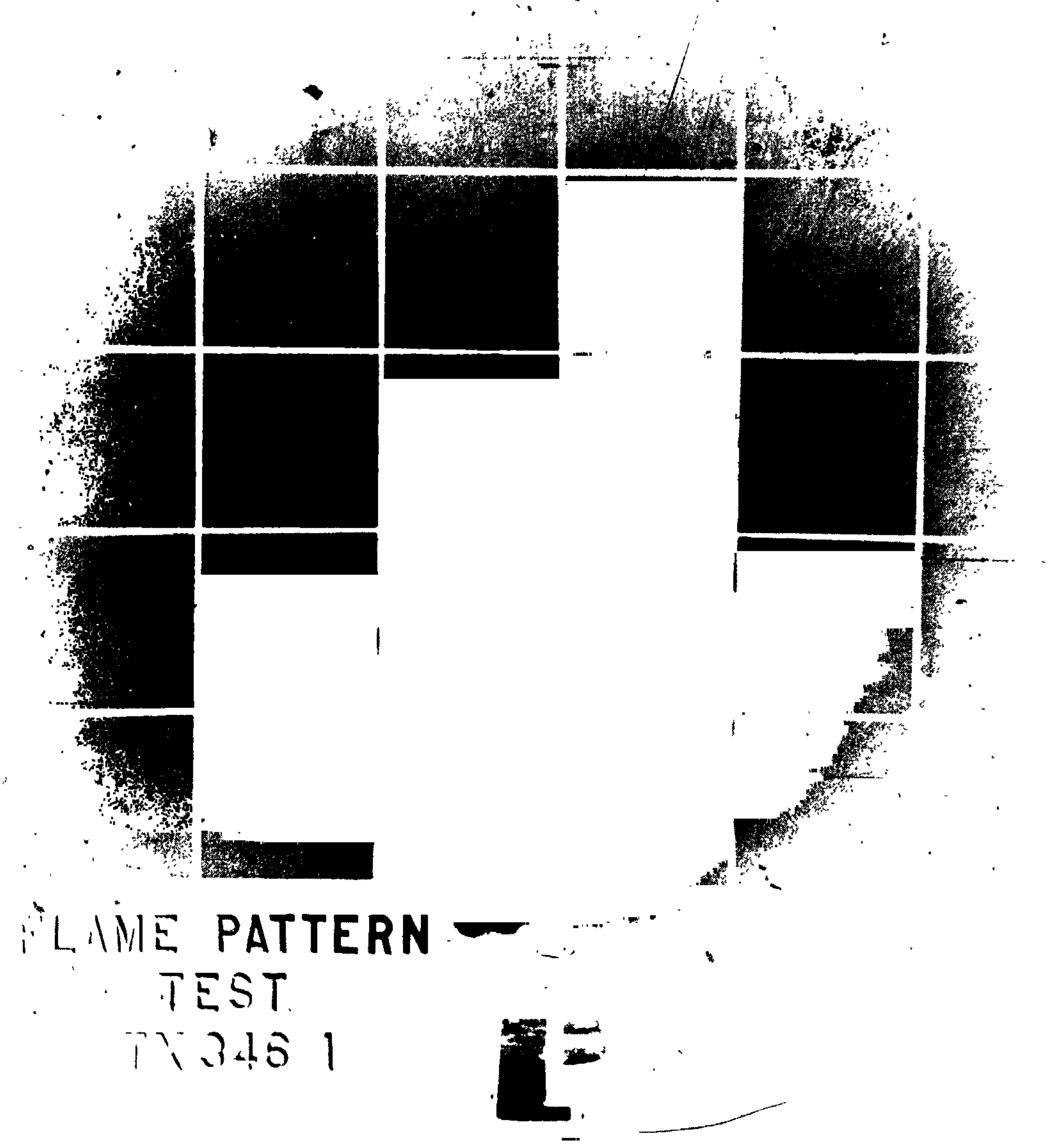


Figure 8. Flame Pattern Produced by TX346-1 Initiator
(Grid lines spaced 6" apart)

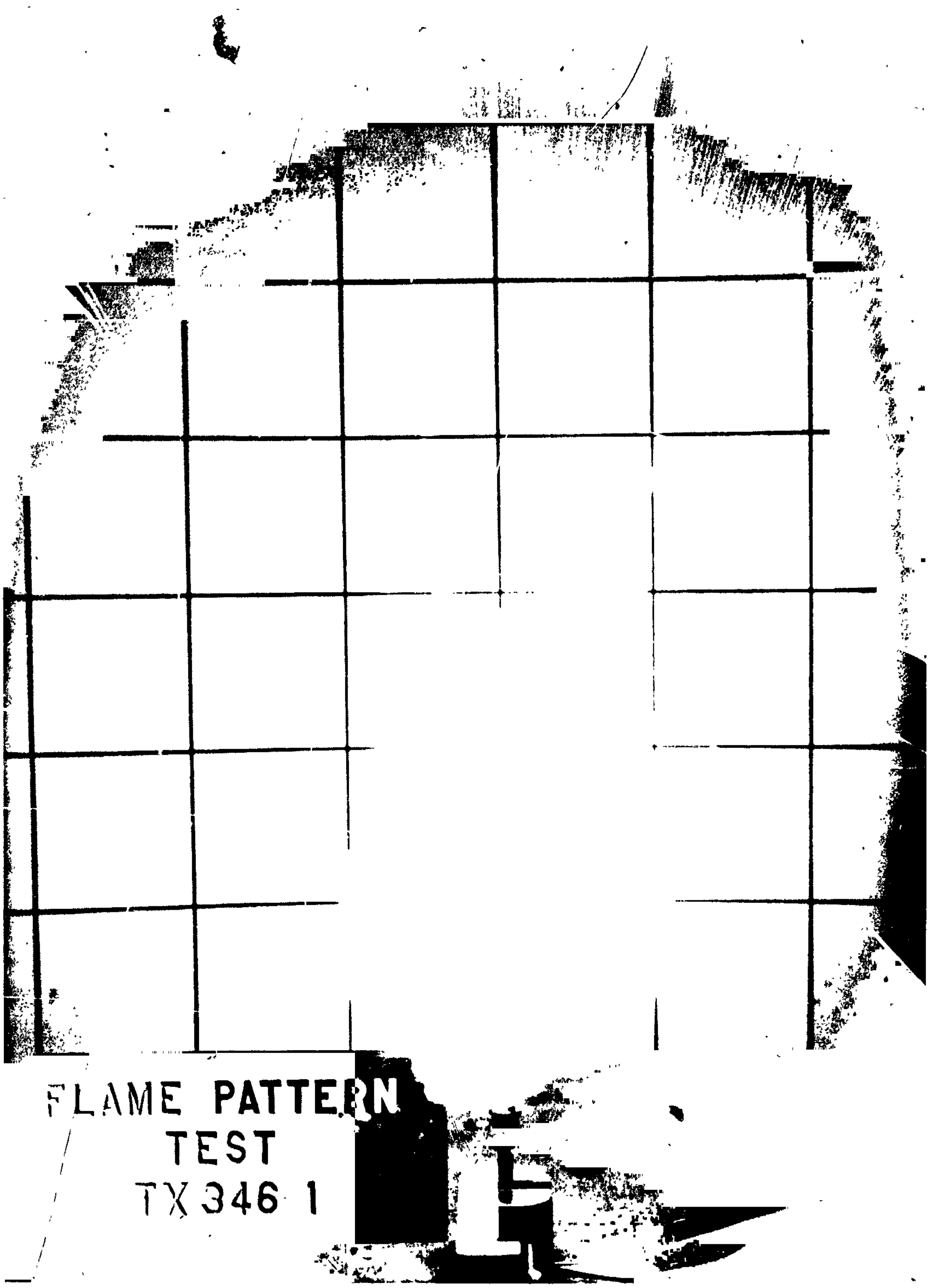


Figure 9. Flame Pattern Produced by TX346-1 Initiator
(Grid lines spaced 6" apart)

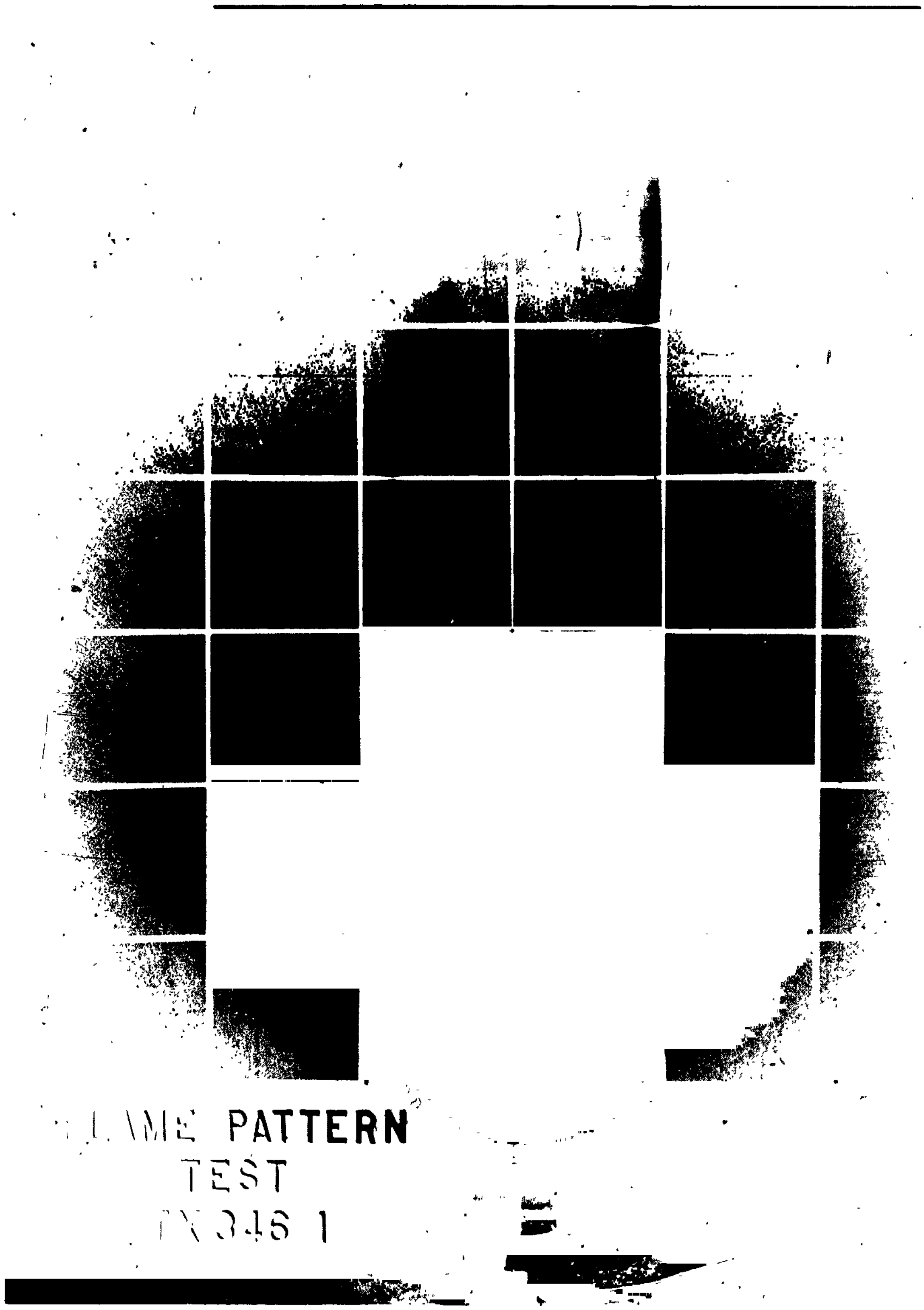


Figure 10. Flame Pattern Produced by TX346-1 Initiator
(Grid lines spaced 6" apart)

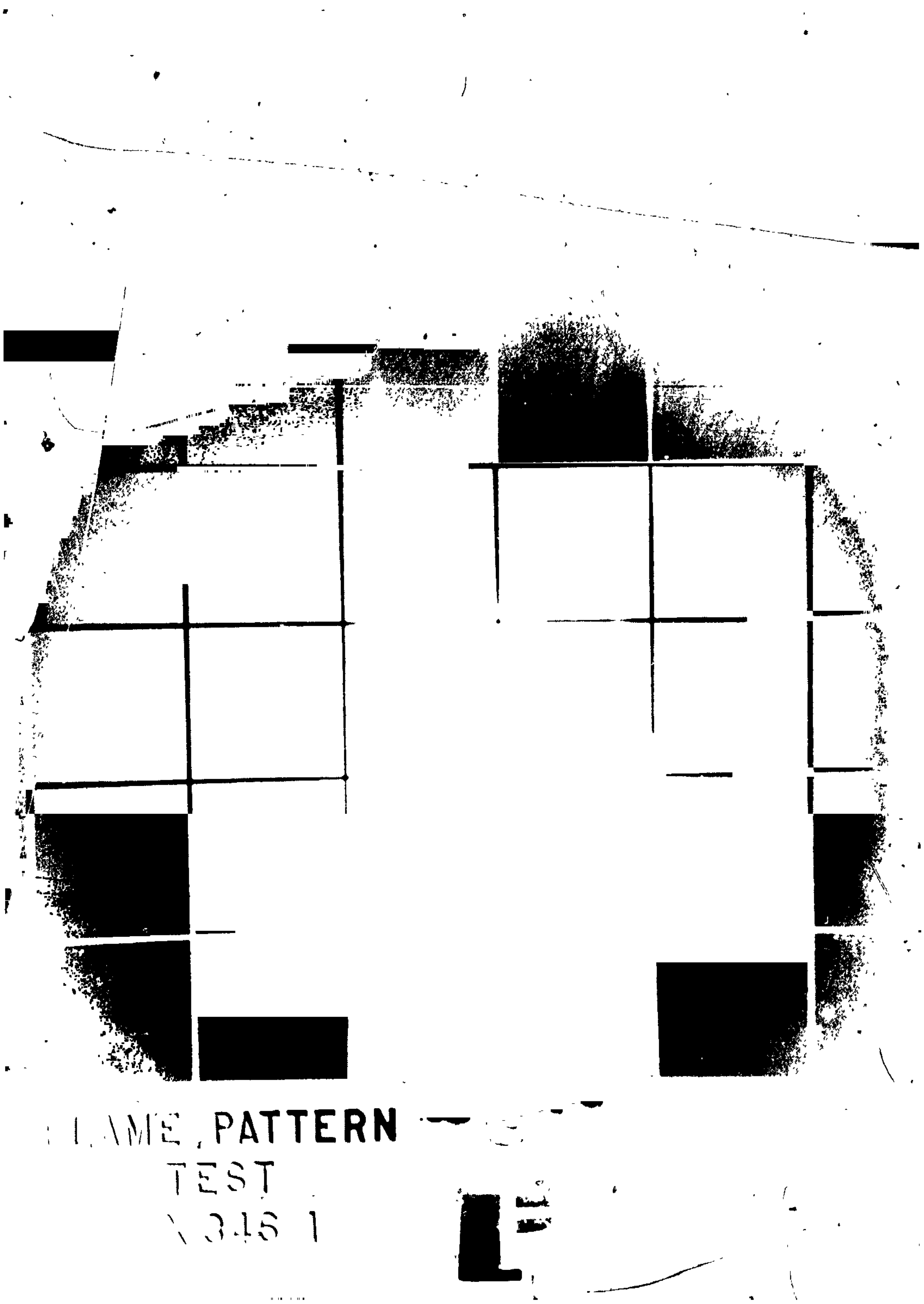


Figure 11. Flame Pattern Produced by TX346-1 Initiator
(Grid lines spaced 6" apart)

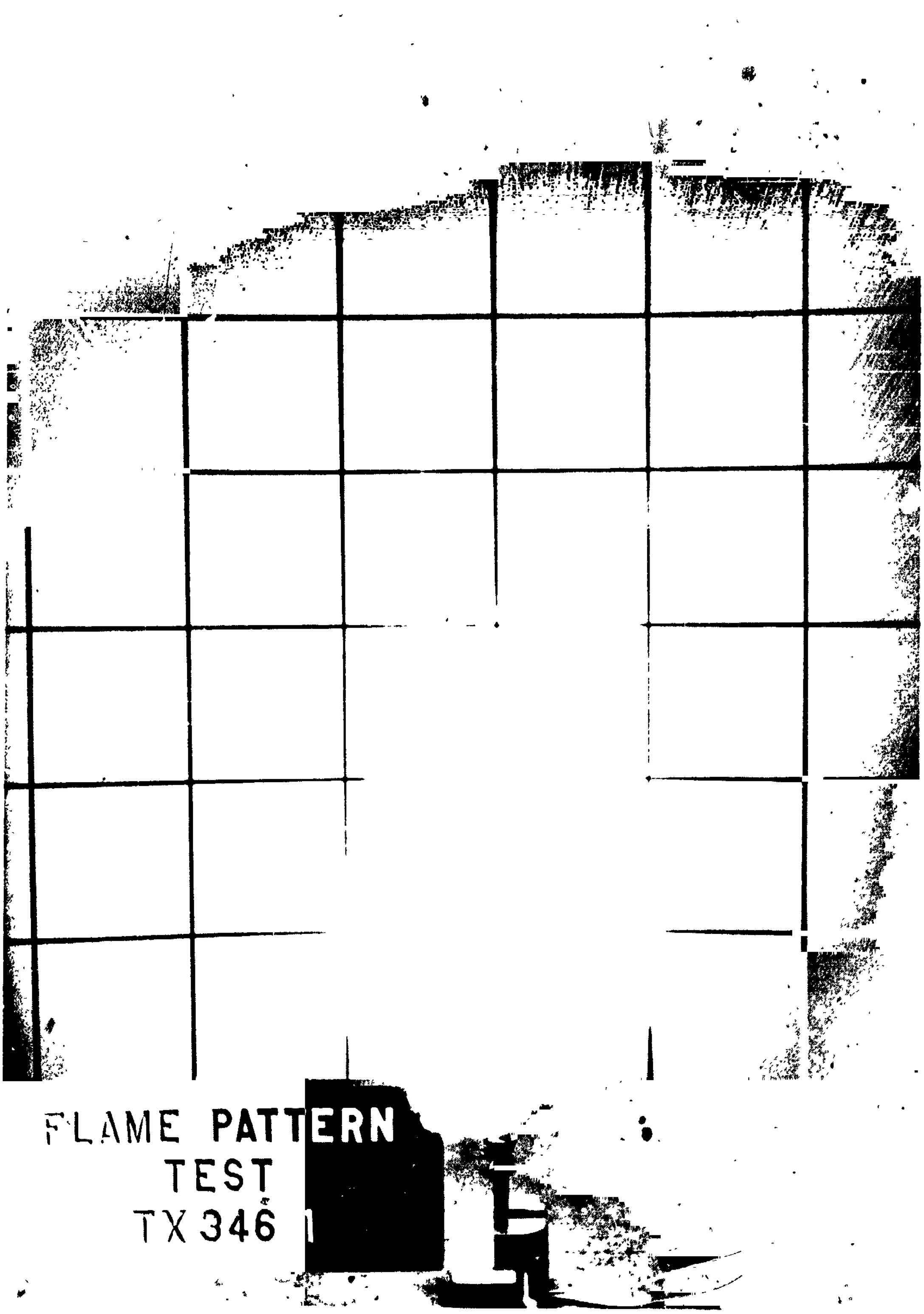


Figure 12. Flame Pattern Produced by TX346-1 Initiator
(Grid lines spaced 6" apart)

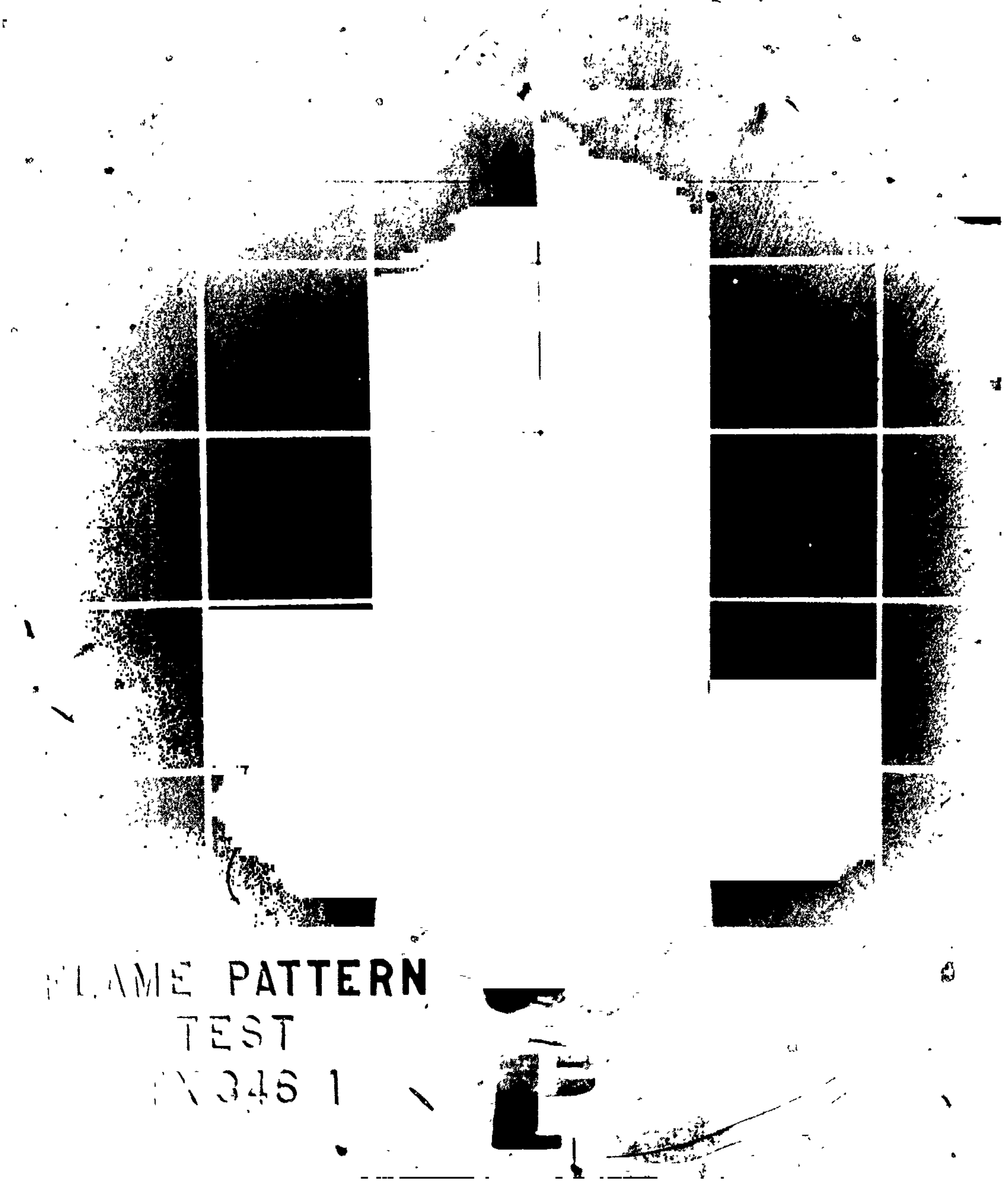


Figure 13. Flame Pattern Produced by TX346-1 Initiator
(Grid lines spaced 6" apart)

Figure 14. Flame Pattern Produced by TX346-1 Initiator
(streak caused by faulty negative)
(Grid lines spaced 6" apart)

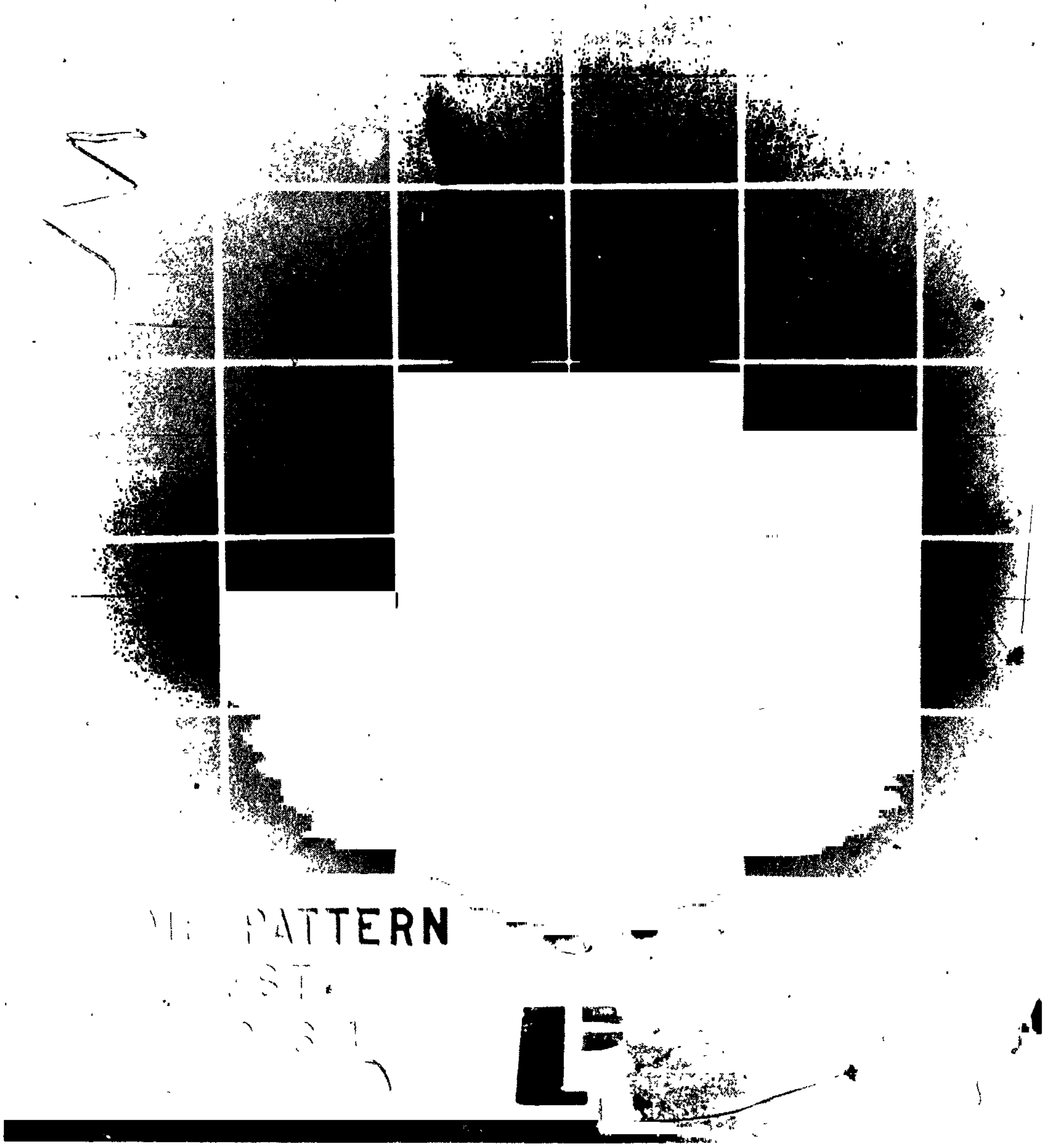


Figure 15. Flame Pattern Produced by TX346-1 Initiator
(Grid lines spaced 6" apart)

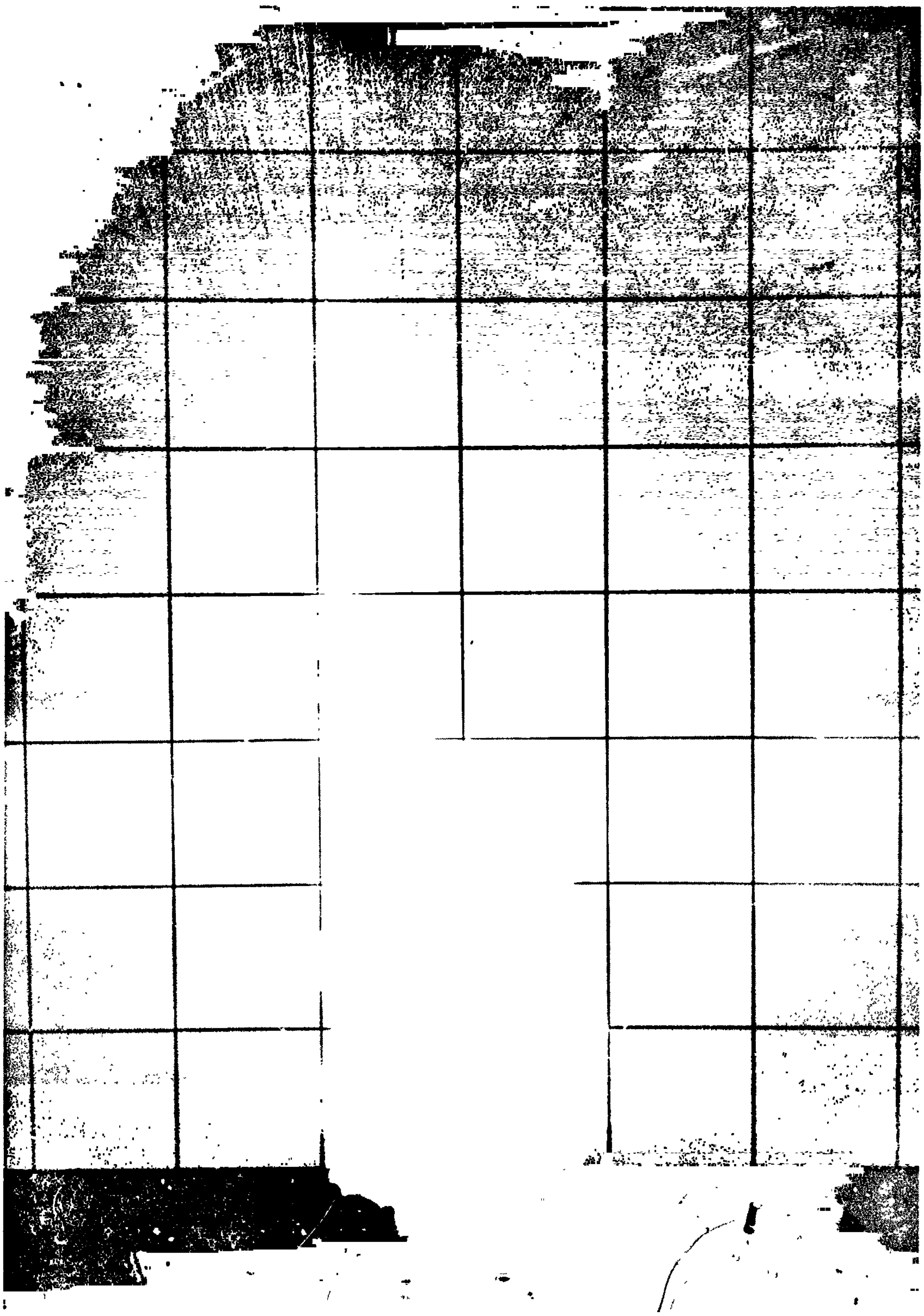


Figure 16. Flame Pattern Produced by TX346-1 Initiator (Grid lines spaced 6" apart)

APPENDIX A

LOT ACCEPTANCE AND QUALIFICATION PLAN

The following tests, measurements, exposures, etc., are presented (and briefly described) in the sequential manner that the initiators were exposed subsequent to fabrication.

