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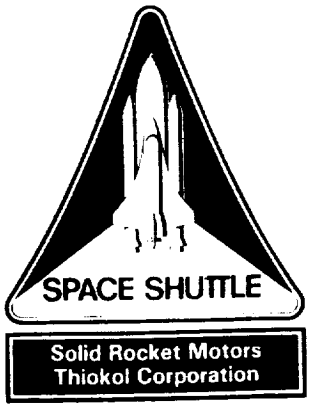

Environmental Data Recorder (EDR) Qualification Final Test Report

15 January 1991

Prepared for

National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

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Thiokol CORPORATION

SPACE OPERATIONS

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Environmental Data Recorder (EDR) Qualification Final Test Report

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ABSTRACT

Qualification testing of the environmental data recorder (EDR) was successfully completed between 31 Oct 1990 and 17 Nov 1990 in the T-53 vibration test building at Thiokol Corporation, Utah-based facilities. The purpose of this test was to qualify the EDR so that it could monitor segments shipped via railcar from Utah to Kennedy Space Center (KSC).

The test consisted of two parts, a transportation test and a functional test. The transportation test verified EDR operation in its intended environment. The functional test verified EDR accuracy. Data from the functional test showed that the EDR accuracies complied with CDW2-3847 requirements.

Since the EDR meets or exceeds all of its test objectives, it has been successfully qualified. It is recommended that the EDR replace the transportation monitoring unit (TMU).

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ABBREVIATIONS AND ACRONYMS

EDR	environmental data recorder
KSC	Kennedy Space Center
TMU	transportation monitoring unit
RSRM	redesigned solid rocket motor
NIST	National Institute of Standards and Technology
CPU	central processing unit

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INTRODUCTION

This report describes the qualification testing of the environmental data recorder (EDR) Model 3 with 10 g accelerometers. This unit is referred to as the EDR-3 or EDR-3-10. The Thiokol part number is 8U77299. Testing was performed per CTP-0223, Revision A. The EDR is a self-contained unit with power supply and data acquisition system capable of measuring temperature, humidity, and acceleration along three different axes.

The purpose of the test was to verify the ability of the EDR to perform its required functions when subjected to various excitations. Previous testing was conducted per ETP-0539, Revision A, as documented in TWR-50218. It is intended that the self-contained and compact EDR will replace the awkward and bulky TMU system currently used to monitor rail shipments. Two attempts to qualify the TMU system were unsuccessful (testing per CTP-0097, Revision D, as documented in TWR-18782). TMU qualification testing demonstrated structural weaknesses in the TMU housing as well as unit failure at low and high temperature extremes. The EDR evaluation testing demonstrated that its improved circuit design and structural housing can function correctly throughout the entire operating temperature range.

The test consisted of two parts, a transportation test and a functional test which was performed at three different temperatures (-35°, 70°, and 145°F, with a tolerance of ±5°F). These values were within the vendor's recommended operating temperature range. These values also provided a temperature range which enveloped historical railcar temperature readings with a ±20°F tolerance at the extremes (CDW2-3487).

The transportation portion of the test was designed to verify the operation of the EDR in the intended environment (e.g. simulated railcar operation and railcar hump).

The functional test was designed to verify the accuracy of the EDR (e.g. simulated typical shock, vibration, and quiescent conditions).

Testing was performed in T-53, Vibration Test Building at Thiokol Corporation, Utah-based Facilities.

1.1 TEST ARTICLE DESCRIPTION

The EDR is a commercially available environmental data recorder manufactured by Instrumented Sensor Technology, Inc of Lansing, Michigan (Drawing 8U77299). The EDR monitors acceleration in three orthogonal axes (X, Y, and Z). The EDR has a programmed triggering operation that can be set to trigger between 0 and 10 g. The EDR continuously stores data into the internal temporary memory. When the programmed trigger level is exceeded, the unit will record inputs from all accelerometer channels into the main memory. The main memory will store information that occurred 0.5 sec before the triggered event and 3.0 sec after. The unit can store approximately 50 (quantity) 3.5-sec events in the internal memory. Temperature readings will be recorded every 0.5 hour.

The EDR stores three accelerometer channels (A001-A003) and one temperature sensor channel (T001) in its internal memory. The EDR was mounted to an L-shaped test fixture (Figures 1 and 2) which enabled the unit to be mounted in one of three different orthogonal directions (X, Y, and Z axis). The X, Y, and Z axis directions are clearly labeled on the EDR housing.

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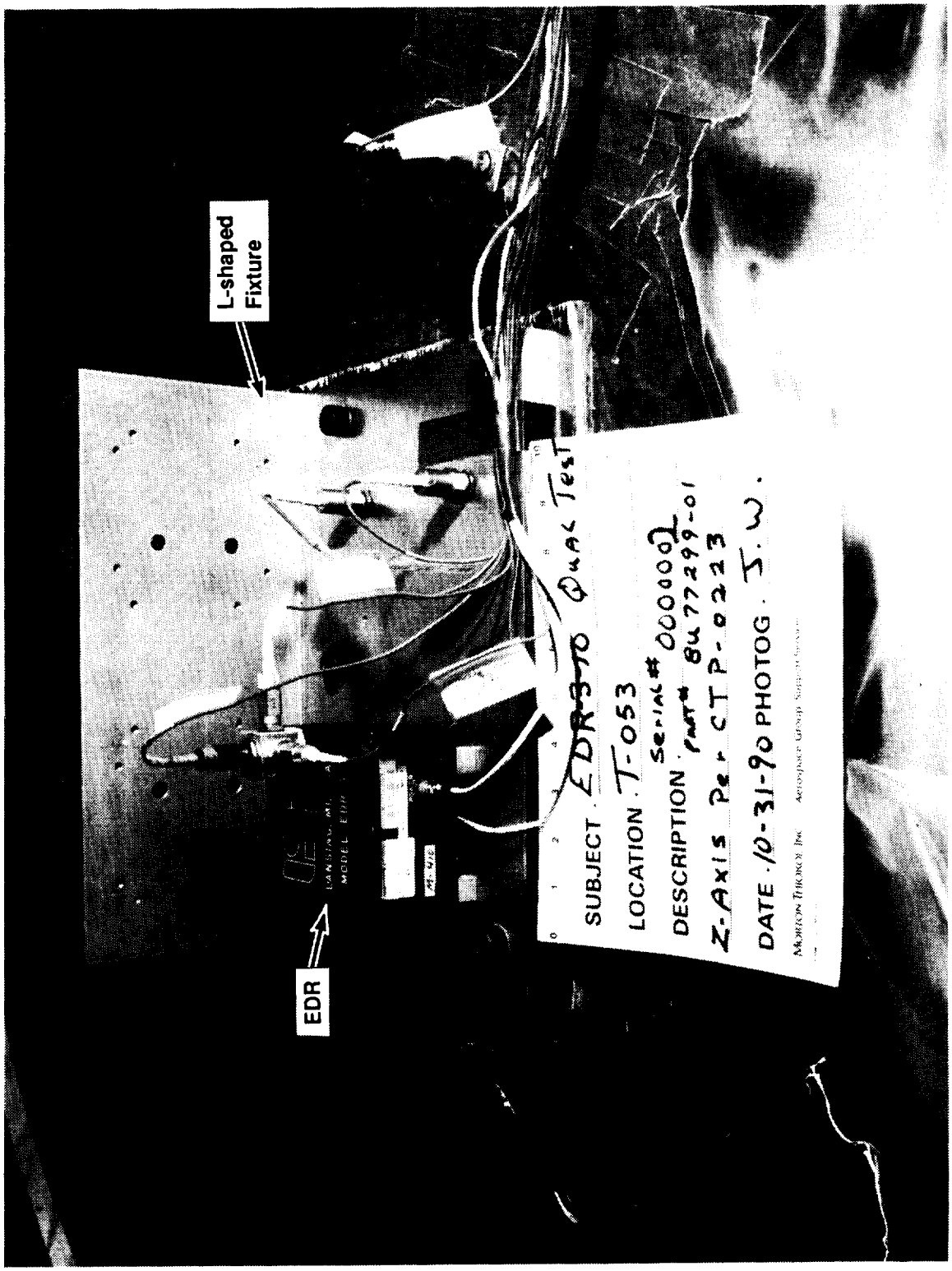

Figure 1. EDR Mounted to L-shaped Test Fixture (Z-axis mounting)

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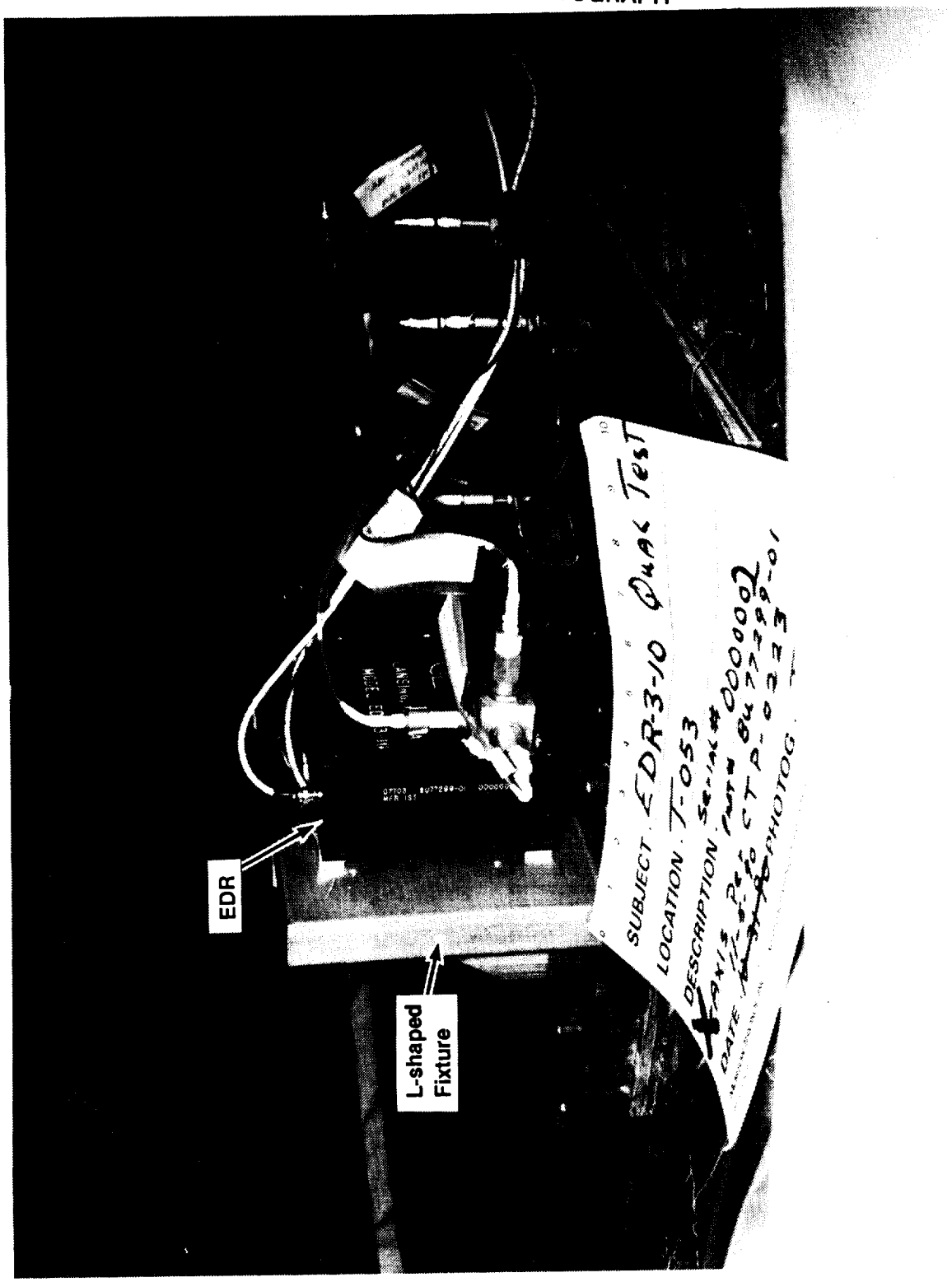

Figure 2. EDR Mounted to L-Shaped Test Fixture (X-axis mounting)

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TEST OBJECTIVES

The EDR test objectives, taken from CTP-0223, Revision A, satisfy the requirements of CPW1-3600, Paragraph 3.2.8 and the CDW2-3847 paragraphs as listed after each test objective.

The following are the qualification test objectives.

a. Certify that the unit scanner will record accelerations 0.5 sec before and 3 sec at a minimum of 120 sps after each triggered event. (3.2.1.2.3 and 3.2.1.2.5)

b. Certify that the EDR-3-10 will record temperature every half hour. (3.2.1.2.2)

c. Certify that any of the three accelerometer channels will trigger the other channels. (3.2.1.2.4)

d. Certify that the triggering systems operate at the preset threshold levels. (3.2.1.2.4)

e. Certify acceleration and temperature accuracy throughout the operating temperature range. (3.2.1.2.1, 3.2.1.2.7, 3.2.1.2.9, 3.2.7 and 3.2.1.2.4)

f. Certify the unit scanner recording capability through various vibration inputs. (3.2.1.2.4 and 3.2.8.1)

g. Certify that the self-contained power source can successfully operate for a minimum of 17 days. (3.2.1.2.10)

h. Certify that the EDR-3-10 will record a minimum of 50 acceleration events of 3.5 sec. (3.2.1.2.6)

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EXECUTIVE SUMMARY

3.1 SUMMARY

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

3.2 CONCLUSIONS

This section discusses conclusions for specific test objectives. CDW2-3847 paragraphs are listed after each test objective. Additional information about the conclusions are in Section 6, Results and Discussions.

Objectives	Conclusions
a. Certify that the unit scanner will record accelerations 0.5 sec before and 3 sec at a minimum of 120 sps after each triggered event. (3.2.1.2.3 and 3.2.1.2.5)	Certified. The EDR recorded 3.5 sec of data at 200 samples per sec each time the trigger level was exceeded.
b. Certify that the EDR-3-10 will record temperature every half hour. (3.2.1.2.2)	Certified. The EDR recorded temperature every half hour during the entire test.
c. Certify that any of the three accelerometer channels will trigger the other channels. (3.2.1.2.4)	Certified. Whenever one accelerometer channel was triggered, the other two channels triggered also.
d. Certify that the triggering systems operate at the preset threshold levels. (3.2.1.2.4)	Certified. The triggering systems operated correctly at the preset threshold levels.

Objectives	Conclusions
e. Certify acceleration and temperature accuracy throughout the operating temperature range. (3.2.1.2.1, 3.2.1.2.7, 3.2.1.2.9, 3.2.7 and 3.2.1.2.4)	Certified. Temperature accuracy was within the required ± 5°F and accelerometer accuracy was within the required ± 10 percent.
f. Certify the unit scanner recording capability through various vibration inputs. (3.2.1.2.4 and 3.2.8.1)	Certified. For each of the various vibration inputs, the EDR-3-10 recorder performed correctly.
g. Certify that the self-contained power source can successfully operate for a minimum of 17 days. (3.2.1.2.10)	Certified. The self-contained power source successfully operated after 17 days and after 44 days.
h. Certify that the EDR-3-10 will record a minimum of 50 acceleration events of 3.5 sec. (3.2.1.2.6)	Certified. Fifty events were recorded by the EDR-3-10 during the four minute sinusoidal dwell test.

The successful testing described demonstrates compliance with design requirements specified in CDW2-3847. Once the EDR-3-10 is implemented for use on railcars, it will satisfy CPW1-3600A Paragraphs 3.2.6.2 and 3.2.8 requirements for Ground Safety and Transportability/Transportation, respectively.

3.3 RECOMMENDATIONS

Since the EDR meets or exceeds all of its qualification objectives, it is recommended that the EDR replace the TMU for monitoring redesigned solid rocket motor (RSRM) segments transported by railcar.

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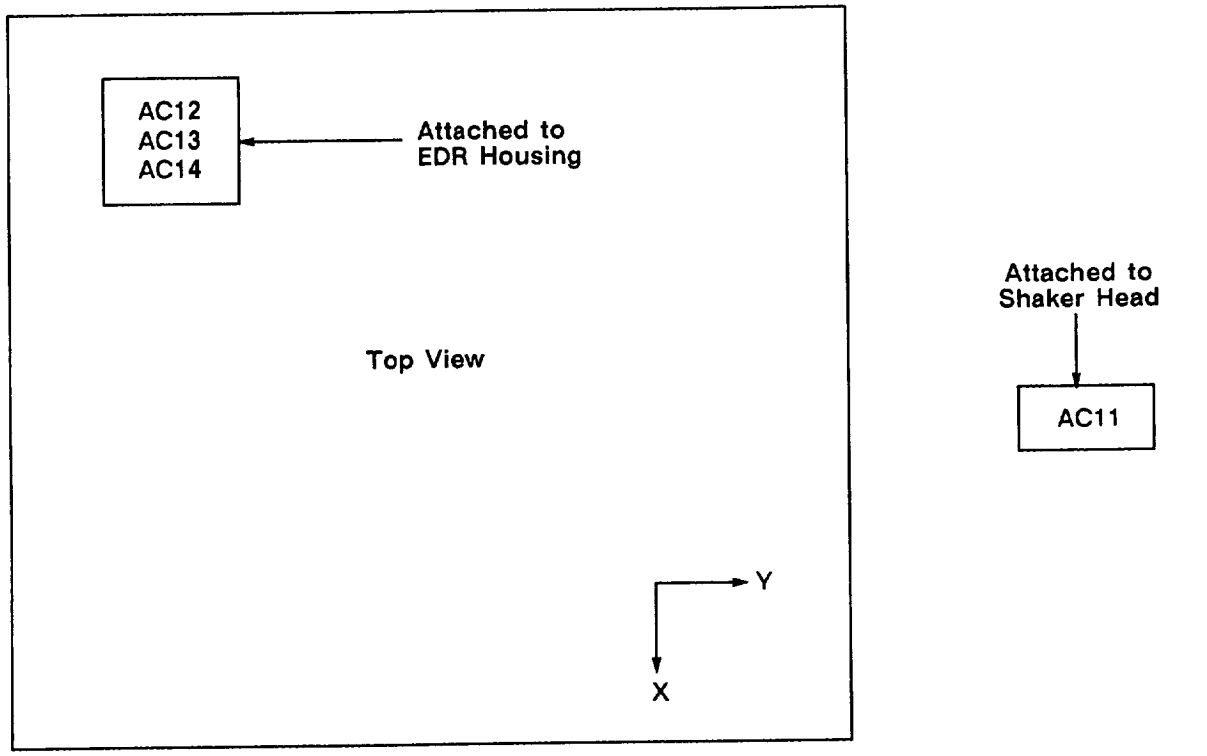
INSTRUMENTATION

Thiokol Corporation provided the EDR, data cable, and a IBM compatible computer for data retrieval and processing. The test facility provided the test fixture, reference/control accelerometer (AC11), reference temperature sensor (TC02), response accelerometers (AC12-AC14) and their associated data acquisition system. Standard laboratory equipment calibrations traceable to the National Institute of Standards and Technology (NIST) were used to support this test. All calibrated measuring and test equipment used to support this test were in compliance with MIL-STD-45662. All instruments were operationally verified as required by the operating limits of the test. Instrumentation was installed in accordance with Table 1 and Figure 3.

Table 1. Instrumentation List

Instrument	Direction	Description	Range
A001	X-Axis	Accelerometer--EDR	10 g
A002	Y-Axis	Accelerometer--EDR	10 g
A003	Z-Axis	Accelerometer--EDR	10 g
AC11	In-line with excitation	Reference/Control--T53	20 g
AC12	X-Axis	Response--T53	20 g
AC13	Y-Axis	Response--T53	20 g
AC14	Z-Axis	Response--T53	20 g
T001	EDR internal probe	Temperature--EDR	-35°/+145°F
TC02		Temperature/Control--T53	-35°/+145°F



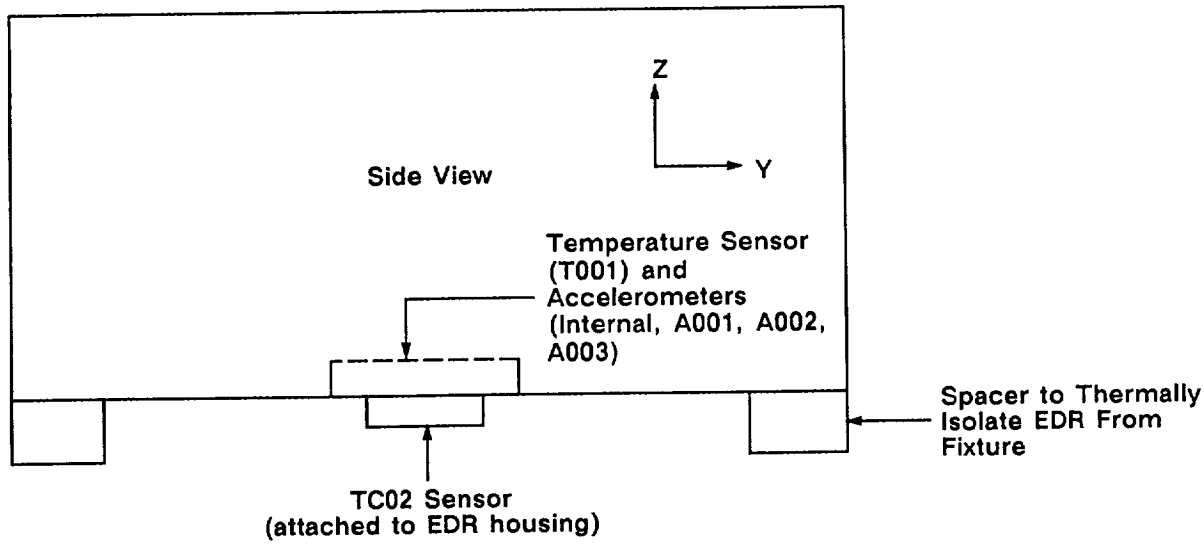


Figure 3. EDR Instrumentation

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PHOTOGRAPHY

Still color photographs of the test article setup and the test control room configuration were taken. Copies of the photographs (series numbers 120009, 120061, 120082, and 120149) are available from the Thiokol Corporation Photographic Services Department.

