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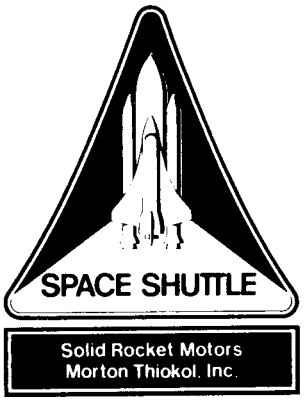

Igniter Heater EMI Transient Test Final Report

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Igniter Heater EMI Transient Test Final Report

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ABSTRACT

Testing to evaluate Redesigned Solid Rocket Motor igniter heater electromagnetic interference (EMI) effects on the Safe and Arm (S&A) device was completed on 22 Nov 1988 at the Morton Thiokol Test Bay T-24. It was suspected that EMI generated by the igniter heater and it's associated electromechanical relay could cause a premature firing of the NASA Standard Initiators (NSIs) inside the S&A.

The maximum voltage induced into the NSI fire lines was one fourth of the NASA specified no-fire limit of one volt (SKB 26100066). As a result, the igniter heaters are not expected to have any adverse EMI effects on the NSIs.

The results of this test did show, however, that power switching causes occasional high transients within the igniter heater power cable. These transients could affect the sensitive equipment inside the forward skirt. It is therefore recommended that the electromechanical igniter heater relays be replaced with zero crossing solid state relays. If the solid state relays are installed, it is also recommended that they be tested, at Kennedy Space Center, for EMI transient effects.

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1.0 INTRODUCTION

This report documents the procedures, performance, and results obtained from the Igniter Heater EMI Transient Test. This test was used to evaluate igniter heater electromagnetic interference (EMI) effects on the NASA Standard Initiators (NSIs). The NSIs are located in the Safe and Arm (S&A) device. It was suspected that EMI generated by the igniter heater and it's associated electromechanical relays could cause a premature firing of a NSI. The purpose of the test was to provide preliminary information for future heater EMI certification testing under CTP-0098, "Qualification Test Plan for the JPS Heater and Sensor Lightning Test."

The test was completed on 22 Nov 1988. Testing was performed in the Morton Thiokol Test Bay T-24, in accordance with ETP-0431, "Test Plan for Igniter Heater EMI Transient Test."

1.1 TEST ARTICLE DESCRIPTION

The test article consisted of a S&A device (1U52295), an igniter heater (1U76341), and associated cables mounted on the fired TEM-01 motor per flight configuration. Kennedy Space Center (KSC) module relays were spliced into the primary and redundant igniter heater power lines. Power was supplied only to the primary relay by the test bay 208V power supply.

Testing was performed with the igniter primary and redundant fire lines installed in two configurations: flight configuration; and a worst case, maximum EMI influence configuration. For the worst case test, the fire lines were wrapped completely around the igniter heater. The fire lines were supplied by United Space Boosters Inc. A precision one ohm resistor was installed on the end of the fire lines to simulate the NSI, and a 27 ohm resistor was installed to simulate the Pyro Initiator Controller (PIC).

2.0 OBJECTIVE

The test objective was to measure transients induced into the NSI fire lines as a result of using electromechanical relays to control power applied to the igniter heater, and make conclusions based on those measurements.

3.0 EXECUTIVE SUMMARY

3.1 SUMMARY

This section contains an executive summary of the key results from test data evaluation and post-test inspection. Additional information and details can be found in Section 6 (Results and Discussion).

Testing of both fire line configurations consisted of repeated On/Off power switching with measurements of each fire line transient level taken during each On/Off switch. Prior to actual testing, ambient noise was measured. The maximum noise level measured was 30 mV peak-to-peak (p-p), which was subtracted from the actual test voltages.

Flight configuration testing was first performed with the relays placed just off the motor, and then with the relays placed inside the instrumentation bunker. Accounting for ambient noise, the maximum voltage induced into the fire line during the latter test was 5mV p-p. This voltage was 46.02 decibels (dB) below the maximum no-fire limit of one volt (NASA specification SKB 26100066).

For the worst case test, the relays were located just off the test motor at 90 degrees. Accounting for ambient noise, the maximum voltage induced into the fire lines was 230mV p-p. This voltage was approximately one fourth of the maximum no-fire limit, which corresponds to 12.76 dB below the limit.

3.2 CONCLUSIONS

The voltage induced into the fire lines by the relay-controlled igniter heater during the flight configuration test was 46.02 dB below the maximum no-fire limit of one volt (NASA specification SKB 26100066). The voltage induced by the worst case, non-flight configuration test was 12.76 dB below maximum no-fire limit. As a result, the igniter heaters are not expected to have any adverse EMI effects on the NSIs inside the S&A.

The results did show, however, that power switching caused occasional high transients within the igniter heater power cable. These transients could have EMI effects on the sensitive equipment within the forward skirt.