Preliminary Measurements (Condition A--Figure A-1)

A. Serialize Each Initiator

B. Record Model Number

C. Record Bridgewire Resistance to Two Decimal Places

Acceptable range is 0.11 to 0.19 ohm.

D. Record Spark Gap Voltage Breakdown

Apply a static d.c. potential, with current limited to 100 microamps, to the pins of the initiator and record breakdown voltage at first indication of current flow as indicated by microammeter. Acceptable range is 700 to 1300 v.d.c.

E. Insulation Resistance

Apply a 1000 v.d.c. potential between the shorted terminals and initiator body and record resistance. Acceptable value is greater than 50 megohms at 1000 v.d.c.

F. Hermetic Seal Check

Using a Radiflo Leak Detector, perform leak test. Acceptable value is less than 1300 counts per minute (1×10^{-8} cc./sec.).

Lot Acceptance (NASA Specification S-1-PS(A)--Figure 2)

Sample A: 10% of Lot

Ten percent of the initiators were selected at random for proof testing. These were subdivided into five subgroups and tested as follows:

1. 20% exposed to 250 v. a. c., 60 cycles for 15 minutes, then fired in a closed bomb for pressure-time

2. 20% exposed to 250 v. a. c., 400 cycles for 15 minutes, then fired in a closed bomb for pressure-time

3. 20% exposed to 200,000 ergs discharge, then fired in a closed bomb for pressure-time

4. 20% tested in a calorimeter for calorific output

5. 20% tested in a closed bomb for pressure-time

Sample B: 5% of Lot

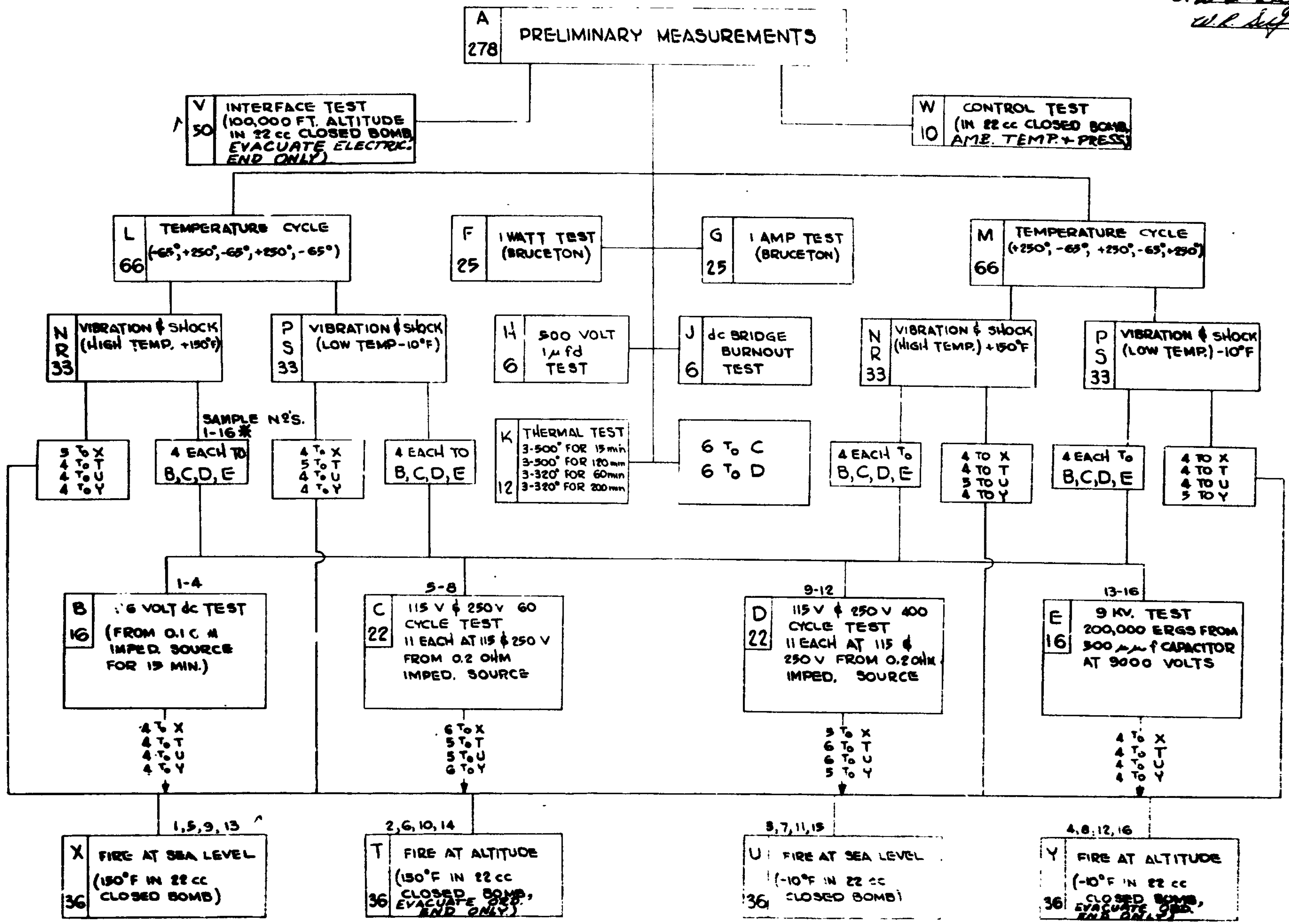
Fabricate initiators without spark gaps or other protective devices and expose to one amp or one watt through bridgewire for five minutes.

Qualification Program (Figure A-1)

For explanation of Figure A-1, see Pages A-4 through A-7.

QUALIFICATION TEST FLOW SHEET
FOR TX-346-1 OR TX-346

APPROVED MAY 31, 1963
BY



* EXAMPLE OF SAMPLE SELECTION PROCEDURE

Figure A-1. Qualification Test Plan "Flow Sheet"

LEGEND FOR FIGURE A-1

I. Functional and Nonfunctional Tests.

Representative no-fire and all-fire tests will be performed on the initiator. The tests planned are as follows:

A. No-Fire Tests--Electrical (72 Units). The acceptance criteria for the following tests shall be that the initiator shall not fire and shall not be rendered inoperative when subjected to the conditions prescribed in Figure A-1. After no-fire testing, all units will be submitted to normal ambient test firing conditions and the data recorded.

1. Twelve Units--Condition B. Apply 36 v. d. c. from a 0.1 ohm impedance source across the initiator terminals and terminals to outer case for 2 minutes.

2. Twenty-four Units--Condition C. Apply a 60-cycle current from a 0.2 ohm impedance source to 12 each at 250 v. a. c. Current shall be applied across the initiator terminals and terminals to outer case for 15 minutes.

3. Twenty-four Units--Condition D. Apply a 400-cycle current from a 1.0 ohm impedance source to 12 each at 115 v. a. c. and at 250 v. a. c. Current shall be applied across the initiator terminals and terminals to outer case for 15 minutes.

4. Twelve Units--Condition E. Discharge 200,000 ergs across the initiator terminals and the terminals to the outer case. The source will be a 500 micro-microfarad capacitor charged to 9000 volts.

B. No-Fire Reliability Tests--Electrical (124 Units). The acceptance criteria for the following tests shall be that the initiator shall not fire, but may be rendered inoperative, when subjected to the conditions described below. The initiators used in these reliability tests shall be of simplified design in that exterior tolerances, threads, and hermetic seal requirements may be deleted. All protective devices shall be removed, but functional characteristics shall remain unchanged.

1. Fifty Units--Condition F. A modified Bruceton analysis shall be conducted on 50 initiators according to the procedure outlined in NAVORD 2101. Direct current shall be applied to the initiators in increments of 0.1 ampere above and below the one watt (I^2R) no fire power. Current shall be applied for 5 minutes in each incremental test. A reliability of 99.95% at a confidence level of 95% shall be predicted by the modified Bruceton test.

2. Fifty Units--Condition G. A modified Bruceton analysis shall be conducted on 50 initiators according to the procedure outlined in NAVORD 2101. Direct current shall be applied to the initiators in increments of 0.1 ampere above and below the one ampere no-fire current. The current shall be applied for 5 minutes in each incremental test. A reliability of 99.95% at a confidence level of 95% shall be predicted by the modified Bruceton test.

3. Twelve Units--Condition H. Discharge a 1 microfarad capacitor charged to 500 volts across the initiator terminals and the terminals to the outer case.

4. Twelve Units--Condition J. Apply a d.c. voltage sufficient to pass a current that will burn out the bridgewire within 5 to 15 seconds of current flow.

C. No-Fire Tests--Thermal (24 Units)--Condition K.

1. Twelve Units. These units may become inoperative.

   a. Expose 6 units to a temperature of 500°F for 15 minutes.

   b. Expose 6 units to a temperature of 500°F for 120 minutes.

2. Twelve Units. These units may become inoperative.

   a. Expose 6 units to a temperature of 320°F for 60 minutes.

   b. Expose 6 units to a temperature of 320°F for 200 minutes.

D. All-Fire Tests (288 Units). The designed experiment shown on Figure A-1 will be employed to evaluate the capability of the initiator to withstand the conditions in the igniter specification as well as to evaluate the effects of the combinations of conditions. The conditions indicated are defined as:

1. Temperature Cycling--Condition L. (This condition satisfies both the temperature cycling and the storage temperature requirements.) Condition 132 units successively to -65, +250, -65, +250, and -65°F for one hour at each temperature with the time of transfer between temperature conditioning boxes not to exceed 5 minutes.

2. Temperature Cycling--Condition M. Condition 132 units successively to +250, -65, +250, -65, and +250°F for one hour at each temperature with the time of transfer between temperature conditioning boxes not to exceed 5 minutes.

3. Vibration Test. The test samples will be mounted in a suitable fixture and subjected (at high Condition N or low Condition P temperatures) to vibration applied both parallel and perpendicular to the longitudinal axis of the initiator. The frequency range from 20 to 2000 c.p.s. will be scanned in 5 minutes (scanning twice in both positions) noting all resonant frequencies under the following conditions: (See Appendix F for deviation.)

   a. 8 g's input through the range of 20 - 100 c.p.s.

   b. .015 inches double amplitude displacement through the range of 100 - 300 c.p.s.

   c. 67 g's input through the range of 300 - 2000 c.p.s.

4. Shock Test. The test samples will be mounted in a suitable fixture and subjected (at high Condition R or low Condition S temperature) to the following condition:

   100 g's for 11 milliseconds at chassis (sine wave).

5. Altitude Firing--Condition T. After conditioning in accordance with the test schedule shown on Figure A-1, test 72 units at an atmospheric pressure equal to or less than 45 microns of Mercury (a simulated altitude of 228,000 feet or higher), and a temperature of +150°F.

6. Temperature Firing--Condition U. After conditioning in accordance with the test schedule shown on Figure A-1, test 72 units at -10°F and ambient pressure.

7. Temperature Firing--Condition X. After conditioning in accordance with the test schedule shown on Figure A-1, test 72 units at +150°F and ambient pressure.

8. Altitude Firing--Condition Y. After conditioning in accordance with the test schedule shown on Figure A-1, test 72 units at an atmospheric pressure equal to, or less than, 45 microns of Mercury (an atmospheric altitude of 228,000 feet or higher) and a temperature of -10°F.

II. Interface Tests (100 Units)--Condition V. Initiator and firing unit interface will be evaluated under a simulated altitude of 100,000 feet. Closed bomb data will be collected simultaneously.

III. Controls (20 Units)--Condition W. Twenty initiators will be test fired at 70°F and without any environmental treatment in order to provide a reference point for data comparison purposes and lot acceptance data for future procurement.

APPENDIX B

FAILURE ANALYSES PERFORMED ON SIX TX346-1 INITIATORS

INTRODUCTION

The TX346-1 initiator was developed to match three major parameters as exhibited by the Aerojet AGX2008 initiator; namely, pressure versus time in a 22 $cm.^3$ closed volume, calorific output, and flame pattern. Subsequent to successful matching of these parameters via design demonstration or configuration tests, a lot of initiators was fabricated for exposure to the various environmental, safety, and functioning conditions per NASA specification S-1-PS(A). Six initiators failed to function, after certain exposures, on application of the firing pulse. NASA-MSFC and Thiokol personnel then met to discuss the disposition of these initiators. It was agreed that Thiokol would perform a failure analysis on these units in an attempt to ascertain the cause of the failures and then recommend a "fix." Demonstration of the adequacy of the "fix" would then be considered by NASA-MSFC and Thiokol.

DISCUSSION

A total of 278 TX346-1 initiators was subjected to the qualification program, as mentioned in the Introduction. This number does not include 28 quality control units and 15 additional 1 watt units which make a total of 321 initiators. Figure B-1, in conjunction with Table B-I, shows where the failures occurred in the program.

The nondestructive test data for each unit were investigated. The data are tabulated in Table B-II. These data were considered normal.

Careful examination of the units began with a check for evidence of firing pulse "arc-over" or "shorting" between the pins in the initiator connector. If such occurred, only a fraction of the firing energy would be delivered to the bridgewire and the wire would not explode, resulting in a "no-fire." No evidence, however, was found in any of the units to indicate "shorting."

The initiators were then subjected to X-ray examination. Three views were used to determine: (1) if charge separation or stratification had resulted from vibration and shock exposure, (2) if the diaphragm were ruptured, (3) the spark gap condition, and (4) if the bridgewire, as well as the bridgewire charge, were intact. Figure B-2 shows a cross-section of the TX346-1 initiator with identification of certain components. The X-ray film showed the charges and spark gaps to be normal. The two main things evident from the X-rays were bulged diaphragms in some units and the existence of a bridgewire in S/N 437. None of the other units had bridgewires remaining.

Next, the units were opened for internal examination, except for S/N 437 which was set aside. The main charges and diaphragm charges of all the initiators were normal. On removal of the charges, thus exposing the "top" of the diaphragm, it was noted that in addition to bulging as caused by bridgewire charge, the diaphragms were also "pocked" from impact of the bridgewire charge. This is normal and indicates functioning of bridgewire charge. No residual bridgewire was found and each initiator did have the required bridgewire charge. A tabulation of all observations is given in Table B-III.

CONCLUSIONS

Initiator S/N 437 did not function when the firing pulse was applied and yet it was found to have a bridgewire. It was concluded that one of two things was responsible; either the firing energy was too low (malfunction of firing unit--see "1" below) or the spark gap did not break down on application of the firing pulse. As can be noted in Table B-II, the spark gap voltage breakdown was normal.

The primary cause of the other initiator failures (except S/N 437) was lack of penetration of the diaphragm by the bridgewire charge. This was due to one or more of the following secondary causes:

1. Low Energy Firing Pulse: Since Thiokol could not measure this parameter simultaneous with pressure versus time, no current versus time record is available for check. The reliability history of the firing unit and the random manner in which the failures occurred, however, limit the possibility of a low energy firing pulse.

2. Abnormally Thick Diaphragms: Thickness measurements of the diaphragms showed them to be in tolerance.

3. Quality of Bridgewire Charge: The raw materials used for the TX346-1 units were the same as used for the TX346's. Pore formation during drying of this charge could have been a contributing factor since pores would tend to decrease the quantity (density) of charge above the bridgewire.

4. <u>Diaphragm--Main Charge Interface</u>: The phenomenon which is most strongly suspected as being the major contributing cause is the texture of the main charge above the diaphragm. The main charge in the TX346-1 offers a firmer "back-up" than in the case of the TX346. The bulk density of the X-418 charge in the TX346 is 0.98 g./cc., while the bulk density of the TXB106 charge in the TX346-1 is 2.07 g./cc. From these data, it can be stated that the bulk density values differ by a factor of 2.1. A simple analogy of this phenomenon would be to place a piece of paper on a sponge to simulate the TX346 and another piece of paper on a solid rubber backing to simulate the TX346-1. Then using the same blunt instrument, the relative ease of piercing the paper on the sponge versus that on the rubber can easily be noted.

Generally, the analyses show that the bridgewire charge output must be increased and more effectively utilized in order to increase reliability. Proposed methods for accomplishing this are discussed below.

RECOMMENDATIONS

1. Since initiator S/N 437 did not fire and it still has a bridgewire, it is recommended that a second attempt be made to fire it under the same conditions as required in the qualification program.

2. Decrease the length of the spacer (BR-40537). This would place the diaphragm nearer the bridgewire and also reduce the volume around the bridgewire, thus increasing pressure on the diaphragm and effecting more efficient transfer of thermal energy from the bridgewire charge to the diaphragm.

3. Increase concentration of explosive in bridgewire charge by changing the ratio of binder to explosive and change to a two-step application technique. These changes would increase the output of the charge and effect closer tolerances on bridgewire charge geometry.

4. Redesign first spacer to decrease free volume of bridgewire and gap cavity. This change would also "direct" or "focus" the bridgewire charge impulse on the diaphragm.

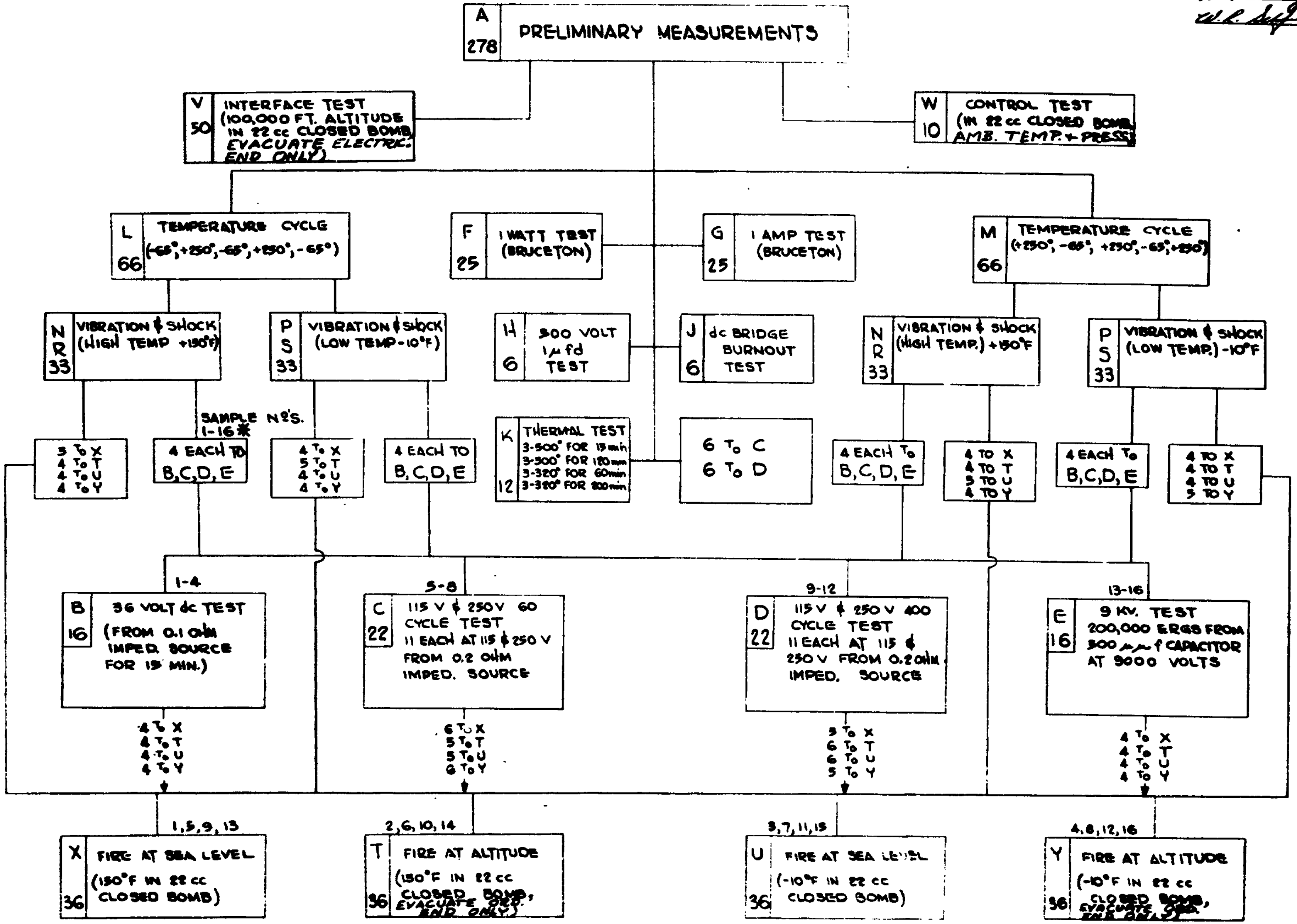
5. Decrease inside diameter of second spacer to create a shearing "edge" for the lead diaphragm similar to the TX346 spacer(s)-diaphragm interface. The shearing action, of course, occurs from pressure applied as a result of the outputs of the bridgewire charge and bridgewire explosion.

The above items 2, 3, 4, and 5 are presented in order of preferred changes relative to small modifications for improving the functioning reliability of the initiator without sacrificing any safety feature. Further, it is felt that since these recommendations would all be positive; that is, improve reliability, only a limited number of confirmation tests would be required to demonstrate the compatibility of these changes with NASA specification S-1-PS(A) requirements.

NOTE: Since the above analysis was performed, initiator S/N 437 was conditioned to -10° F, installed in a closed bomb (Condition "U"), and subjected to the same firing pulse (2000 volts; 0.75 mfd.) as before. Again, the unit did not function, however, the voltage was increased to 2500 volts and it functioned. The pressure-time data were normal (See Appendix D, Table D-VIII). The test results indicate that the problem was in the spark gap, itself, and low temperature conditioning caused a shift in the breakdown characteristic. None of the other units tested in the qualification program exhibited this affect.

APPROVED MAY 31, 1963
BY

QUALIFICATION TEST FLOW SHEET
FOR TX-346-1 OR TX-346



* EXAMPLE OF SAMPLE SELECTION PROCEDURE

Figure B-1. Qualification Test Plan "Flow Sheet"

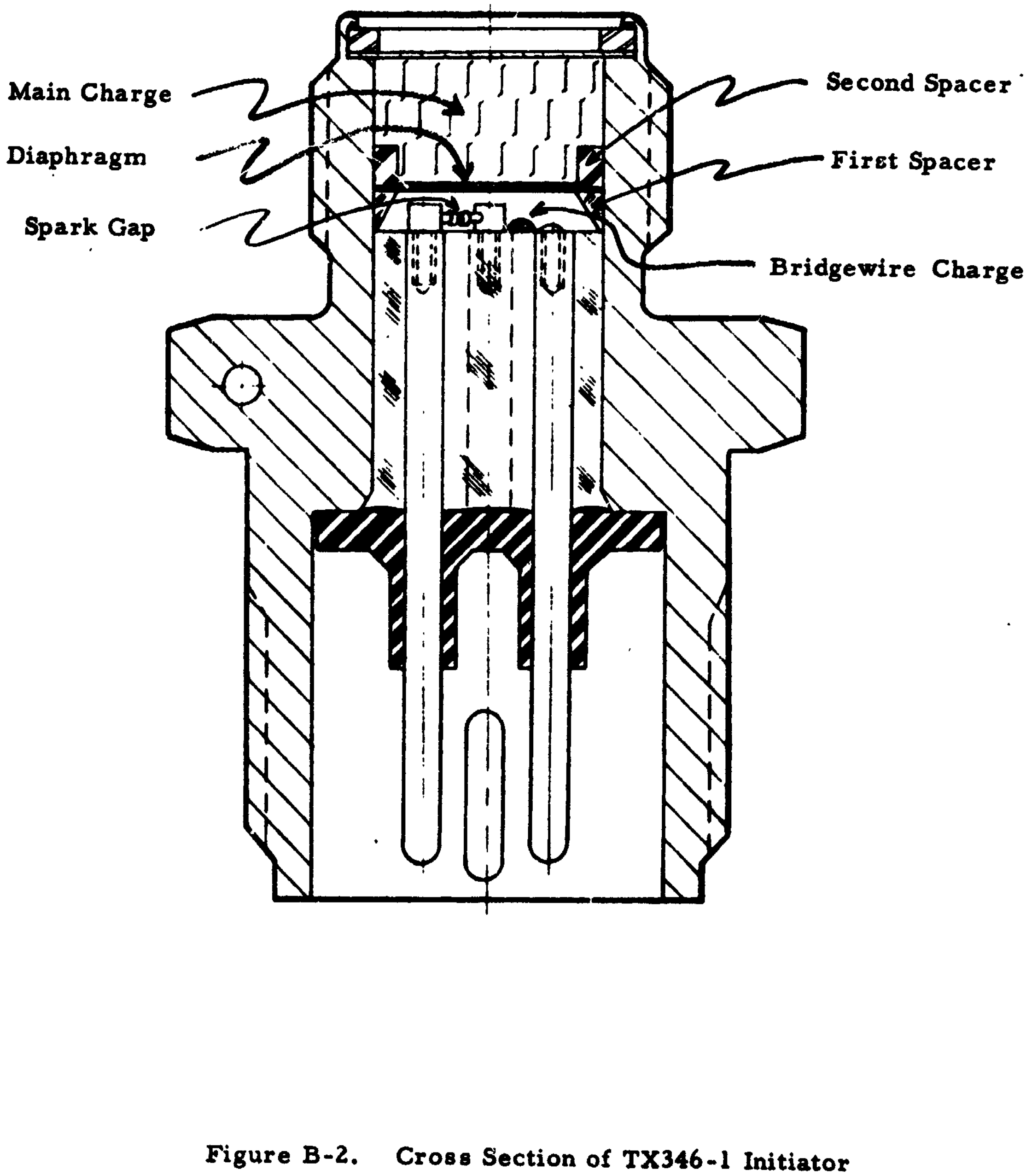


Figure B-2. Cross Section of TX346-1 Initiator

TABLE B-I

PRETEST EXPOSURE AND TEST CONDITIONS
FOR TX346-1 FAILURES

S/N	Pretest Exposures[1]	Test Condition[1]
392	L. NR, B	X
437	L, NR, D	Y
492	none	V
575	L, PS	U
635	L, PS	Y
660	M, PS	T

[1]See Figure B-1 for explanation of symbols.

TABLE B-II

NONDESTRUCTIVE TEST DATA FOR TX346-1 INITIATOR FAILURES

S/N	Bridgewire Resistance, ohms		Dielectric at 1000 volts, megohms		D. C. Spark Gap Breakdown[1], volts		"Radiflo" Leak Test 1×10^{-8} cc./sec.
	Initial	Before Functioning Test	Pretest	Post-test	Initial	Before Functioning Test	
392	0.16	0.16	>50	N/A	950	1050	Satisfactory
437	0.15	0.15	>50	>50	1100	1200	Satisfactory
492	0.16	0.16	>50	N/A	750	N/A	Satisfactory
575	0.16	0.16	>50	N/A	1050	1100	Satisfactory
635	0.16	0.16	>50	N/A	950	800	Satisfactory
660	0.15	0.15	>50	N/A	750	700	Satisfactory

[1] Thiokol Test Instrument.

TABLE B-III

FAILURE ANALYSIS SUMMARY OF OBSERVATIONS ON TX346-1 INITIATORS

S/N	Bridgewire			Bridgewire Charge		Spark Gap			Diaphragm		Main Charge		Diaphragm Charge		Remarks
	X-ray	Electrical	Visual	X-ray	Visual	X-ray	Electrical	Visual	X-ray	Visual	X-ray	Visual	X-ray	Visual	
392	None Visible	Open Circuit	Missing	Not Visible	Pulverized	OK	N/A	OK	Bulged	Pocked & Bulged	OK	OK	Not Visible	OK	1
437	Visible	0.15 ohms	Not Opened	Not Visible	Not Opened	OK	1100 volts	Not Opened	OK	Not Opened	OK	Not Opened	OK	Not Opened	1
492	None Visible	Open Circuit	Missing	Not Visible	Pulverized	OK	N/A	OK	Bulged	Pocked & Bulged	OK	OK	Not Visible	OK	1
575	None Visible	Open Circuit	Missing	Not Visible	Pulverized	OK	N/A	OK	Bulged	Pocked & Bulged	OK	OK	Not Visible	OK	1
635	None Visible	Open Circuit	Missing	Not Visible	Broken into pieces, some remaining on glass	OK	N/A	OK	Bulged Slightly	Pocked & Bulged	OK	OK	Not Visible	OK	1
660	None Visible	Open Circuit	Missing	Not Visible	Pulverized	OK	N/A	OK	Bulged Slightly	Pocked & Bulged	OK	OK	Not Visible	OK	1

[1] The diaphragms of all initiators were measured relative to thickness and found to be normal.