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RESULTS AND DISCUSSIONS

6.1 TEST ARTICLE ASSEMBLY

The test article consisted of an EDR-3-10 (8U77299-01 S/N 0000002) environmental data recording unit mounted to an L-shaped test fixture which was attached to an electrodynamic exciter. A thermocouple was attached to the EDR housing to verify proper conditioning temperature. Prior to any testing, proper temperature conditioning was verified by Quality inspectors. A control accelerometer was mounted to the test fixture to control the shock/vibration input signal. Three response accelerometers were attached to the EDR housing to determine resonant frequencies of the EDR's structure. A personal computer was used to process the EDR data (Figure 4).

Temperature conditioning was maintained by circulating conditioned hot or cold air through an insulated plywood shroud which was lowered over the entire test article (Figures 5 and 6). A data logger was used to record temperatures (Figure 4).

6.2 TEST DESCRIPTION

The test consisted of two parts, a transportation test and a functional test.

The transportation portion of the test was designed to verify the operation of the EDR in the intended environment (e.g. simulated railcar operation and railcar hump).

The functional test was designed to verify the accuracy of the EDR (e.g. simulated typical shock, vibration, and quiescent conditions).

Testing was performed in the T-53 vibration test building at Thiokol Corporation, Utah-based facilities.

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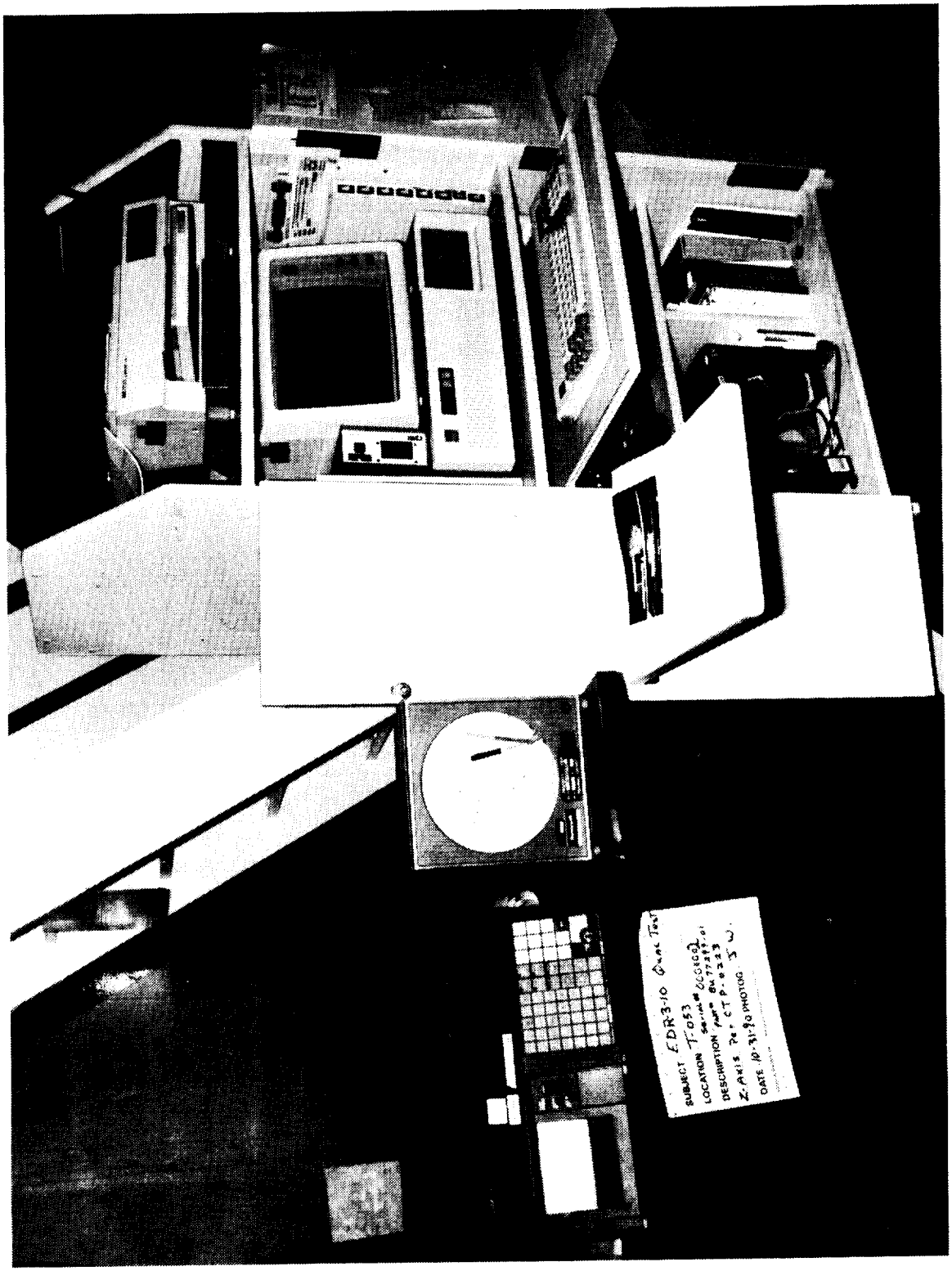

Figure 4. Temperature Data Logger (left) and Personal Computer (right)

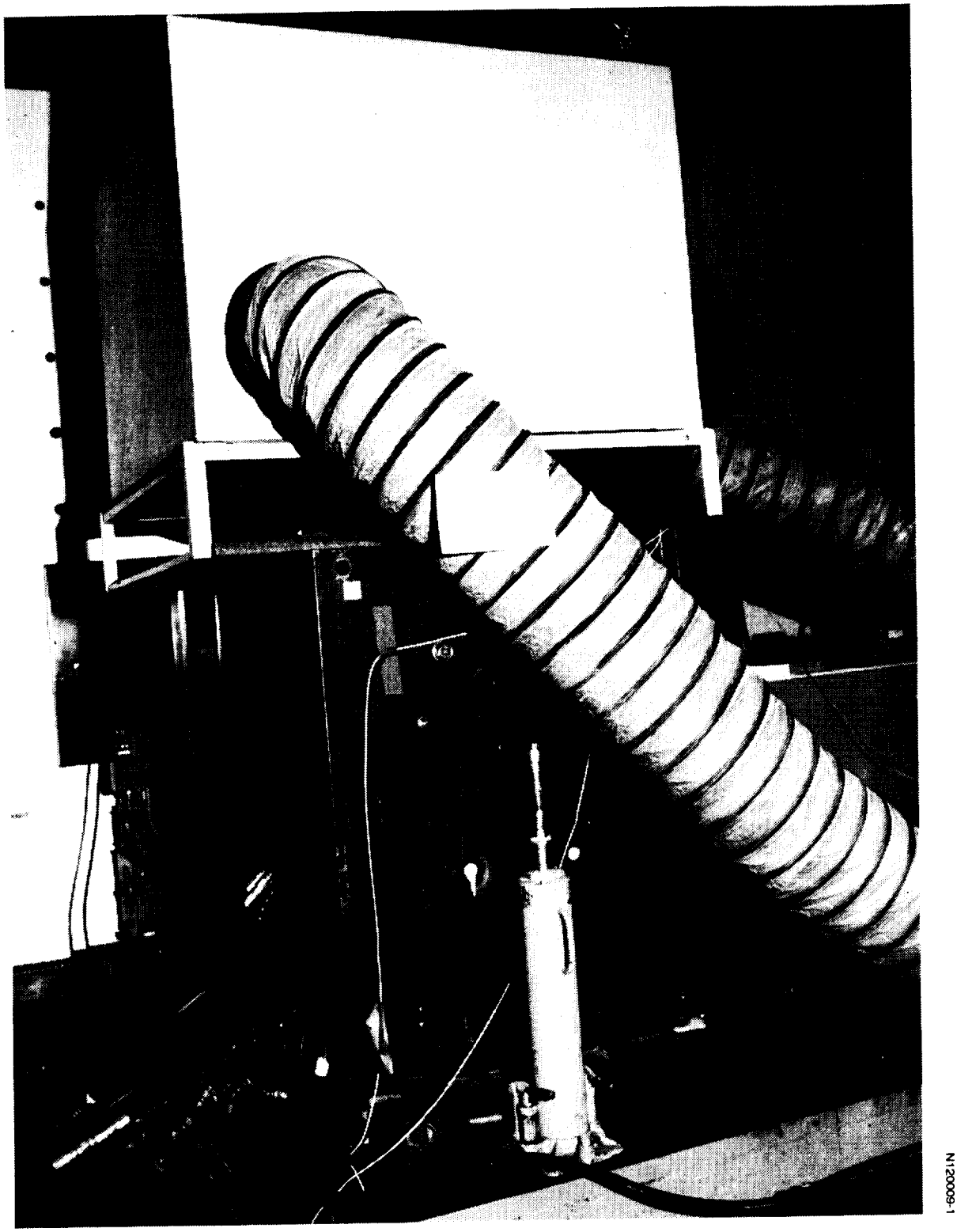

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Figure 5. Test Facility Shaker With Environmental Conditioning Shroud Over EDR

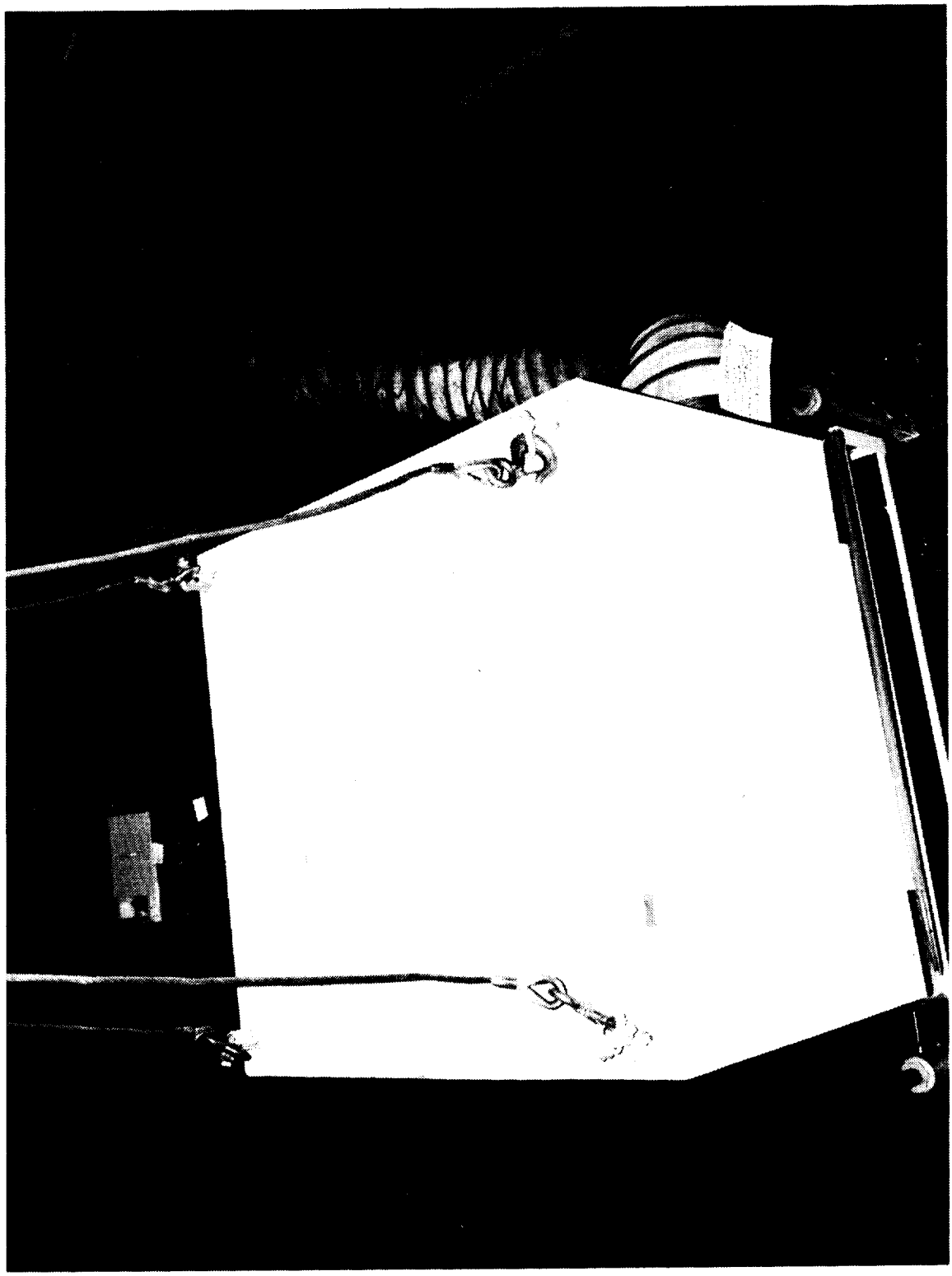

Figure 6. Environmental Conditioning Shroud Setup

6.2.1 Transportation Testing

The purpose of the transportation test was to verify the EDR design can survive the intended railcar environment.

The transportation test was conducted with the test specimen mounted in all axes directions and at three different temperatures (-35°, 70°, 145°F).

Table 2. Transportation Test Criteria

Transportation Test
Vibration (in each mutually perpendicular axis): 5-130 Hz at 1.2 g peak 130-185 Hz at 0.0014 in. DA 185-2000 Hz at 2.5 g peak Sine sweep at 5-2,000-5 Hz at 1 Oct/min Sine dwell for 15 minutes per major resonant frequency.
Five shocks (in three mutually perpendicular axes) to fulfill the shock spectra below: 20-160 Hz at +6 dB/Oct 160-340 Hz at 10 g peak 340-400 Hz at -6 dB/Oct Five shocks each direction per axis.

The following was accomplished:

a. The test specimen was subjected to the sine sweep vibration criteria listed in Table 2 (SE-019-049-2H).

b. Major resonant frequencies were identified.

c. 15-minute sinusoidal dwells were performed at the sine sweep amplitude defined in Table 2 for each major resonance identified.

d. The test specimen was subjected to five shocks in each direction per the shocks levels defined in Table 2. Any shock pulse that results in a spectrum as severe as that presented was acceptable.

The EDR successfully operated during and after the transportation tests. This satisfies CDW2-3847, Paragraph 3.2.7 and 3.2.8.1 requirements. The following paragraphs provide further assessment of the transportation testing.

6.2.1.1 Transportation Sine Sweep Test. Table 3 lists the EDR housing resonant frequencies found during the sine sweep test (5 - 2,000 - 5 Hz). Resonant frequencies were determined by a greater than 2-to-1 amplification ratio between any response accelerometer (mounted on the surface of the EDR unit) and the control accelerometer (mounted on the top of the test fixture). A 15-minute sine dwell was performed at each frequency listed in Table 3. Test facility plots are located in Appendix A. At the completion of these tests, the EDR continued to operate without any anomalies.

Table 3. Transportation Testing EDR-3-10 Resonant Frequencies

Temperature (°F)	X-axis	Y-axis	Z-axis
-35 ± 5	732 Hz 1,166 Hz 1,368 Hz	808 Hz 1,069 Hz	None
70 ± 5	703 Hz 1,135 Hz	684 Hz 968 Hz	1,181 Hz
140 ± 5	627 Hz 974 Hz	636 Hz	1,034 Hz

6.2.1.2 Transportation Shock Test. The EDR was subjected to five transportation shocks in each axis and at each temperature as defined in Table 2. A sample plot

of the test facility input shock for this test is located in Appendix A. After completion of transportation shock testing, the EDR continued to operate without any anomalies.

6.2.2 Functional Testing

The purpose of the functional testing was to verify that the EDR's recording capabilities at all three test temperatures are within acceptable tolerances. Recorded data had to be within ± 10 percent of the test standard to be acceptable. During all functional testing the EDR was in the active recording mode. The following paragraphs provide further assessment of the functional test results.

6.2.2.1 0.5 G Sine Dwell Test. The EDR was subjected to a 0.5 g sine dwell for one minute in each axis and at each temperature. The EDR shock/vibration trigger level was programmed at 0.7 g. The 0.5 g sine input was below the programmed trigger level and the EDR operated correctly and did not trigger during this test.

6.2.2.2 3.0 G Sine Dwell Test. The EDR was subjected to a 3.0 g sine dwell for 15 sec in each axis and at each temperature. The 3.0 g sine input is above the 0.7 g trigger level. During this test the EDR operated correctly. The triggering system triggered and continuously recorded the entire 15 sec. A triggered event occurs when the trigger level is exceeded. For this qualification test, the EDR was programmed to record for 3.5-sec (0.5 sec of pretrigger data and 3 sec of post-trigger data) whenever the trigger level was exceeded. Appendix B contains the test results and EDR recorded plots during the 15-sec 3 g sine dwell tests. All EDR recorded data in each axis and at each temperature was within the ± 10 percent accuracy requirement.

6.2.2.3 0.5 g Low Frequency Shock Test. The EDR was subjected to three 0.5 g half sine pulse, 0.04-sec duration shocks in each axis and at each temperature. These shocks were below the programmed trigger level (0.7 g) and the EDR operated correctly and did not trigger during this test.

6.2.2.4 2.0 g Low Frequency Shock Test. The EDR was subjected to three 2.0 g half sine pulse, 0.04-sec duration shocks in each axis and at each temperature. These shocks are above the programmed trigger level (0.7 g) and the EDR operated correctly. The trigger system recorded one triggered event (3.5 sec of data) for each 2.0 g input shock. Test facility controlled input shock and the EDR recorded shock plots are located in Appendix B. All EDR recorded data in each axis and at each temperature was within the ± 10 percent accuracy requirement.

6.2.2.5 High Frequency Shock Test. The EDR was subjected to three 20 g terminal sawtooth, 0.005-sec duration shocks in the X-axis at each temperature. The purpose of this test was to demonstrate the ability of the low-pass filter in the EDR to attenuate any high frequency shock/vibration. The EDR's 3 dB cutoff frequency is 60 Hz. The unit's low pass filter correctly filtered the high frequency inputs and the unit did not trigger on any of the signals. During this test the EDR trigger level was programmed between 1.5 and 1.8 g. This was necessary due to some low-frequency, low g level, movement of the test facility shaker prior to the actual 20 g shock. A sample plot of the test facility input high-frequency shock for this test is located in Appendix B. This test successfully demonstrated that a high-frequency shock would not trigger the EDR.

Each of the three accelerometers in the EDR has its own low-pass filter (Figure 7). All three of these filters are identical; therefore, it was only necessary to perform this test in one axis (X-axis) and at each temperature range. Thus, the Y- and Z-axis low-pass filters are qualified by similarity. Appendix B contains a typical frequency response plot for the EDR low-pass filter showing that the EDR recording capability is well within 0.7 to 30 Hz as required by CDW2-3847 Paragraph 3.2.1.2.7.

6.2.2.6 Acceleration Event Test. The EDR was subjected to four minutes of sinusoidal dwell input above the trigger level. This was conducted to demonstrate that the EDR memory could record fifty 3.5-sec triggered events. During this test fifty events were stored in the EDR's internal memory. Appendix C contains the

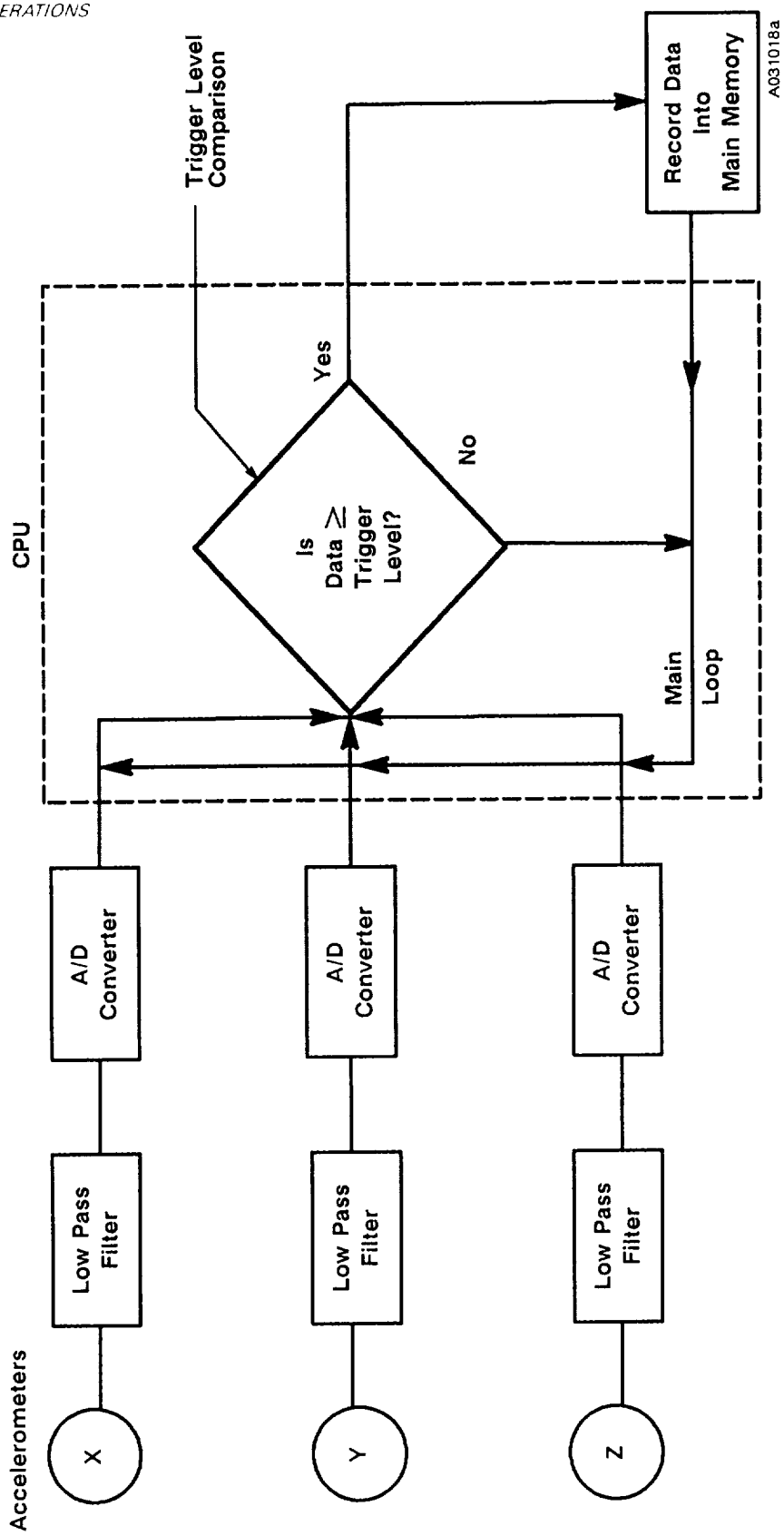

Figure 7. EDR Acceleration Monitoring Logic

EDR triggered event summary sheet (Vibration Frame Report) as well as continuous plots for all fifty triggered events. This test demonstrates compliance with the data storage capacity requirement specified in CDW2-3847, Paragraph 3.2.1.2.6.