3.3 RECOMMENDATIONS

The results of this test showed that power switching causes occasional high transients within the igniter heater power cable. While the levels of these transients were below the no-fire limit of the NSIs, the transients could affect the sensitive equipment within the forward skirt. It is therefore recommended that the electromechanical igniter heater relays be replaced with zero crossing solid state relays. Solid state relays would significantly reduce transients within the igniter heater power cable. If the solid state relays are installed, it is also recommended that they be tested, at KSC, for EMI transient effects.

4.0 INSTRUMENTATION

Testing was first conducted using the Hewlet Packard (HP) Digital Storage Scope and printer (model no. 54201), as called out in ETP-0431. The HP scope was defective, however, and all test data was then collected using a Nicolet Digital Oscilloscope (model no. 2090-III). Because the Nicolet scope had no printer, all transient amplitude and duration results were recorded by hand. Both scopes were zeroed and calibrated using a self check function.

5.0 PHOTOGRAPHY

Still color photographs were taken of the test article, test set-up, instrumentation, and disassembly. Copies of the series of photographs taken (Negative Series 107234) are available form the Morton Thiokol Photographic Services Department.

6.0 RESULTS AND DISCUSSION

6.1 TEST ARTICLE ASSEMBLY

The fired TEM-01 test article was configured with the igniter heater (1U76341) and S&A (1U52295) installed per flight configuration. Kennedy Space Center (KSC) module relays were spliced into the primary and redundant igniter heater power lines. These relays were flight configuration, electromechanical units. The relays were either placed near the forward dome at 90 degrees, or in the instrumentation bunker, as described in section 6.2.

Testing was performed with the igniter primary and redundant fire lines installed in two configurations: flight configuration; and a worst case, maximum EMI influence configuration. The fire lines were supplied by United Space Boosters Inc. A precision one ohm resistor was installed on the end of the fire lines to simulate the NSI, and a 27 ohm resistor was installed to simulate the Pyro Initiator Controller (PIC).

For the flight configuration testing, the fire lines were installed perpendicular to, and in contact with the igniter heater at 180 degrees. ETP-0431 specified that additional testing should be performed with a one and two inch gap between the fire lines and igniter. Since the in-contact configuration placed the fire lines closest to the signal source, and subjected the fire lines to the highest possible induced voltage, it was decided that testing with a vertical separation between the heater and fire lines would not be performed.

The worst case scenario test was performed with a configuration that would allow the igniter heater to induce the maximum EMI influence into the fire lines. For this test, the fire lines were wrapped completely around the igniter heater. To ensure that contact was maintained during the test, tape was used to hold the fire lines in place.

6.2 TEST AND RESULTS

Testing of both fire line configurations consisted of repeated On/Off power switching with measurements of each fire line transient level taken during each On/Off switch. Power was supplied only to the primary igniter heater relay by the test bay 208V power supply.

Testing was first conducted using the Hewlet Packard (HP) oscilloscope and printer (model no. 54201), as called out in ETP-0431. During testing, the HP measured voltages were consistently above the maximum no-fire limit of one volt (NASA specification SKB 26100066, "Design and Performance Specification for NSI-1 (NASA Standard Initiator-1)"). After checking the test setup and equipment, the HP scope did not pass a self check and eventually failed completely. Testing, as described below, was then repeated using the Nicolet Digital Oscilloscope (model no. 2090-III).

ETP-0431 specified 25 and 35 On/Off transient measurements for the flight and worst case configuration tests, respectively. These amounts were estimates of what would be needed to obtain a sufficient statistical sample of the AC sine wave period and a consistent amount of maximum amplitude measurements. Throughout testing, however, when amplitudes did not increase significantly with additional measurements, less than the specified amount of measurements were taken.

Ambient Noise Measurements

In an attempt to characterize EMI affects other than those emitted from the igniter heater and the test equipment, ambient noise level measurements were taken prior to the actual testing (Tables 1 and 2). Noise came from test bay equipment such as lighting, fans, and motors. Table 1 lists transient levels taken with all test equipment Off, except for Nicolet scope and

the 208V power supply (power was not connected to the igniter heaters). Table 2 lists transient levels with all test equipment Off, except the Nicolet scope. Only five measurements were necessary for each condition because the source measured was relatively constant (non-AC), and the five measurements for each condition were sufficiently consistent. No significant difference between the two configurations was detected. The maximum noise level measured from each configuration was 30 mV peak-to-peak (p-p), which was subtracted from the actual test voltages.

Test 1. Flight Configuration Fire Lines, Relays Located Near Test Article

For the first flight configuration test, the relays were located just off the test motor at 90 degrees. The relays and the Nicolet scope were located on opposite sides of the test motor.