APPENDIX C

PERTINENT EXCERPTS FROM NASA-MSFC SPECIFICATION S-1-PS(A)

4. REQUIREMENTS

4.1 EBW Firing Units - The EBW ignition system shall use a firing unit furnished by NASA on a GFE basis. Two (2) basic types of units shall be furnished.

4.1.1 Flight Firing Unit - A fixed voltage unit which discharges a 1 ± 0.2 microfarad capacitor charged to 2300 ± 100 volts.

4.1.2 Laboratory Firing Unit - A variable voltage unit which discharges three (3) different capacitor circuits charged to various voltage levels. For the purpose of this program, the 0.75 microfarad capacitor circuit charged to 2000 volts (nominal) shall be used.

4.2 Initiator (EBW)

4.2.1 The initiator shall be capable of reproducible ignition at all altitudes below 300,000 feet over the temperature range of -10°F to +150°F.

4.2.2 Sealing - The initiator shall be hermetically sealed. No leakage in excess of 1×10^{-8} cc./second is allowed. The Radiflo or approved equal process shall be used for verification.

4.2.3 Function Criteria - The initiator shall function satisfactorily when properly connected to the firing units of paragraph 4.1 and exposed to the discharge of a 1 ± 0.25 microfarad capacitor charged to 2000 - 2400 volts d.c. The nominal firing energy shall come from the discharge of a 1 microfarad capacitor charged to 2300 volts.

4.2.4 Insulation - The insulation resistance when measured across the terminals to housing of the initiator shall be in excess of 50 megohms. The measurement shall be made by a 1000 volt instrument under standard room temperature

(80 ± 20°F) and pressure conditions.

4.2.5 <u>Mounting Threads</u> - The initiator body threads for attaching the unit to the igniter shall be 9/16-18UNF-3A.

4.2.6 <u>Temperature</u> - The initiator shall function after being subjected to a temperature of 350°F (500°F desired) for a period of 15 minutes and temperatures of -65°F to +250°F (300°F desired) for 60 minutes.

4.2.7 <u>Storage Temperature</u> - The initiator shall function properly after being subjected to storage temperatures of -65°F to +165°F for a period of two (2) years. The above requirement shall be considered a design requirement only, and as such, shall be a prime factor in material selections. The contractor shall not be required to prove the initiator storage capability under this program.

4.2.8 <u>Vibration</u> - The initiator shall function properly during or after being subjected to the vibration conditions listed below. The vibration input shall be applied as follows:

A. Through the center of gravity in a direction parallel with the longitudinal (major) axis of the initiator. (On a vertical displacement table with the bridgewire down).

B. Through the center of gravity in a direction perpendicular to the longitudinal axis of the initiator.

4.2.8.1 <u>Survey</u> - Scan the frequency range from 20 to 2000 c.p.s. in five (5) minutes (scanning twice in both positions "A" and "B" noting the frequency of all resonant points), for the following conditions:

(1) 20 - 100 c.p.s. @ 8 g's

(2) 100 - 300 c.p.s. @ .015 inch a displacement

(3) 300 - 2000 c.p.s. @ 70 g's

4.2.8.2 <u>Endurance</u> - The units shall be subjected to additional vibration conditioning at each resonant frequency determined above in accordance with the schedule below. (If no resonant frequencies are found, the requirements of this paragraph shall be deleted.) The units shall be vibrated for five (5) minutes in both positions "A" and "B."

(1) 20 - 100 c.p.s. @ 5 g's

(2) 100 - 300 c.p.s. @ 0.01 inch a displacement

(3) 300 - 2000 c.p.s. @ 50 g's

4.2.9 Shock - The initiator shall function during or after being subjected to one of the following shock test conditions:

(1) 100 g's for 10 milliseconds at chassis (triangular wave) or

(2) 100 g's for 8 milliseconds at chassis (sine wave) or

(3) 100 g's for 6 milliseconds at chassis (square wave)

4.2.10 The initiator shall not fire when subjected to the following conditions:

4.2.10.1 When power outputs listed below are applied in any order across initiator terminals and terminals to housing. (The unit shall not be rendered inoperative):

4.2.10.1.1 36 volts d.c. from a 0.1 ohm impedance source, for 15 minutes.

4.2.10.1.2 115 and 250 volts a.c., 60 cycles from a 0.2 ohm impedance source, for 15 minutes.

4.2.10.1.3 115 and 250 volts a.c., 400 cycles from a 1.0 ohm impedance source, for 15 minutes.

4.2.10.1.4 Discharge of 200,000 ergs from a 500 micro-microfarad capacitor charged to 9000 volts.

4.2.10.2 When power outputs listed below are applied across the initiator terminals with all diodes, spark gaps, or other protected devices removed. (The unit may be rendered inoperative.)

4.2.10.2.1 One watt of direct current for five (5) minutes. A no-fire reliability of 99.9% at a 95% confidence level shall be demonstrated.

4.2.10.2.2 One ampere of direct current for five (5) minutes. A no-fire reliability of 99.9% at a 95% confidence level shall be demonstrated.

4.2.10.2.3 Discharge of a 1 microfarad capacitor charged to 500 volts.

4.2.10.2.4 A varying d.c. current increasing from zero at the rate of 0.5 ampere per second until the unit fires. The current may be increased by a step method but a constant rate of change is preferred. The integral of the curve prior to firing must exceed one (1) ampere-second and perferably shall exceed four (4) ampere-seconds.

4.2.10.3 Exposure to the following temperatures (the unit may be rendered inoperative):

A. 400°F for a period of 120 minutes (500°F desired).

B. 250°F for a period of 200 minutes (320°F desired).

4.2.11 Removal - The initiator shall be so designed that it may be readily removed from the igniter for inspection or replacement.

4.2.12 Ordnance Output - The TX346-1 initiator shall reproduce and match the ordnance output of the AGX-2008 initiator as shown by Figure 1. The AGX-2008 is produced by the Aerojet-General Corporation, Downey Division, Downey, California. Samples of the initiator will be furnished to the vendor by MSFC on a GFE basis. The procedure required for demonstrating the output matching shall be subject to the approval of MSFC. The TX346 initiator shall reproduce and match the Thiokol TX255 (XM6) squib.

4.2.13 Connector - The initiator shall mate with a Bendix RB type plug, No. 10-42612-3S.

5. TEST REQUIREMENTS

5.1 A series of test programs shall be established to prove that the initiators under consideration meet the requirements of this specification. These programs shall include, but not be limited to the initiator pre-flight rating tests (PFRT) and the initiator qualification program.

5.2 Upon their establishment, the above test programs shall become a portion of this specification.

6. GENERAL REQUIREMENTS

6.1 The initiators, components, and test apparatus shall be subject to inspection by authorized government inspectors. All tests required for proof testing shall be subject to witnessing by representatives of the contractor and the procuring agency. At convenient times prior to and after the tests, random samples of the initiators shall be examined to determine if they conform to all requirements of the contract and specifications under which they were built. The procuring agency may require examination of various components and initiators prior to, during, or after proof tests. The results of all such examinations shall be reported as a portion of the monthly reports required under this program.

6.2 Test Apparatus and Procedures - Schematic drawings and descriptions of all test apparatus, and outline diagrams showing points of measuring apparatus and application, shall be furnished prior to the initiation of tests under paragraph 5 herein. Test procedures and methods to be used shall be submitted to the procuring agency for approval prior to the initiation of tests under paragraph 5.

6.3 Instrumentation Calibration - Each instrument and other measuring apparatus, upon which the accuracy of test results depends, shall be calibrated frequently enough to insure attainment of steady state accuracy of ± 1/2 percent of the specified value of the measurement and ± 2°F for environment temperature. Calibration records shall be maintained and shall be made available to authorized representatives of the procuring agency upon request.

6.4 Automatic Recording Equipment - Automatic recording equipment of adequate response shall be used to obtain data during transient conditions of initiator operation requiring the evaluation of time versus component operation variables.

6.5 Temperature Conditioning Time - Conditioning time for an initiator shall be such that all parts of the component shall have reached a temperature within 5°F of the specified temperature. A component shall be considered conditioned when it has been continuously exposed to the specified temperature for the conditioning time, making suitable allowance for the starting temperature. During the conditioning time, the conditioning chamber shall not vary more than ± 5°F from the specified temperature.

6.6 Simulated High Altitudes - The term "simulated high altitude conditions" used herein, shall be defined as a test chamber environment with an atmospheric pressure simulating an altitude of 225,000 feet to produce high altitude ignition conditions.

FIGURE 1

ORDNANCE OUTPUT DEFINITION

(Applicable to TX346-1 Initiator)

1. General - The procedure outlined below shall establish the procedure for verifying the matching of the ordnance output of one high voltage initiator to that of the AGX-2008 initiator used for igniter development. The matching is defined in terms of function time, peak pressure, time to peak pressure, and total caloric output. A statistical procedure is not considered necessary and the sample numbers shown herein are minimums.

2. Test Equipment - The test equipment used by various ordnance component vendors and government facilities is somewhat similar but not necessarily identical. Therefore, the output matching or lack of equality will be established on a comparative basis. A representative sample of AGX-2008 initiators will be fired using the available equipment and the data compared to that of a like number of candidate units. All test equipment and procedures shall be subject to the approval of MSFC.

3. Test Records - Permanent test records shall be maintained by the testing agency and should include, but not be limited to the following:

   a. Test sample number and type of unit.

   b. Tests performed.

   c. Test results.

   d. Date of test.

   e. Test method.

   f. Instrumentation used for initiation and recording of data.

   g. Date of latest instrumentation or recording equipment calibration.

   h. Dimensioned drawings or sketches of all special test equipment.

4. <u>Firing Unit</u> - The firing unit used for the storage and release of the high voltage/high current firing pulse shall be as defined in S-1-PS.

5. <u>Test Series</u>

a. <u>Pressure Versus Time Signature (12 Initiators)</u>

(1) Install the AGX-2008 (and subsequently the candidate initiator) in a closed bomb having a free volume of 15 to 30 cc. (22 cc. desired). Initiate and permanently record the pressure versus time signature, noting the following points:

(a) Function time (time from application of firing energy to first indication of pressure).

(b) Time to peak pressure from application of firing energy.

(c) Peak pressure.

(2) The output of the candidate initiator will be considered as matching that of the AGX-2008 if its function time, time to peak pressure, and peak pressure are within plus 10%, minus 0%, of the calculated average range of the 12 AGX-2008 initiators tested.

b. <u>Total Caloric Output (3 Initiators)</u>

(1) Install the entire initiator in the oxygen bomb of a Parr, Plain Jacket Oxygen Bomb Calorimeter or equivalent and initiate the unit.

(2) Note the temperature rise in accordance with the accepted procedure of the equipment used, and calculate the total caloric output of the initiators. The output of the candidate initiator will be considered as matching that of the AGX-2008 if its total caloric output is within plus 25% or minus 10% of the recorded range of the three AGX-2008 initiators tested.

c. <u>Candidate Vendor Tests (5 Initiators)</u>

A total of five (5) spare standard initiators will be furnished by MSFC which the vendor may use at his discretion. The test results obtained need not be recorded or reported to MSFC; however, all additional tests must be reported. The serial numbers of the five (5) initiators to be used by the vendor will be recorded by the vendor prior to the test series. All AGX-2008 initiators remaining after completion of the test program shall be returned to MSFC.

6.7 Inspection After Tests - All test hardware and expended initiators shall be retained following all test programs until the completion of the contract or until directed otherwise by MSFC.

7. DEFINITIONS

7.1 The components, nomenclature and data definitions of AGC-30038 shall apply to this specification unless revised herein.

7.2 Initiator - The term initiator shall be defined as the primary source of the chain of pyrotechnic ignition action. The term is comparable to "squib" and the unit contains the bridgewire.

7.3 Igniter - The igniter shall be defined as all components of the ignition device attached to the motor itself; including initiators, pellets, igniter body, basket, etc.

7.4 Ignition System - The term ignition system shall be defined as the entire source of ignition energy and shall be comprised of the igniter, the firing unit, and all interconnecting wires between the two (2) units.

7.5 Firing Unit - The term firing unit shall be defined as the EBW power supply and shall be the source of the high voltage electrical power.

7.6 Hermetically Sealed - The term hermetically sealed shall be defined as a seal design which precludes the flow of gas either in or out of the initiator prior to firing. A leak rate of less than 1×10^{-8} cc. per second is adequate.

7.7 Lot - The term lot used in Figure 2 is defined as a group of initiators, subassemblies, or components processed as a single group. The term may be further defined for the following specific items, as:

7.7.1 Ordnance Mixture - A lot of ordnance mixture is defined as a quantity of raw materials mixed together in one operation.

7.7.2 Bridgewire Material - A lot of bridgewire material is defined as wire taken from a single reel or reels composed of material from a single draw operation.

7.7.3 Initiator Bodies - A lot of initiator bodies is defined as bodies manufactured and inspected as a single group.

7.7.4 Initiator Assembly - A lot of initiator assemblies is defined as a group of initiators assembled from single lots of initiator bodies, ordnance mixture, bridgewires, etc. The lot of final assemblies shall be inspected and proof tested as a single group.

III. QUALITY CONTROL CRITERIA

1. The quality control criteria established herein are intended to establish a program to assure that all flight EBW initiators are capable of meeting the Marshall Space Flight Center requirements. The program is also applicable to developmental or test lots of initiators; however, all or individual sections may be waived by the procuring agency. The requirements are primarily intended to apply to the Aerojet-General Corporation AGX-2008 high voltage (EBW) initiator but may apply to other initiators if desired. This document forms an amendment to the initiator specification, S-1-PS, Exploding Bridgewire (EBW) Initiator for the S-I Retro Rocket. The inclusion of this document shall hereafter be implied in references to specification S-1-PS(A).

2. The initiator shall be capable of meeting all the preceding requirements of the initiator specification S-1-PS, Exploding Bridgewire (EBW) Initiator for the S-I Retro Rocket.

3. The initiator shall conform to the envelope requirements of drawing number SPS-11, EBW Initiator Outline.

4. All initiators produced for flight use shall meet the following minimum quality control requirements. Additional detail requirements may be specified by MSFC and/or the contractor but the criteria below are mandatory.

   A. For each lot of initiators manufactured for flight use, ten (10) units or 10% of the total lot size (whichever number is the greater) shall be selected at random for proof testing. The number of samples selected for proof testing shall always be a multiple of ten (10) and shall be tested as follows:

      (1) One unit from each five (5) test samples shall be exposed to the 250 volt a.c. test defined by paragraph 4.2.10.1.2 of specification S-1-PS. The unit shall subsequently be fired by the laboratory firing unit.

      (2) One unit from each five (5) test samples shall be exposed to the 250 volt a.c. test defined by paragraph

4.2.10.1.3 of specification S-1-PS. The unit shall subsequently be fired by the laboratory firing unit.

(3) One unit from each five (5) test samples shall be exposed to the 200,000 erg test defined by paragraph 4.2.10.1.4 of specification S-1-PS. The unit shall subsequently be fired by the laboratory firing unit.

(4) Two units from each five (5) test samples shall be fired by the laboratory firing unit to provide ordnance output control data.

B. The safety certification and control samples listed above shall be subsequently fired by the laboratory firing unit defined in paragraph 4.1.2 of specification S-1-PS. The following test data and correlation criteria shall be followed prior to lot acceptance:

(1) All of the units specified in paragraphs 4.A. (1), 4.A. (2), 4.A. (3) and half of the units specified in paragraph 4.A. (4) shall be fired in a suitable chamber and the pressure versus time signature recorded. The ordnance output definition procedure of Figure 1 shall be followed and the criteria specified therein shall be met. The performance data recorded from the AGX-2008 initiators tested in the prequalification program of contract NAS 8-510, shall constitute the standard by which all AGX-2008 data is compared. Other initiators will be evaluated by the procedure of Figure 1. using previously accepted AGX-2008 initiators for standards.

(2) Half of the units specified in paragraph 3.2. (4) shall be fired in a suitable calorimeter and the caloric output data recorded as outlined in Figure 1. The caloric data recorded from AGX-2008 initiators tested in the prequalification program of contract NAS 8-510 shall constitute the standard by which all AGX-2008 data is compared. Other initiators will be evaluated by the procedure of Figure 1, using previously accepted AGX-2008 initiators for standards.

B. For each lot of initiators manufactured for flight use, a minimum of five (5) or 5% of the lot size (whichever number is the greater) special initiators shall be manufactured without spark gaps, diodes or other protective devices. The units shall be subjected to the one watt/one ampere test specified in paragraphs 4.2.10.2.1 or 4.2.10.2.2 of specification S-1-PS. Only one of the aforementioned test conditions shall be conducted: The most severe test resulting from calculations of the total induced wattage shall be selected. The units shall otherwise simulate the flight item as accurately as possible and the ordnance charge and bridgewire material shall be taken from the same lot as the flight items. The special units shall be processed and assembled (where possible) concurrent with the flight initiators: however, the units will not be included in the lot size determination.

C. The following inspections shall be established in the contractors quality control program. The program below establishes the minimum steps acceptable and is not all inclusive.

(1) Each part, subcomponent, or assembly shall be inspected and certified to meet the drawing requirements.

(2) All threads shall be inspected for burrs or flaws and drawing conformity.

(3) The insulation resistance specified in paragraph 4.2.4 of specification S-1-PS shall be checked on all initiator body assemblies.

(4) The spark gap breakdown voltage of each initiator assembly shall be checked and recorded. The breakdown shall occur at voltages above 700 volts d.c. and below 1300 volts d.c.

(5) The quality of the ordnance mixture shall be established for each lot. The contractor shall establish adequate quality control procedures for the ordnance mixture and its ingredients; subject to MSFC approval. Upon approval, the procedure shall become a portion of this specification.

5. All test data required herein shall be permanently recorded and copies shall be forwarded to MSFC (% the contract technical supervisor). The tests shall be conducted in accordance with good ethical practice and all test conditions shall be met. The failure of any one unit tested, as outlined above, will result in the rejection of the entire lot for flight use. The lot of initiators may be used for ground tests upon the approval of MSFC. All rejected units not destroyed, shall be adequately tagged or marked (machinist dye preferred) to preclude their inadvertent

flight use.

IV. LIST OF SPECIFICATION CHANGES

1. Revision (A)

   A. Add paragraph 3.3 and 3.4.

   B. Change paragraph 4.2.10.2.4 from "a d.c. voltage sufficient to pass a current that will burn out the bridgewire in 10 ± 5 seconds," to the present wording.

   C. Add paragraph 7.7.

   D. Add Figure One (1).

   E. Add Figure Two (2).

   F. Add Figure Three (3).

APPENDIX D

LOT ACCEPTANCE AND QUALIFICATION PROGRAM TEST DATA

The test results from the Lot Acceptance and Qualification programs are presented in tabular and graphic form, with each being appropriately titled. Refer to the Legend shown below for explanation of symbols found in the tables. Included as another aid in following the flow of initiators through the Qualification program is Figure D-1.

TX346 initiator data can be found in Tables D-I through D-IV, D-IX and D-XI; TX346-1 initiator data can be found in Tables D-V through D-VIII, D-X and D-XI. Pressure-time signature plots, as derived from the tabulated data, are shown on Figures D-2, D-3 and D-4.

LEGEND

Pretest Environmental Exposures

L. Temperature cycle (-65°, +250°, -65°, +250°, -65°F) 1 hour each

M. Temperature cycle (+250°, -65°, +250°, -65°, +250°F) 1 hour each

NR. Vibration and shock at +150°F

PS. Vibration and shock at -10°F

Safety Tests:

B. 36 volts d. c. from a 0.1 ohm impedance source

C. 115 V and 250 V 60 cycle test

D. 115 V and 250 V 400 cycle test

E. 9.0 K.V. test, 200,000 ergs from a 0.0005 mfd. capacitor charged to 9,000 volts

F. 1 watt test

H. 500 V, 1 mfd. test

J. d. c. bridgewire burnout

K. Thermal test

Test Conditions:

T. Tested at 150°F in 22 cc. closed bomb--ordnance end only evacuated to 225,000 feet (0.11 mm. Hg.)

U. Tested at -10°F in 22 cc. closed bomb at ambient pressure

V. Interface test--tested in a 22 cc. closed bomb--electric connector end only evacuated to 100,000 feet (8.02 mm. Hg.)

W. Control test--tested in a 22 cc. closed bomb at ambient temperature and pressure

X. Tested at 150°F in 22 cc. closed bomb at ambient pressure

Y. Tested at -10°F in 22 cc. closed bomb--ordnance end only evacuated at 225,000 feet (0.11 mm. Hg.)

Test Results:

t_1 The time, in milliseconds, from the application of firing pulse to the first pressure rise.

t_2 The time, in milliseconds, from first pressure rise to maximum pressure.

P_{max} The maximum pressure (psig).

TABLE D-I

TX346 INITIATOR LOT ACCEPTANCE PRESSURE-TIME DATA

Serial Number	Safety Tests	Test Results t_1 [4]	t_2 [5]	P_{max} [6]
178	3	0.2	1.0	300
180	-	0.2	0.6	345
196	-	0.2	1.4	325
202	3	0.2	0.6	355
259	-	0.2	1.0	340
446	3	0.2	1.0	320
475	1	0.3	0.6	305
543	-	0.4	1.0	285
587	3	0.4	0.5	350
598	3	0.4	0.6	335
606	-	0.4	1.4	360
677	3	0.4	0.9	275
706	1	0.3	1.3	310
710	1	0.3	0.7	340
757	2	0.4	1.0	325
782	2	0.4	0.6	300
783	2	0.4	1.6	270
789	1	0.4	0.5	325
800	2	0.3	1.6	235
807	1	0.4	1.2	285
812	2	0.3	1.5	260
817	2	0.4	1.0	320
918	1	0.4	0.6	325

Legend:
1. 250 v.a.c., 400 c.p.s.
2. 250 v.a.c., 60 c.p.s.
3. 9 KV discharge from 500 picofarad capacitor.
4. Time from application of firing pulse to initial pressure rise (milliseconds).
5. Time from initial pressure rise to maximum pressure (milliseconds).
6. Maximum pressure developed in a 22 cc. closed bomb (psig).

Test Conditions:
Temperature — 75°F
Pressure — Ambient
Firing Pulse — 2 KV @ 0.75 Mfd.

TABLE D-II

TX346 INITIATOR LOT ACCEPTANCE CALORIFIC DATA

Serial Number	Resistance (ohm)	Calories Per Initiator
250	0.13	301
263	0.13	317
580	0.13	213
809	0.12	335
841	0.13	288

Pretest Exposures: None

Test Conditions: Pressure - Ambient (air) in Parr Calorimeter
Firing Pulse - 2KV @ 0.75 Mfd.

TABLE D-III

TX346 LOT ACCEPTANCE ONE WATT DATA

Serial Number	Resistance (ohm)	Current (amp)	Results
89	0.11	3.03	No Fire--Dud
162	0.12	2.88	No Fire--Dud
83, 141, 150, 169	0.13	2.77	No Fire--Dud
46, 65, 79, 99, 105, 114, 120, 144	0.14	2.67	No Fire--Dud
167	0.17	2.43	No Fire--Dud

Pretest Exposures: None

Test Conditions: Temperature — 75°F
Pressure — Ambient

TABLE D-IV

TX346 INITIATOR QUALIFICATION PROGRAM TEST RESULTS

S/N	Bridgewire Resistance ohm	Insulation Resistance	Spa. .c Gap d. c. Voltage Breakdown	Radiflo	Pretest Environmental Exposures	Safety Tests	Test Condition	Test Results t_1	t_2	P_{max}	Remarks Pass	Fail
178	0.14	Pass	1200	Pass	--		Lot Acceptance Test- .ee Table D-I				X	
180	0.12	Pass	1200	Pass	--		Lot Acceptance Test--See Table D-I				X	
181	0.17	Pass	N/A	Pass	--	K	500°F for 15 min.		No Fire--Dud		X	
184	0.13	Pass	850	Pass	--	C	Y	0.4	1.5	160	X	
188	0.16	Pass	850	Pass	--	--	V	2.4	0.6	330	X	
196	0.15	Pass	1050	Pass	--		Lot Acceptance Test--See Table D-I				X	
202	0.14	Pass	1150	Pass	--		Lot Acceptance Test--See Table D-I				X	
207	0.17	Pass	N/A	Pass	--	J	--		No Fire--Dud		X	
211	0.16	Pass	N/A	Pass	--	J	--		No Fire--Dud		X	
217	0.15	Pass	800	Pass	L, PS	--	X	0.3	0.8	235	X	
219	0.13	Pass	725	Pass	--	--	V	2.6	0.6	270	X	
228	0.12	Pass	800	Pass	M, PS	E	Y	0.4	0.9	210	X	
230	0.13	Pass	800	Pass	--	--	V	2.0	1.2	275	X	
231	0.12	Pass	1200	Pass	L, NR	--	X	0.3	0.7	310	X	
247	0.17	Pass	850	Pass	--	D	T	0.5	2.3	215	X	
248	0.14	Pass	700	Pass	M, NR	B	T	0.4	1.2	230	X	
249	0.17	Pass	N/A	Pass	--	J	--		No Fire--Dud		X	
250	0.13	Pass	700	Pass	--		Lot Acceptance Test--See Table D-II				X	
251	0.15	Pass	850	Pass	--	--	V	0.3	1.5	310	X	
252	0.17	Pass	N/A	Pass	--	K	500°F for 15 min.		No Fire--Dud		X	
258	0.15	Pass	1000	Pass	L, NR	--	X	0.5	0.6	285	X	
259	0.14	Pass	700	Pass	--		Lot Acceptance Test--See Table D-I				X	
260	0,14	Pass	N/A	Fail	--	H	--		No Fire--Dud		X	
261	0,16	Pass	N/A	Pass								
262	0.14	Pass	700	Pass	--	C	X	0.3	0.6	265	X	
263	0.13	Pass	700	Pass	--		Lot Acceptance Test--See Table D-II				X	
264	0,13	Pass	950	Pass	--	--	V	1.4	0.6	300	X	
267	0,17	Pass	N/A	Pass	--	J	--		No Fire--Dud		X	
269	0.15	Pass	N/A	Pass	--	K	320°F for 60 min.		No Fire--Dud		X	
276	0.15	Pass	N/A	Pass	--	J	--		No Fire--Dud		X	
278	0.16	Pass	N/A	Pass	--	H	--		No Fire--Dud		X	
280	0.16	Pass	N/A	Pass	--	K	320°F for 60 min.		No Fire--Dud		X	
281	0.17	Pass	N/A	Pass	--	K	320°F for 60 min.		No Fire--Dud		X	
282	0.16	Pass	N/A	Pass	--	J	--		No Fire--Dud		X	
298	0.17	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
301	0.15	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
302	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
304	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	

TABLE D-IV

(CONTINUED)

S/N	Bridgewire Resistance ohm	Insulation Resistance	Spark Gap d. c. Voltage Breakdown	Radiflo	Pretest Environmental Exposures	Safety Tests	Test Condition	Test Results t_1	t_2	P_{max}	Remarks Pass	Fail
308	0.17	Pass	N/A	Pass	--	K	500°F for 15 min.		No Fire--Dud		X	
310	0.17	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
313	0.17	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
314	0.14	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
323	0.17	Pass	N/A	Pass	--	K	500°F for 120 min.		No Fire--Dud		X	
324	0.13	Pass	900	Pass	L, NR	--	X	0.4	0.5	305	X	
333	0.17	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
339	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
340	0.16	Pass	N/A	Pass	--	K	320°F for 200 min.		No Fire--Dud		X	
342	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
343	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
345	0.17	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
347	0.17	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
348	0.17	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
351	0.17	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
358	0.13	Pass	700	Pass	--	--	V	2.6	1.0	350	X	
359	0.12	Pass	850	Pass	L, NR	B	Y	0.4	1.3	185	X	
361	0.15	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
364	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
367	0.13	Pass	700	Pass	M, NR	--	X	0.3	0.6	260	X	
369	0.15	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
370	0.17	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
371	0.17	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
372	0.14	Pass	N/A	Fail	--	H	--		No Fire--Dud		X	
373	0.17	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
379	0.14	Pass	850	Pass	--	F	--		No Fire--Dud		X	
383	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
399	0.13	Pass	750	Pass	M, NR	--	U	0.4	0.8	260	X	
403	0.15	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
411	0.15	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
423	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
426	0.14	Pass	1000	Pass	--	--	W	0.2	0.4	305	X	
434	0.15	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
436	0.14	Pass	850	Pass	--	--	W	0.3	1.5	280	X	
440	0.13	Pass	750	Pass	--	C	Y	0.2	1.3	195	X	
446	0.14	Pass	1100	Pass	--		Lot Acceptance Test--See Table D-I				X	
468	0.13	Pass	1000	Pass	--	--	V	1.7	1.5	340	X	
472	0.13	Pass	900	Pass	--	C	U	0.4	0.6	330	X	

TABLE D-IV

(CONTINUED)