6.2.2.7 17-Day Operational Test. After the unit operated for 17 days, the EDR was programmed to trigger at 0.7 g and subjected to four 2.0 g shocks in the X-axis direction at -35°, 70°, and 145 ±5°F. Test results are presented in Table 4. All recorded data was within defined tolerances (Appendix C). This test demonstrates compliance with the power supply duration requirement specified in CDW2-3847 paragraph 3.2.1.2.10.

Table 4. 17-Day Test Results

-35°F			70°F			145°F		
EDR	T-53	Error (%)	EDR	T-53	Error (%)	EDR	T-53	Error (%)
2.72 g	2.71 g	0.4	2.70 g	2.71 g	-0.4	2.66 g	2.68 g	-0.7
1.92 g	2.04 g	-5.9	2.68 g	2.73 g	-1.8	2.70 g	2.62 g	3.1
1.92 g	1.95 g	-3.0	2.70 g	2.71 g	-0.4	2.68 g	2.60 g	3.1
1.88 g	2.05 g	-8.3	2.72 g	2.71 g	0.4	2.66 g	2.60 g	2.3
1.94 g	2.00 g	-3.0						

During this 17-day period the power supply of the EDR was subjected to power demands in extreme excess to any actual rail car recording environment. Over this period, 257 triggered events were recorded by the EDR. In an actual shipment it is expected that less than 10 events will be recorded. Additional battery power was consumed during qualification testing when data was downloaded for analysis. On an actual shipment, the data will typically be downloaded once upon arrival at KSC. However, during qualification testing, data was downloaded several times a day and sometimes at -35°F.

At the completion of this test the EDR remained in the active recording mode to demonstrate the longevity of the power supply.

6.2.2.8 Additional Test on Day 44. After the EDR operated for 44 days, additional testing was conducted to demonstrate that after an extended time period the EDR was capable of operation at the temperature extremes. The EDR was subjected to four 2 g shocks in the X-axis at -35°, 70°, and 145° ±5°F (same as the 17 Day test). The results of this test are shown in Table 5. All data recorded by the EDR unit on day 44 were within acceptable tolerances (Appendix C). At the completion of this test, the EDR unit remained in the active mode to continue collecting temperature data.

Table 5. 44-Day Test Results

-35°F			70°F			145°F		
EDR	T-53	Error (%)	EDR	T-53	Error (%)	EDR	T-53	Error (%)
2.38 g	2.33 g	-0.8	2.42 g	2.44 g	2.1	2.46 g	2.40 g	2.5
2.30 g	2.33 g	0.8	2.42 g	2.40 g	-1.3	2.46 g	2.33 g	5.6
2.40 g	2.33 g	-1.7	2.36 g	2.40 g	3.0	2.50 g	2.42 g	3.3
2.36 g	2.33 g	0.8	2.42 g	2.40 g	1.3	2.44 g	2.37 g	3.0

The EDR is designed to conduct a battery self-check prior to recording any data. No data will be collected by the EDR if the batteries become to weak to accurately record shock\vibration or temperature. In the event that batteries become to weak to operate the EDR, the unit will cycle itself to the standby mode. Thus, all data recorded by the EDR, regardless of the number of days the unit has been operating, shall be accepted as legitimate environmental data.

As of 14 Jan 1991, the EDR had operated for 76 continuous days. At the time of this publication the EDR was still operating.

6.2.2.9 Acceleration Accuracy. During all shock/vibration testing described previously, the EDR unit recorded 3.5 sec of data at 200 samples per second whenever the EDR programmed trigger level (0.7 g) was exceeded. All acceleration data was stored in a digital format in the recording unit's internal memory, and the data was within the ± 10 percent accuracy requirement. Each triggered event contains 700 samples. One hundred samples (0.5 sec) of pretrigger data and 600 samples (3 sec) of post-trigger data. Appendix B contains an EDR recorded acceleration data versus the test facility response recorded acceleration data. A review of all post-test data verifies that the design requirements specified in CDW2-3847, Paragraphs 3.2.1.2.3, 3.2.1.2.4, 3.2.1.2.5, and 3.2.1.2.9 were met.

Thiokol Metrology Lab has independently verified the acceleration accuracy of the EDR. A letter of compliance is submitted with this report in Appendix D. Figure 8 shows the Metrology Lab verification test setup. As stated in the metrology memo, the EDR calibration is verified at 1, 3, 5, 7, and 9 g. The T-53 test facility used to conduct this qualification test could only shock/vibrate the EDR at low frequencies to a maximum of 3 g. The additional metrology data is submitted with this test report to qualify the EDR throughout its entire operating range.

6.2.2.10 Temperature Accuracy. Throughout the entire test when the EDR was in the active recording mode, temperature data was collected every 30 minutes. Appendix E contains a plot of the complete temperature record. The Thiokol Metrology Lab has independently verified the EDR temperature recording accuracy (Appendix D). The qualification test temperature data and Metrology report demonstrates compliance with temperature monitoring requirements specified in CDW2-3847, Paragraphs 3.2.1.2.1 and 3.2.1.2.2.

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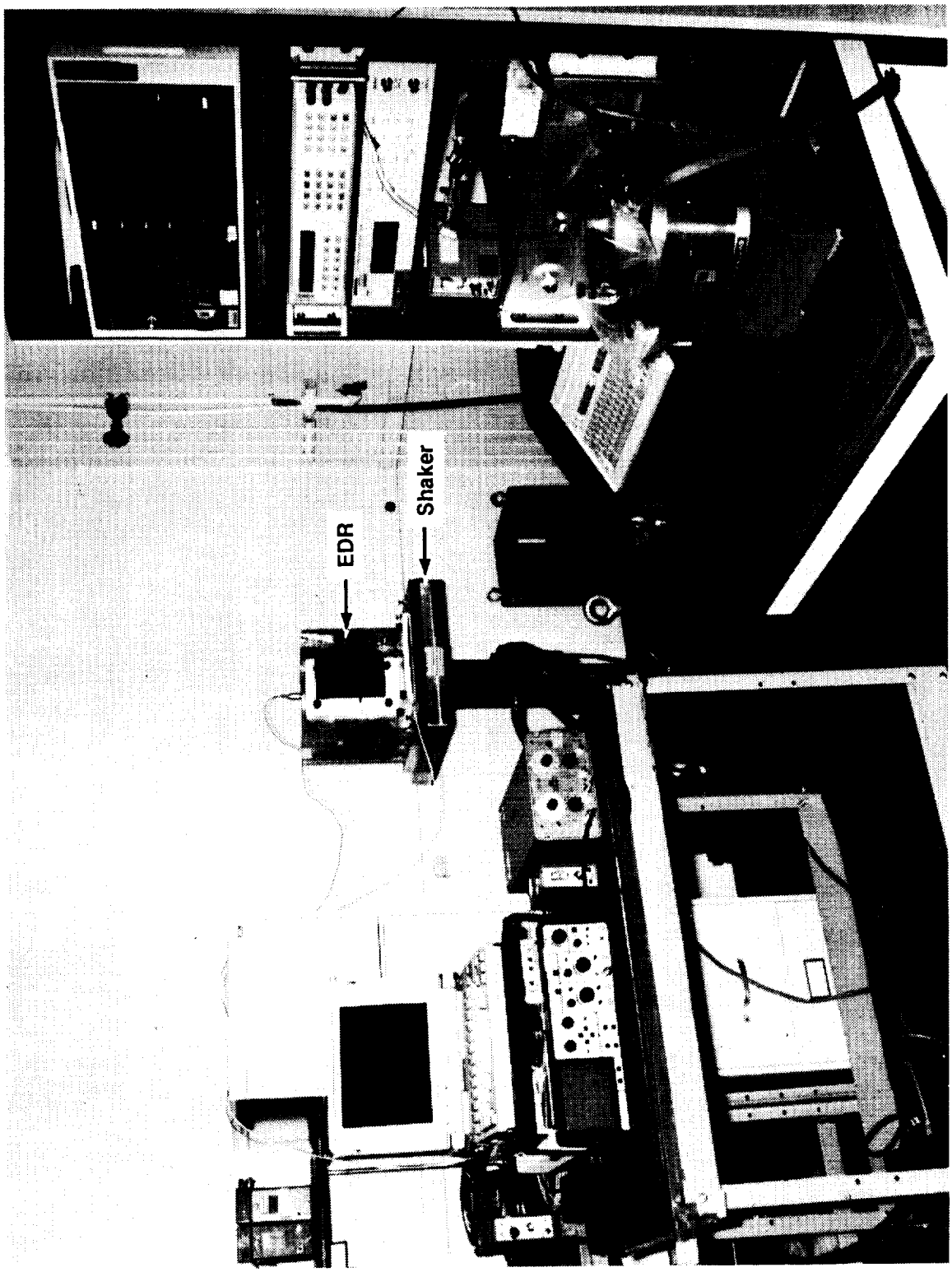


Figure 8. Thiokol Metrology Lab EDR Calibration and Verification Setup

6.2.3 Auxiliary Battery Pack

An auxiliary battery pack (BP-3T) for the EDR is available for extended recording periods. This pack is contained within a NEMA-style metal housing. It uses the identical batteries as the EDR unit and has identical fuse/diode protection. It contains twice as many batteries as the EDR and will triple the normal recording duration of the EDR. By similarity this auxiliary battery pack is qualified. The auxiliary battery pack is intended for use only when unusual shipping circumstances arise which require extended recording capability.

6.2.4 EDR Triggering System

The EDR has a programmable trigger level which can be programmed at any level between 0 and 10 g. A trigger level of 0.7 g was used during the qualification testing to demonstrate the EDR's ability to trigger correctly. During qualification testing, shock/vibration inputs at 0.5 g were used to demonstrate that the unit would not trigger. Other shock/vibration inputs at 2, 2.5, and 3 g were used to demonstrate that the EDR would trigger at shock/vibration levels above 0.7 g. Figure 9 shows an EDR recorded trigger event. As the test facility shaker is coming up to full level, the EDR triggered 0.5 sec into the recorded event when the programmed trigger level was exceeded.

6.2.4.1 Triggering System Theory of Operation. While the EDR is in the active recording mode, input shock/vibration data from the accelerometers is converted to a digital signal at the programmed sample rate. For qualification testing, the sample rate was set at 200 samples per sec. Thus, the EDR's central processing unit (CPU) compares digitalized shock/vibration values from all three accelerometers to a digitalized triggered level that was programmed by the user at a rate of 200 samples per sec. If any of the digitalized inputs from any accelerometer exceeds the trigger level for a predetermined time period (trigger threshold level), the EDR considers the input signal a valid triggered event and acceleration data from all three accelerometers is recorded into the EDR's main memory for storage. Figure 7 shows a block diagram of this operation.

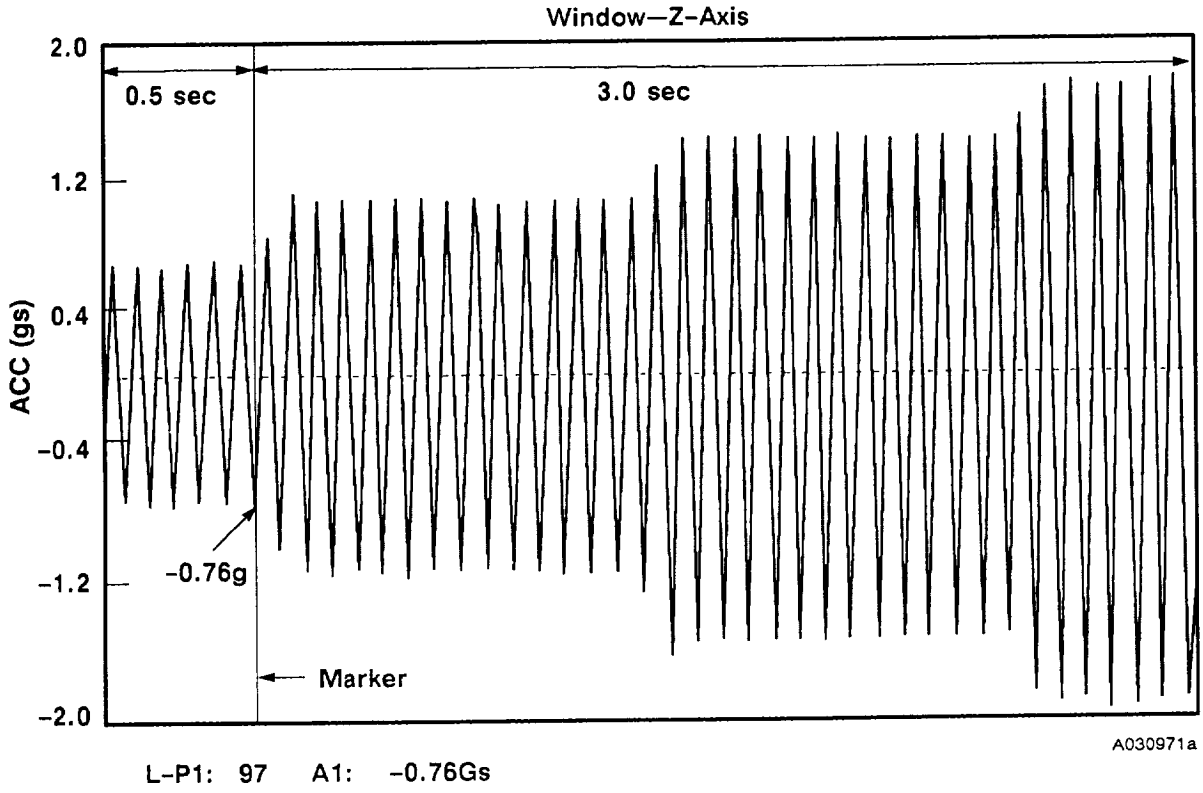


Figure 9. EDR Recorded Trigger Event

As long as the EDR records acceleration data accurately (this is verified by periodic metrology calibration checks), the triggering system will receive accurate input data from the accelerometers and will compare it to the digitalized trigger level programmed by the user. The accuracy of the digital comparison is not affected by which triggered level the user programmed. For this test 0.7 g was programmed as the trigger level. Based on this operational description of the triggering system, it is evident that the CPU could have compared the accelerometer input signal to a programmed 2-g trigger level just as easily, and that the unit would have triggered correctly when the 2-g level was exceeded. Therefore, by this analysis, the EDR is qualified to be used at any programmed trigger level within the entire operational range of the instrument (0 to 10 g). This verifies compliance for an adjustable trigger level as specified in CDW2-3847, Paragraph 3.2.1.2.4.

7

APPLICABLE DOCUMENTS

The latest revision of the following documents are applicable to the extent specified herein.

Document No.	Title
CTP-0097	Transportation Monitor Unit Qualification Test Plan
CDW2-3847	Performance, Design and Verification Requirements Transportation Environmental Recording Unit Model Designator, P77-0491
CPW1-3600	Prime Equipment Contract End Item (CEI) Detail Specifications.
CTP-0223	Environmental Data Recorder (EDR-3-10) Qualification Test Plan
DPD 400	Data Procurement Document
ETP-0539	Evaluation of EDR-3 Vibration, Shock, Temperature, and Humidity Recording Unit
GS & HM	Thiokol Corporation, Space Operations, General Safety and Health Manual (Data Sheets)
SE-019-049-2H	Solid Rocket Booster Vibration, Acoustic & Shock Design & Test Criteria
SW-E-0002	Space Shuttle GSE General Design Requirements
TWR-10161	Quality Plan for Space Shuttle Solid Rocket Motor Project
TWR-15902	Safety Plan for Space Shuttle Redesigned Solid Rocket Motor Project
TWR-18782	Transportation Monitoring Unit Qualification Final Test Report
TWR-50218	Evaluation of EDR-3 Vibration, Shock, Temperature, and Humidity Recording Unit Final Test Report

Military Standard	Title
MIL-STD-45662	Calibration System Requirements

Drawing No.	Title
8U77299	Transportation Environmental Recording Unit

Appendix A

Transportation Testing
Sine Sweep and Shock Test Data

Appendix A

Transportation Test
Sine Sweep and Shock Test Data

This appendix contains sample data from the EDR transportation test conducted per CTP-0223A paragraph 8.2.1.1. All data collected demonstrated full compliance to the test objectives.

The other high frequency spike is due to a resonant frequency of the T-53 shaker armature, not the EDR unit.

A-13 Response plot (AC13 Y-axis) for the Y-axis 145 Degree F test. Major resonant frequency at 636 Hz.

A-14 Response plot (AC14 Z-axis) for the Z-axis 145 Degree F test. Major resonant frequency at 1034 Hz. The other high frequency spike is due to a resonant frequency of the T-53 shaker armature, not the EDR unit.

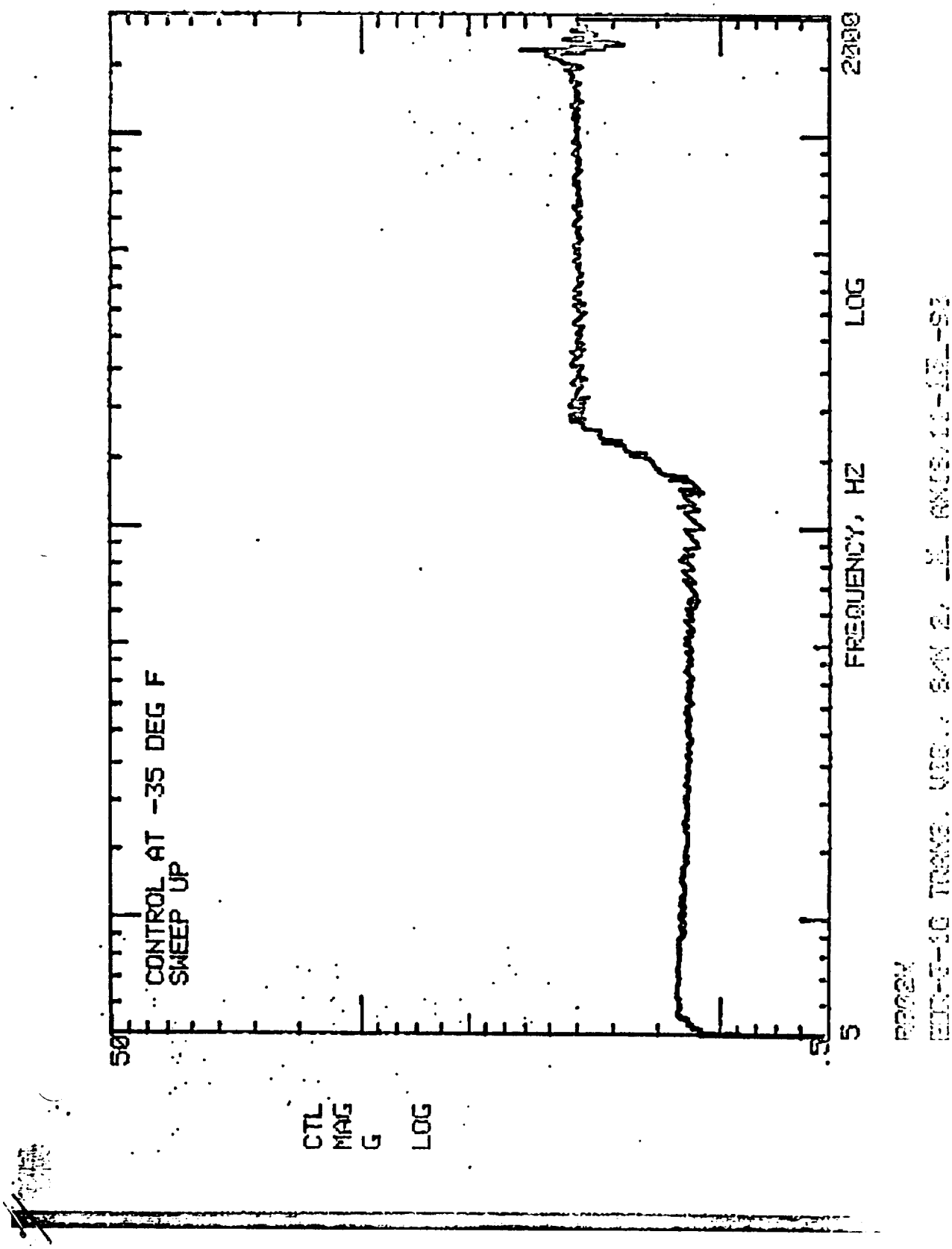
A-15 Response plot (AC12 X-axis) for the Z-axis 145 Degree F transportation test. Major resonant frequency at 974 Hz.

A-16 Transportation 10g shock pulse sample. The test article was subjected to five 10g shocks in each axis at all three temperature ranges (-35, 70, and 145 +/- 5 Degree F). This particular plot is shock #1 at 140 Degree F with the EDR unit mounted with excitation in the Y-axis. All other plots for the other four shocks, as well as the other axes at all temperatures are identical to this sample.

EDR-3-10 RESONANT FREQUENCIES

Temperature (Deg F)	X-axis	Y-axis	Z-axis
-35 ± 5	732 Hz 1166 Hz 1368 Hz	808 Hz 1069 Hz	None
70 ± 5	703 Hz 1135 Hz	684 Hz 968 Hz	1181 Hz
140 ± 5	627 Hz 974 Hz	636 Hz	1034 Hz

The test article was subjected to a 15-minute sine dwell at each of the frequencies identified above.