The maximum voltage induced into the fire lines was 114 mV p-p, with a duration of 1.5 milliseconds (Table 3). Accounting for ambient noise, the maximum voltage induced into the fire lines was 84 mV p-p. This voltage was approximately one twelfth of the maximum no-fire limit of one volt (NASA specification SKB 26100066), which corresponds to 21.51 decibels (dB) below the limit.

Test 2. Flight Configuration Fire Lines, Relays Located Within Instrumentation Bunker

To eliminate EMI influence that the relay may have induced on the fire lines during the first test, the test was redone with the relays placed inside the instrumentation bunker. This resulted in a more accurate flight configuration simulation (for flight, the relays are located within the Mobile Launch Platform (MLP), distanced from the igniters).

The maximum voltage induced into the fire lines was 35 mV p-p, with a duration of 1.5 milliseconds (Table 4). Accounting for ambient noise, the maximum voltage induced into the fire lines was 5mV p-p. This voltage was 46.02 dB below the maximum no-fire limit of one volt (NASA specification SKB 26100066).

Test 3. Non-Flight/Worst Case Configuration - Fire Lines Wrapped Around Igniter Heater

For the worst case test, the relays were located just off the test motor at 90 degrees. The relays and the Nicolet scope were located on opposite sides of the test motor.

The maximum voltage induced into the fire lines was 260mV p-p, with a duration of less than 1.5 milliseconds (Table 5). Accounting for ambient noise, the maximum voltage induced into the fire lines was 230mV p-p. This voltage was approximately one fourth of the maximum no-fire limit of one volt (NASA specification SKB 26100066), which corresponds to 12.76 dB below

the limit.

Rapid Switching, Worst Case Configuration Test

This test was performed with the HP scope, before the Nicolet scope was used. The test consisted of switching the power On and Off rapidly for 15 seconds, and measuring the resulting transients. Although the HP scope was not calibrated correctly, it was accurate for measuring relative measurements. The relay chatter transient levels measured were similar to those measured in the worst case On/Off test. It was determined that it was not necessary to repeat this test using the Nicolet scope.

Reading #	Maximum Output (mV)	Minimum Output (mV)
1	15	-15
2	15	-10
3	15	-10
4	15	-10
5	15	-15

Table 1. Test Bay Ambient Noise Levels, 208V Power Source Turned On

Reading #	Maximum Output (mV)	Minimum Output (mV)
1	15	15
2	15	-10
3	15	-10
4	15	-10
5	15	-15

Table 2. Test Bay Ambient Noise Levels, 208V Power Source Turned Off

Reading #	Maximum Output (mV)	Minimum Output (mV)
1	-5.5	-1.0
2	5.0	-18.0
3	18.0	-5.5
4	43.0	-2.0
5	2.0	-2.0
6	31.5	-24.0
7	47.5	-66.5
8	18.5	-1.5
9	6.0	-8.5
10	14.5	-19.0
11	2.5	-4.0
12	1.0	-2.0
13	8.0	-5.0
14	2.5	-25.0
15	15.5	20.5
16	7.0	-3.0
17	1.0	-2.5
18	2.0	-3.0
19	2.5	-9.5
20	2.0	-2.0

Table 3. Fire Line Voltage, Induced by Igniter Heater Transients - Flight Configuration Fire Lines, Relay Located in Test Bay

Reading #	Maximum Output (mV)	Minimum Output (mV)
1	10	-20
2	15	-20
3	10	-20
4	10	-20
5	20	-10
6	15	-15
7	15	-10
8	15	-10
9	20	-10
10	20	-10
11	20	-15
12	15	-10
13	15	-10
14	15	-10
15	15	-10
16	15	-10

Table 4. Fire Line Voltage, Induced by Igniter Heater Transients - Flight Configuration Fire Lines, Relay Located in Instrumentation Bunker

Reading #	Maximum Output (mV)	Minimum Output (mV)
1	15	-15
2	10	-15
3	10	-15
4	10	-15
5	15	-15
6	20	-20
7	10	-10
8	10	-20
9	10	-20
10	15	-20
11	15	-20
12	10	-20
13	8	-20
14	0	-260
15	5	-20
16	10	-20
17	30	-20

Table 5. Fire Line Voltage, Induced by Igniter Heater Transients - Worst Case Fire Line Configuration, Relay Located in Test Bay

7.0 APPLICABLE DOCUMENTS

Document No.	Title
CTP-0098	Qualification Test Plan for the JPS Heater and Sensor Lightning Test (CTP-0098 was not released upon release of this test report.)
ETP-0431	Test Plan for Igniter Heater EMI Transient Test
SKB 26100066	Design and Performance Specification for NSI-1 (NASA Standard Initiator-1)
TWR-15723	Redesign D&V Plan

Drawing No.	Title
1U52295	S & A Device
1U76341	Heater

Distribution List

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