S/N	Bridgewire Resistance ohm	Insulation Resistance	Spark Gap d. c. Voltage Breakdown	Radiflo	Pretest Environmental Exposures	Safety Tests	Test Condition	Test Results t_1	t_2	P_{max}	Remarks Pass	Fail
475	0.13	Pass	800	Pass	--		Lot Acceptance Test--See Table D-I				X	
479	0.12	Pass	900	Pass	--	D	Y	0.3	1.0	210	X	
486	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
510	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
511	0.16	Pass	N/A	Pass	--	K	500°F for 120 min.		No Fire--Dud		X	
516	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
522	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
543	0.13	Pass	1000	Pass	--		Lot Acceptance Test--See Table D-I				X	
545	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
547	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
563	0.15	Pass	950	Pass	--	--	W	0.4	0.5	285	X	
578	0.14	Pass	1000	Pass	L, PS	--	X	0.3	0.6	270	X	
579	0.12	Pass	1200	Pass	M, NR	B	U	0.4	1.0	275	X	
580	0.13	Pass	800	Pass	--		Lot Acceptance Test--See Table D-II				X	
587	0.13	Pass	750	Pass	--		Lot Acceptance Test--See Table D-I				X	
589	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
593	0.13	Pass	750	Pass	--	--	W	0.3	1.0	275	X	
597	0.12	Pass	1050	Pass	L, NR	B	X	0.3	0.7	295	X	
598	0.14	Pass	1050	Pass	--		Lot Acceptance Test--See Table D-I				X	
600	0.15	Pass	950	Pass	M, NR	C	T	0.4	1.2	160	X	
606	0.12	Pass	750	Pass	--		Lot Acceptance Test--See Table D-I				X	
608	0.12	Pass	700	Pass	--	--	W	0.4	0.7	265	X	
613	0.13	Pass	700	Pass	--	--	V	0.4	0.5	270	X	
622	0.12	Pass	700	Pass	--	F	--		No Fire--Dud		X	
626	0.14	Pass	850	Pass	--	--	V	0.8	1.1	295	X	
627	0.13	Pass	1000	Pass	--	D	U	0.3	2.1	220	X	
630	0.14	Pass	900	Pass	--	D	L	0.3	0.8	255	X	
638	0.14	Pass	N/A	Fail	--	H	--		No Fire--Dud		X	
644	0.12	Pass	850	Pass	--	--	V	0.8	1.0	245	X	
648	0.13	Pass	700	Pass	--	--	W	0.3	0.4	300	X	
649	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
653	0.14	Pass	700	Pass	--	--	W	0.3	1.7	265	X	
654	0.13	Pass	950	Pass	--	--	W	0.3	1.2	290	X	
658	0.14	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
659	0.14	Pass	1050	Pass	--	--	W	0.4	1.0	325	X	
662	0.14	Pass	1000	Pass	--	D	T	0.4	1.4	220	X	
665	0.13	Pass	900	Pass	L, NR	--	Y	0.1	2.0	205	X	
668	0.17	Pass	N/A	Pass	--	K	320°F for 200 min.		No Fire--Dud		X	

TABLE D-IV

(CONTINUED)

S/N	Bridgewire Resistance ohm	Insulation Resistance	Spark Gap d. c. Voltage Breakdown	Radiflo	Pretest Environmental Exposures	Safety Tests	Test Condition	Test Results t_1	Test Results t_2	Test Results P_{max}	Remarks Pass	Remarks Fail
673	0.17	Pass	N/A	Pass	--	F	--	No Fire--Dud			X	
674	0.14	Pass	700	Pass	--	--	V	0.7	1.9	295	X	
677	0.13	Pass	800	Pass	--	--	Lot Acceptance Test--See Table D-I				X	
678	0.12	Pass	850	Pass	L, PS	--	X	0.4	0.7	310	X	
679	0.13	Pass	1000	Pass	--	C	X	0.3	0.8	270	X	
690	0.13	Pass	1150	Pass	--	C	T	0.4	1.8	160	X	
691	0.14	Pass	800	Pass	--	--	W	0.5	0.6	300	X	
696	0.14	Pass	950	Pass	L, PS	D	X	0.4	0.8	280	X	
697	0.13	Pass	700	Pass	--	--	V	0.7	1.0	340	X	
698	0.16	Pass	N/A	Pass	--	F	--	No Fire--Dud			X	
700	0.13	Pass	900	Pass	M, NR	D	U	0.4	0.8	230	X	
701	0.14	Pass	1000	Pass	L, NR	E	Y	0.4	0.9	205	X	
702	0.13	Pass	850	Pass	M, PS	B	T	0.3	1.4	200	X	
703	0.14	Pass	850	Pass	--	--	V	2.0	0.8	285	X	
704	0.13	Pass	1150	Pass	--	--	V	1.3	1.5	250	X	
705	0.13	Pass	900	Pass	M, PS	--	T	0.4	1.3	190	X	
706	0.13	Pass	700	Pass	--		Lot Acceptance Test--See Table D-I				X	
707	0.13	Pass	1100	Pass	L, PS	--	X	0.4	0.8	255	X	
708	0.14	Pass	750	Pass	M, PS	--	T	0.4	1.4	240	X	
710	0.13	Pass	900	Pass	--		Lot Acceptance Test--See Table D-I				X	
711	0.13	Pass	700	Pass	--	--	V	2.4	2.0	285	X	
713	0.13	Pass	950	Pass	--	--	V	2.5	0.5	275	X	
714	0.13	Pass	700	Pass	L, NR	--	X	0.4	0.7	290	X	
715	0.13	Pass	700	Pass	--	--	V	0.4	1.1	280	X	
716	0.12	Pass	900	Pass	M, NR	B	Y	0.3	1.2	170	X	
717	0.13	Pass	850	Pass	M, NR	--	X	0.3	1.2	265	X	
718	0.12	Pass	1050	Pass	M, PS	--	X	0.4	0.8	270	X	
719	0.14	Pass	950	Pass	L, NR	E	U	0.3	0.6	305	X	
720	0.13	Pass	750	Pass	L, PS	--	T	0.4	1.2	230	X	
721	0.12	Pass	700	Pass	--	--	V	2.5	2.5	255	X	
722	0.13	Pass	900	Pass	--	--	V	1.6	1.2	255	X	
723	0.13	Pass	800	Pass	--	--	V	2.4	0.6	400	X	
724	0.13	Pass	900	Pass	M, PS	B	Y	0.4	1.0	230	X	
725	0.13	Pass	750	Pass	--	--	V	0.6	1.1	315	X	
726	0.12	Pass	1100	Pass	M, NR	--	U	0.3	0.6	335	X	
728	0.14	Pass	750	Pass	M, NR	--	Y	0.3	1.4	195	X	
729	0.13	Pass	750	Pass	L, PS	--	T	0.4	1.7	145	X	
730	0.13	Pass	950	Pass	L, NR	D	Y	0.5	1.2	205	X	

TABLE D-IV

(CONTINUED)

S/N	Bridgewire Resistance ohm	Insulation Resistance	Spark Gap d. c. Voltage Breakdown	Radiflo	Pretest Environmental Exposures	Safety Tests	Test Condition	Test Results t_1	Test Results t_2	Test Results P_{max}	Remarks Pass	Remarks Fail
732	0.14	Pass	750	Pass	L, NR	--	X	0.4	0.6	335	X	
733	0.13	Pass	700	Pass	--	--	V	0.7	0.7	310	X	
735	0.12	Pass	700	Pass	--	--	V	0.6	2.2	255	X	
737	0.13	Pass	1000	Pass	L, PS	--	T	0.4	1.6	165	X	
738	0.13	Pass	700	Pass	--	--	V	0.7	0.5	385	X	
739	0.15	Pass	1050	Pass	M, NR	--	T	0.4	1.2	185	X	
740	0.12	Pass	1000	Pass	M, NR	C	U	0.3	0.8	200	X	
741	0.13	Pass	950	Pass	L, NR	--	T	0.4	1.4	205	X	
743	0.14	Pass	700	Pass	M, NR	--	U	0.4	0.6	300	X	
745	0.15	Pass	975	Pass	M, PS	D	T	0.5	1.4	150	X	
746	0.15	Pass	750	Pass	M, PS	--	Y	0.3	1.1	200	X	
747	0.12	Pass	1150	Pass	M, NR	--	Y	0.4	0.9	230	X	
748	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
749	0.12	Pass	750	Pass	M, PS	--	Y	0.3	1.3	190	X	
750	0.1[illegible]	Pass	800	Pass	M, NR	C	X	0.4	0.6	300	X	
754	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
756	0.15	Pass	N/A	Pass	--	K	320°F for 200 min.		No Fire--Dud		X	
757	0.14	Pass	750	Pass	--		Lot Acceptance Test--See Table D-I				X	
759	0.12	Pass	700	Pass	--	--	V	0.8	0.8	260	X	
760	0.14	Pass	900	Pass	L, PS	--	T	0.4	1.6	170	X	
761	0.15	Pass	750	Pass	L, PS	--	T	0.4	1.3	165	X	
763	0.12	Pass	1050	Pass	M, PS	C	Y	0.5	2.5	145	X	
764	0.12	Pass	800	Pass	L, PS	--	U	0.4	1.1	315	X	
765	0.13	Pass	N/A	Fail	--	H	--		No Fire--Dud		X	
766	0.14	Pass	750	Pass	--	--	V	0.8	1.2	290	X	
767	0.12	Pass	700	Pass	L, PS	--	U	0.4	0.7	240	X	
768	0.13	Pass	900	Pass	M, PS	B	T	0.5	1.9	145	X	
770	0.13	Pass	700	Pass	M, PS	B	X	0.3	1.5	235	X	
773	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
774	0.12	Pass	900	Pass	M, PS	E	X	0.3	1.0	350	X	
775	0.12	Pass	1000	Pass	L, NR	B	T	0.3	1.2	260	X	
776	0.14	Pass	800	Pass	L, NR	B	U	0.4	0.7	280	X	
777	0.12	Pass	800	Pass	M, PS	--	U	0.3	0.8	285	X	
778	0.13	Pass	850	Pass	M, PS	--	T	0.4	1.2	185	X	
779	0.13	Pass	800	Pass	--	--	V	0.7	1.3	280	X	
780	0.13	Pass	700	Pass	L, PS	--	U	0.4	0.5	365	X	
781	0.12	Pass	700	Pass	L, PS	-	U	0.3	0.6	355	X	
782	0.16	Pass	850	Pass	--		Lot Acceptance Test--See Table D-I				X	

TABLE D-IV

(CONTINUED)

S/N	Bridgewire Resistance ohm	Insulation Resistance	Spark Gap d. c. Voltage Breakdown	Radiflo	Pretest Environmental Exposures	Safety Tests	Test Condition	Test Results			Remarks	
								t_1	t_2	P_{max}	Pass	Fail
783	0.17	Pass	900	Pass	--		Lot Acceptance Test--See Table D-I				X	
785	0.15	Pass	1150	Pass	M, NR	--	Y	0.5	0.9	220	X	
786	0.14	Pass	850	Pass	M, PS	--	Y	0.4	1.0	275	X	
788	0.14	Pass	700	Pass	--	--	V	1.0	1.3	285	X	
789	0.14	Pass	900	Pass	--		Lot Acceptance Test--See Table D-I				X	
790	0.16	Pass	750	Pass	M, PS	--	Y	0.4	1.0	220	X	
791	0.12	Pass	750	Pass	M, NR	D	X	0.3	0.6	265	X	
792	0.13	Pass	850	Pass	M, NR	D	T	0.4	1.1	285	X	
793	0.13	Pass	850	Pass	M, NR	--	X	0.4	0.5	350	X	
794	0.12	Pass	700	Pass	--	--	V	1.2	1.3	315	X	
795	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
796	0.15	Pass	850	Pass	L, NR	--	T	0.4	1.1	225	X	
797	0.14	Pass	1100	Pass	L, NR	E	T	0.3	1.2	235	X	
799	0.15	Pass	1050	Pass	M, NR	--	Y	0.4	1.1	210	X	
800	0.15	Pass	775	Pass	--		Lot Acceptance Test--See Table D-I				X	
801	0.13	Pass	1100	Pass	L, NR	--	U	0.4	0.9	245	X	
802	0.13	Pass	900	Pass	L, PS	C	T	0.2	1.5	135	X	
803	0.13	Pass	850	Pass	L, NR	D	X	0.4	0.7	305	X	
804	0.12	Pass	900	Pass	M, NR	E	X	0.4	1.2	240	X	
805	0.13	Pass	850	Pass	L, PS	C	X	0.4	0.5	315	X	
807	0.13	Pass	1200	Pass	--		Lot Acceptance Test--See Table D-I				X	
808	0.13	Pass	950	Pass	M, NR	--	T	0.4	1.3	190	X	
809	0.12	Pass	700	Pass	--		Lot Acceptance Test--See Table D-II				X	
810	0.13	Pass	750	Pass	L, NR	D	T	0.5	1.8	165	X	
811	0.13	Pass	700	Pass	--	--	V	0.6	1.4	260	X	
812	0.13	Pass	750	Pass	--		Lot Acceptance Test--See Table D-I				X	
813	0.13	Pass	700	Pass	--	C	X	0.4	0.4	310	X	
814	0.13	Pass	975	Pass	L, PS	C	U	0.4	0.8	285	X	
817	0.14	Pass	950	Pass	--		Lot Acceptance Test--See Table D-I				X	
818	0.12	Pass	750	Pass	M, NR	--	T	0.4	1.2	215	X	
820	0.13	Pass	750	Pass	--	--	V	0.8	1.0	285	X	
821	0.15	Pass	750	Pass	M, PS	--	U	0.4	0.6	305	X	
822	0.13	Pass	750	Pass	L, NR	--	U	0.4	0.8	285	X	
823	0.13	Pass	900	Pass	L, NR	--	U	0.3	0.7	355	X	
824	0.14	Pass	750	Pass	--	--	V	1.2	0.8	345	X	
825	0.14	Pass	750	Pass	M, NR	D	X	0.4	0.6	280	X	
826	0.12	Pass	950	Pass	M, PS	--	Y	0.3	1.1	235	X	
827	0.12	Pass	850	Pass	M, NR	--	U	0.4	0.8	295	X	

TABLE D-IV

(CONTINUED)

S/N	Bridgewire Resistance ohm	Insulation Resistance	Spark Gap d. c. Voltage Breakdown	Radiflo	Pretest Environmental Exposures	Safety Tests	Test Condition	Test Results t_1	Test Results t_2	Test Results P_{max}	Remarks Pass	Remarks Fail
828	0.12	Pass	750	Pass	--	--	V	2.4	0.8	50	X	
829	0.12	Pass	750	Pass	L, PS	B	Y	0.3	1.2	210	X	
83[illegible]	0.14	Pass	900	Pass	L, PS	--	Y	0.4	1.2	205	X	
835	0.15	Pass	750	Pass	M, NR	--	T	0.4	1.3	190	X	
836	0.14	Pass	700	Pass	--	--	V	1.5	1.3	240	X	
837	0.12	Pass	850	Pass	L, PS	--	Y	0.4	1.9	170	X	
838	0.14	Pass	700	Pass	M, PS	--	Y	0.4	0.9	200	X	
839	0.14	Pass	1050	Pass	M, NR	E	T	0.4	1.1	200	X	
840	0.13	Pass	750	Pass	M, NR	E	U	0.3	1.2	295	X	
841	0.13	Pass	700	Pass	--		Lot Acceptance Test--See Table D-II				X	
842	0.15	Pass	N/A	Fail	--	H	--		No Fire--Dud		X	
843	0.13	Pass	700	Pass	--	--	V	0.6	1.4	245	X	
844	0.13	Pass	700	Pass	--	--	V	0.8	1.3	245	X	
845	0.13	Pass	1000	Pass	L, NR	--	T	0.3	1.1	170	X	
847	0.17	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
848	0.14	Pass	1150	Pass	L, PS	--	Y	0.4	1.2	180	X	
849	0.13	Pass	700	Pass	M, PS	--	X	0.4	0.6	320	X	
850	0.13	Pass	700	Pass	L, PS	--	Y	0.4	1.2	175	X	
851	0.14	Pass	700	Pass	M, PS	--	U	0.3	0.6	280	X	
853	0.12	Pass	1200	Pass	M, PS	--	T	0.4	1.4	190	X	
856	0.13	Pass	900	Pass	L, PS	D	U	0.4	0.5	350	X	
857	0.15	Pass	N/A	Pass	--	K	500°F for 120 min.		No Fire--Dud		X	
858	0.15	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
859	0.13	Pass	900	Pass	L, PS	D	Y	0.3	1.0	230	X	
861	0.13	Pass	850	Pass	M, PS	D	Y	0.3	1.1	195	X	
862	0.12	Pass	850	Pass	L, NR	--	U	0.3	0.7	310	X	
863	0.17	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
864	0.14	Pass	1050	Pass	L, PS	D	T	0.4	1.2	170	X	
865	0.14	Pass	850	Pass	--	--	V	0.4	1.3	2[illegible]0	X	
867	0.14	Pass	700	Pass	L, NR	--	Y	0.4	1.0	200	X	
868	0.15	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
869	0.14	Pass	950	Pass	L, NR	--	Y	0.4	1.1	220	X	
870	0.14	Pass	1000	Pass	M, NR	B	Y	0.4	1.8	160	X	
871	0.12	Pass	725	Pass	--	--	V	0.9	1.1	335	X	
872	0.13	Pass	800	Pass	L, PS	E	Y	0.3	1.4	200	X	
873	0.15	Pass	1100	Pass	M, PS	--	X	0.4	0.5	220	X	
875	0.13	Pass	950	Pass	M, PS	D	U	0.4	1.0	250	X	
877	0.14	Pass	900	Pass	L, NR	C	U	0.4	1.0	330	X	

TABLE D-IV

(CONTINUED)

S/N	Bridgewire Resistance ohm	Insulation Resistance	Spark Gap d. c. Voltage Breakdown	Radiflo	Pretest Environmental Exposures	Safety Tests	Test Condition	Test Results t_1	t_2	P_{max}	Remarks Pass	Fail
878	0.12	Pass	900	Pass	--	D	X	0.4	2.5	220	X	
879	0.13	Pass	[illegible]00	Pass	L, NR	D	X	0.4	1.4	235	X	
880	0.14	Pass	700	Pass	--	--	V	0.6	1.8	270	X	
881	0.13	Pass	800	Pass	M, NR	--	U	0.4	0.5	275	X	
882	0.14	Pass	700	Pass	--	--	V	1.1	1.5	290	X	
883	0.13	Pass	750	Pass	--	--	V	1.0	1.8	270	X	
884	0.13	Pass	950	Pass	M, PS	--	U	0.3	1.3	250	X	
885	0.14	Pass	850	Pass	--	--	V	2.5	0.7	315	X	
887	0.16	Pass	N/A	Pass	--	F	--	No Fire--Dud			X	
888	0.13	Pass	850	Pass	L, PS	B	U	0.4	1.0	280	X	
889	0.13	Pass	1000	Pass	L, PS	E	X	0.4	0.5	335	X	
890	0.16	Pass	750	Pass	--	--	V	1.6	1.4	280	X	
891	0.16	Pass	N/A	Pass	--	F	--	No Fire--Dud			X	
893	0.13	Pass	950	Pass	M, PS	--	Y	0.4	1.0	210	X	
895	0.13	Pass	1150	Pass	M, PS	C	X	0.3	0.5	315	X	
897	0.13	Pass	1100	Pass	L, PS	E	T	0.3	1.3	190	X	
898	0.13	Pass	700	Pass	L, NR	--	T	0.4	1.4	185	X	
899	0.13	Pass	990	Pass	--	--	V	1.7	0.8	275	X	
900	0.13	Pass	1050	Pass	--	--	V	Scope Failed to Trigger			X	
901	0.12	Pass	1100	Pass	--	--	V	1.8	1.4	240	X	
902	0.13	Pass	750	Pass	L, NR	--	X	0.4	1.0	265	X	
903	0.13	Pass	1150	Pass	L, NR	C	X	0.4	1.9	225	X	
904	0.13	Pass	1000	Pass	M, NR	E	Y	0.3	1.3	170	X	
905	0.12	Pass	750	Pass	M, PS	B	U	0.3	0.7	280	X	
906	0.13	Pass	750	Pass	L, PS	B	X	Scope Failed to Trigger			X	
907	0.16	Pass	N/A	Pass	--	F	--	No Fire--Dud			X	
908	0.13	Pass	700	Pass	--	--	V	2.4	0.6	285	X	
909	0.13	Pass	[illegible]50	Pass	L, PS	B	T	0.4	1.4	130	X	
911	0.13	Pass	825	Pass	M, PS	C	X	0.3	0.5	330	X	
912	0.17	Pass	850	Pass	M, PS	E	T	0.4	1.2	165	X	
913	0.13	Pass	700	Pass	--	--	V	0.9	0.9	250	X	
914	0.13	Pass	700	Pass	--	--	V	0.8	0.8	230	X	
915	0.13	Pass	700	Pass	--	--	V	1.1	1.0	240	X	
917	0.12	Pass	750	Pass	L, NR	D	U	0.3	1.3	265	X	
918	0.14	Pass	1000	Pass	--		Lot Acceptance Test--See Table D-I				X	
920	0.13	Pass	700	Pass	L, NR	--	T	0.3	1.4	185	X	
921	0.13	Pass	700	Pass	L, NR	C	Y	0.4	0.8	280	X	
922	0.13	Pass	800	Pass	M, NR	--	U	0.4	0.8	275	X	

TABLE D-IV

(CONTINUED)

S/N	Bridgewire Resistance ohm	Insulation Resistance	Spark Gap d. c. Voltage Breakdown	Radiflo	Pretest Environmental Exposures	Safety Tests	Test Condition	Test Results t_1	Test Results t_2	Test Results P_{max}	Remarks Pass	Remarks Fail
923	0.12	Pass	750	Pass	M, PS	C	U	0.4	0.5	385	X	
924	0.13	Pass	950	Pass	M, NR	D	Y	0.3	1.1	210	X	
925	0.13	Pass	1050	Pass	M, PS	E	U	0.3	0.6	275	X	

TABLE D-V

TX346-1 INITIATOR LOT ACCEPTANCE PRESSURE-TIME DATA

Serial Number	Safety Tests	Test Results: t_1 [4]	t_2 [5]	P_{max} [6]
315	-	0.5	0.7	800
318	3	0.4	0.6	730
338	-	0.4	0.6	760
352	1	0.4	0.8	675
387	1	0.4	0.8	720
402	1	0.4	0.7	720
420	3	0.4	0.6	745
421	2	0.4	0.7	680
459	1	0.4	0.6	690
461	3	0.4	0.6	690
471	2	0.4	0.6	690
500	-	0.4	0.6	680
519	3	0.5	0.5	740
527	2	0.4	0.8	680
528	1	0.4	0.6	705
530	2	0.4	0.8	700
582	1	0.4	0.6	720
650	3	0.4	0.6	685
692	2	0.4	0.7	670
693	-	0.6	0.8	700
742	3	0.4	0.6	680
866	-	0.4	0.8	650
585	2	0.4	0.8	700

Legend:
1. 250 v.a.c., 400 c.p.s.
2. 250 v.a.c., 60 c.p.s.
3. 9KV discharge from 500 picofarad capacitor.
4. Time from application of firing pulse to initial pressure rise (milliseconds).
5. Time from initial pressure rise to maximum pressure (milliseconds).
6. Maximum pressure developed in a 22 cc. closed bomb (psig).

Test Conditions: Temperature — 75°F
Pressure — Ambient
Firing Pulse — 2 KV @ 0.75 Mfd.

TABLE D-VI

TX346-1 INITIATOR LOT ACCEPTANCE CALORIFIC DATA

Serial Number	Resistance (ohm)	Calories Per Initiator
558	0.16	977
614	0.16	1045
734	0.16	992
815	0.15	1042
687	0.15	1001

Pretest Exposures: None

Test Conditions: Pressure - Ambient (air) in Parr Calorimeter
Firing Pulse - 2 KV @ 0.75 Mfd.

TABLE D-VII

TX346-1. INITIATOR LOT ACCEPTANCE ONE WATT DATA

Serial Number	Resistance (ohm)	Current (amp)	Results
1, 18, 159	0.11	3.03	No Fire--Dud
81, 125, 143, 153	0.12	2.88	No Fire--Dud
19, 56, 121, 123	0.13	2.77	No Fire--Dud
55, 87, 90, 117	0.14	2.67	No Fire--Dud

Pretest Exposures: None

Test Conditions: Temperature — 75°F
Pressure — Ambient

TABLE D-VIII

TX346-1 INITIATOR QUALIFICATION PROGRAM TEST RESULTS

S/N	Bridgewire Resistance ohm	Insulation Resistance	Spark Gap d. c. Voltage Breakdown	Radiflo	Pretest Environmental Exposures	Safety Tests	Test Condition	Test Results t_1	Test Results t_2	Test Results P_{max}	Remarks Pass	Remarks Fail
213	0.17	Pass	1200	Pass	--	D	U	0.4	0.6	670	X	
265	0.17	Pass	900	Pass	L, PS	--	T	0.4	1.1	555	X	
268	0.17	Pass	N/A	Pass	--	H	--		No Fire--Dud		X	
270	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
271	0.14	Pass	N/A	Pass	--	H	--		No Fire--Dud		X	
272	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
273	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
274	0.15	Pass	N/A	Pass	--	K	500°F for 15 min.		No Fire--Dud		X	
277	0.17	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
279	0.15	Pass	850	Pass	M, PS	--	T	0.4	1.2	470	X	
283	0.18	Pass	900	Pass	L, NR	B	Y	0.4	1.4	405	X	
284	0.17	Pass	750	Pass	--	--	V	2.1	0.9	675	X	
286	0.16	Pass	N/A	Pass	--	J	--		No Fire--Dud		X	
287	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
288	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
292	0.17	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
293	0.17	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
294	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
296	0.15	Pass	1150	Pass	--	--	V	2.5	0.8	730	X	
299	0.16	Pass	N/A	Pass	--	J	--		No Fire--Dud		X	
300	0.15	Pass	1300	Pass	--	--	U	0.4	0.6	655	X	
303	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
305	0.15	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
306	0.16	Pass	950	Pass								
307	0.16	Pass	N/A	Pass	--	H	--		No Fire--Dud		X	
309	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
311		Pass		Fail								
312	0.16	Pass	N/A	Pass	--	K	320°F for 200 min.		No Fire--Dud		X	
315	0.16	Pass	700	Pass	--		Lot Acceptance Test--See Table D-V				X	
316	0.16	Pass	850	Pass	L, PS	B	X	0.4	0.6	685	X	
317	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
318	0.17	Pass	700	Pass	--		Lot Acceptance Test--See Table D-V				X	
319	0.17	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
320	0.17	Pass	N/A	Pass	--	K	320°F for 60 min.		No Fire--Dud		X	
321	0.15	Pass	800	Pass	M, PS	--	Y	0.4	1.8	410	X	
322	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
325	0.16	Pass	N/A	Pass	--	K	320°F for 200 min.		No Fire--Dud		X	
326	0.16	Pass	800	Pass	--	--	V	2.4	0.6	715	X	

TABLE D-VIII

(CONTINUED)

S/N	Bridgewire Resistance ohm	Insulation Resistance	Spark Gap d. c. Voltage Breakdown	Radiflo	Pretest Environmental Exposures	Safety Tests	Test Condition	Test Results t_1	Test Results t_2	Test Results P_{max}	Remarks Pass	Remarks Fail
327	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
328	0.17	Pass	1100	Pass	--	--	V	2.6	0.6	675	X	
329	0.15	Pass	850	Pass	--	C	Y	0.4	1.6	360	X	
331	0.16	Pass	950	Pass	L, PS	--	T	0.4	1.1	475	X	
332	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
334	0.14	Pass	N/A	Pass	--	H	--		No Fire--Dud		X	
336	0.16	Pass	700	Pass	NR	--	X	0.5	0.6	735	X	
337	0.16	Pass	850	Pass	L, PS	B	U	0.4	0.4	680	X	
338	0.19	Pass	700	Pass	--		Lot Acceptance Test--See Table D-V				X	
344		Pass		Fail								
349	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
350	0.17	Pass	800	Pass	--	D	Y	0.4	1.2	505	X	
352	0.16	Pass	700	Pass	--		Lot Acceptance Test--See Table D-V				X	
353	0.15	Pass	1100	Pass	L, NR	--	X	0.4	0.6	655	X	
354	0.15	Pass	750	Pass	M, NR	B	Y	0.4	1.2	505	X	
355	0.15	Pass	850	Pass	M, NR	--	U	0.4	0.6	715	X	
356	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
357	0.16	Pass	750	Pass	M, PS	C	U	0.3	0.8	650	X	
362	0.17	Pass	N/A	Pass	--	J	--		No Fire--Dud		X	
363	0.15	Pass	1000	Pass	M, NR	--	Y	0.4	1.7	390	X	
366	0.16	Pass	1300	Pass	L, PS	--	Y	0.4	1.6	360	X	
374	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
375	0.15	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
376	0.15	Pass	700	Pass	L, PS	B	T	0.4	1.0	510	X	
377	0.15	Pass	N/A	Pass	--	K	500°F for 15 min.		No Fire--Dud		X	
378	0.16	Pass	1050	Pass	L, NR	--	U	0.4	0.7	670	X	
381		Pass		Fail								
382	0.15	Pass	900	Pass	L, PS	--	U	0.4	0.6	625	X	
385	0.14	Pass	900	Pass	--	--	V	1.8	0.8	650	X	
386	0.15	Pass	1200	Pass	--	--	V	2.6	0.7	755	X	
387	0.16	Pass	700	Pass	--		Lot Acceptance Test--See Table D-V				X	
388	0.17	Pass	850	Pass	M, PS	D	T	0.4	1.6	375	X	
389	0.15	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
390	0.16	Pass	850	Pass	L, NR	--	U	0.4	0.6	700	X	
391	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
392	0.16	Pass	950	Pass	L, NR	B	X		No Fire			X
393	0.16	Pass	N/A	Pass	--	J	--		No Fire--Dud		X	
394	0.16	Pass	N/A	Pass	--	K	500°F for 120 min.		No Fire--Dud		X	

TABLE D-VIII

(CONTINUED)

S/N	Bridgewire Resistance ohm	Insulation Resistance	Spark Gap d. c. Voltage Breakdown	Radiflo	Pretest Environmental Exposures	Safety Tests	Test Condition	Test Results t_1	Test Results t_2	Test Results P_{max}	Remarks Pass	Remarks Fail
395	0.15	Pass	850	Pass	M, NR	--	U	0.4	0.6	655	X	
397	0.17	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
398	0.16	Pass	1100	Pass	M, NR	--	Y	0.4	1.5	435	X	
400	0.16	Pass	1250	Pass	M, PS	--	U	0.4	0.7	645	X	
401	0.16	Pass	1300	Pass	--	C	Y	0.4	1.2	490	X	
402	0.16	Pass	700	Pass	--		Lot Acceptance Test--See Table D-V				X	
406	0.16	Pass	900	Pass	--	--	V	2.5	0.8	695	X	
407	0.15	Pass	1150	Pass	M, PS	C	Y	0.5	0.5	400	X	
408	0.16	Pass	750	Pass	L, PS	C	Y	0.4	1.1	475	X	
409	0.16	Pass	700	Pass	M, NR	C	X	0.6	0.9	665	X	
410	0.16	Pass	800	Pass	L, PS	--	Y	0.3	1.2	480	X	
412	0.16	Pass	N/A	Pass	--	K	320°F for 60 min.		No Fire--Dud		X	
413	0.16	Pass	750	Pass	--	--	V	1.8	0.9	565	X	
414	0.16	Pass	800	Pass	--	--	V	0.9	0.3	665	X	
415	0.16	Pass	1250	Pass	M, PS	--	U	0.4	0.6	705	X	
416	0.15	Pass	1000	Pass	--	--	V	1.7	0.6	705	X	
417	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
418	0.16	Pass	1050	Pass	--	--	W	0.4	0.8	675	X	
419	0.15	Pass	1000	Pass	M, PS	D	Y	0.4	1.8	385	X	
420	0.15	Pass	700	Pass	--		Lot Acceptance Test--See Table D-V				X	
421	0.16	Pass	700	Pass	--		Lot Acceptance Test--See Table D-V				X	
422	0.16	Pass	1050	Pass	M, NR	D	T	0.4	1.3	475	X	
424	0.16	Pass	1050	Pass	L, PS	C	X	0.5	1.0	655	X	
425	0.15	Pass	700	Pass	M, PS	--	T	0.4	1.2	460	X	
427	0.16	Pass	950	Pass	M, NR	--	T	0.5	1.2	355	X	
428	0.15	Pass	750	Pass	--	--	V	1.0	0.8	685	X	
429	0.15	Pass	700	Pass	L, NR	C	Y	0.5	1.2	475	X	
430	0.16	Pass	900	Pass	L, PS	D	Y	0.4	1.3	425	X	
431	0.15	Pass	900	Pass	M, PS	--	Y	0.5	1.5	405	X	
432	0.16	Pass	800	Pass	L, NR	D	X	0.5	0.9	625	X	
433	0.16	Pass	750	Pass	M, NR	B	T	0.4	1.3	460	X	
435	0.15	Pass	950	Pass	M, NR	--	U	0.4	0.6	705	X	
437	0.15	Pass	1100	Pass	L, NR	D	Y	0.6	0.5	680		*
441	0.15	Pass	1050	Pass	--	D	T	0.4	1.3	415	X	
442	0.15	Pass	700	Pass	L, PS	B	Y	0.4	1.2	440	X	

*Would not fire when pulsed twice with 2.0 KV, 0.75 mfd. --fired with 2.5 KV, 0.75 Mfd.