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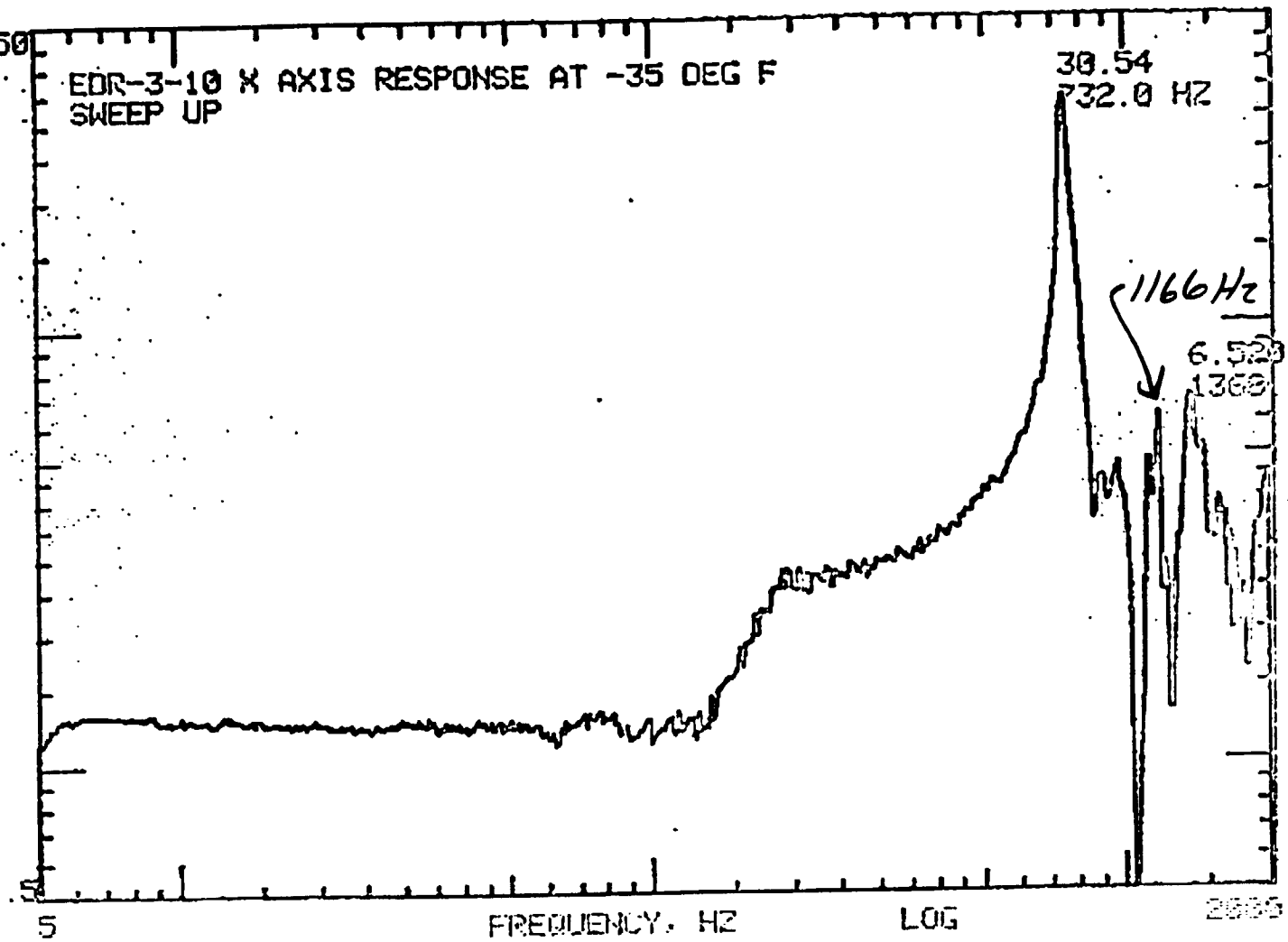

CH 2

MON MAG G

A-6

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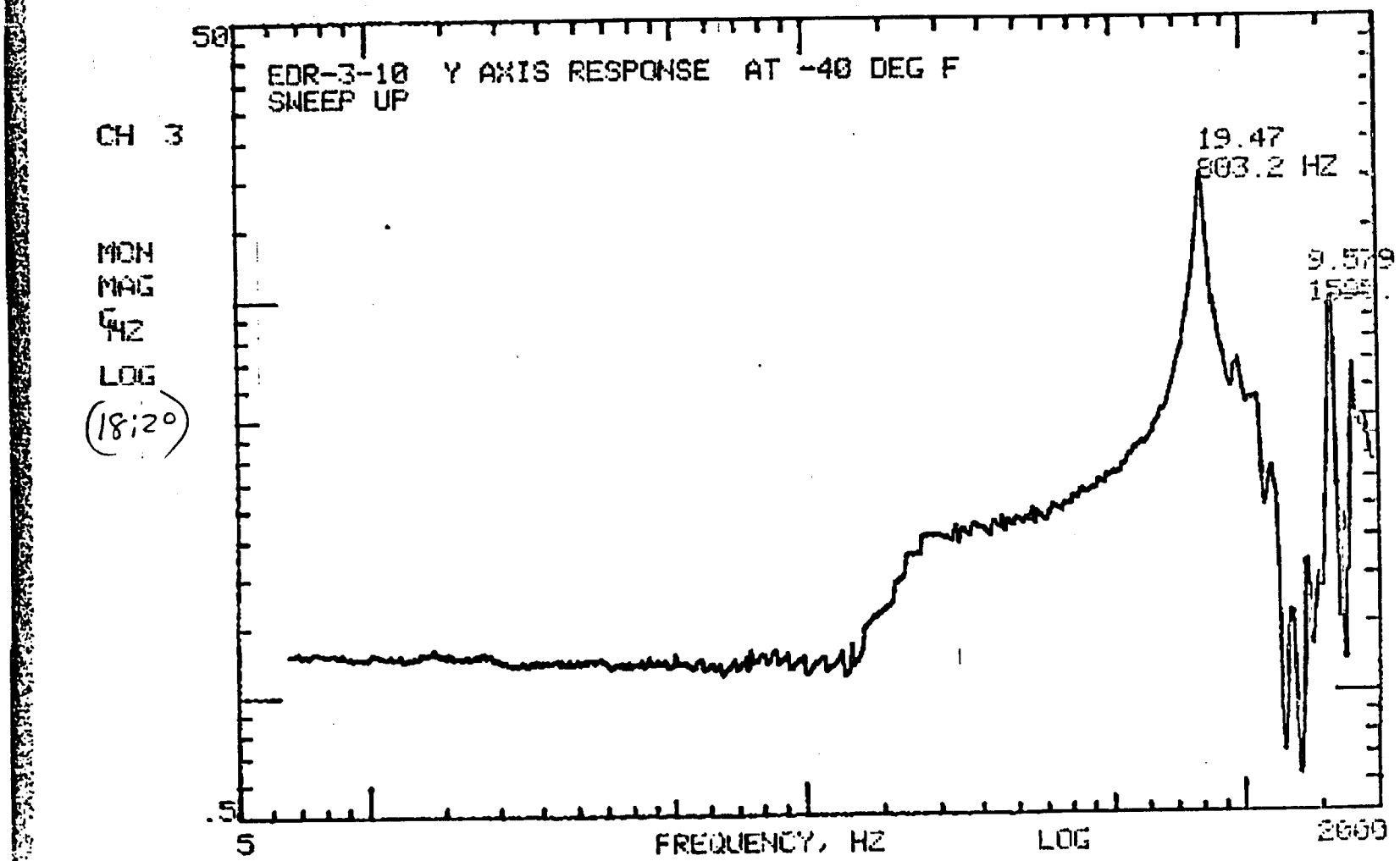
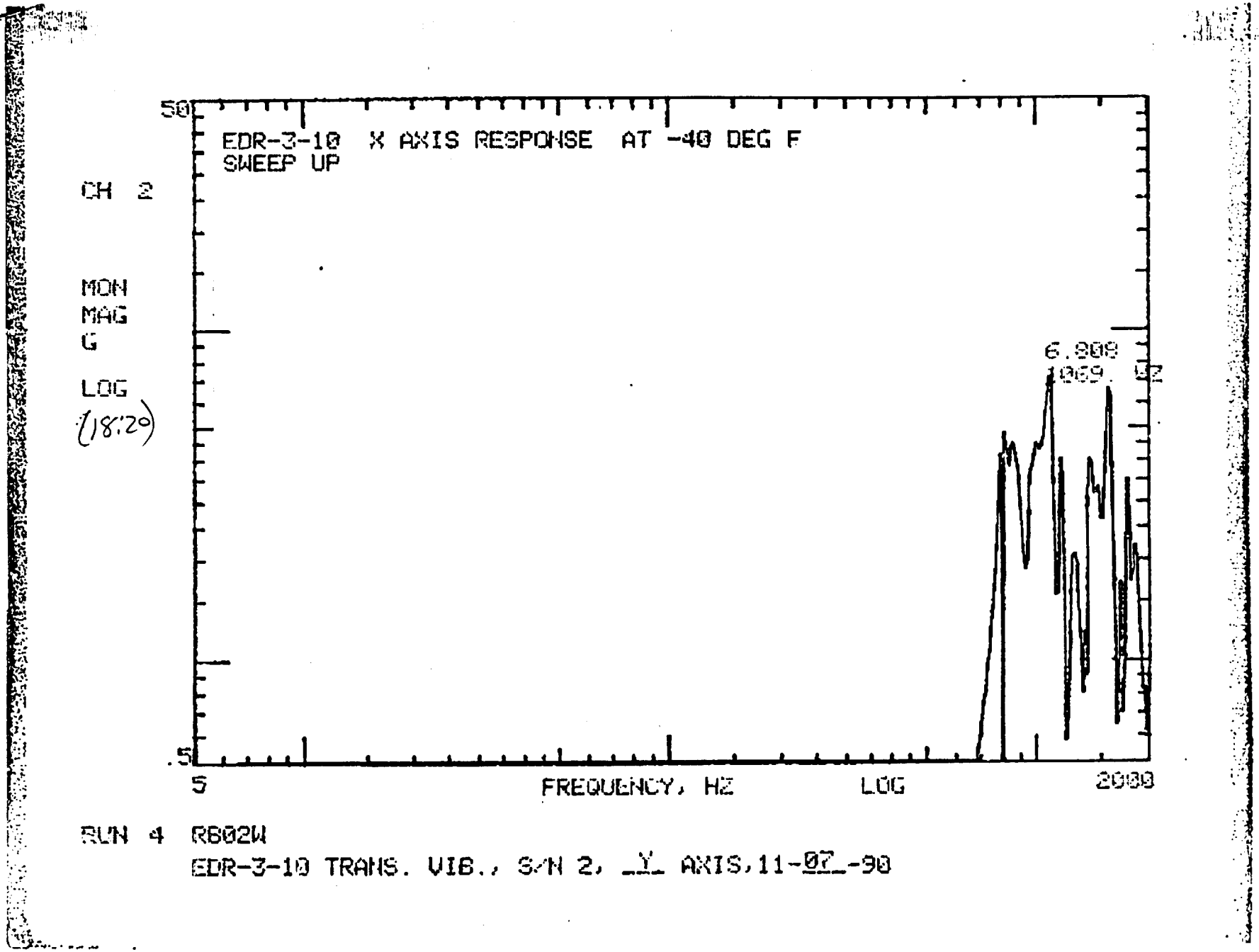


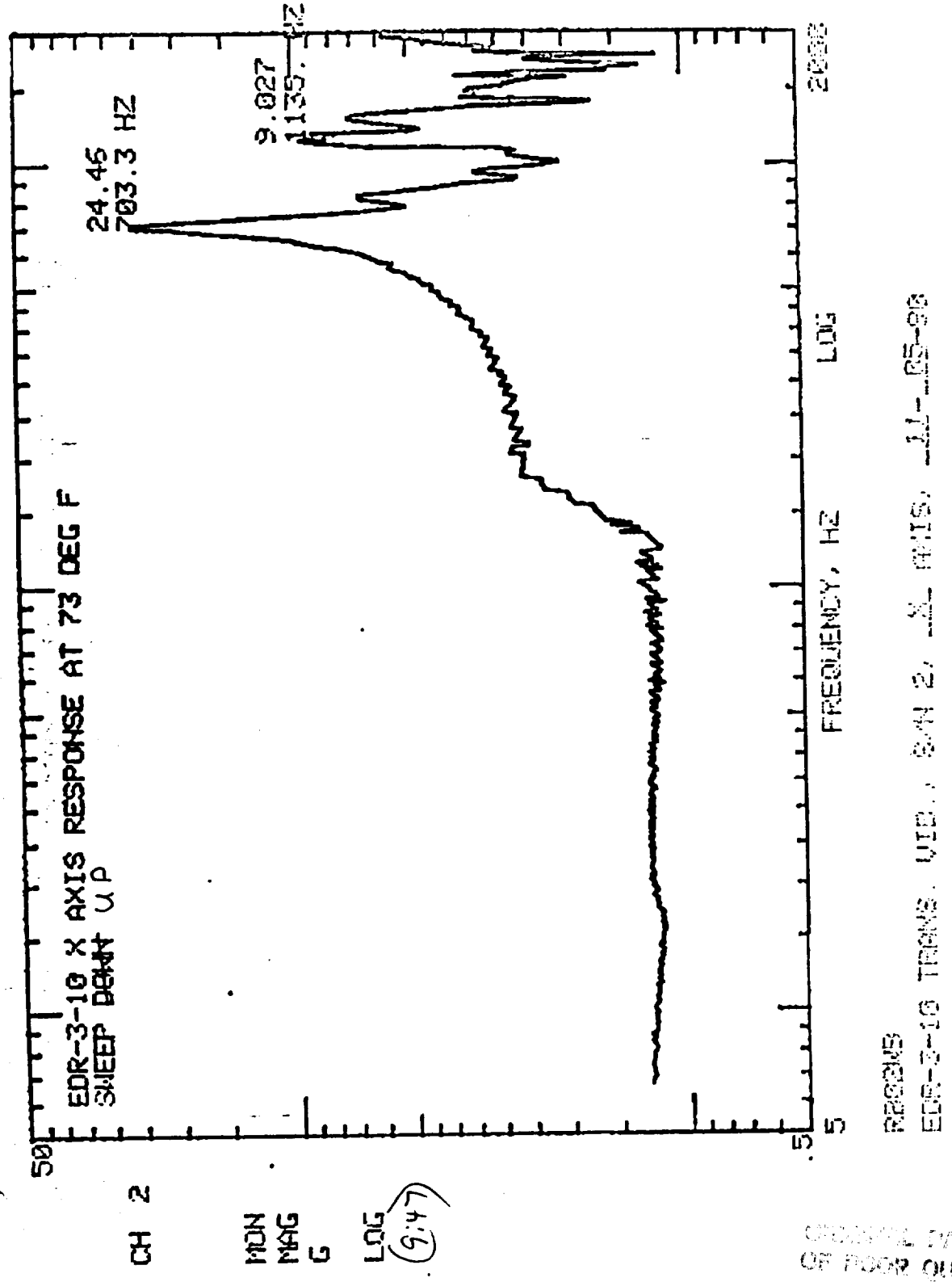
RUN 4 RB02W

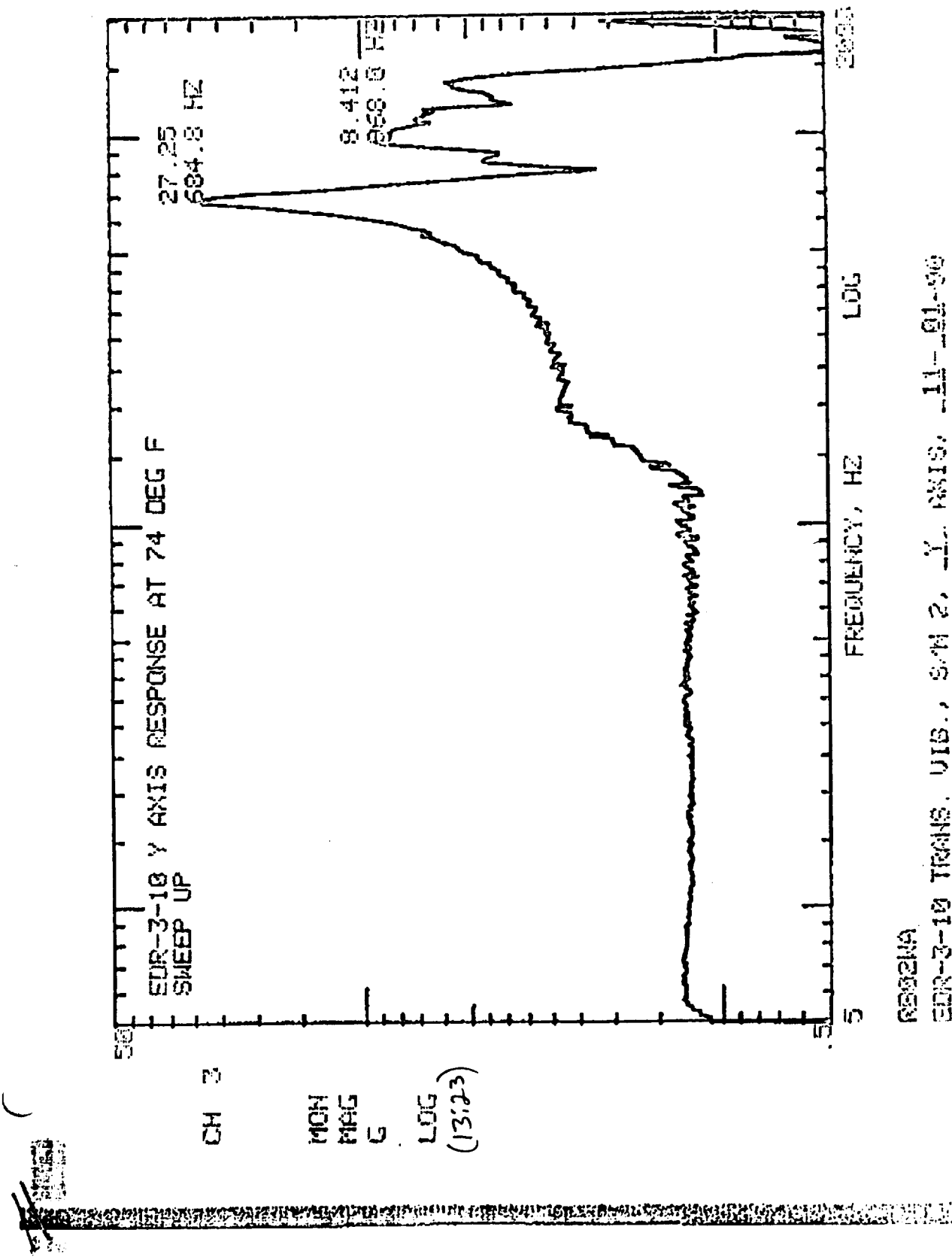
EDR-3-10 TRANS. VIB., S/N 2, Y AXIS, 11-07-90