TABLE D VIII

(CONTINUED)

S/N	Bridgewire Resistance ohm	Insulation Resistance	Spark Gap d. c. Voltage Breakdown	Radiflo	Pretest Environmental Exposures	Safety Tests	Test Condition	Test Results t_1	Test Results t_2	Test Results P_{max}	Remarks Pass	Remarks Fail
443	0.16	Pass	800	Pass	M, PS	B	Y	0.5	1.5	410	X	
445	0.16	Pass	1200	Pass	M, NR	--	U	0.4	0.7	650	X	
449	0.17	Pass	900	Pass	L, NR	--	X	0.4	0.6	765	X	
451	0.15	Pass	800	Pass	--	--	V	2.6	0.8	745	X	
452	0.16	Pass	750	Pass	L, NR	B	U	0.4	0.6	640	X	
453	0.15	Pass	850	Pass	NR	D	X	0.6	0.8	750	X	
454	0.15	Pass	1000	Pass	--	--	W	0.4	0.8	680	X	
455	0.15	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
456	0.15	Pass	950	Pass	M, PS	--	X	0.4	0.8	500	X	
457	0.15	Pass	750	Pass	M, NR	B	X	0.6	0.7	800	X	
458	0.16	Pass	1000	Pass	--	--	V	2.4	0.7	705	X	
459	0.16	Pass	700	Pass	--		Lot Acceptance Test--See Table D-V				X	
461	0.15	Pass	700	Pass	--		Lot Acceptance Test--See Table D-V				X	
462	0.16	Pass	750	Pass	--	D	T	0.4	1.3	410	X	
463	0.15	Pass	800	Pass	M, NR	C	Y	0.4	1.5	420	X	
464	0.15	Pass	1050	Pass	--	--	V	2.3	0.7	665	X	
465	0.16	Pass	700	Pass	L, NR	C	U	0.4	0.6	675	X	
466	0.15	Pass	1100	Pass	--	--	V	0.5	0.4	640	X	
469	0.16	Pass	800	Pass	M, NR	--	X	0.2	0.8	665	X	
470	0.15	Pass	750	Pass	--	--	W	0.4	0.8	635	X	
471	0.15	Pass	700	Pass	--		Lot Acceptance Test--See Table D-V				X	
473	0.15	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
474	0.16	Pass	750	Pass	M, NR	--	T	0.4	1.1	485	X	
476	0.16	Pass	750	Pass	M, PS	--	X	0.6	0.6	630	X	
477	0.15	Pass	850	Pass	--	--	V	2.4	0.7	655	X	
478	0.16	Pass	750	Pass	L, NR	D	U	0.3	0.8	635	X	
480	0.16	Pass	800	Pass	M, PS	--	X	0.5	0.7	740	X	
481	0.16	Pass	900	Pass	M, NR	--	X	0.4	0.7	655	X	
482	0.15	Pass	1000	Pass	L, PS	D	T	0.4	1.7	355	X	
483	0.17	Pass	850	Pass	--	--	V	1.6	0.6	750	X	
484	0.16	Pass	800	Pass	L, NR	D	T	0.4	1.4	405	X	
485	0.16	Pass	800	Pass	L, PS	--	Y	0.4	1.6	370	X	
488	0.16	Pass	800	Pass	L, NR	C	T	0.4	1.1	465	X	
489	0.15	Pass	1050	Pass	--	--	V	2.4	0.4	700	X	
490	0.16	Pass	850	Pass	--	C	X	0.4	0.9	665	X	
491	0.17	Pass	850	Pass	--	--	V	0.8	0.7	620	X	
492	0.16	Pass	750	Pass	--	--	V		No Fire			X
493	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	

TABLE D-VIII

(CONTINUED)

S/N	Bridgewire Resistance ohm	Insulation Resistance	Spark Gap d. c. Voltage Breakdown	Radiflo	Pretest Environmental Exposures	Safety Tests	Test Condition	Test Results t_1	Test Results t_2	Test Results P_{max}	Remarks Pass	Remarks Fail
494	0.15	Pass	800	Pass	--	--	V	2.2	0.8	670	X	
496	0.17	Pass	1200	Pass	M, PS	D	U	0.4	0.7	650	X	
497	0.16	Pass	N/A	Pass	--	K	500°F for 120 min.		No Fire--Dud		X	
498	0.16	Pass	1050	Pass	--	--	V	0.6	0.7	710	X	
500	0.16	Pass	700	Pass	--		Lot Acceptance Test--See Table D-V				X	
501	0.15	Pass	800	Pass	M, PS	--	T	0.4	1.5	405	X	
503	0.15	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
504	0.15	Pass	900	Pass	--	--	V	2.4	0.5	655	X	
505	0.15	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
507	0.15	Pass	1050	Pass	--	--	V	2.5	0.7	720	X	
508	0.16	Pass	750	Pass	L, PS	--	X	0.4	0.6	650	X	
509	0.15	Pass	750	Pass	--	--	V	2.3	0.6	710	X	
512	0.15	Pass	900	Pass	--	--	V	2.2	0.7	665	X	
513	0.15	Pass	950	Pass	M, PS	--	Y	0.4	1.4	435	X	
514	0.16	Pass	900	Pass	M, PS	--	Y	0.5	1.7	410	X	
515	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
517	0.15	Pass	850	Pass	M, NR	--	U	0.4	0.6	725	X	
518	0.15	Pass	900	Pass	L, PS	C	T	0.4	1.4	410	X	
519	0.16	Pass	700	Pass	--		Lot Acceptance Test--See Table D-V				X	
521	0.16	Pass	750	Pass	M, NR	--	T	0.4	1.2	485	X	
524		Pass		Fail								
525	0.16	Pass	N/A	Pass	--	H	--		No Fire--Dud		X	
527	0.16	Pass	700	Pass	--		Lot Acceptance Test--See Table D-V				X	
528	0.17	Pass	900	Pass	--		Lot Acceptance Test--See Table D-V				X	
529	0.16	Pass	950	Pass	M, PS	B	X		Defective Film (Blank)		X	
530	0.16	Pass	700	Pass	--		Lot Acceptance Test--See Table D-V				X	
531	0.16	Pass	850	Pass	L, PS	--	T	0.3	1.1	485	X	
534	0.15	Pass	800	Pass	--	--	V	1.8	0.6	745	X	
535	0.17	Pass	850	Pass	L, PS	--	X	0.4	0.8	645	X	
536	0.16	Pass	900	Pass	M, PS	--	U	0.4	0.6	670	X	
537	0.16	Pass	900	Pass	M, PS	--	U	0.5	0.6	700	X	
538	0.16	Pass	800	Pass	L, PS	--	T	0.4	1.3	470	X	
539	0.16	Pass	800	Pass	M, NR	--	Y	0.4	1.8	365	X	
540	0.16	Pass	900	Pass	--	--	V	2.2	0.8	675	X	
541	0.16	Pass	900	Pass	L, NR	--	Y	0.4	1.5	445	X	
542	0.15	Pass	900	Pass	--	--	W	0.4	0.6	680	X	
544	0.15	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
546	0.16	Pass	750	Pass	M, PS	--	T	0.5	1.0	570	X	

TABLE D-VIII

(CONTINUED)

S/N	Bridgewire Resistance ohm	Insulation Resistance	Spark Gap d. c. Voltage Breakdown	Radiflo	Pretest Environmental Exposures	Safety Tests	Test Condition	Test Results t_1	Test Results t_2	Test Results P_{max}	Remarks Pass	Remarks Fail
548	0.16	Pass	1250	Pass	M, NR	--	X	0.5	0.8	590	X	
549	0.15	Pass	1000	Pass	L, PS	D	X	0.4	0.8	800	X	
550	0.14	Pass	750	Pass	L, NR	--	T	0.5	1.0	570	X	
551	0.14	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
552	0.16	Pass	850	Pass	L, PS	D	U	0.4	0.7	645	X	
553	0.15	Pass	1000	Pass	L, PS	--	U	0.4	0.7	675	X	
554	0.15	Pass	1150	Pass	--	--	V	0.9	0.6	715	X	
555	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
556	0.15	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
557	0.17	Pass	800	Pass	L, NR	--	Y	0.5	1.4	430	X	
558	0.16	Pass	900	Pass	--		Lot Acceptance Test--See Table D-VI				X	
559	0.16	Pass	950	Pass	L, NR	--	X	0.4	0.8	625	X	
560	0.16	Pass	1050	Pass	--	--	V	2.7	0.6	710	X	
561	0.16	Pass	1100	Pass	L, PS	--	T	0.4	1.1	485	X	
562	0.14	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
565	0.16	Pass	750	Pass	--	C	X	0.5	0.7	595	X	
567	0.17	Pass	1100	Pass	L, NR	--	X	0.4	0.8	615	X	
568	0.16	Pass	950	Pass	--	--	V	2.7	0.8	695	X	
569	0.14	Pass	800	Pass	M, PS	--	X	0.4	0.7	665	X	
570		Pass		Fail								
571	0.16	Pass	800	Pass	L, NR	--	Y	0.4	1.3	460	X	
572	0.16	Pass	900	Pass	L, NR	--	Y	0.4	1.7	380	X	
573		Pass		Fail								
575	0.16	Pass	1050	Pass	L, PS	--	U		No Fire			
576	0.16	Pass	850	Pass	L, NR	--	Y	0.5	1.4	400	X	
577	0.17	Pass	850	Pass	--	--	W	0.4	0.6	670	X	
582	0.15	Pass	700	Pass	--		Lot Acceptance Test--See Table D-V				X	
583	0.15	Pass	950	Pass	--	--	W	0.4	0.8	700	X	
584	0.16	Pass	900	Pass	--	--	V	2.2	0.6	745	X	
585	0.16	Pass	950	Pass	--		Lot Acceptance Test--See Table D-V				X	
586	0.16	Pass	1150	Pass	--	--	V	2.6	0.7	725	X	
588	0.16	Pass	1200	Pass	M, PS	--	T	0.6	1.4	470	X	
590	0.16	Pass	1100	Pass	L, NR	--	T	0.4	1.0	555	X	
591	0.15	Pass	1050	Pass	L, PS	--	X	0.5	0.7	560	X	
592	0.15	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
594	0.16	Pass	800	Pass	L, NR	--	X	0.5	0.7	600	X	
595	0.15	Pass	900	Pass	--	--	V	1.6	0.8	695	X	
599	0.16	Pass	800	Pass	L, NR	--	X	0.4	0.7	605	X	

TABLE D-VIII

(CONTINUED)

S/N	Bridgewire Resistance ohm	Insulation Resistance	Spark Gap d. c. Voltage Breakdown	Radiflo	Pretest Environmental Exposures	Safety Tests	Test Condition	Test Results t_1	Test Results t_2	Test Results P_{max}	Remarks Pass	Remarks Fail
603	0.16	Pass	1150	Pass	--	--	V	2.4	0.6	645	X	
605	0.16	Pass	1150	Pass	--	D	Y	0.4	1.6	375	X	
607	0.16	Pass	850	Pass	--	--	V	2.5	0.8	575	X	
609	0.16	Pass	850	Pass	M, PS	B	U	0.4	0.5	625	X	
610	0.16	Pass	750	Pass	--	--	V	0.7	0.9	730	X	
611	0.16	Pass	850	Pass	--	--	V	1.0	0.7	695	X	
612	0.16	Pass	850	Pass	M, PS	D	X	0.5	0.8	660	X	
614	0.16	Pass	1100	Pass	--		Lot Acceptance Test--See Table D-VI				X	
615	0.15	Pass	N/A	Pass	--	J	--		No Fire--Dud		X	
616	0.16	Pass	800	Pass	L, NR	--	U	0.4	0.5	655	X	
617	0.16	Pass	1300	Pass	L, PS	--	U	0.4	0.8	615	X	
618	0.16	Pass	1150	Pass	--	--	W	0.4	0.8	665	X	
619	0.16	Pass	1050	Pass	M, PS	B	T	0.4	1.1	485	X	
620	0.16	Pass	750	Pass	M, NR	--	Y	0.4	1.6	410	X	
621	0.16	Pass	900	Pass	M, NR	--	T	0.3	0.9	650	X	
623	0.16	Pass	850	Pass	M, PS	--	U	0.4	0.4	705	X	
624	0.16	Pass	1050	Pass	L, PS	--	U	0.3	0.5	750	X	
625	0.16	Pass	800	Pass	L, NR	B	T	0.4	1.4	445	X	
628	0.17	Pass	800	Pass	M, PS	--	X	0.4	0.7	650	X	
629	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
631	0.16	Pass	850	Pass	L, PS	--	U	0.4	0.6	645	X	
632	0.15	Pass	1000	Pass	L, NR	--	T	0.4	1.1	470	X	
633	0.16	Pass	1050	Pass	L, PS	--	X	0.5	0.7	630	X	
634	0.16	Pass	800	Pass	M, NR	B	U	0.4	0.7	605	X	
635	0.16	Pass	950	Pass	L, PS	--	Y		No Fire			X
636	0.17	Pass	900	Pass	L, PS	--	U	0.4	0.6	705	X	
637	0.16	Pass	750	Pass	--	C	T		No Record		X	
640	0.16	Pass	1100	Pass	L, NR	--	T	0.3	1.2	675	X	
642	0.15	Pass	950	Pass	--	--	V	1.9	0.7	705	X	
645		Pass		Fail								
646	0.16	Pass	1050	Pass	L	P, S	X	0.4	0.7	645	X	
647	0.15	Pass	1050	Pass	--	--	V	2.2	0.7	745	X	
650	0.17	Pass	700	Pass	--		Lot Acceptance Test--See Table D-V				X	
651	0.16	Pass	850	Pass	M, NR	--	X	0.4	0.6	680	X	
652	0.15	Pass	900	Pass	M, PS	--	Y	0.4	1.4	455	X	
655	0.17	Pass	1050	Pass	--	--	V	2.4	0.6	690	X	
656	0.16	Pass	1100	Pass	L, NR	--	U	0.3	0.9	635	X	
657	0.15	Pass	1150	Pass	M, PS	C	X	0.5	0.7	620	X	

TABLE D-VIII

(CONTINUED)

S/N	Bridgewire Resistance ohm	Insulation Resistance	Spark Gap d. c. Voltage Breakdown	Radiflo	Pretest Environmental Exposures	Safety Tests	Test Condition	Test Results t_1	t_2	P_{max}	Remarks Pass	Fail
660	0.15	Pass	750	Pass	M, PS	--	T		No Fire			X
661	0.16	Pass	1150	Pass	--	--	V	2.1	0.7	710	X	
663	0.16	Pass	900	Pass	--	D	U	0.4	0.8	655	X	
664	0.16	Pass	1050	Pass	L, NR	--	X	0.8	0.6	670	X	
666	0.15	Pass	900	Pass	--	--	U	2.4	0.6	715	X	
667	0.17	Pass	900	Pass	L, NR	--	U	0.8	0.7	615	X	
669	0.16	Pass	950	Pass	--	C	U	0.3	0.5	700	X	
671	0.16	Pass	850	Pass	L, NR	D	U	0.4	0.6	705	X	
672		Pass		Fail								
676	0.17	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
680	0.15	Pass	900	Pass	--	--	V	1.0	0.7	660	X	
681	0.15	Pass	1150	Pass	--	--	V	2.3	0.6	710	X	
683	0.16	Pass	950	Pass	L, NR	C	X	0.4	0.8	615	X	
684	0.15	Pass	900	Pass	--	--	W	0.4	0.8	710	X	
685	0.16	Pass	950	Pass	L, PS	--	Y	0.4	1.6	410	X	
686	0.17	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
687	0.15	Pass	700	Pass	--		Lot Acceptance Test--See Table D-VI				X	
688	0.16	Pass	N/A	Pass	-	F	--		No Fire--Dud		X	
689	0.15	Pass	900	Pass	--	--	V	2.3	0.8	665	X	
692	0.15	Pass	700	Pass	--		Lot Acceptance Test--See Table D-V				X	
693	0.16	Pass	700	Pass	--		Lot Acceptance Test--See Table D-V				X	
694	0.15	Pass	800	Pass	M, PS	--	Y	0.4	1.6	405	X	
695	0.16	Pass	800	Pass	L, PS	--	T	0.4	1.2	485	X	
699	0.16	Pass	750	Pass	--	--	W	0.4	0.7	680	X	
709	0.17	Pass	900	Pass	M, NR	--	T		No Record		X	
712	0.14	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
727	0.16	Pass	1200	Pass	--	--	W	0.4	0.8	705	X	
731	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
734	0.16	Pass	700	Pass	--		Lot Acceptance Test--See Table D-VI				X	
736	0.16	Pass	800	Pass	--	--	V	2.3	0.9	665	X	
742	0.16	Pass	750	Pass	--		Lot Acceptance Test--See Table D-V				X	
744	0.15	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
751	0.16	Pass		Pass	--	--	V	2.1	0.8	650	X	
752	0.16	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
755	0.16	Pass	900	Pass	L, NR	--	T	0.4	1.5	435	X	
758	0.15	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
762	0.16	Pass	1150	Pass	M, NR	C	T	0.4	1.1	475	X	
769	0.16	Pass	N/A	Pass	--	K	500°F for 15 min.		No Fire--Dud		X	

TABLE D-VIII

(CONTINUED)

S/N	Bridgewire Resistance ohm	Insulation Resistance	Spark Gap d. c. Voltage Breakdown	Radiflo	Pretest Environmental Exposures	Safety Tests	Test Condition	Test Results t_1	Test Results t_2	Test Results P_{max}	Remarks Pass	Remarks Fail
772	0.15	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
815	0.15	Pass	700	Pass	--		Lot Acceptance Test--See Table D-VI				X	
816	0.17	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
830	0.15	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	
846	0.17	Pass	N/A	Pass	--	J	--		No Fire--Dud		X	
854	0.16	Pass	N/A	Pass	--	K	500°F for 120 min.		No Fire--Dud		X	
860	0.17	Pass	800	Pass	--	--	V	2.5	0.7	670	X	
866	0.16	Pass	700	Pass	--		Lot Acceptance Test--See Table D-V				X	
874	0.17	Pass	850	Pass	M, NR	D	Y	0.6	1.3	410	X	
876		Pass		Fail								
894	0.16	Pass	N/A	Pass	--	K	320°F for 200 min.		No Fire--Dud		X	
896	0.16	Pass	N/A	Pass	--	K	320°F for 60 min.		No Fire--Dud		X	
916	0.16	Pass	N/A	Pass	--	H	--		No Fire--Dud		X	
919	0.15	Pass	N/A	Pass	--	F	--		No Fire--Dud		X	

TABLE D-IX

TX346 INITIATOR VIBRATION TEST DATA

S/N[1]	No. of Scans Axial	Transverse	S/N[1]	No. of Scans Axial	Transverse	S/N[2]	No. of Scans Axial	Transverse	S/N[2]	No. of Scans Axial	Transverse
324	2	1	808	1	2	859[3]	1	2	895	1	2
317	2	1	825	1	2	909[3]	1	2	224	1	2
810	2	1	835	1	2	760[3]	1	2	202	1	2
801	2	1	799	1	2	879[3]	1	2	875	1	2
595	2	1	747	1	2	851[3]	1	2	853	1	2
732	2	1	792	1	2	679[3]	1	2	718	1	2
917	2	1	881	2	1	856[3]	2	1	770	2	1
352	1	2	750	2	1	897[3]	2	1	746	2	1
902	1	2	726	2	1	707[3]	2	1	708	2	1
810	1	2	739	2	1	764	1	2	725	2	1
701	2	1	600	2	1	767	1	2	649	2	1
898	2	1	840	2	1	864	1	2	912	2	1
845	2	1	716	1	2	761	1	2	923	1	2
803	2	1	700	1	2	906	1	2	745	1	2
877	2	1	744	1	2	881	1	2	905	1	2
822	2	1	924	1	2	578	2	1	777	1	2
796	1	2	870	1	2	805	2	1	893	1	2
869	1	2	904	1	2	217	2	1	705	1	2
867	1	2	844	2	1	831	2	1	790	2	1
776	1	2	717	2	1	814	2	1	763	2	1
775	1	2	922	2	1	883	2	1	778	2	1
920	1	2	367	2	1	837	1	2	696	2	1
903	2	1	793	2	1	802	1	2	911	2	1
258	2	1	728	2	1	737	1	2	786	2	1

TABLE D-IX

(CONTINUED)

S/N[1]	No. of Scans		S/N[1]	No. of Scans		S/N[2]	No. of Scans		S/N[2]	No. of Scans	
	Axial	Transverse		Axial	Transverse		Axial	Transverse		Axial	Transverse
619	2	1	768	1	2	848	1	2	832	1	2
749	2	1	785	1	2	850	1	2	861	1	2
655	2	1	899	1	2	872	1	2	827	1	2
862	2	1	248	1	2	829	2	1	228	1	2
741	1	2	818	1	2	781	2	1	884	1	2
730	1	2	579	1	2	826	2	1	873	1	2
787	1	2	743	2	1	780	2	1	774	2	1
823	1	2	678	2	1	724	2	1	821	2	1
231	1	2	700	2	1	720	2	1	791	2	1
921	1	2									

<u>Legend</u>:
1. Test temperature was 150°F.
2. Test temperature was -10°F.
3. Accidentally exposed to 75 g. @ 300 c.p.s. for 5 seconds.

TABLE D-X

TX346-1 INITIATOR VIBRATION TEST DATA

S/N[1]	No. of Scans		S/N[1]	No. of Scans		S/N[2]	No. of Scans		S/N[2]	No. of Scans	
	Axial	Transverse		Axial	Transverse		Axial	Transverse		Axial	Transverse
616	1	2	463	1	2	482	1	2	357[3]	1	2
488	1	2	762	1	2	376	1	2	609[3]	1	2
484	1	2	422	1	2	422	1	2	407[3]	1	2
567	1	2	521	1	2	408	1	2	514[3]	1	2
465	1	2	427	1	2	531	1	2	612[3]	1	2
283	1	2	651	1	2	410	1	2	529[3]	1	2
656	2	1	300	2	1	382	2	1	431[3]	2	1
667	2	1	709	2	1	617	2	1	321[3]	2	1
392	2	1	539	2	1	366	2	1	657[3]	2	1
664	2	1	517	1	2	575	2	1	694	1	2
432	2	1	457	1	2	424	2	1	480	1	2
636	2	1	626	1	2	685	2	1	476	1	2
625	1	2	435	1	2	591	1	2	537	1	2
526	1	2	548	1	2	485	1	2	456	1	2
390	1	2	474	1	2	430	1	2	443	1	2
255	1	2	398	2	1	538	1	2	546	2	1
599	1	2	874	2	1	553	1	2	425	2	1
541	1	2	433	2	1	518	1	2	536	2	1
452	2	1	453	2	1	646	2	1	569	2	1
590	2	1	409	2	1	549	2	1	388	2	1
478	2	1	395	2	1	628	2	1	588	2	1
632	2	1	671	1	2	316	2	1	279	1	2
572	2	1	355	1	2	561	2	1	628	1	2

TABLE D-X

(CONTINUED)

S/N[1]	No. of Scans		S/N[1]	No. of Scans		S/N[2]	No. of Scans		S/N[2]	No. of Scans	
	Axial	Transverse		Axial	Transverse		Axial	Transverse		Axial	Transverse
429	2	1	336	1	2	508	2	1	619	1	2
395	1	2	637	1	2	695	1	2	415	1	2
594	1	2	363	1	2	550	1	2	660	1	2
557	1	2	378	1	2	265	1	2	652	1	2
640	1	2	469	2	1	535	1	2	623	2	1
571	1	2	350	2	1	635	1	2	513	2	1
447	1	2	445	2	1	331	1	2	400	2	1
613	2	1	354	2	1	633	2	1	419	2	1
437	2	1	481	2	1	337	2	1	501	2	1
550	2	1	621	2	1	631	2	1	496	2	1

Legend:
1. Test temperature was 150°F.
2. Test temperature was -10°F.
3. Accidentally exposed to 70 g. @ 225 c.p.s. for 5 seconds.

TABLE D-XI

INITIATOR SHOCK TEST DATA

TX346 Serial Numbers	Test Temperature °F	Remarks	TX346-1 Serial Numbers	Test Temperature °F	Remarks
678, 728, 768, 825	150		437, 478, 484, 571	150	
726, 835, 922, 924	150		429, 567, 632, 636	150	no record
361, 716, 743, 870	150	no record	625, 656, 664, 755	150	
248, 747, 839, 904	150		392, 541, 550, 599	150	shocked twice
399, 600, 717, 793	150		390, 594, 616, 667	150	
579, 740, 804	150		283, 353, 640, 683	150	no record
700, 750, 799, 818	150		452, 488, 576, 590	150	
739, 792, 881	150	shocked twice	432, 449, 465, 557	150	
785, 808, 840	150		572	150	shocked 3 times
258, 324, 714, 862	150	shocked twice	354, 463, 469, 620	150	no record
810, 822, 869, 898	150	shocked twice	350, 378, 395, 453	150	
701, 741, 803, 917	150		398, 457, 621, 651	150	
231, 359, 796, 797	150		433, 445, 539, 709	150	
665, 749, 776, 921	150	shocked twice	300, 355, 409, 521	150	
730, 775, 845, 920	150		517, 548, 634, 874	150	
597, 732, 823, 903	150		422, 427, 474, 481	150	
719, 867, 877, 902	150		336, 363, 435, 762	150	
801	150	no record	671	150	
745, 763, 790, 923	-10		321, 407, 476, 537	-10	
708, 770, 827, 861	-10		425, 569, 619, 628	-10	
718, 746, 858, 895	-10		409, 496, 588, 657	-10	
696, 724, 778, 779	-10		431, 513, 623, 660	-10	
777, 791, 884, 905	-10		388, 419, 456, 536	-10	

TABLE D-XI

(CONTINUED)

TX346 Serial Numbers	Test Temperature °F	Remarks	TX346-1 Serial Numbers	Test Temperature °F	Remarks
702, 705, 911, 912	-10		453, 501, 529, 612	-10	
821, 849, 873, 925	-10		400, 480, 546, 652	-10	
228, 786, 838, 893	-10	shocked twice	279, 357, 415, 694	-10	
875	-10		514	-10	
767, 864, 872, 879	-10		316, 410, 633, 695	-10	
805, 851, 888	-10		432, 552, 635, 646	-10	
720, 760, 761, 897	-10		531, 535, 561, 631	-10	
737, 780, 909	-10		337, 4[illegible]2, 518, 575	-10	
217, 764, 814, 856	-10		382, [illegible], 508, 685	-10	
707, 729, 859	-10		265, 408, 549, 553	-10	
679, 781, 802, 889	-10		331, 430, 617, 624	-10	shocked twice--no recor
826, 837, 848, 906	-10		366, 376, 485, 591	-10	shocked twice
578, 829, 831, 850	-10	shocked twice	538	-10	shocked twice

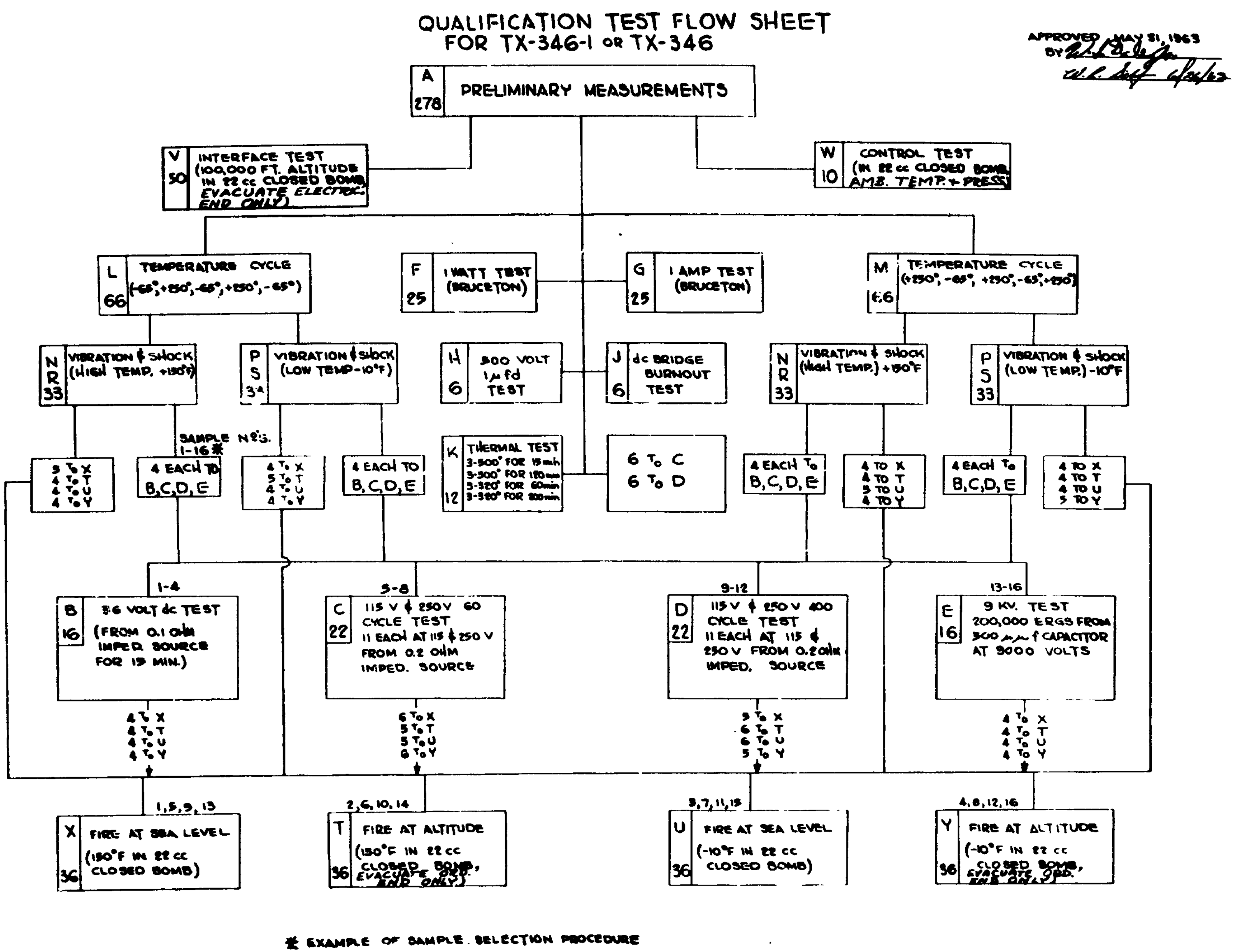


Figure D-1. Qualification T st Plan "Flow Sheet."

Closed Bomb Volume - 22 cc
Pressure Transducer - "Photocon"
Firing Pulse - 2000 volts; 0.75 mfd.

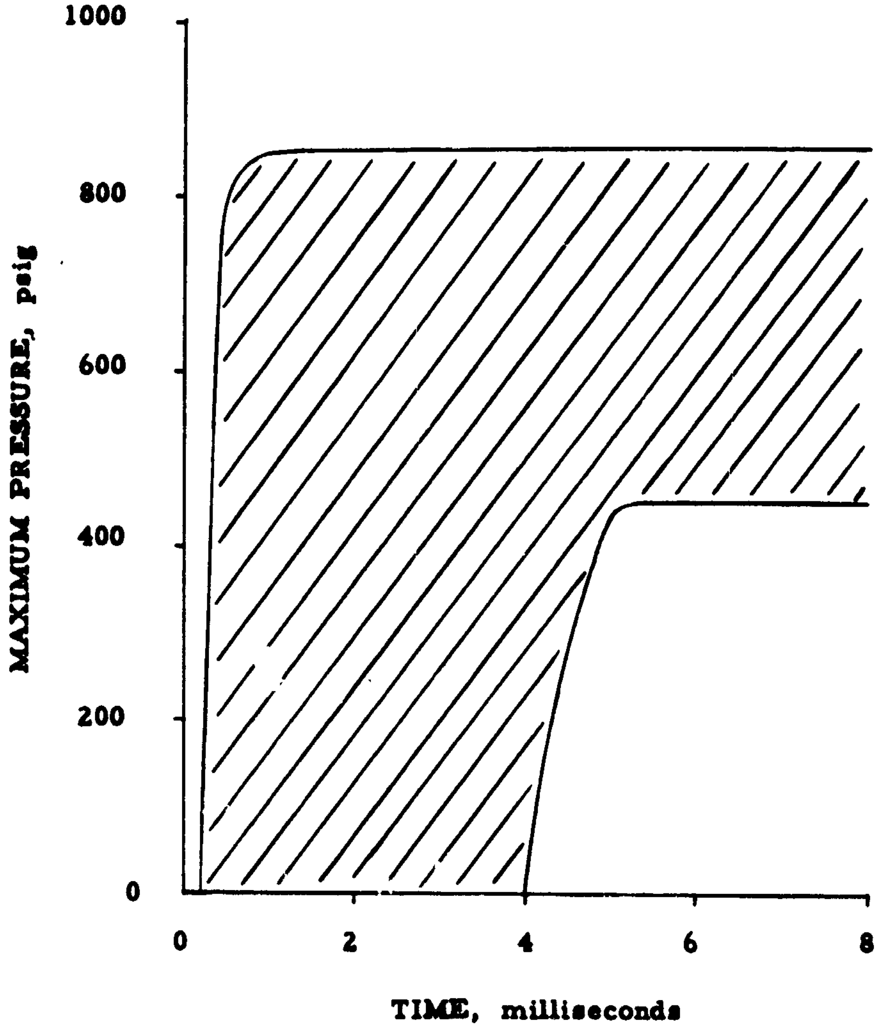


Figure D-2. TX346-1 Initiator Maximum Pressure versus Time

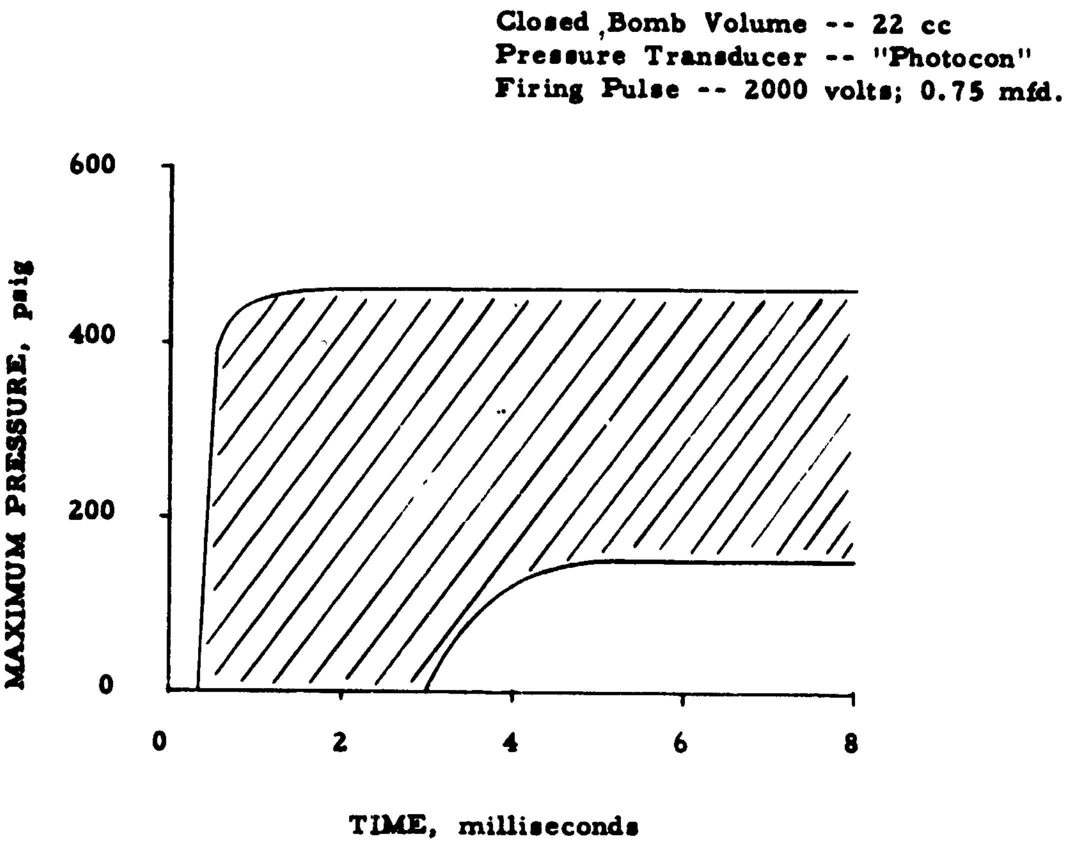


Figure D-3. TX346 Initiator Maximum Pressure versus Time

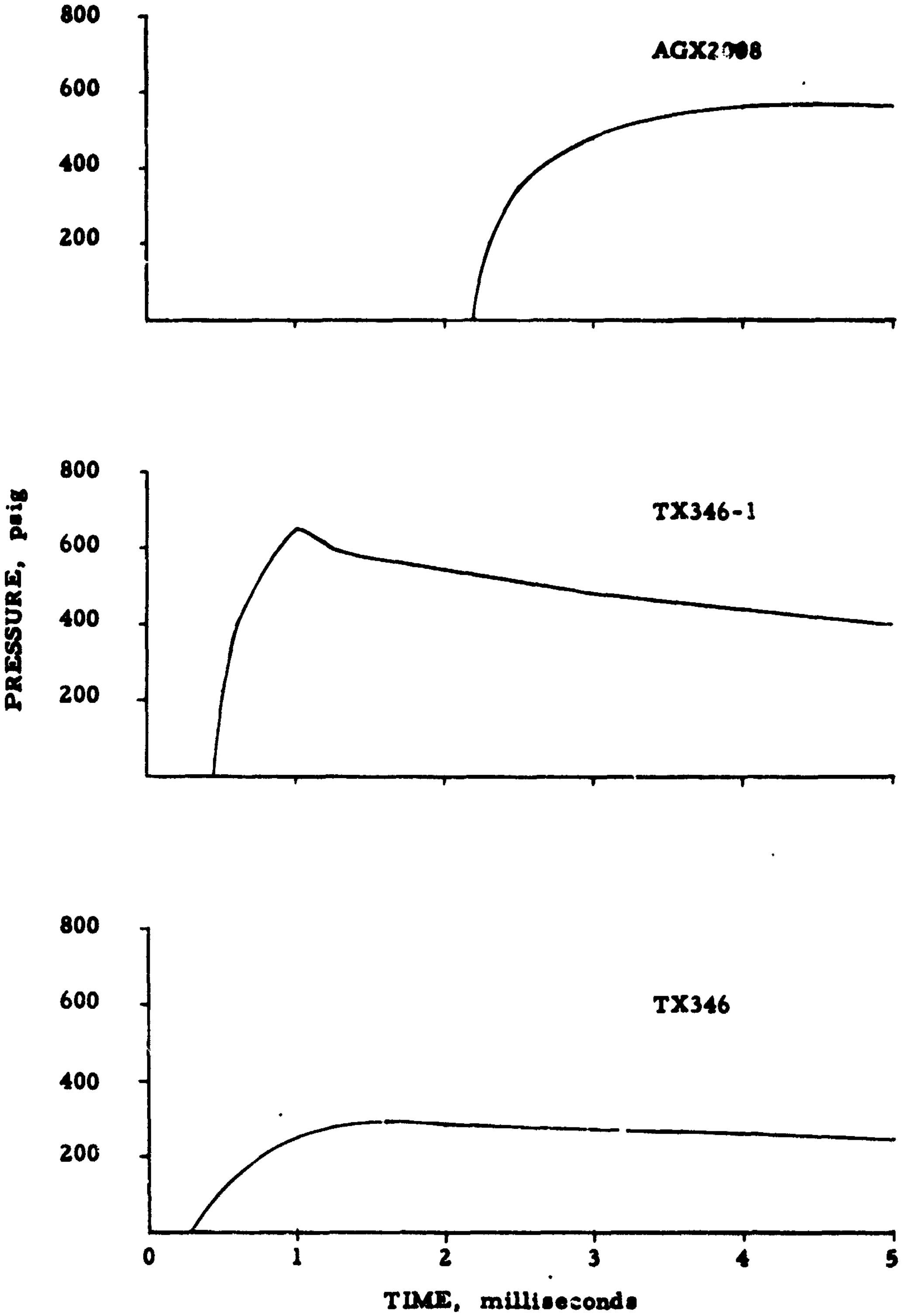


Figure D-4. Typical Maximum Pressure versus Time Signatures of Initiators Fired in a 22 cm^3 Closed Bomb

APPENDIX E

TX346 AND TX346-1 INITIATOR QUALIFICATION PROGRAM

TEST INSTRUMENTATION

This appendix consists of descriptive information, such as sketches, circuit diagrams, and photographs, of the equipment used during the qualification testing of the TX346 and TX346-1 initiators. Each piece of test gear is described in an appropriate section with the sketches, circuits, etc., referenced as figures. The section titles define the test measurement and/or exposure.

Bridgewire Resistance

This parameter was measured with an Allegany Instrument Company "Alinco" Igniter Circuit Tester, Model 101-5AF. This instrument has an accuracy of ± 0.01 ohm. It consists of a bridge circuit with a galvanometer. The galvanometer is balanced to a null point with the ohmic readout presented on a vernier scale whose readability is 0.005 ohm. The maximum current output of this instrument is 10 milliamperes.

Insulation Resistance

A Sorenson (Beta Electric Division) High Voltage Power Supply, Model 1030-2R & D with a 0 to 20 microammeter was used for this measurement. Some units were also checked with a Douglas Aircraft Company EBW Initiator Test Set, P/N 5866057).

Spark Gap Voltage Breakdown

Same as for Insulation Resistance.

Leak Detector

A Consolidated Electrodynamics Corporation "Radiflo" Leak Detector, Type 24-510A, and Ratemeter, Type 24-027, were utilized for leak testing. This equipment is owned by NASA-MSFC. The initiators were exposed to Krypton 85 gas at 30 psia for a period of 3.4 hours and then checked for leaks with the Ratemeter.

Thirty-Six V. D. C. from 0.1 Ohm Impedance Source

Three lead-acid 12-volt secondary batteries, with an interval resistance of hundreths of an ohm, were connected in series and used as the voltage source. The external circuit consisted of a mercury switch, 6-foot leads (Belden 8677, #16 A. W. G., duplex), a 0.-10 amperes Westinghouse current meter (0.25% accuracy), and the initiator under test. A R. C A. Vacuum Tube Volt Meter (V. T. V. M.) was used to monitor voltage (Figure E-1). Initiators were tested pin to pin and pins to case. The ammeter remain .d at zero during both the pin to pin and pins to case tests.

115 V. A. C. /240 V. A. C. 60 C. P. S.

The alternating current (60 c. p. s.) was supplied by a step-down transformer by the selection of the correct transformer taps. This test was monitored with an R. C. A. V. T. V. M. across the initiator. Initiators were tested pin to pin and case to pins. The test circuit is shown on Figure E-2, diagram "A." Since the source impedance for this test could not exceed 0.2 ohm, some computations were made to confirm compliance with this requirement. Figure E-3 shows the power distribution system and the derivation of impedance values. These values were then used in the following equations to determine the source impedance values.

Equations for transformers and cables:

when,

$$\text{per unit ohms} = \frac{(\text{ohms impedance})\ (\text{KVA base})}{(\text{line to line KV})^2 \times 1000} \tag{1}$$

then,

$$\text{ohms impedance} = \frac{(\text{per unit ohms})\ (\text{KV})^2\ (1000)}{\text{KVA base}} \tag{2}$$

therefore,

$$\text{ohms impedance on base } KV_2 = \text{ohms impedance on base } KV_1 \left(\frac{\text{base } KV_2}{\text{base } KV_1}\right)^2 \tag{3}$$

Assuming a "per unit system" of:

KVA base = 10,000
KV base = 44 (Figure E-3)

and a "per unit ohms" of:

12.91 (Figure E-3)

we can then apply equations (2) and (3) in sequence:

$$\text{ohms impedance} = \frac{(12.91)(44)^2\,(1000)}{10,000} =$$

2490 ohms at 44 KV (2)

$$\text{ohms impedance on base } KV_2 = \frac{(2490)(0.24)^2}{(44)^2} =$$

0.073 ohm at 240 V (3)

and

$$\text{ohms impedance on base } KV_2 = \frac{(2490)(0.115)^2}{(44)^2} =$$

0.017 ohm at 115 V (3)

These calculations show that the source impedance values are less than the maximum specified limit.

115 V.A.C./250 V.A.C. 400 C.P.S.

The alternating current (400 c.p.s.) was supplied by a 45 K.W.H. Stewart and Stevens generating plant (Figure E-4). This generator has an internal impedance of .02 ohm. The external circuit, including lines and load had a d.c. resistance of approximately 0.4 ohm. The tests were monitored by the generator instrumentation and a R.C.A. V.T.V.M. across the initiator. Initiators were tested pin to pin and pins to case. The circuit for these tests is shown on Figure E-2, Diagram "B."

Exposure to 200,000 Ergs

This test is equivalent to discharging a 500 picofarad capacitor charged to 9000 volts d.c. A Sorenson High Voltage Power Supply, Model 1030-2R & D, was used as a voltage source. The capacitor discharge was triggered through a Jennings Manufacturing Company Vacuum Relay, Model No. R2G (60 KV rating). The initiators were exposed to this pulse pin to pin and pins to case. The test circuit is shown on Figures E-5 and E-6. A view of the console is shown on Figure E-7.

Discharge of a 1 Microfarad Capacitor Charged to 500 Volts

A General Laboratory Associates bench model firing unit was used for this test. This unit has circuitry incorporated in it to monitor charging voltage. The arc gap was shunted in the test initiators to insure full capacitor discharge through the bridgewire. The circuit for these tests is presented on Figure E-8.

D. C. Bridge Burn Out Test

Three lead-acid 12-volt secondary batteries with an internal resistance of hundredths of an ohm were connected in series and used to supply current for these tests. The external circuitry consisted of the batteries, 6-foot leads (Belden #8677 No. 16 A. W. G. duplex wire), a Westinghouse 0 - 10 ampere (0.25% accurary) ammeter, and a transistorized regulator to control voltage and current. The voltage was controlled at 36 volts, while the current was increased in increments of 0.5 ampere per second from zero to bridge burnout. The circuit is shown on Figure E-9.

One Watt Test

An Electro Products Laboratories power supply was used to supply current for this test. The external circuitry consisted of the power supply, a mercury switch, current and volt meters and the initiator. Calibration was attained using the same circuitry with the substitution of a resistor of the same ohmic value as the initiator bridgewire and adjusting the power supply to the proper voltage-current values using W (watts) = I^2R. The circuitry is shown on Figure E-10.

Interface Test

Interface tests were conducted using the apparatus shown on Figure E-11. The entire flight type EBW firing unit, closed bomb with transducer and necessary wiring were placed inside a vacuum chamber and the pressure was reduced to 8.0 mm. mercury (100,000 ft.). The initiator was then fired and pressure-time data recorded by photographing the oscilloscope.

Functional Test

Ambient Pressure

Functional testing with the closed bomb internal volume at ambient pressure was conducted using the equipment setup shown on Figure E-12.

Reduced Pressure

Functional testing with the closed bomb internal volume at reduced pressure was conducted using the equipment setup shown on Figure E-13.

Calorific Output Test

The calorific output determinations performed on candidate pyrotechnic compositions as well as final initiators were made using a Parr Oxygen Bomb Calorimeter, Series No. 1200. It was modified to accept a complete initiator for total calorific output determinations. Figure E-14 shows the EBW firing unit on the left and the calorimeter on the right.

Vibration Test

The vibration equipment employed consisted of an M. B. Manufacturing Company Type C-10 Shaker driven by a Type T-51 Amplifier with a B and K automatic sweep. During the test, the adapter was instrumented with an Endevco 2242 pickup and the level control achieved with the B and K servo unit and the shaker pickup coil. The equipment is shown on Figures E-15 and E-16.

In each case, the initiators were preconditioned to saturation at the required temperature, mounted on the vibration adapter in groups of 12 and maintained at the conditioned temperature throughout the test. The vibration adapter was designed to hold 6 initiators on each axis constituting a shaker load of less than 2 pounds. The test sequence involved mounting the initiators, performing the required vibration program, reversing the initiators to the other axis and repeating the required program. This program was adhered to with two exceptions as noted on Tables D-IX and D-X.

Shock Test

The shock tests were performed on a Barry Controls "Varipulse 15575" (Figure E-17) using Thiokol test adapters. The arrangement of the test adapters and the specimens is shown in Figure E-18. The test table was instrumented with a calibrated Endevco Model 2242 Accelerometer. The output from the pickup was amplified and displayed on a Tektronix Model 551 oscilloscope. The displayed acceleration versus time trace was photographed with a Polaroid Land Camera for a permanent record.

Prior to testing, each group of 33 initiators was preconditioned at the test temperature in its transporting cannister. An insulated transporting box was saturated along with each group for use as a portable, preconditioned storage unit. The shock test adapters were also preconditioned before each (group) test series. To begin testing, one group of initiators, one storage unit, and two test adapters were removed from conditioning. An AN6290-6 O-ring was installed on each initiator and the initiators were placed back in the storage unit. Four initiators were removed from the storage unit at one time and were installed in a test adapter. While the test adapter was installed on the shock test machine, tested, and removed, 4 more were installed on the second test adapter. The operation was timed so the initiators would not be out of the storage unit more than 3 or 4 minutes before testing.

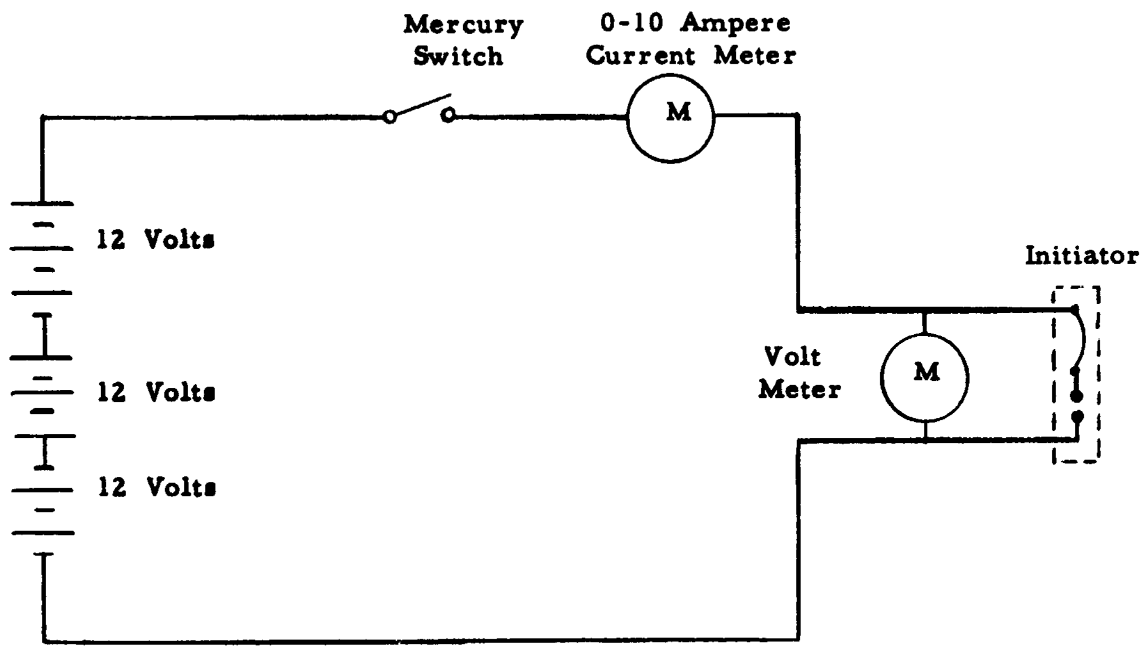


Figure E-1. Circuit Schematic for 36 v.d.c. Safety Tests

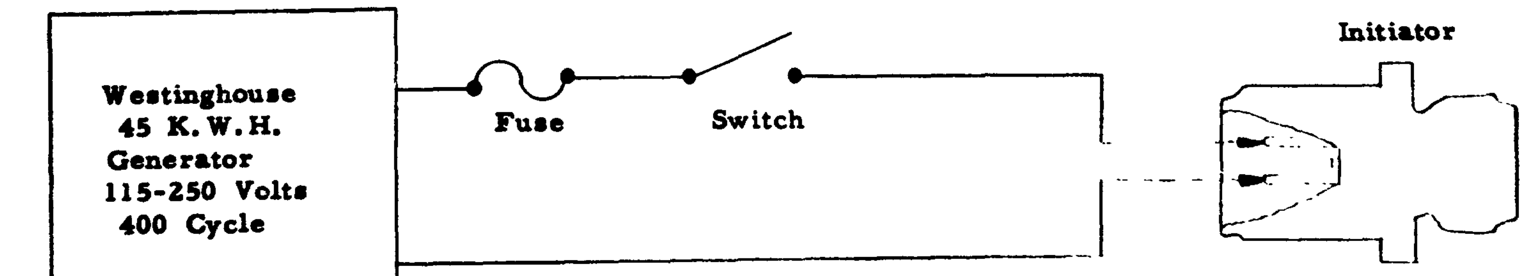


Diagram "B"

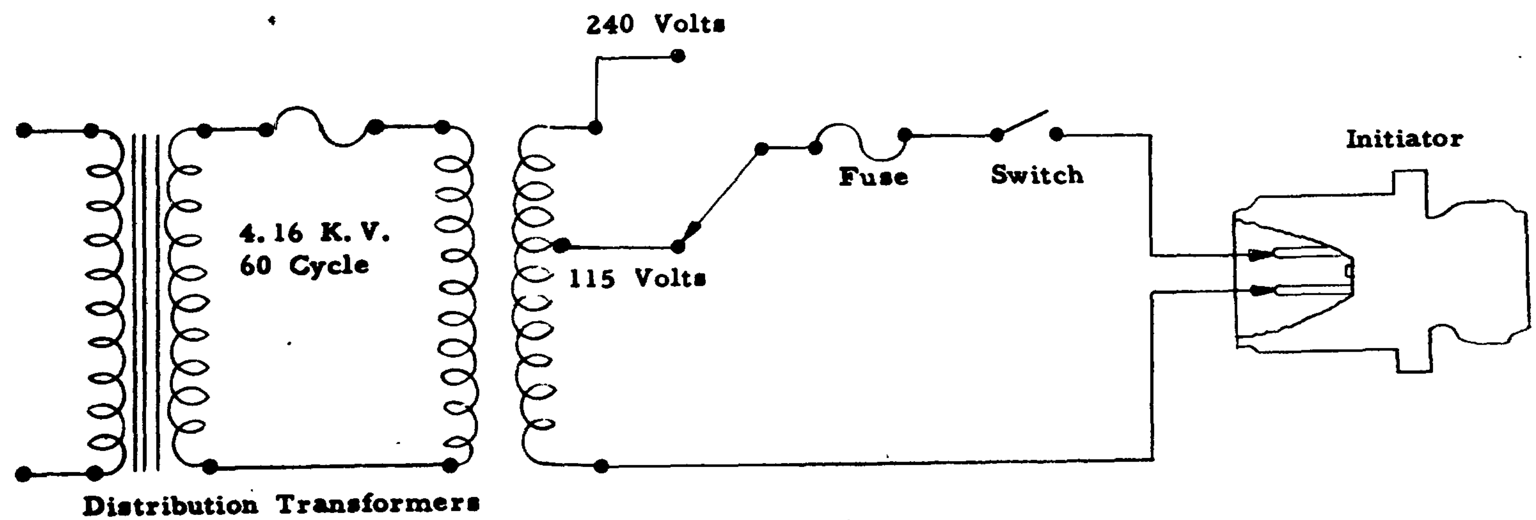


Diagram "A"

Figure E-2. Circuit Schematic for 115/240 Volt 60 Cycle Test / 115/250 Volt 400 Cycle Test