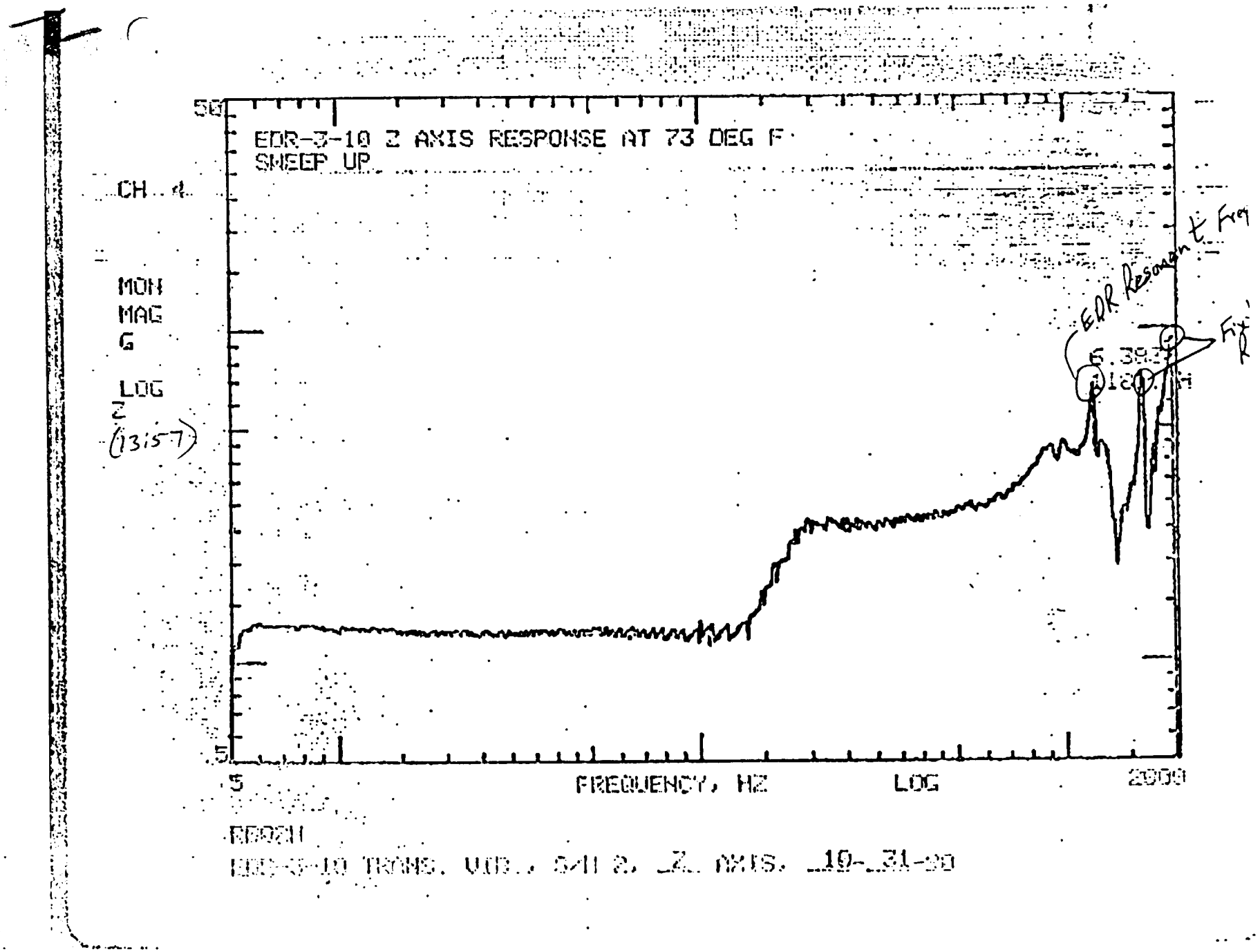


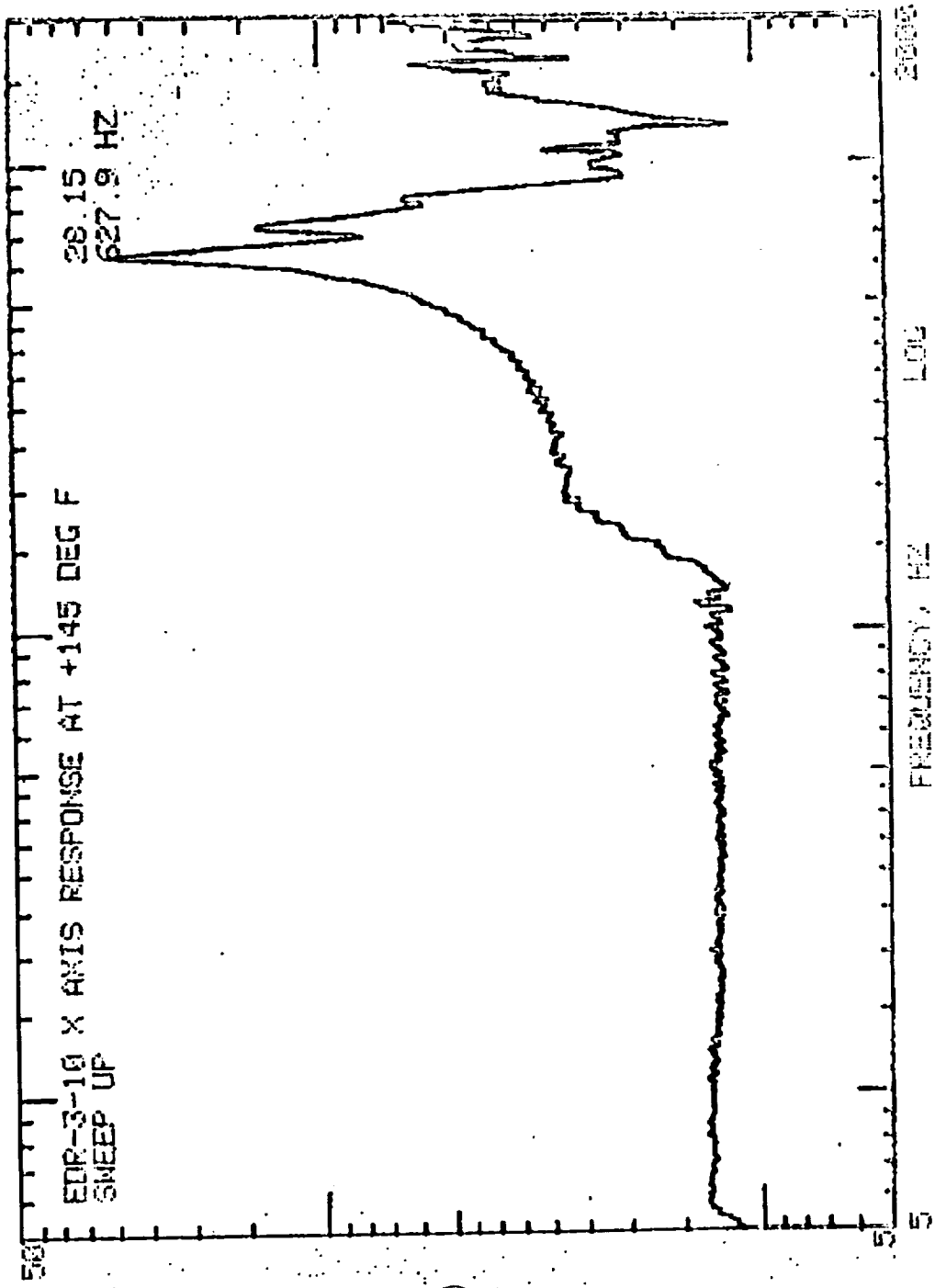
RUN 4 RB02W

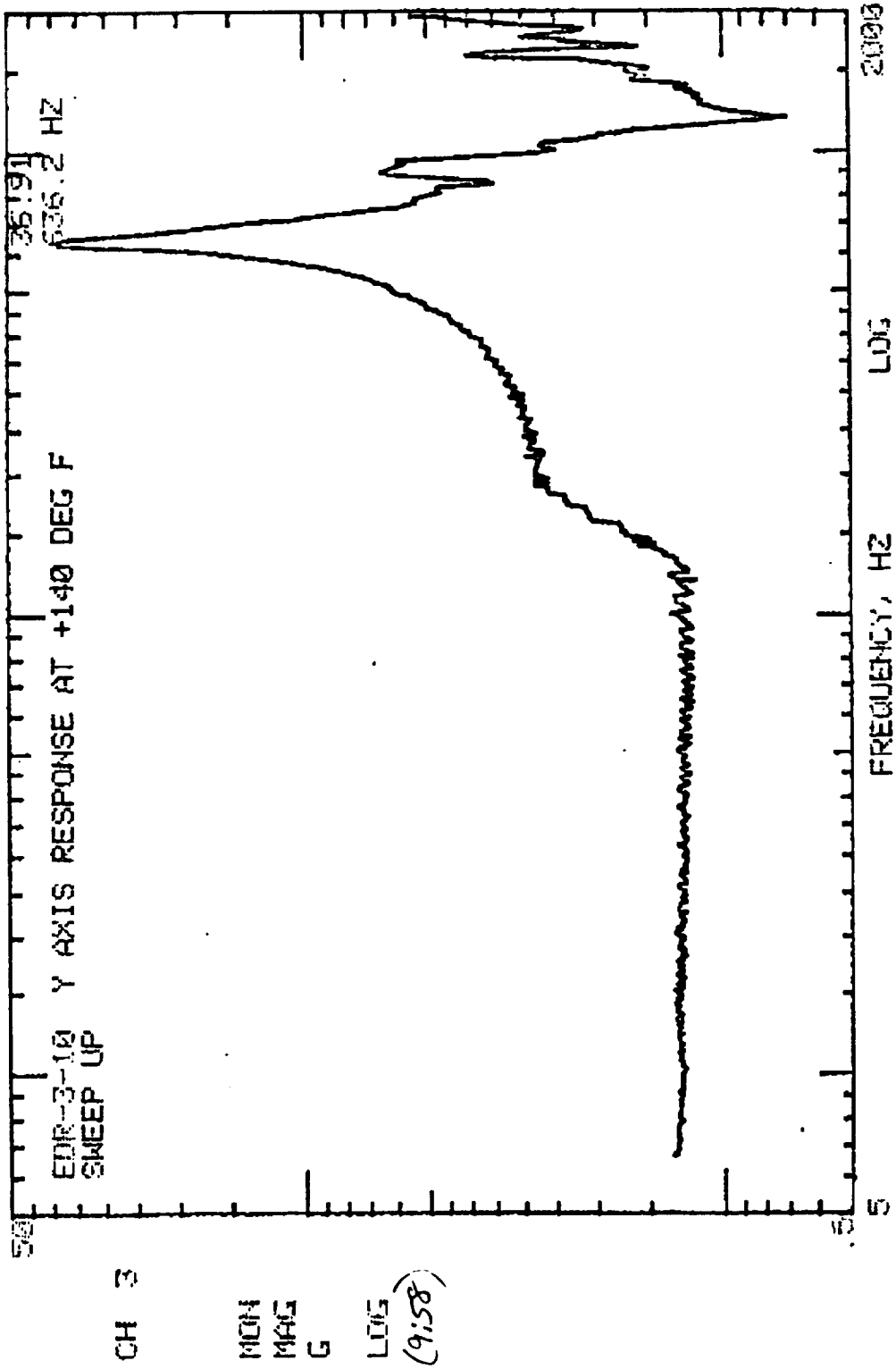
EDR-3-10 TRANS. VIB., S/N 2, _Y_ AXIS, 11-07-90

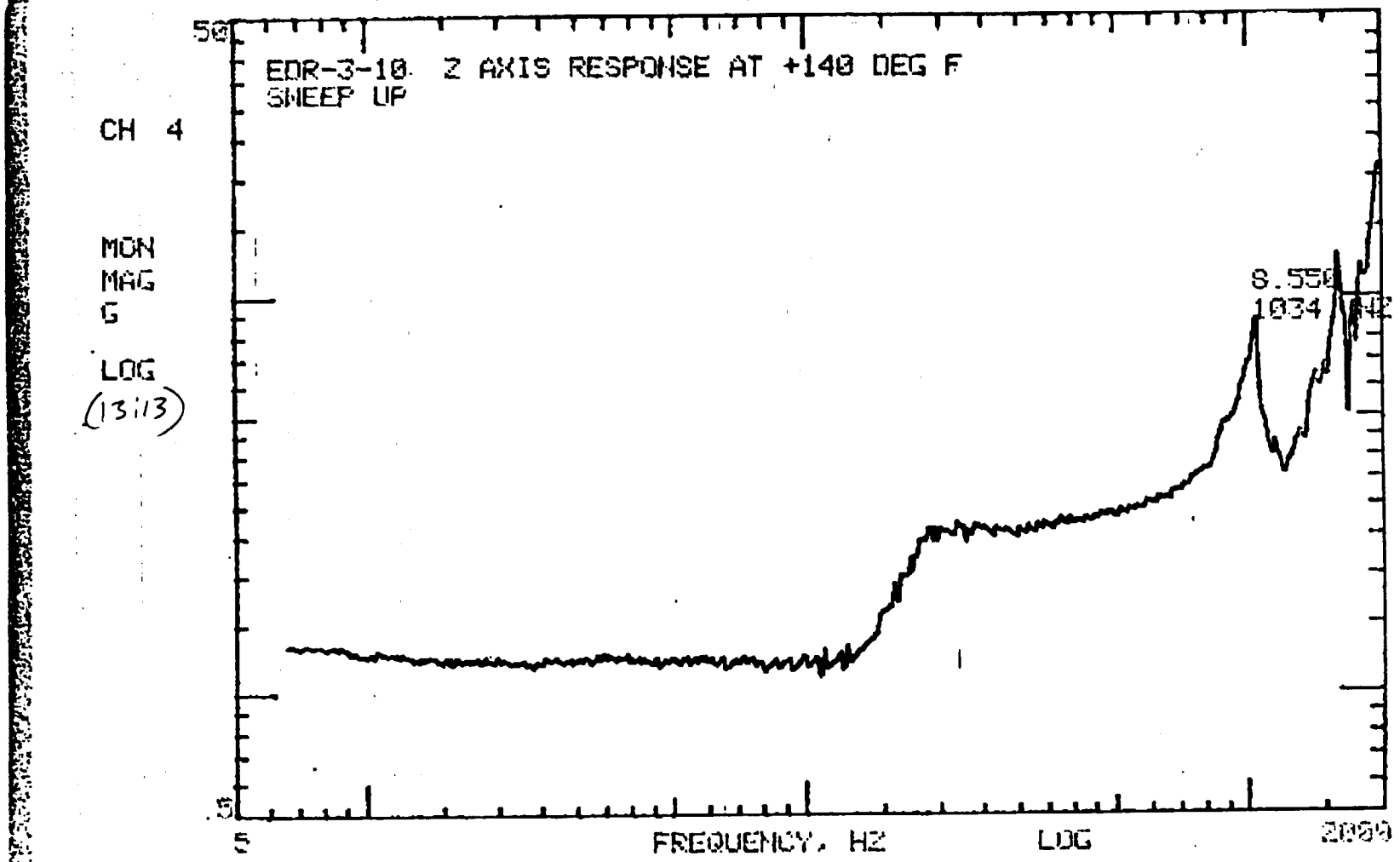



EDR-3-10 Y AXIS RESPONSE AT 74 DEG F
SWEEP UP
27.25
684.8 HZ
8.412
659.9 HZ
CH 2
MON MAG G
LOG (13,23)
FREQUENCY, HZ
LOG
EDR-3-10 TRANS. VIB., SCH 2, Y AXIS, 11-01-90



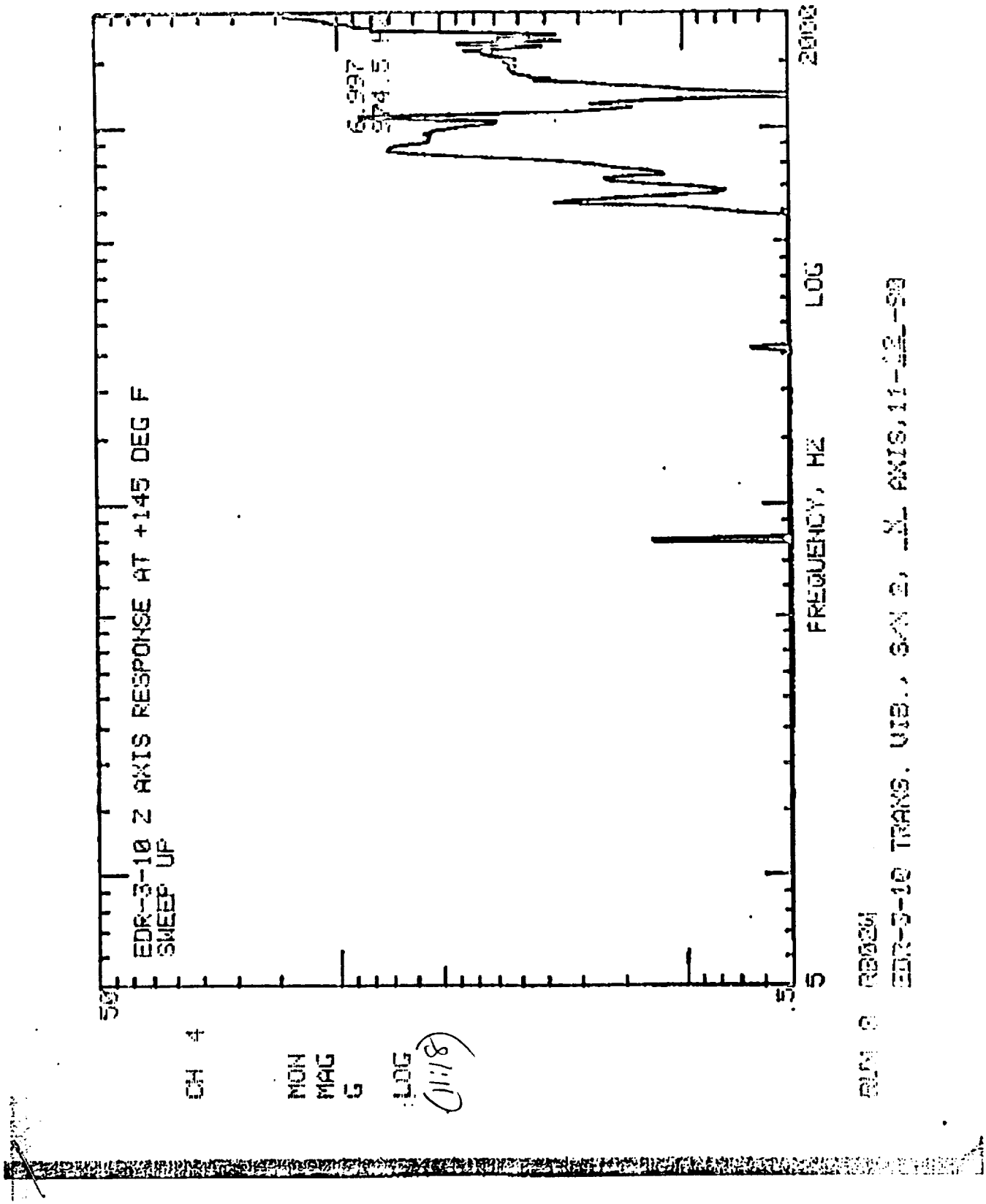






RUN 7 R303W

EDR-3-10 TRANS. VIB., S/N 2, Z AXIS, 11-09-90



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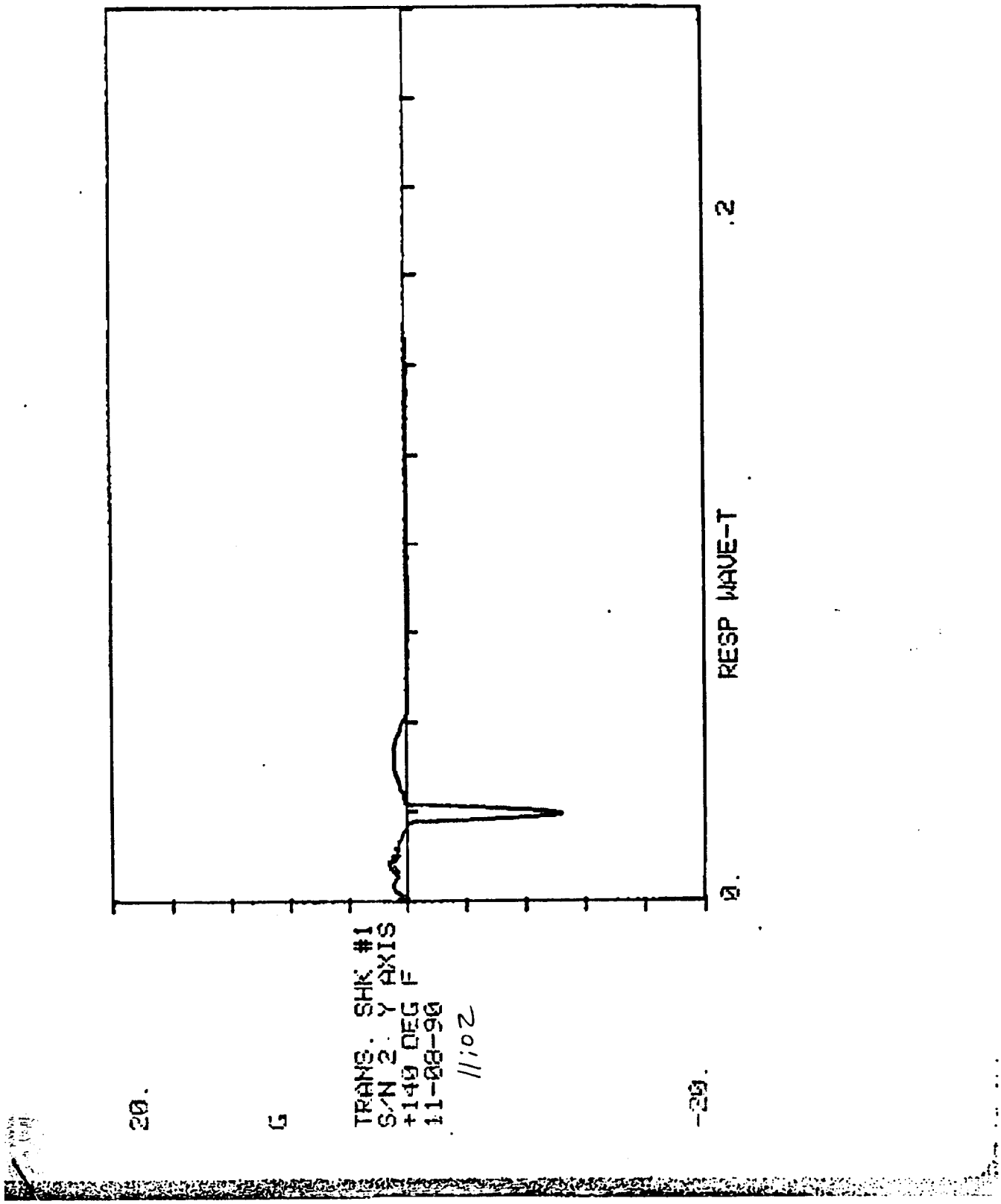

TRANS. SHK #1
S/N 2 Y AXIS
+149 DEG F
11-08-90
11:02
G
20.
-20.
0.
.2
RESP WAVE-T

Appendix B

Functional Test
Calibrated Sine Dwell and Shock Test Data

Appendix B

Functional Test
Calibrated Sine Dwell and Shock Test Data

This appendix contains sample data from the EDR functional test conducted per CTP-0223A paragraph 8.2.1.2. All data collected demonstrated full compliance to the test objectives.

Page	Description
B-4 to B-6	Functional Summary Test results. All percent error calculations indicate full compliance to test objectives.
B-7	Functional 0.5g shock pulse sample. This sample represents the 0.5g low frequency shocks use to demonstrate that a shock below the trigger level would not cause the EDR to record a triggered event.
B-8 to B-16	3g sine dwell test data. The 3g input is above the EDR trigger level (0.7g) and caused several continuous triggered events. The top portion is a condensed plot of five continuous recorded triggered 3.5-second events. The middle portion an expanded plot of one of the triggered events plotted above it. The bottom portion is the T-53 test facility printout of the sinusoidal input.
B-8	X-axis at -35 +/- 5 Degree F plot.
B-9	X-axis at 70 +/- 5 Degree F plot.
B-10	X-axis at 145 +/- 5 Degree F plot.
B-11	Y-axis at -35 +/- 5 Degree F plot.
B-12	Y-axis at 70 +/- 5 Degree F plot.
B-13	Y-axis at 145 +/- 5 Degree F plot.
B-14	Z-axis at -35 +/- 5 Degree F plot.
B-15	Z-axis at 70 +/- 5 Degree F plot.
B-16	Z-axis at 145 +/- 5 Degree F plot.
B-17 to B-34	2g calibrated shock test data samples. The 2g input is above the EDR trigger level (0.7) and caused a single triggered event for each 2g shock. There are two pages of data for each triggered event shock. The first page top plot is a graph of all three axis together during the triggered event. The first page bottom plot is an expanded single axis graph of the input signal which caused the trigger event. The second page top plot shows the expanded single axis with a marker indicating the exact peak g-level. The second page plot shows the T-53 test facility input shock graph.
B-17, 18	X-axis at -35 +/- 5 Degree F.
B-19, 20	X-axis at 70 +/- 5 Degree F.
B-21, 22	X-axis at 145 +/- 5 Degree F.