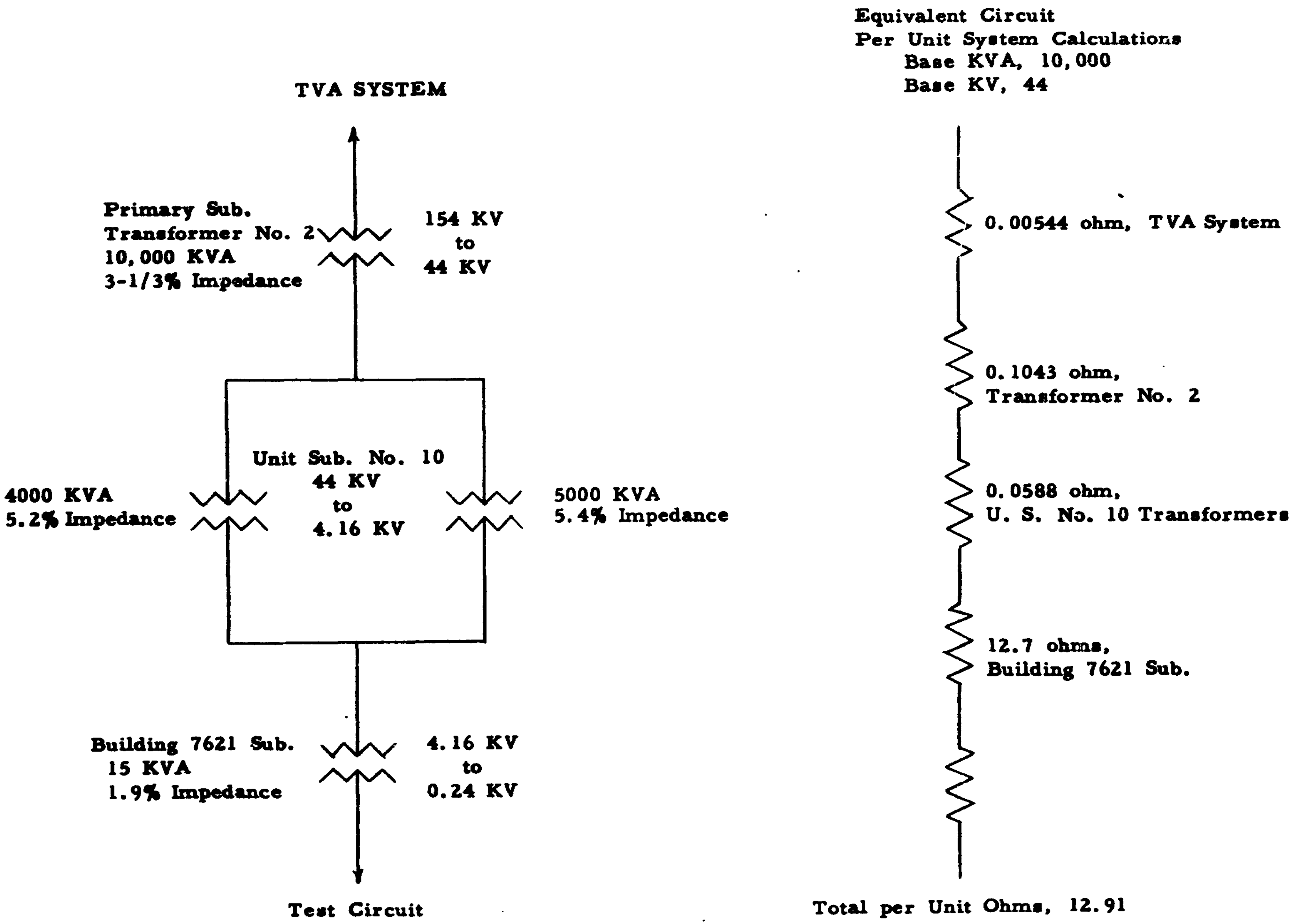


Figure E-3. Source Impedance Diagrams for 115 and 250 volts A.C. 60 Cycle Tests

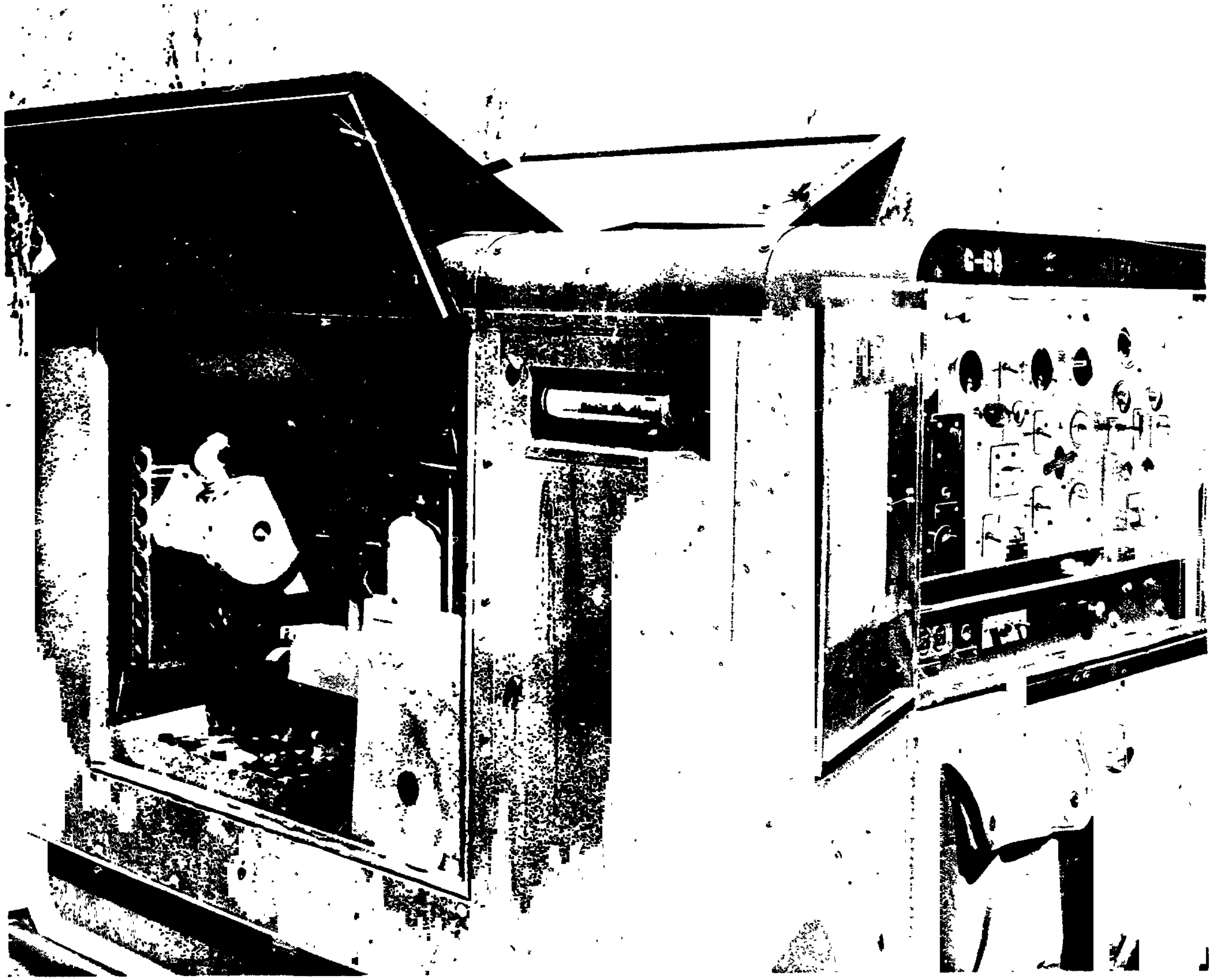


Figure E-4. U. S. Army 45 K. W. Generator

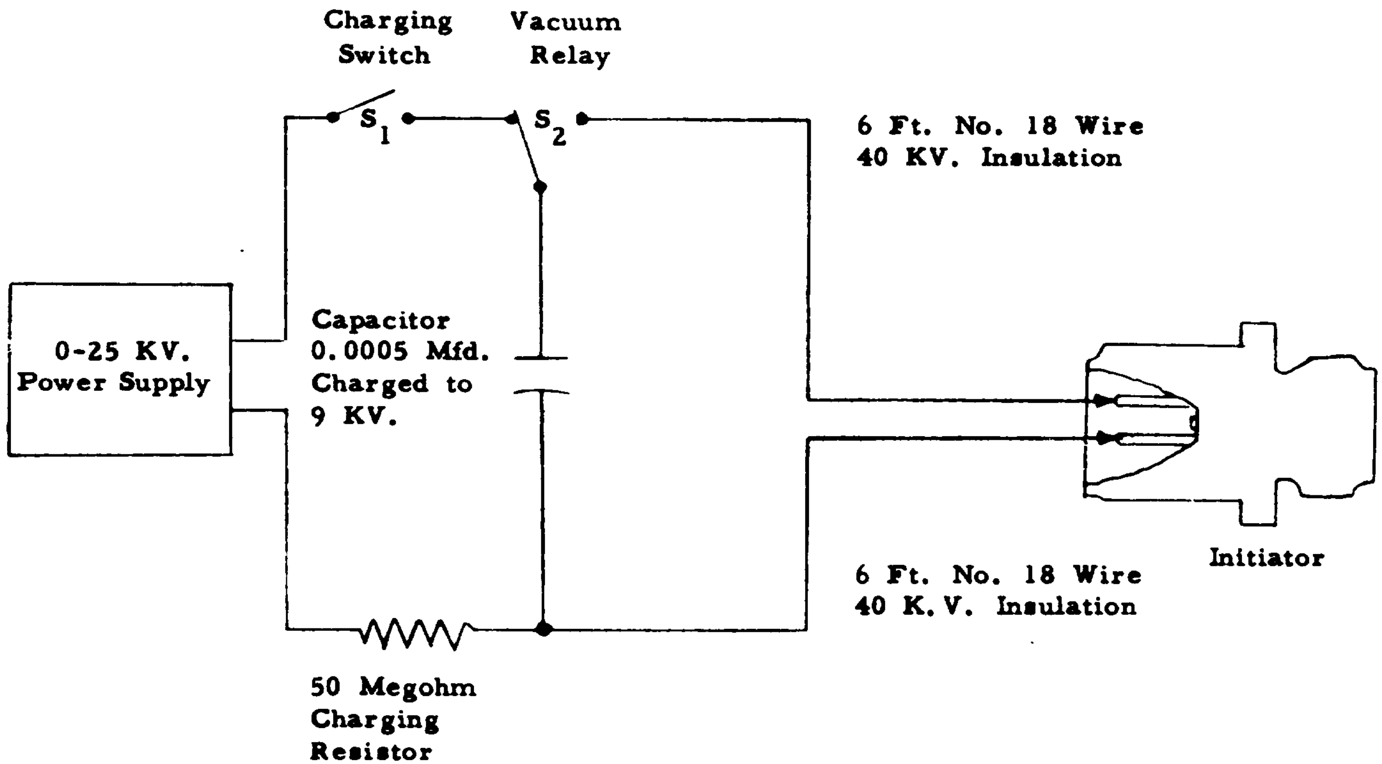


Figure E-5. Circuit Schematic for Electrostatic Sensitivity Test (Through Initiator Bridgewire)

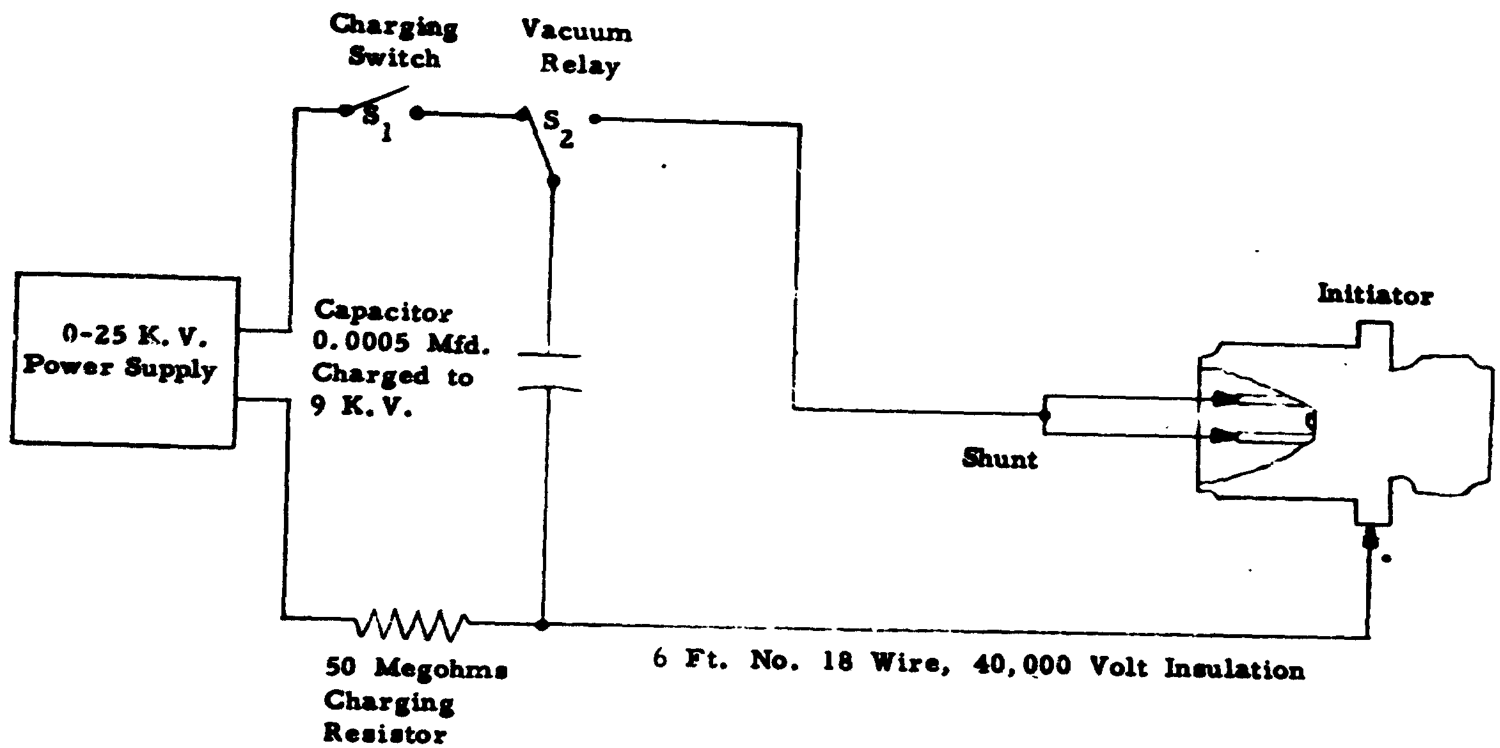


Figure E-6. Circuit Schematic for Electrostatic Sensitivity Test (Body to Pins)

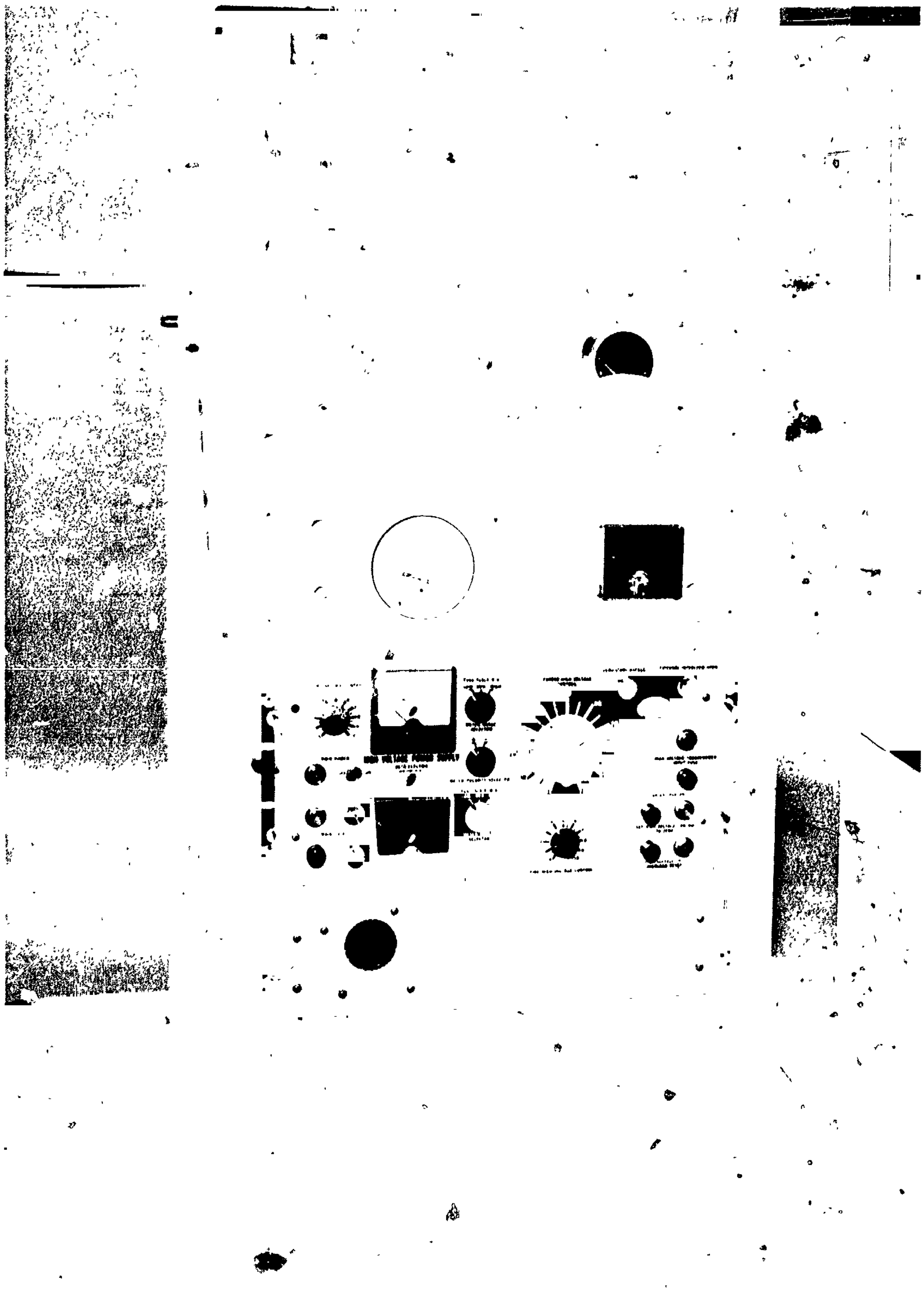


Figure E-7. Console Containing 30 K.V. Power Supply and Related Circuitry for Electrostatic Sensitivity Tests

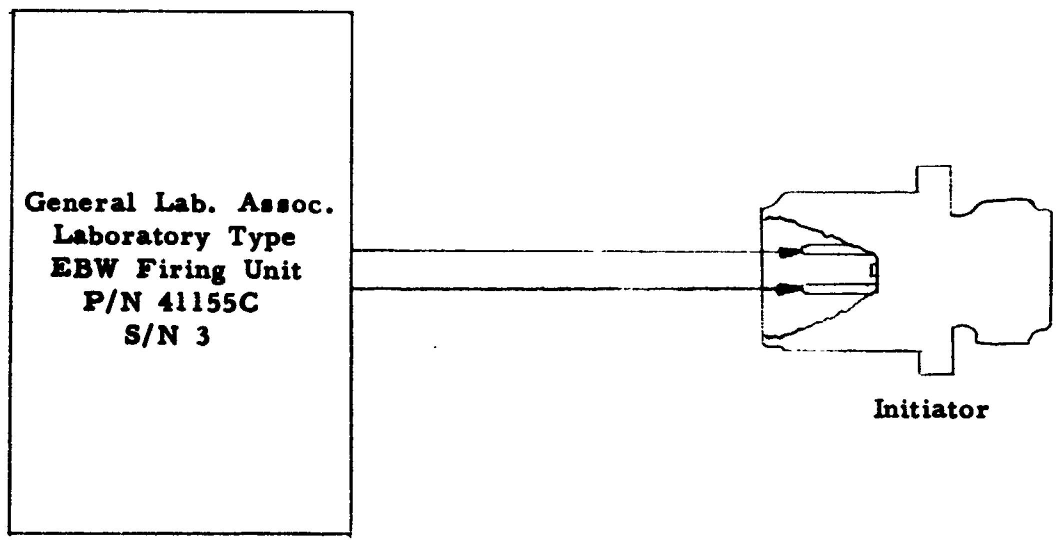


Figure E-8. Circuit Diagram for 500 Volt; 1 Mfd. Discharge Test

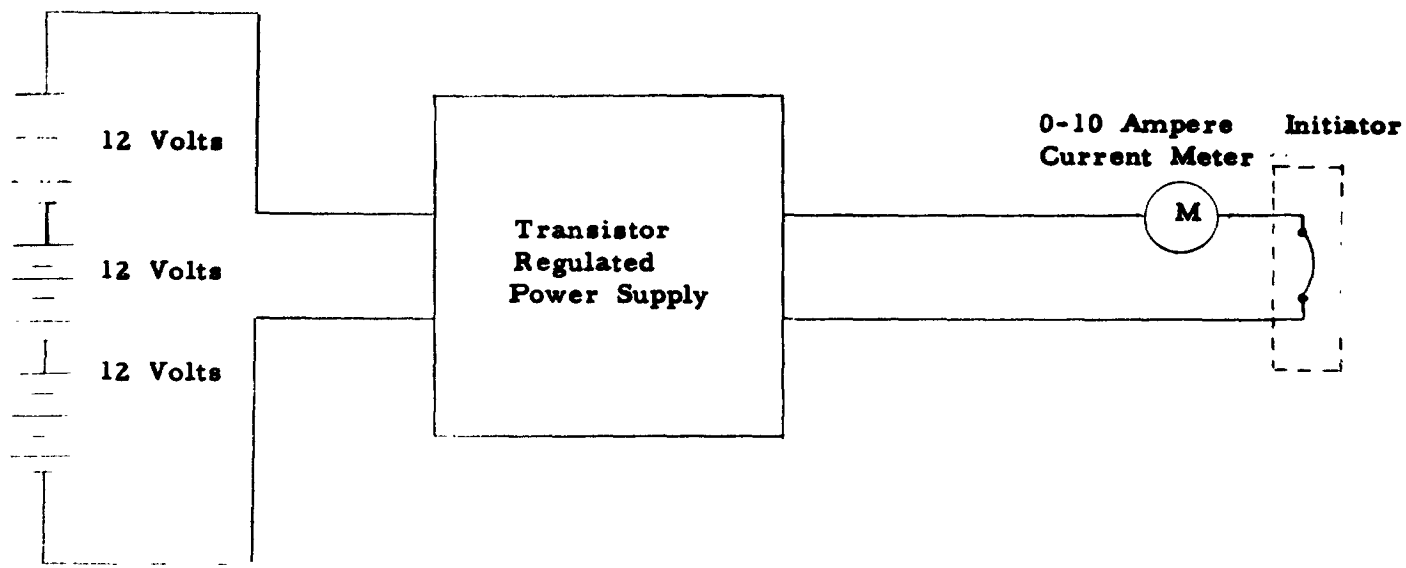


Figure E-9. Circuit Schematic for d.c. Bridge Burnout Tests

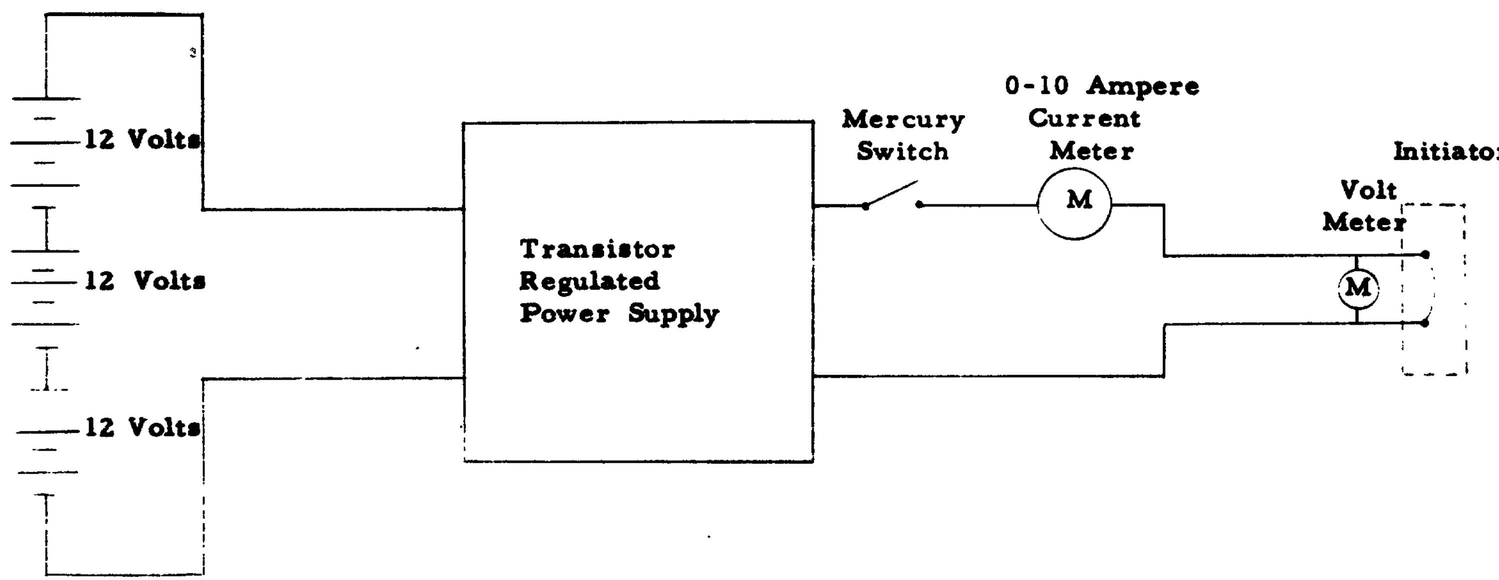


Figure E-10. Circuit Schematic for 1 Watt Test

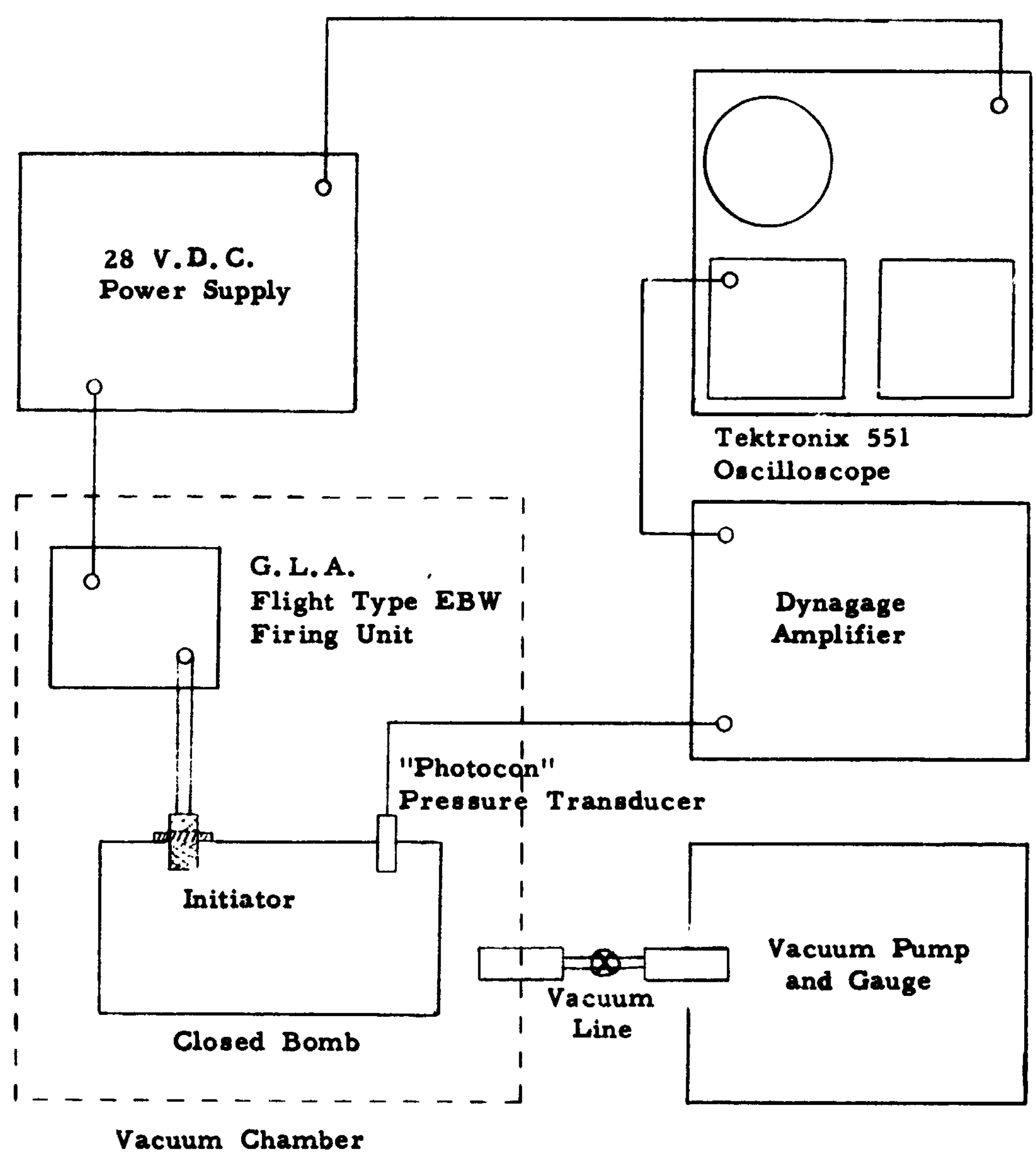


Figure E-11. Schematic of Interface Test Apparatus

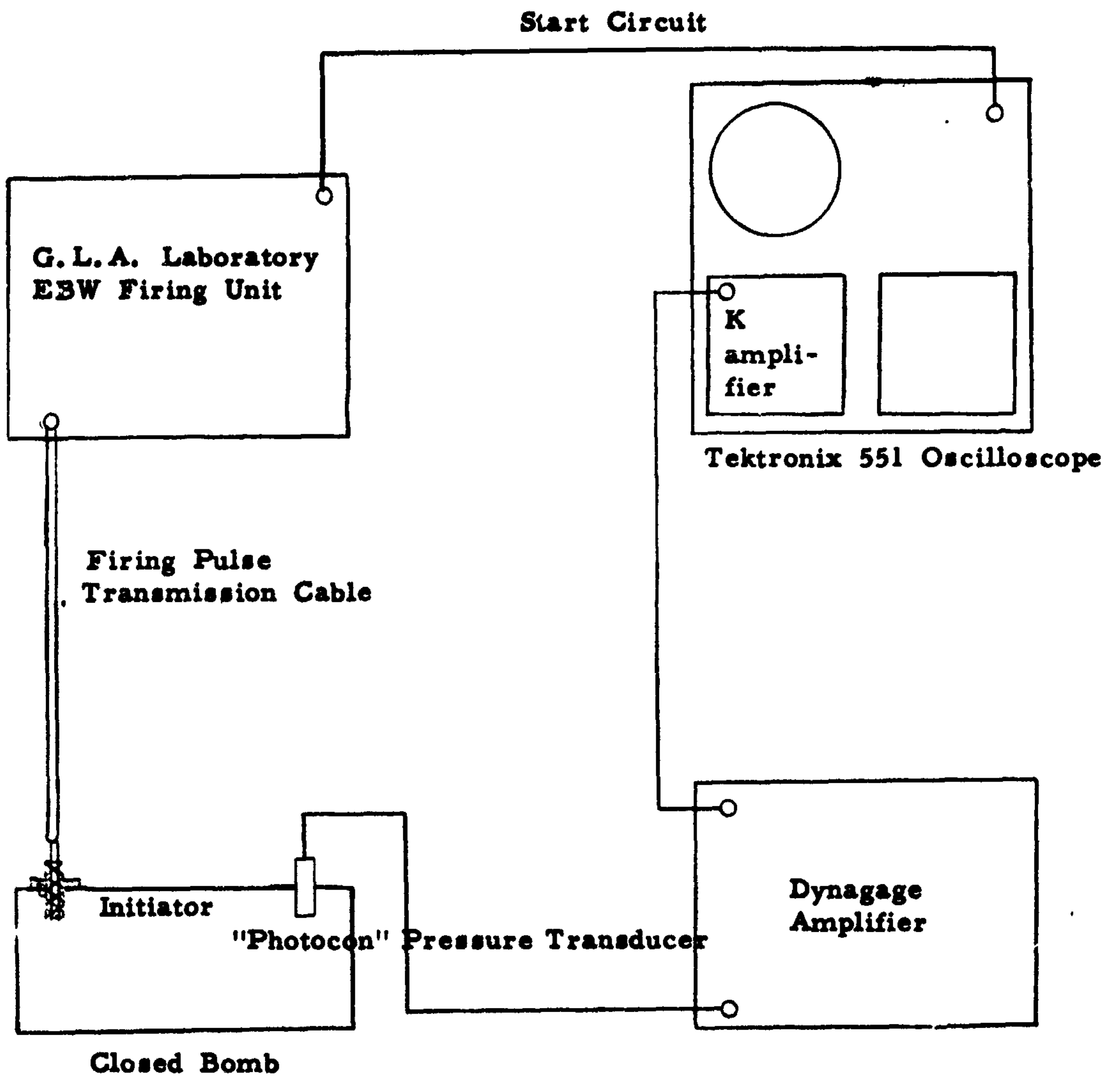


Figure E-12. Equipment Set-Up for Functional Testing at Ambient Pressure

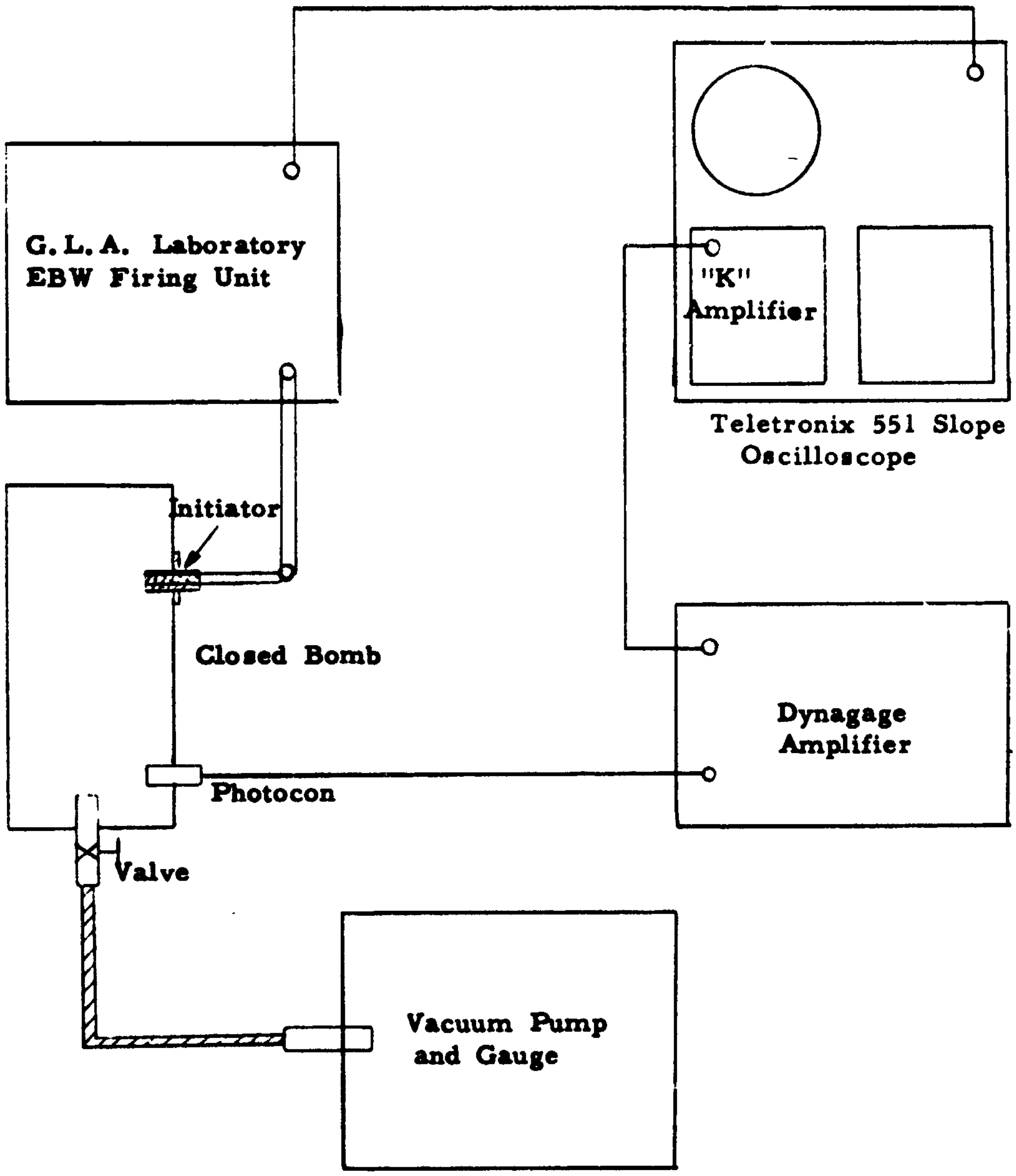


Figure E-13. Equipment Set-Up for Functional Testing at Reduced Pressure

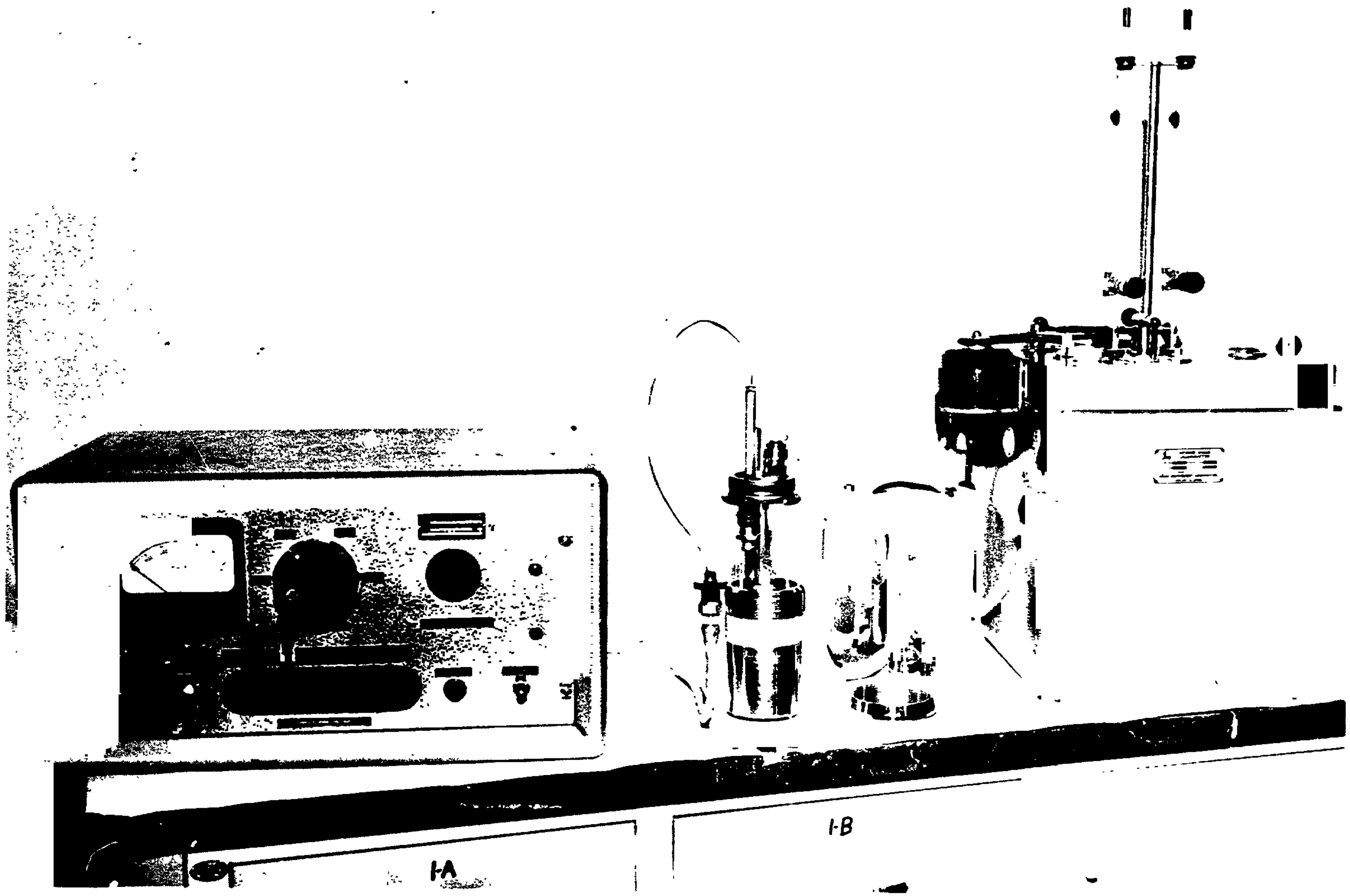


Figure E-14. EL. Firing Unit and Calorimeter

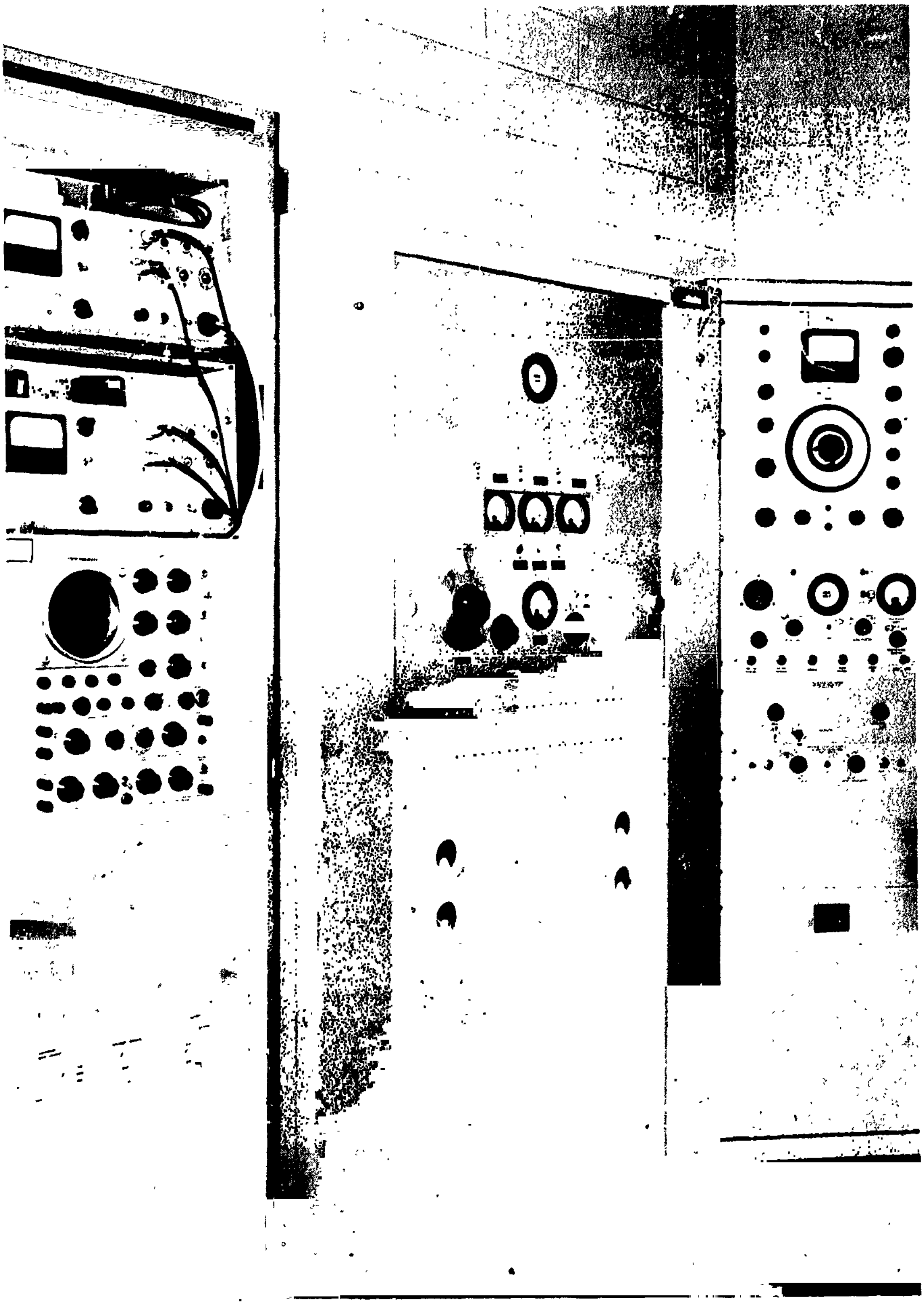


Figure E-15. Vibrator Control Console

Figure E-16. Vibrator Table

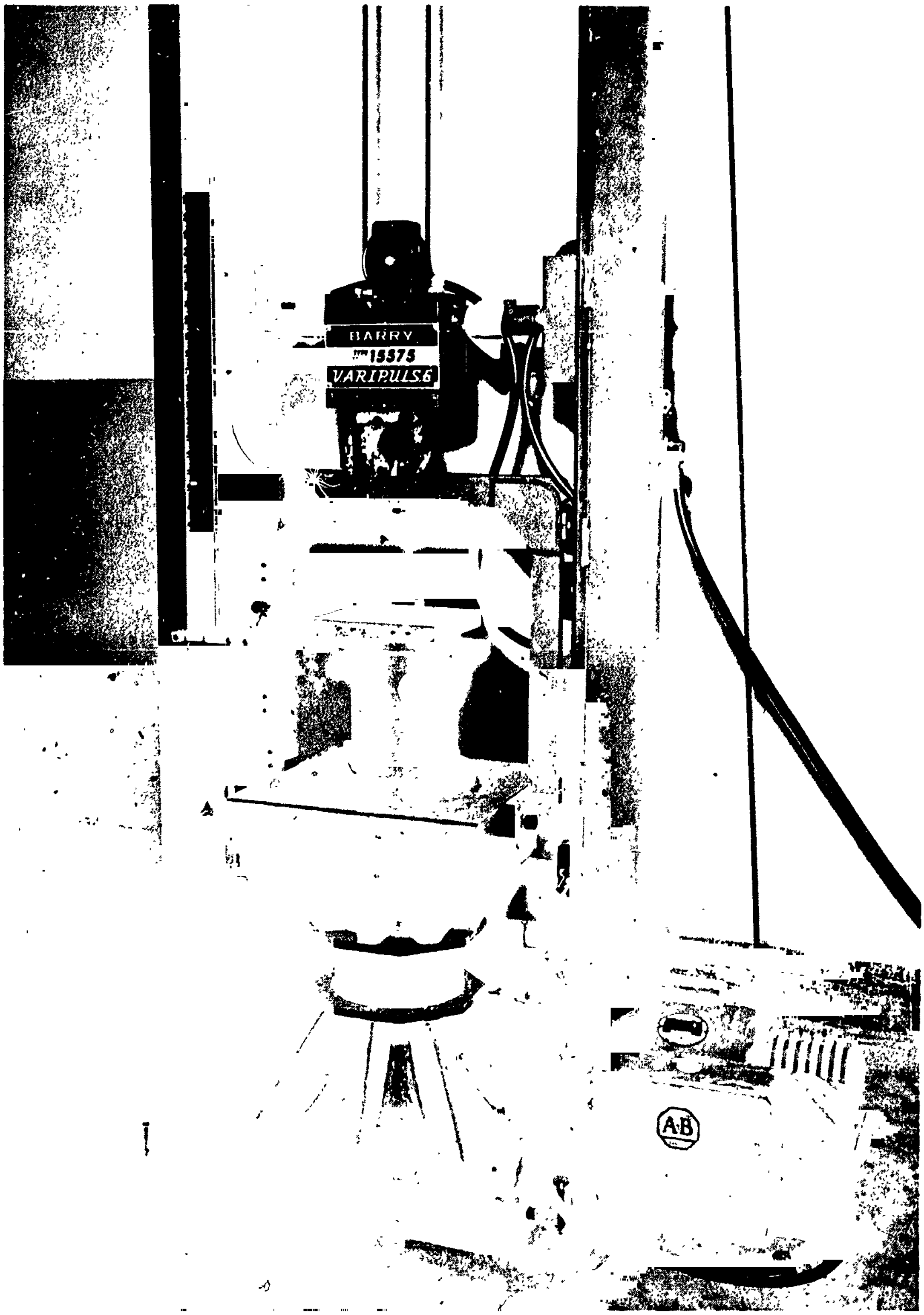


Figure E-17. Shock Tester

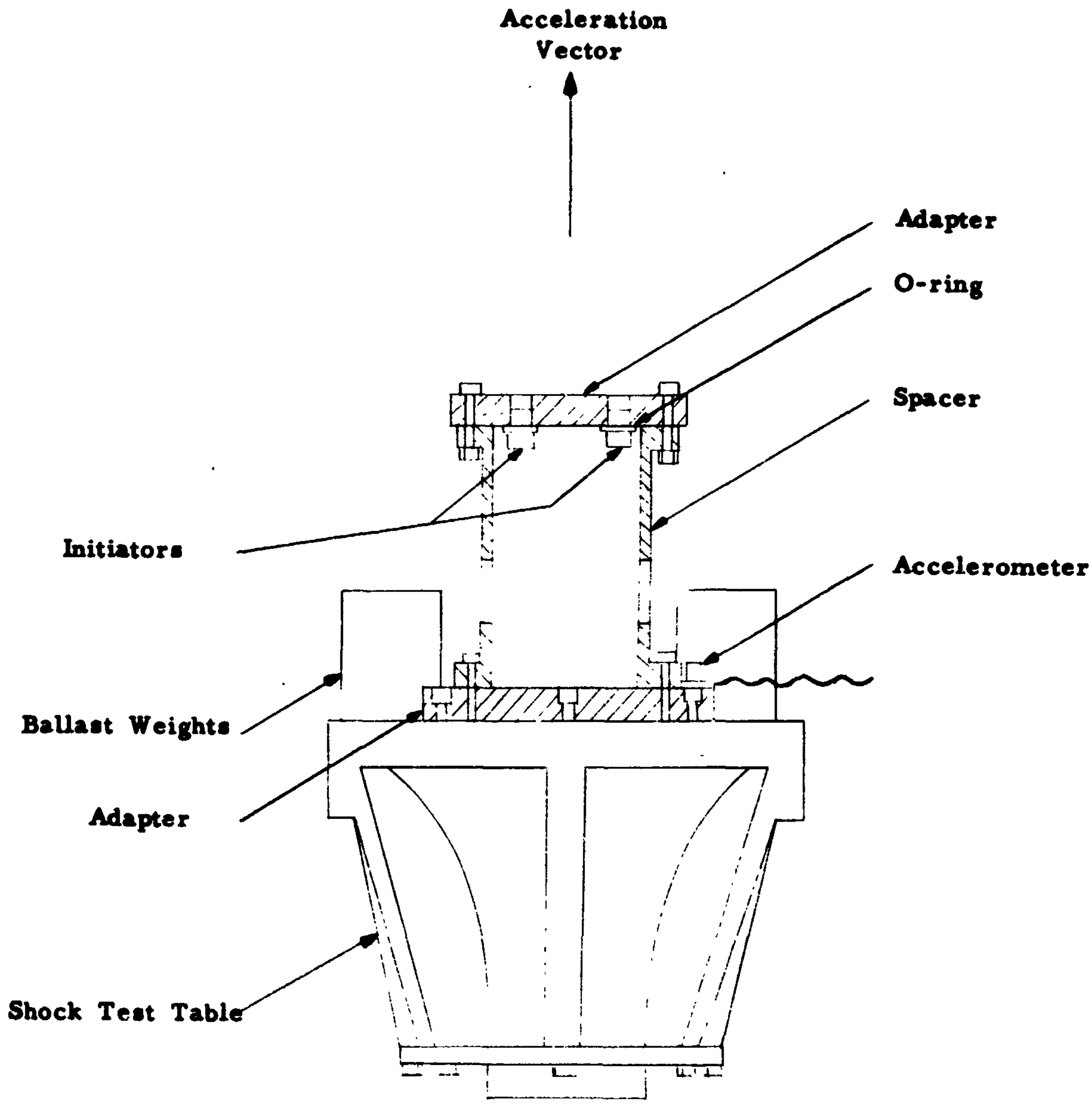


Figure E-18. Assembly for TX346 and TX346-1 Initiator Shock Tests

APPENDIX F
QUALIFICATION PROGRAM DEVIATIONS AND CERTIFICATIONS

Some deviations to the Qualification Program were necessary during the course of this contract. These deviations along with pertinent certifications are incorporated as subsequent pages of this Appendix in their original form.

THIOKOL CHEMICAL CORPORATION
ALPHA DIVISION—HUNTSVILLE PLANT
HUNTSVILLE, ALABAMA

64-01049 Jan 17 1964

George C. Marshall Space Flight Center
NASA
Purchasing Office
Huntsville, Alabama 35812

Attention: PR-RDC

Subject: Changes to Test Plan Under Contract NAS8-5448, Qualification Program for S IV Ullage and Retro Motor Initiator

Reference: Meeting held on January 9, 1964 between Messrs. Hester and Wear of NASA and Messrs. Graves and Jackson of Thiokol

Gentlemen:

The purpose of this letter is to document the agreements reached during the referenced meeting.

One portion of contract NAS8-5448 involves the qualification of the TX-346 and TX-346-1 initiators. This qualification program requires certain tests that are designed to prove that the initiators can meet the design requirements stipulated by NASA. The referenced meeting was held to clarify these tests. The tests and the agreed changes are listed below in the same sequence as they appear in appendix A of the monthly report for the period 3 June thru 2 July 1963.

I. Item 2a. (1), Page 2, states that 36 VDC from a 0.1 ohm impedance source shall be applied across the initiator terminals and terminals to outer case for 15 minutes. This time was reduced to 2 minutes.

II. Item 2b. (1), Page 3, is the one watt-no fire test. It was agreed that the lowest bridgewire resistance obtained while testing the 50 units involved will be used in calculating the test current (amperes) for all units.

III. Item 2b, (2), Page 3, is the one ampere-no fire test. Since the one watt-no fire test (Item 2b (1)) is much more severe than the one ampere-no fire test (approximately 2.5 amperes will be used in the one watt-no fire test) this test is eliminated. The 50 units originally scheduled for this test will be tested under the one watt-no fire test.

IV. Item 2d, (3) (c), Page 5, is found under the vibration test requirements. This paragraph states that the initiators will be subjected to an input of seventy G's acceleration through the range of 300 to 2,000 CPS. Due to equipment limitation, only 67 G's acceleration can be obtained at Thiokol. It was agreed that this input would be acceptable for this test.

In addition to the above changes to the qualification test plan, it was agreed that a gap breakdown voltage of 700 to 1,300 DC would be used in accepting the qualification program initiators. This breakdown voltage is to be obtained by the static application of DC volts and is to be measured by a Thiokol manufactured gap checker. This breakdown range of 700 to 1,300 VDC is a change to the NASA Specification S-1-PS(A) Figure 2, which required 800 to 1,300 VDC breakdown range.

Permission was granted to manufacture a number of initiators over and above the minimum number of 306 of each type for use as possible spares.

All other portions of the contract remain unchanged. If there are any additions or deletions to the above changes to Initiator Qualification Program, please contact the undersigned.

Very truly yours,

**ORIGINAL SIGNED BY
W. I. DALE, JR.**

W. I. Dale, Jr.
Project Manager
Special Projects

HEJackson:bt

(See page 2a)

THIOKOL CHEMICAL CORPORATION
ALPHA DIVISION—HUNTSVILLE PLANT
HUNTSVILLE, ALABAMA

cc: Marshall Space Flight Center
NASA
Huntsville, Alabama

Attn: Mr. L. O. Wear - P&VED

bcc: Mr. S. Zeman
Mr. A. Graves

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GEORGE C. MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA 35812

IN REPLY REFER TO:

R-QUAL-AVR

64-05925

April 15, 1964

Thiokol Chemical Corporation
Alpha Division
Building 7621
Redstone Arsenal, Alabama

Attention: Mr. E. G. Graves

Dear Sir:

The squibs which you submitted for test have been evaluated and the following comments are offered for your consideration.

All squibs were leak tested by the Radiflo system which uses a radioactive isotope, Krypton 85, as a tracer gas. The squibs were exposed to the radioactive gas for a period of 3.4 hours at 30 psia, pounds per square inch absolute, at a leak rate sensitivity of 1×10^{-8} cc/sec. The parts were tested in eight different lots. The group TX-346 has a total of six rejects while the group TX-346-1 has a total of twelve rejects.

You were verbally advised of the rejection details and other aspects of the testing; therefore, no other reports will be forthcoming.

Very truly yours,

Dieter Grau
Director
Quality & Reliability Assurance Laboratory

1- 64-26788

2 361.1

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GEORGE C. MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA 35812

IN REPLY REFER TO:

PR-RM

Mr. Marshall, 539-0617

MAY 2 9 1964

Thiokol Chemical Corporation
Alpha Division
Huntsville, Alabama

Gentlemen:

A Change Order designated as Modification No. 2 under your Contract NAS8-5448 is forwarded herewith.

Please acknowledge receipt of the Change Order in the space provided on the duplicate copy of this letter.

Sincerely yours,

William D. McKinney
Contracting Officer

1 Enc:
Modification No. 2

DISTRIBUTION
ORIG.
ACTION
SIGN.
REVIEW
"
INFO.
"
"
"

CHANGE ORDER
(OR ADMINISTRATIVE CHANGE)

PAGE NO.	1
NO. OF PAGES	2

REQUISITION NO./PURCHASE AUTHORITY	CONTRACT (Order) NO.	MODIFICATION NO.
1-3-50-00806 (IF)	NAS8-5448	2

TO: (Contractor's name and address)

Thiokol Chemical Corporation
Alpha Division
Huntsville, Alabama

ISSUED BY

PURCHASING OFFICE
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
GEORGE C. MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA Marshall/tp

ACCOUNTING AND APPROPRIATION DATA

No Change

[X] PURSUANT TO THE "CHANGES" CLAUSE OF THE ABOVE-NUMBERED CONTRACT, THE FOLLOWING CHANGES ARE MADE THEREIN.

[ ] THE ABOVE-NUMBERED CONTRACT IS MODIFIED TO REFLECT THE FOLLOWING ADMINISTRATIVE CHANGES.

Article II - Scope of Work is amended as follows:

Proceed with qualification testing as required by Initiator Specification S-1-PS (A) except for paragraphs 4.2.8.1, 4.2.8.2, and 4.2.9. These paragraphs should be amended as follows:

a. Paragraph 4.2.8.1 survey - "Scan the frequency range from 20 to 2000 CPS in five minutes (scanning twice in both positions 'a' and 'b', noting the frequency of all resonant points), for the following conditions:

(1) 20-150 CPS at 8.6 G Peak

(2) 150-260 CPS at .0075 inch D. A. Displacement

(3) 260-2000 CPS at 28.0 G Peak."

b. Paragraph 4.2.8.2 endurance - "The units shall be subjected to additional vibration conditioning at each resonant frequency determined above in accordance with the schedule below. (If no resonant frequencies are found, the requirements of this paragraph shall be deleted.) The units shall be vibrated for five minutes in both positions 'a' and 'b'.

(1) 20-150 CPS at 4.3 G Peak

(2) 150-260 CPS at .00375 inch D. A. displacement

(3) 260-2000 CPS at 14.0 G Peak."

Except as hereby modified, all terms and conditions of said contract as heretofore modified remain unchanged and in full force and effect.

DATE MAY 29 1964

UNITED STATES OF AMERICA

BY [signature]
SIGNATURE OF CONTRACTING OFFICER

William J. McKinnay
TYPED NAME OF CONTRACTING OFFICER

MSFC - FORM 64-1 (JUNE 60)

c. Paragraph 4.2.9 shock - "The initiator shall be capable of functioning during and after being subjected to three shocks of 55.0 G's peak in one direction along each of three mutually perpendicular axes. (A total of nine shocks.) The shock pulse shall have a triangular wave form with a rise time and decay each of 1 millisecond (± 1.5 millisecond). Deviation from the specified pulse amplitude of ± 15 percent (including instrumentation error) are allowed."

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