B-23, 24 Y-axis at -35 +/- 5 Degree F.
B-25, 26 Y-axis at 70 +/- 5 Degree F.
B-27, 28 Y-axis at 145 +/- 5 Degree F.
B-29, 30 Z-axis at -35 +/- 5 Degree F.
B-31, 32 Z-axis at 70 +/- 5 Degree F.
B-33, 34 Z-axis at 145 +/- 5 Degree F.

B-35 High frequency 20g shock sample. This sample represents the 20g high frequency shocks use to demonstrate the EDR's low-pass filter.

B-36 Typical EDR low-pass filter characteristics plot.

X-Axis Functional Test Results

		EDR	T-53	% Error
-35 Degree F Test				
	0.5g Sine Dwell (stage 1)	No triggered events		
*	3g Sine Dwell (stage 2)	3.02	2.96	2.0%
	0.5g Shock (stage 3)	No triggered events		
	2g Shock (stage 4)	2.66	2.62	1.5%
		2.26	2.28	-0.9%
		1.62	1.68	-3.6%
*		2.20	2.33	-5.6%
		2.18	2.33	-6.4%
	20g High Freq. Shock (stage 5)	No triggered events		
70 Degree F Test				
	0.5g Sine Dwell (stage 1)	No triggered events		
*	3g Sine Dwell (stage 2)	3.10	2.99	3.7%
	0.5g Shock (stage 3)	No triggered events		
*	2g Shock (stage 4)	2.08	2.10	-1.0%
		2.12	2.11	0.5%
		2.06	2.11	-2.4%
	20g High Freq. Shock (stage 5)	No triggered events		
145 Degree F Test				
	0.5g Sine Dwell (stage 1)	No triggered events		
*	3g Sine Dwell (stage 2)	3.04	2.95	3.1%
	0.5g Shock (stage 3)	No triggered events		
	2g Shock (stage 4)	2.26	2.18	3.7%
*		2.26	2.18	3.7%
		2.26	2.22	1.8%
	20g High Freq. Shock (stage 5)	No triggered events		

* Time vs acceleration plots available for review in this appendix pages B-8 to B-10 and B-17 to B-22.

Y-Axis Functional Test Results

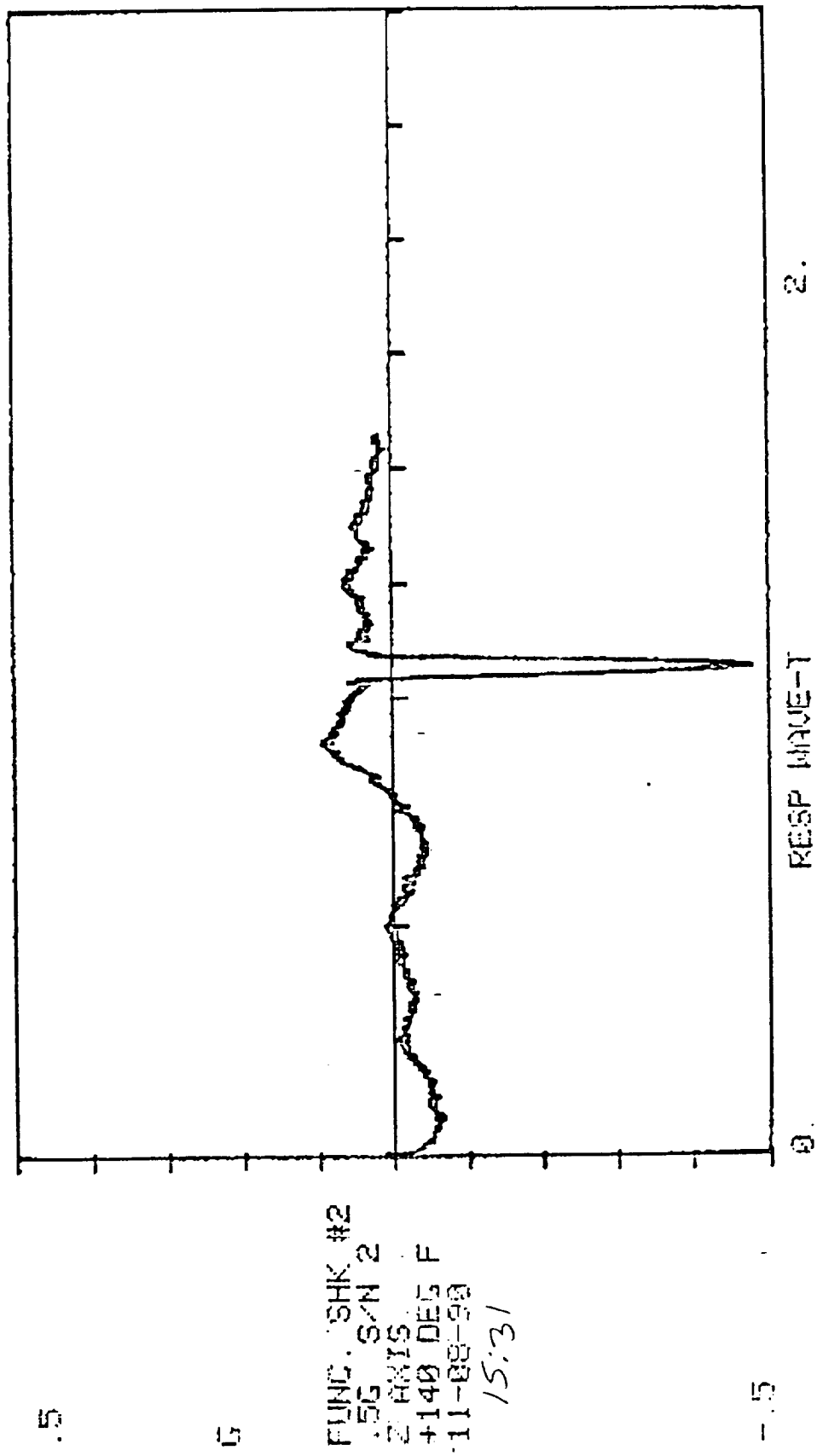
	EDR	T-53	% Error
-35 Degree F Test			
0.5g Sine Dwell (stage 1)	No triggered events		
* 3g Sine Dwell (stage 2)	2.9	2.85	1.8%
0.5g Shock (stage 3)	No triggered events		
2g Shock (stage 4)	1.98	2.08	-4.8%
*	2.04	2.08	-1.9%
	2.04	2.08	-1.9%
20g High Freq. Shock (stage 5)	No triggered events		
70 Degree F Test			
0.5g Sine Dwell (stage 1)	No triggered events		
* 3g Sine Dwell (stage 2)	2.92	2.98	-2.0%
0.5g Shock (stage 3)	No triggered events		
* 2g Shock (stage 4)	2.04	2.08	-1.9%
	2.08	2.10	-1.0%
	2.16	2.26	-4.4%
20g High Freq. Shock (stage 5)	No triggered events		
145 Degree F Test			
0.5g Sine Dwell (stage 1)	No triggered events		
* 3g Sine Dwell (stage 2)	3.00	2.95	1.7%
0.5g Shock (stage 3)	No triggered events		
2g Shock (stage 4)	2.54	2.51	1.2%
*	2.56	2.55	0.4%
	2.56	2.55	0.4%
20g High Freq. Shock (stage 5)	No triggered events		

* Time vs acceleration plots available for review in this appendix pages B-11 to B-13 and B-23 to B-28.

Z-Axis Functional Test Results

		EDR	T-53	% Error
-35 Degree F Test				
	0.5g Sine Dwell (stage 1)	No triggered events		
*	3g Sine Dwell (stage 2)	3.06	2.92	4.8%
	0.5g Shock (stage 3)	No triggered events		
*	2g Shock (stage 4)	1.58	1.70	-7.1%
		1.60	1.70	-5.9%
		1.56	1.70	-8.2%
	20g High Freq. Shock (stage 5)	No triggered events		
70 Degree F Test				
	0.5g Sine Dwell (stage 1)	No triggered events		
	3g Sine Dwell (stage 2)	2.80	2.77	1.1%
*		2.96	2.93	1.0%
	0.5g Shock (stage 3)	No triggered events		
	2g Shock (stage 4)	2.06	2.1	-1.9%
*		2.28	2.3	-0.9%
		2.28	2.3	-0.9%
	20g High Freq. Shock (stage 5)	No triggered events		
145 Degree F Test				
	0.5g Sine Dwell (stage 1)	No triggered events		
*	3g Sine Dwell (stage 2)	3.02	2.99	1.0%
	0.5g Shock (stage 3)	No triggered events		
	2g Shock (stage 4)	2.06	2.08	-1.0%
*		2.06	2.08	-1.0%
		2.06	2.06	0.0%
20g High Freq. Shock (stage 5)		No triggered events		

* Time vs acceleration plots available for review in this appendix pages B-14 to B-16 and B-29 to B-34.



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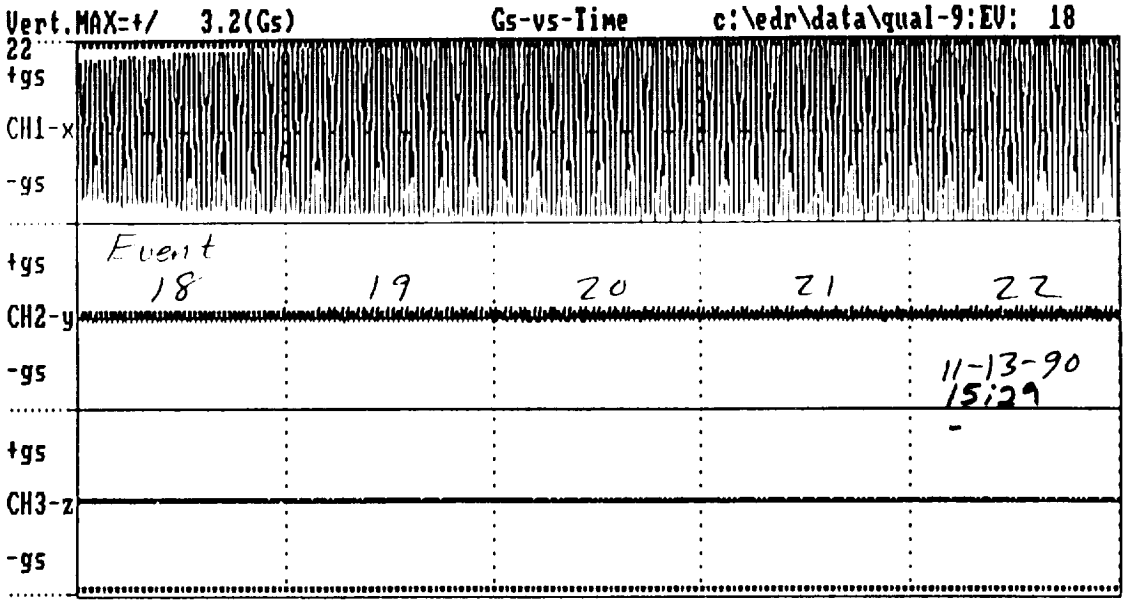
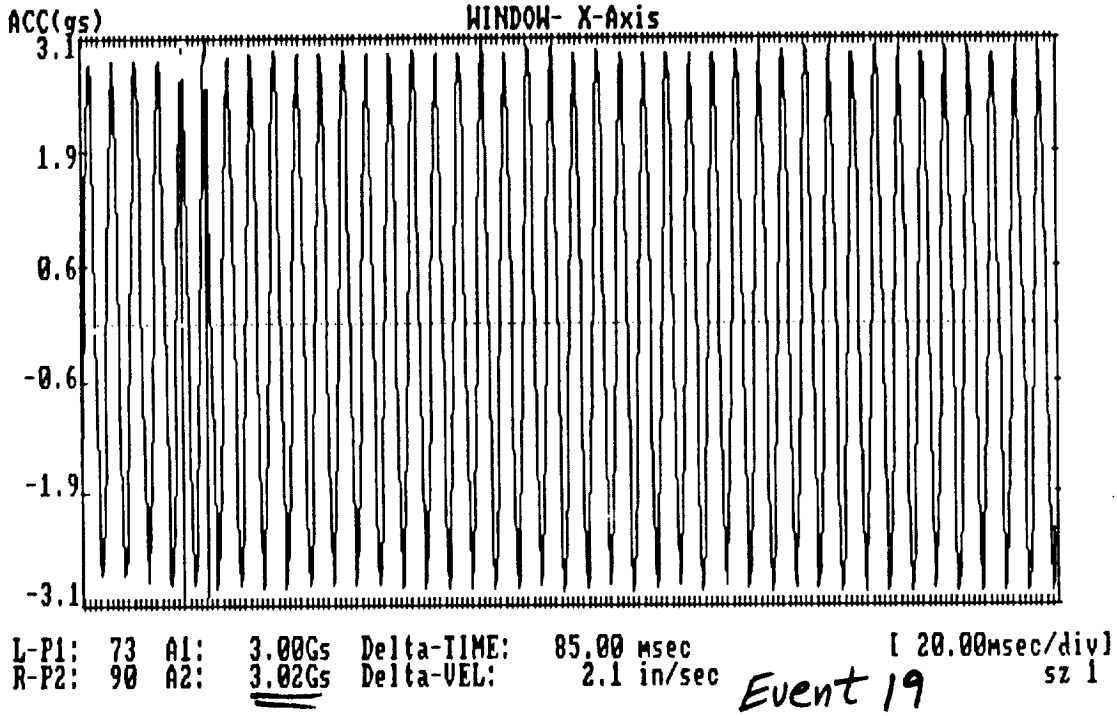


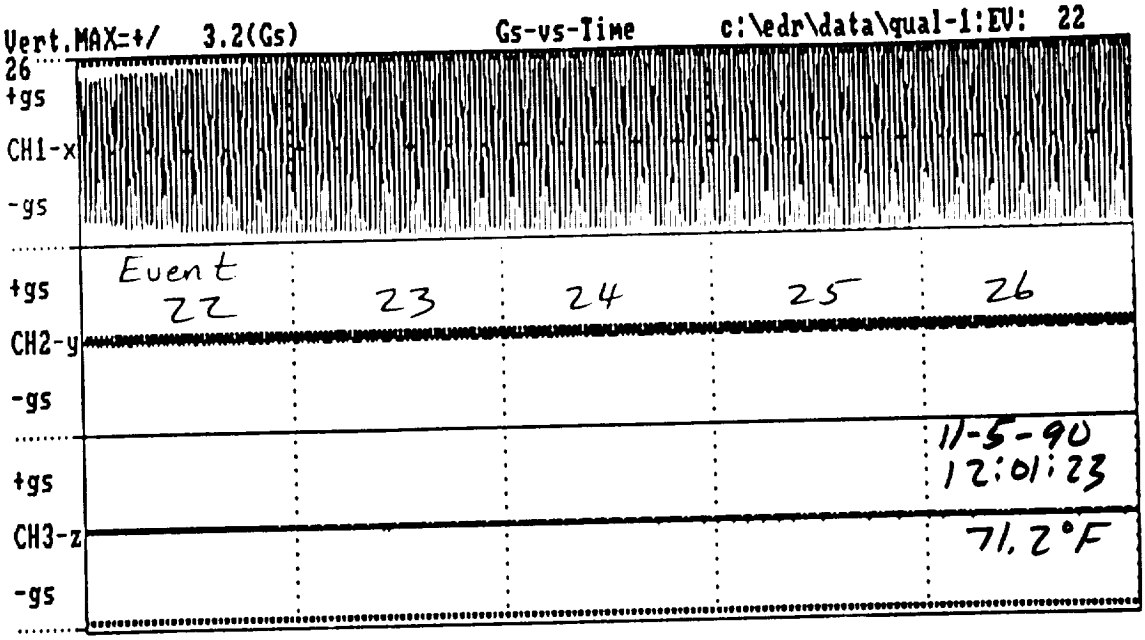


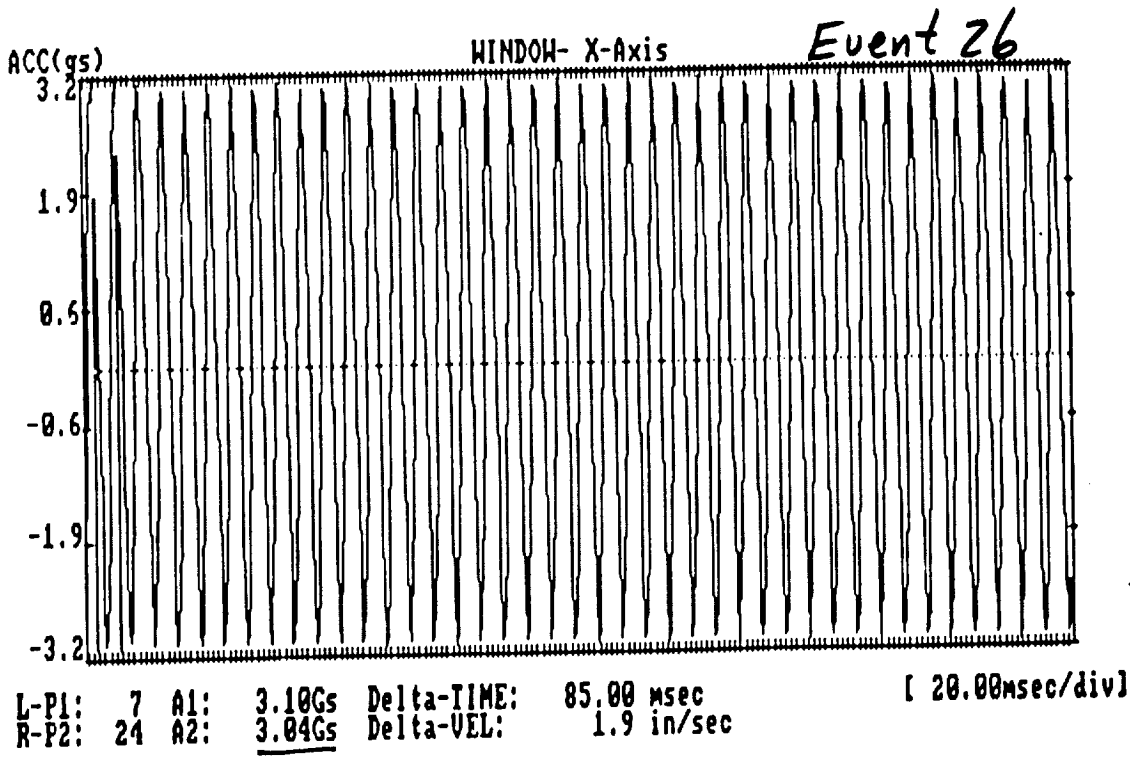
EDR-3-10 FUNCTIONAL TEST, X AXIS, S/N 2, -35 DEG F, 11-13-90
15:29

3G 12HZ

T-53 input signal

RB02WG
12.00 HZ, 2.963 G ---------- CONTROL



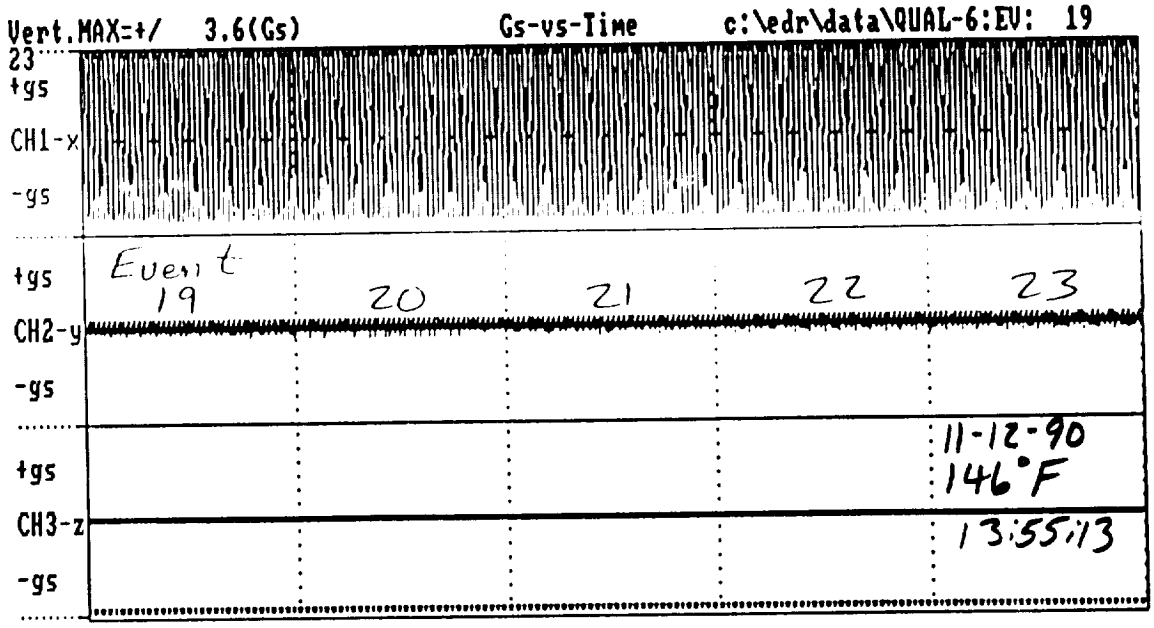


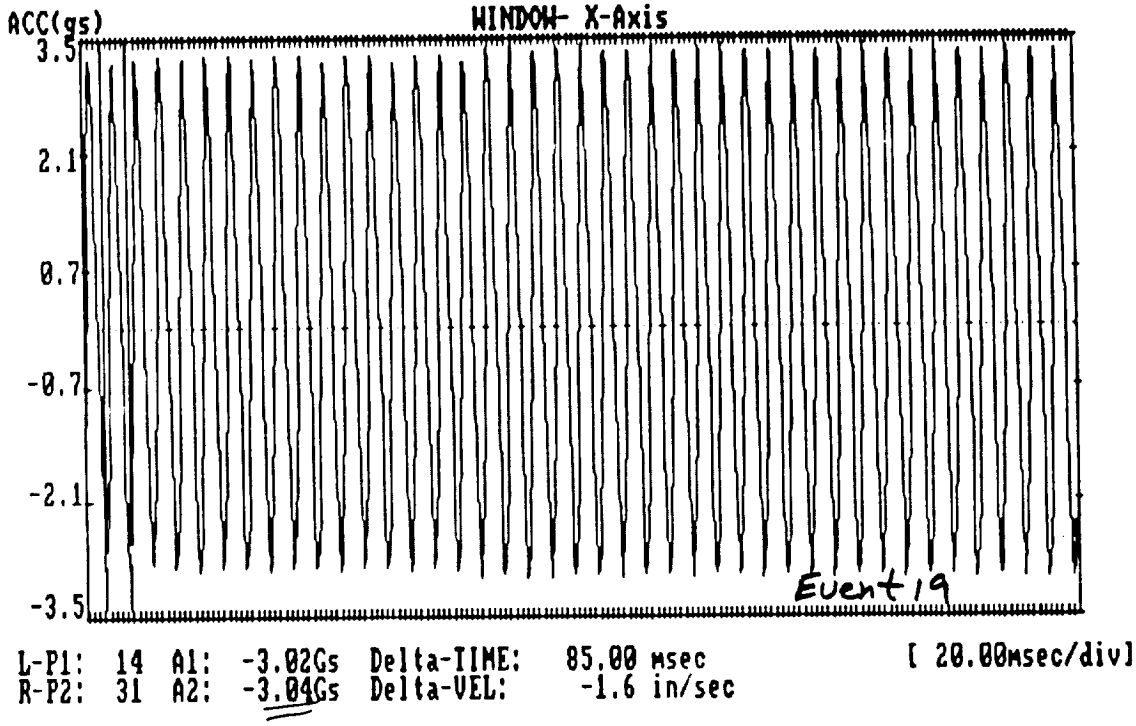
FUNTIONAL TEST, EDR-3-10 S/N 2, X AXIS, 11-05-90 1st
71 DEG F 12:01

T-53

12 HZ AT 3 G

RESING
12.00 HZ, 2.990 G



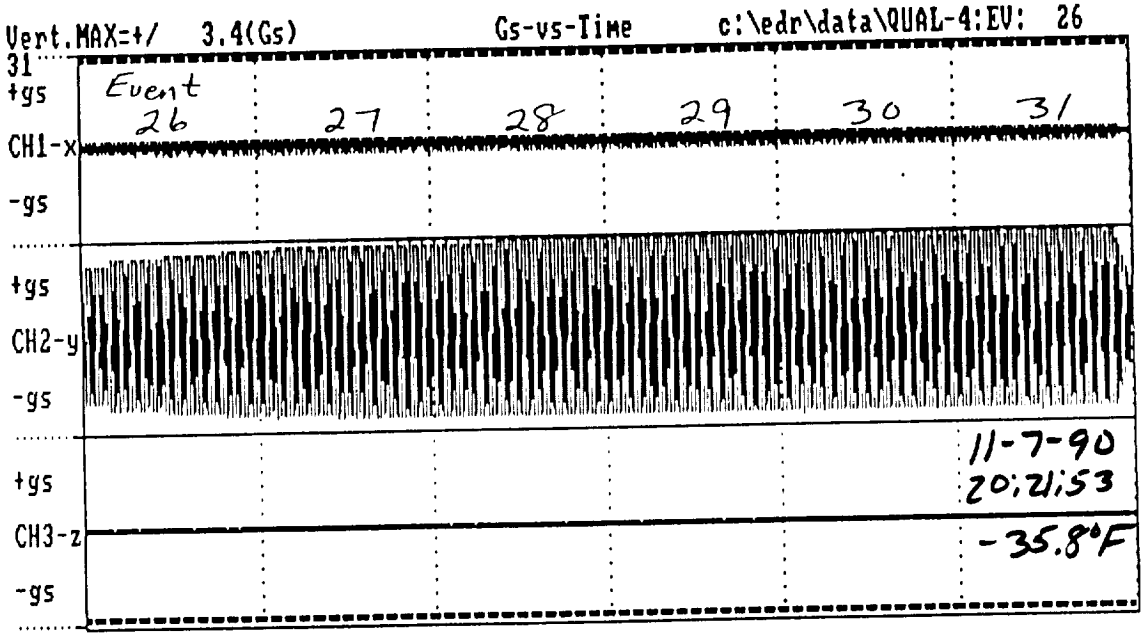


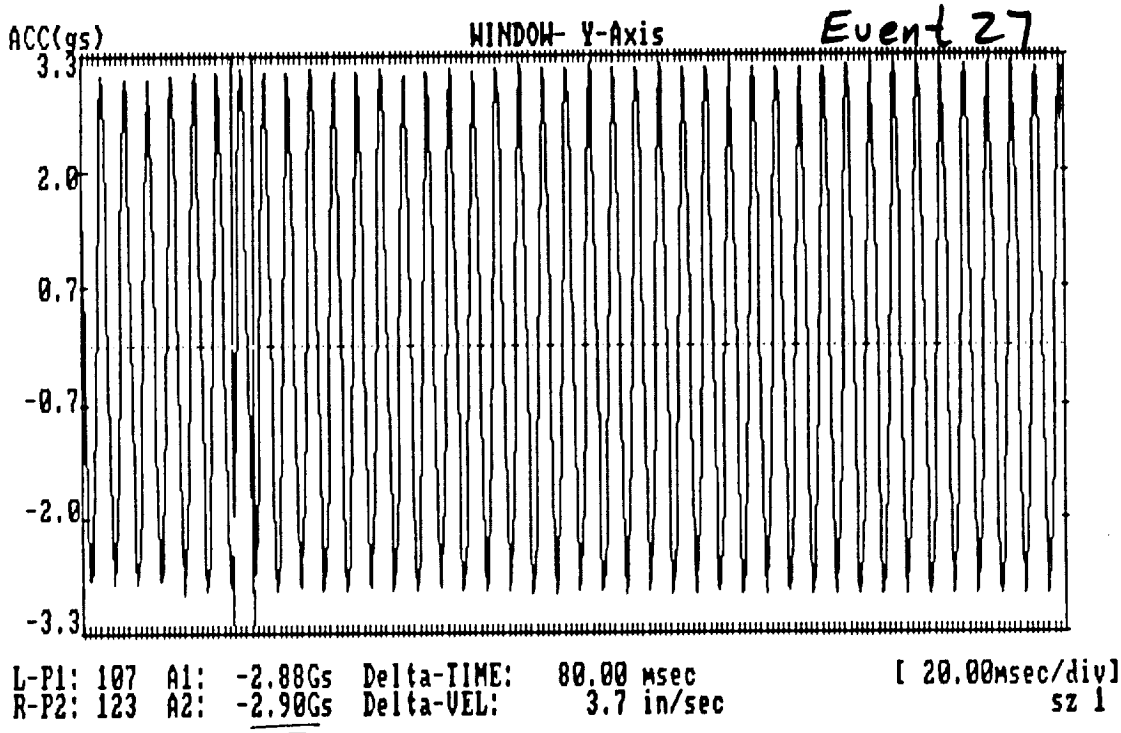
EDR-2-10 FUNCTIONAL TEST, S/N 2, X AXIS, +145 DEG F, 11-12-90
12HZ AT 3G

13:55

T-53

RS02WG
12.00 HZ, 2.948 G ---------- CONTROL



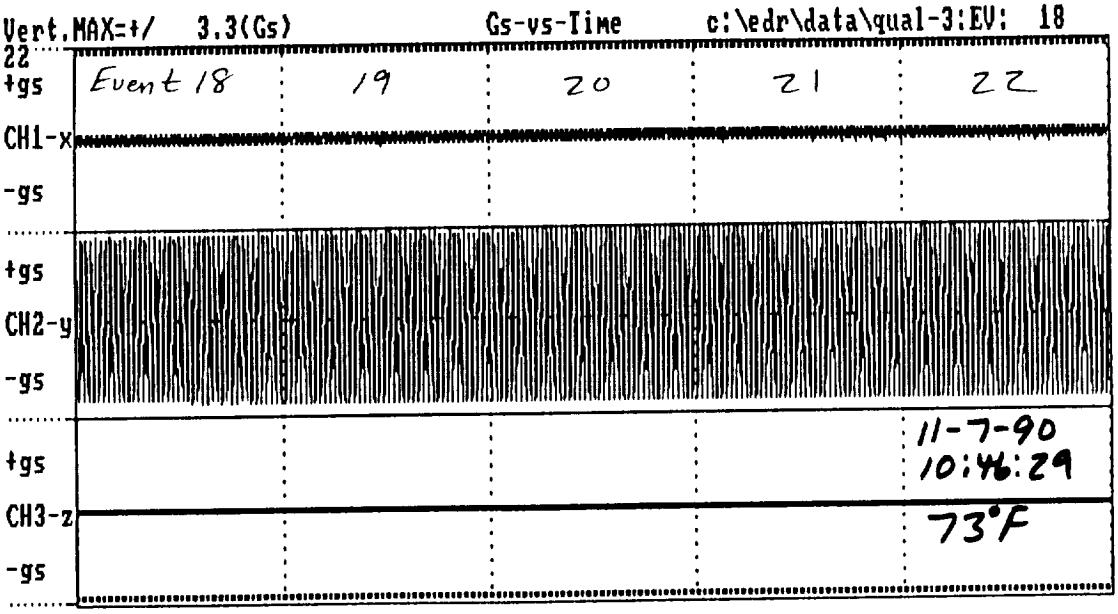


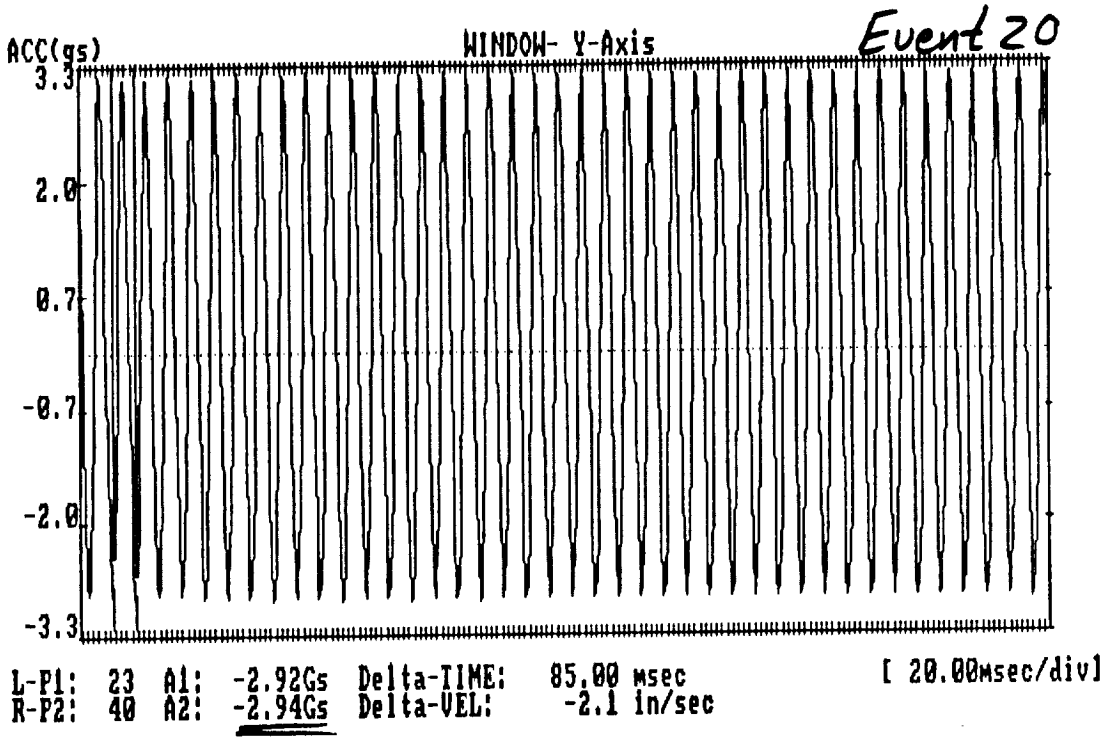
EDR-3-10 FUNCTIONAL TEST, Y AXIS, S/N 2, -40 DEG F, 11-07-90

20:21
20:22

3G AT 12HZ T-53

RB02WG
12.00 HZ, 2.856 G ———————————— CONTROL

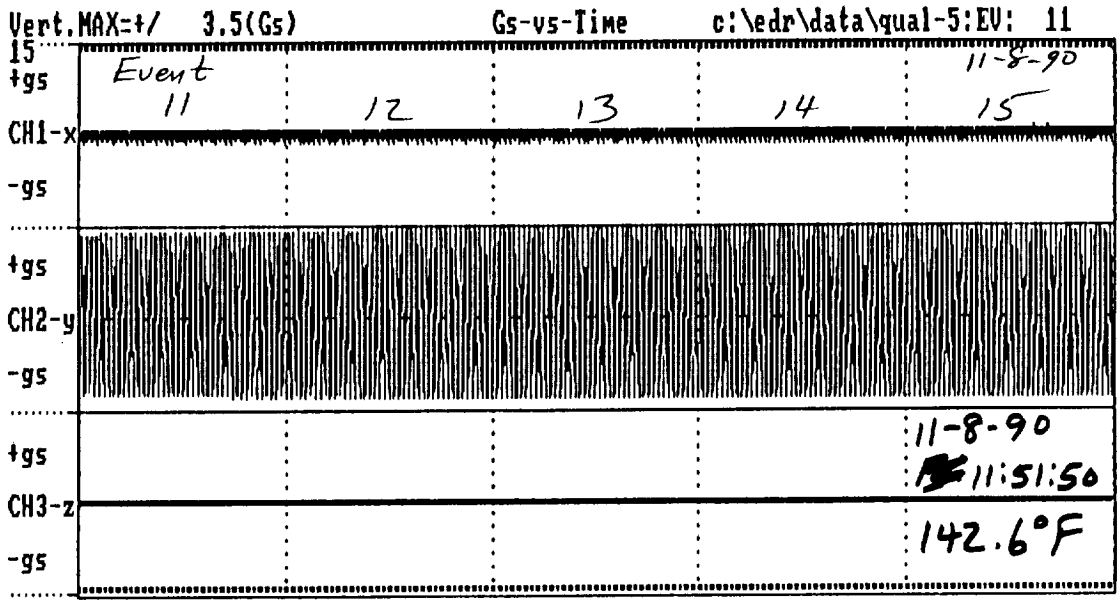


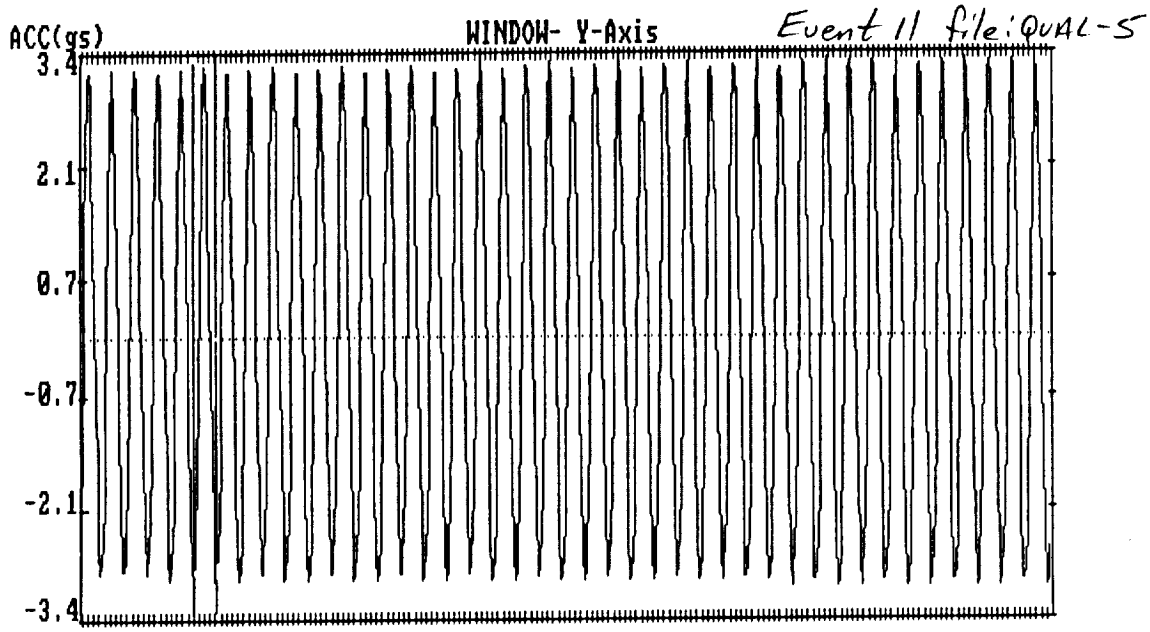


EDR-3-10 FUNTIONAL TEST, 3G AT 12 HZ. Y AXIS, S/N 2, 11-07-90
70 DEG F

T-53

RB02WG
12.00 HZ, 2.981 G



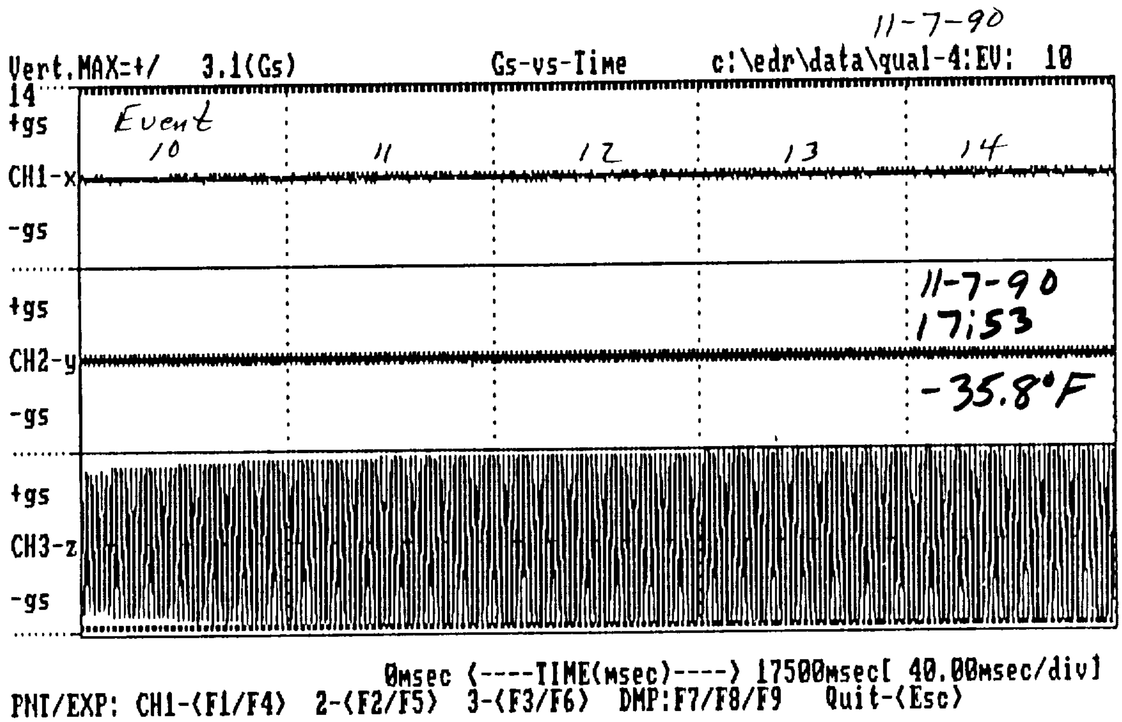


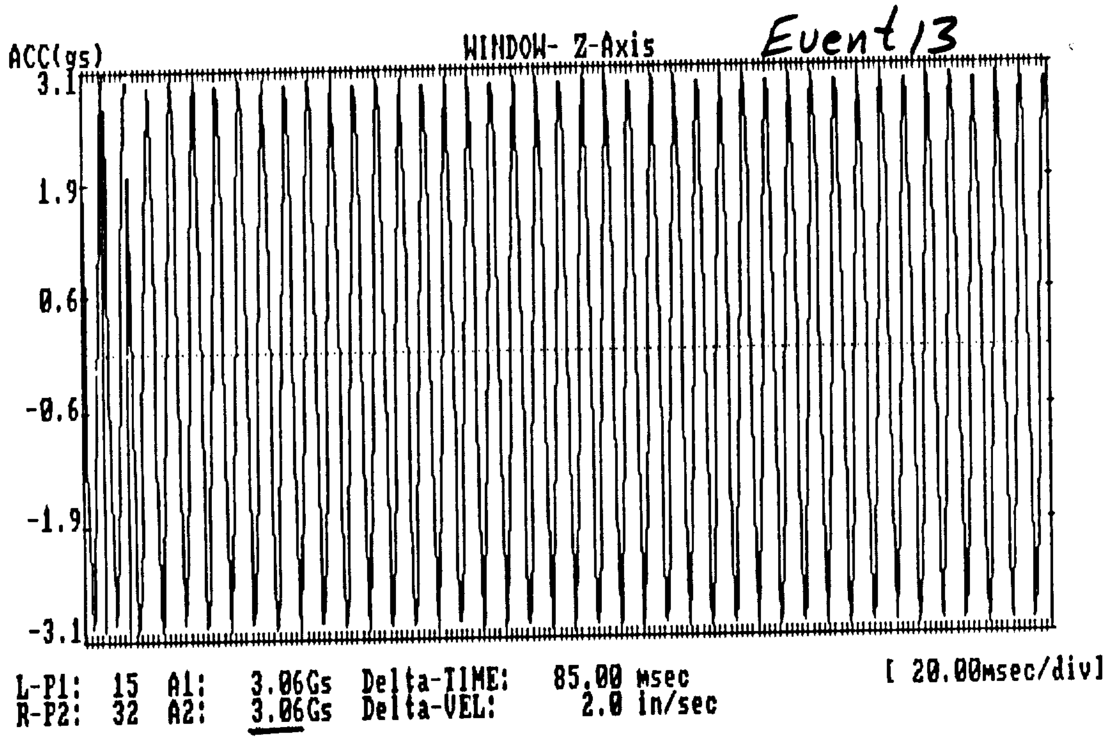
EDR-3-10 FUNCTONAL TEST, S/N 2, Y AXIS, +140 DEG F, 11-08-90
12HZ AT 3G

11:51

T-53

RB02WG
12.00 HZ, 2.954 G ---------- CONTROL





EDR-3-10 FUNCTIONAL TEST, 3G AT 12 HZ, S/N 2, Z AXIS, 11-07-90
-40 DEG F
17:53

T-53

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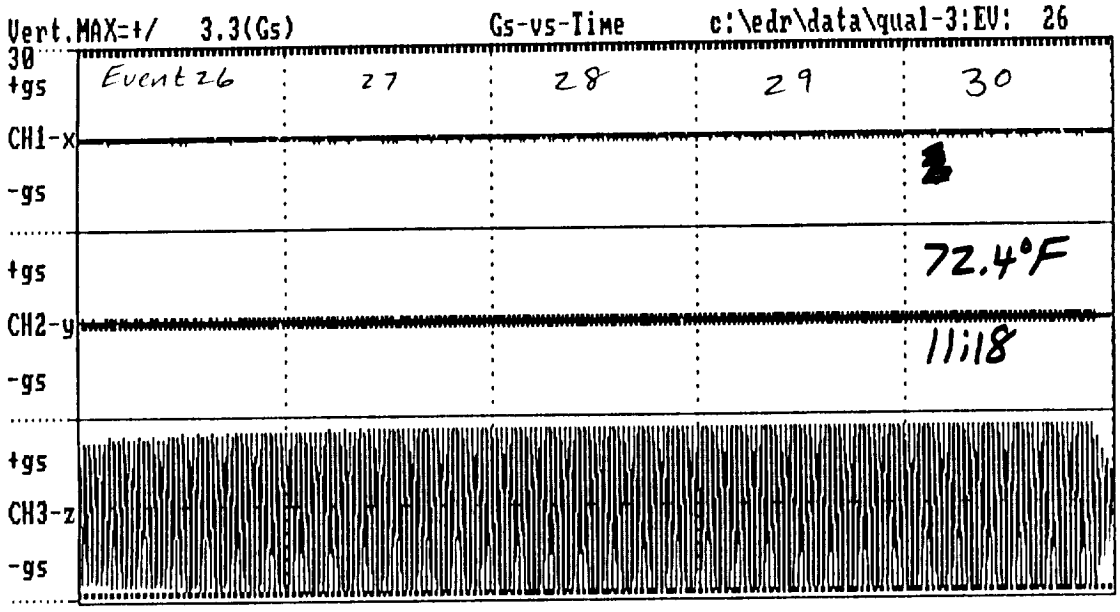
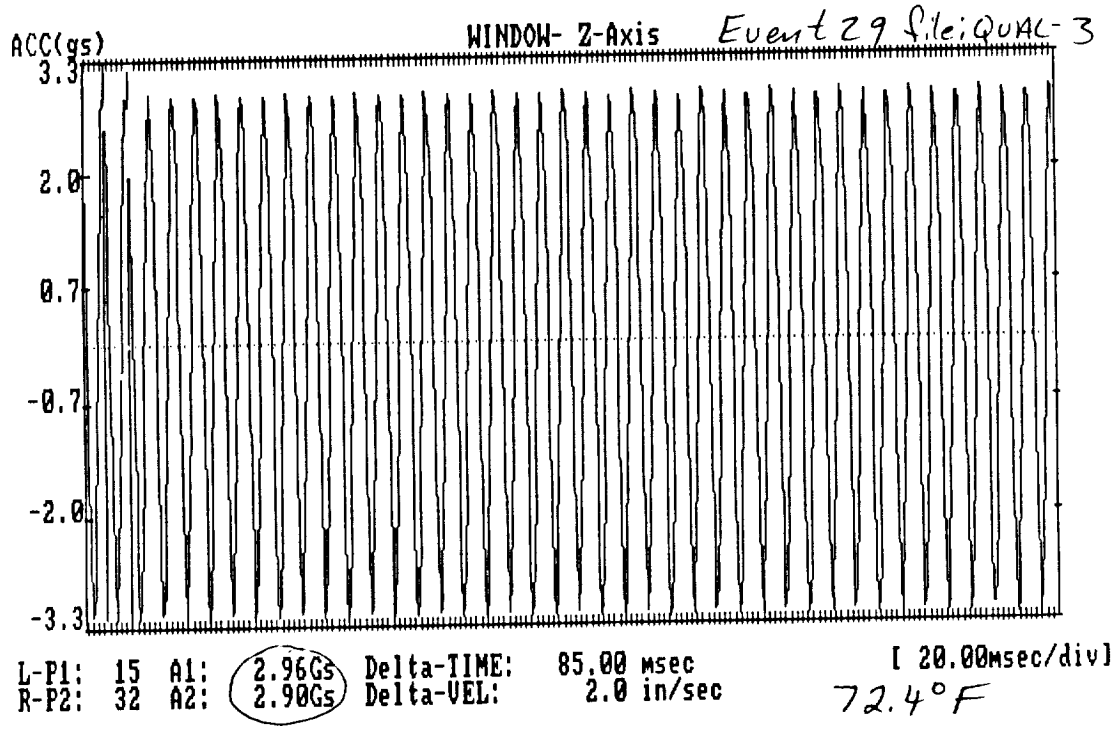
RB02WG
12.00 HZ, 2.923 G ------------------- CONTROL

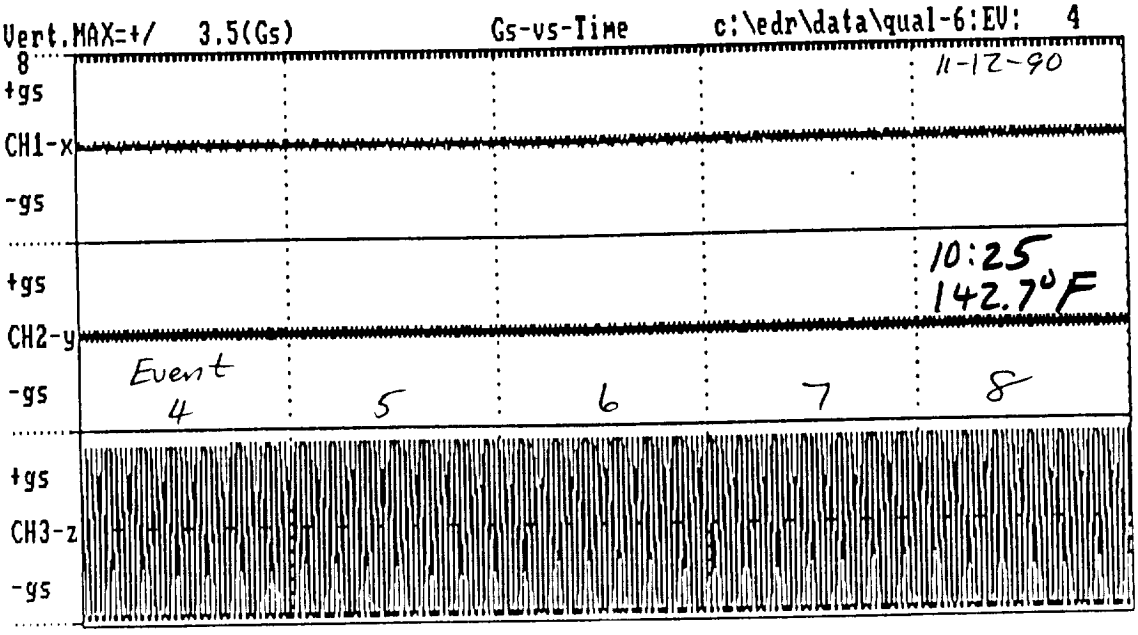


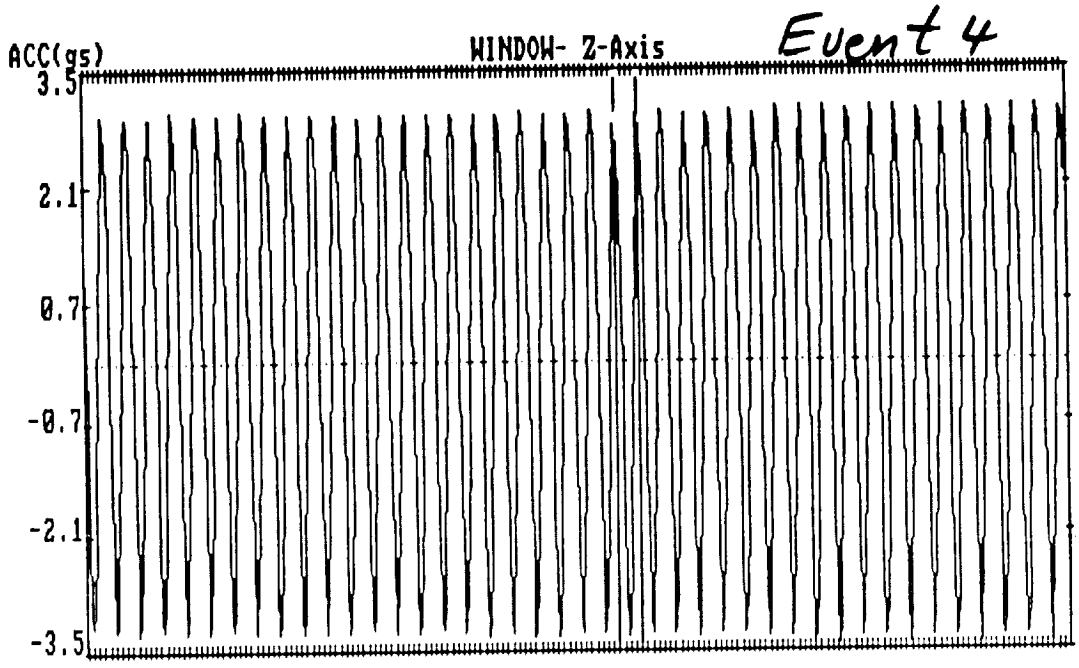


EDR-3-10 FUNCTIONAL TEST, 3 G AT 12 HZ, Z AXIS, S/N 2, 11-07-90
72 DEG F

T-53

RB02WG
12.00 HZ, 2.929 G ———————————— CONTROL



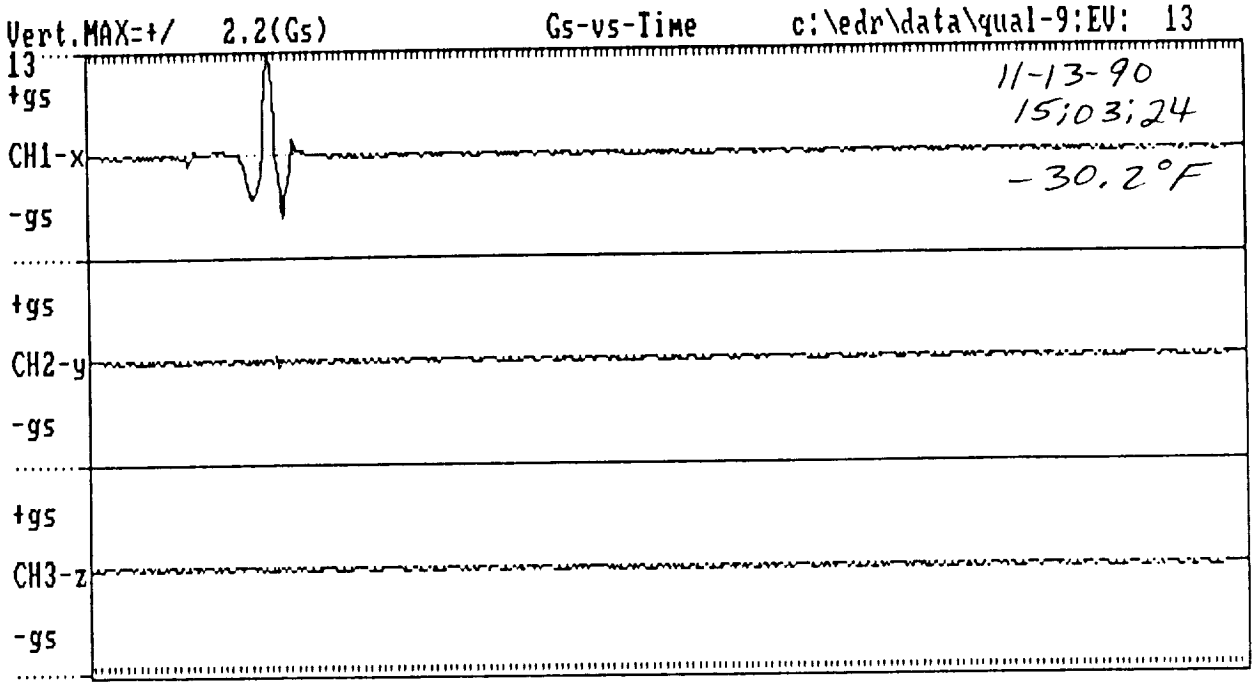


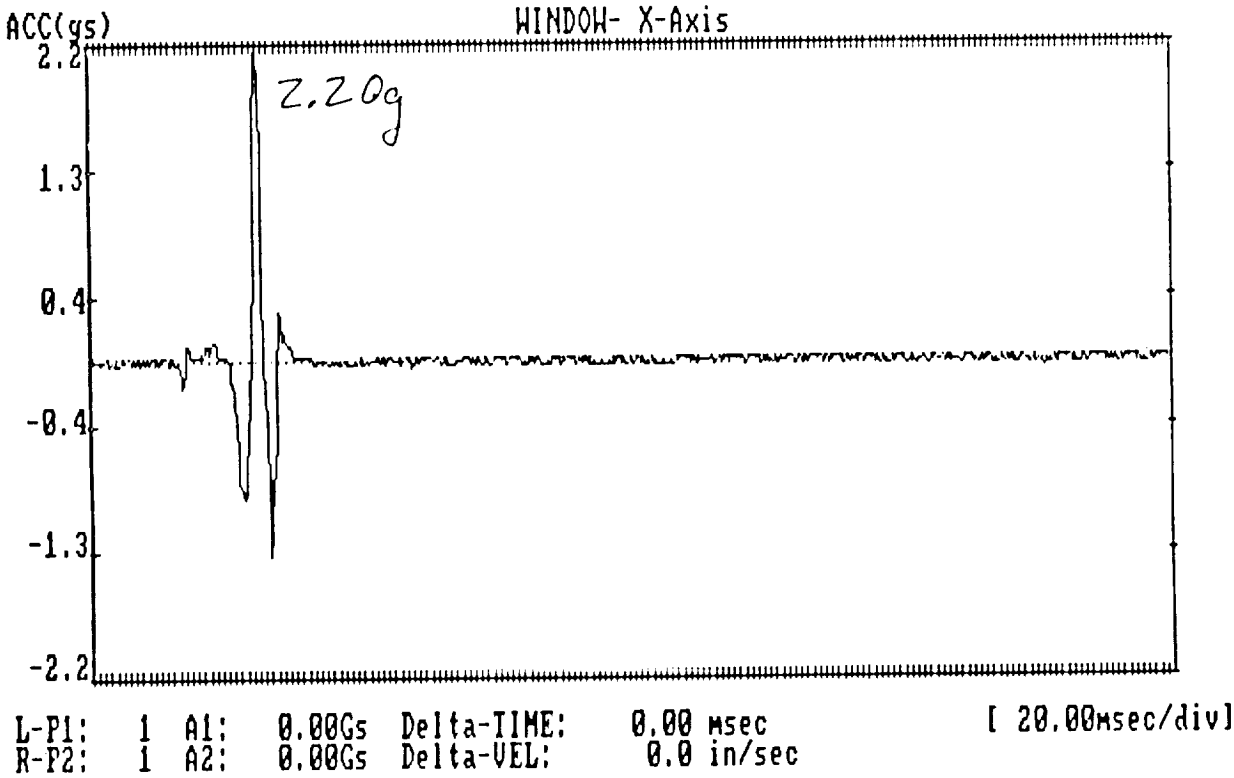
11:25

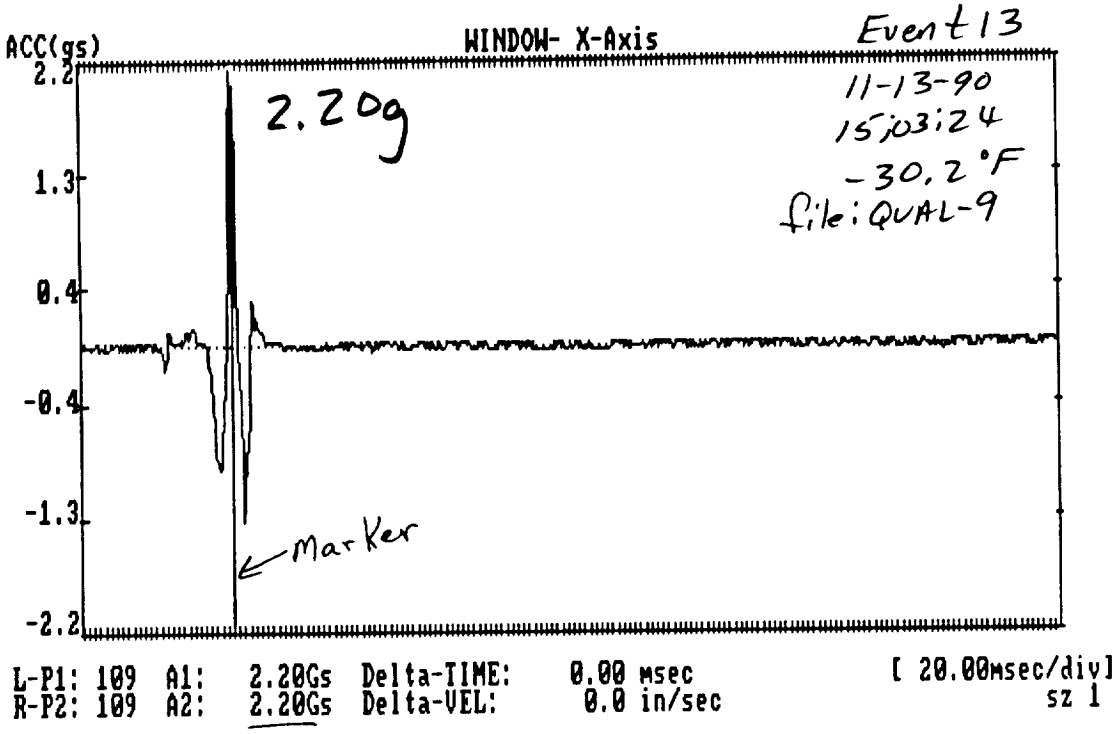
EDR-3-10 FUNCTIONAL TEST, S/N 2, Z AXIS, +145 DEG F, 11-12-90
12HZ AT 3G

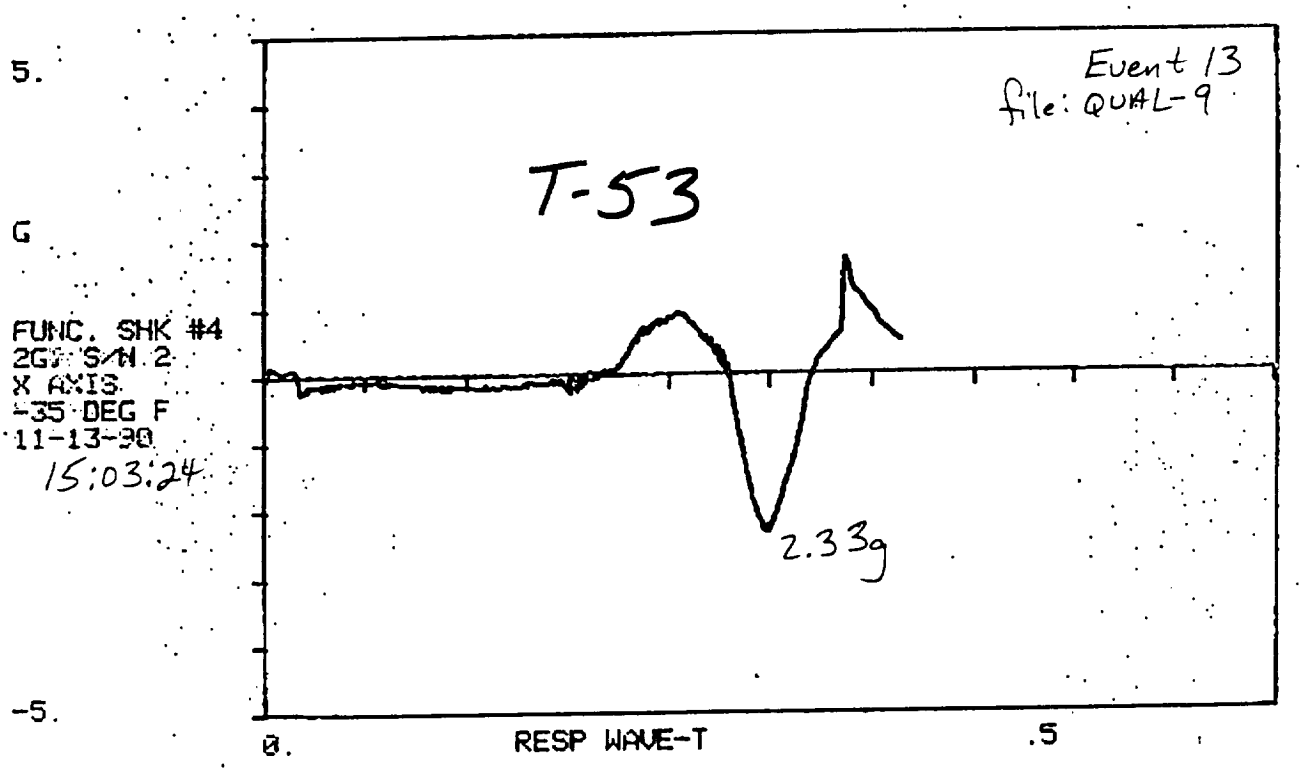
T-53

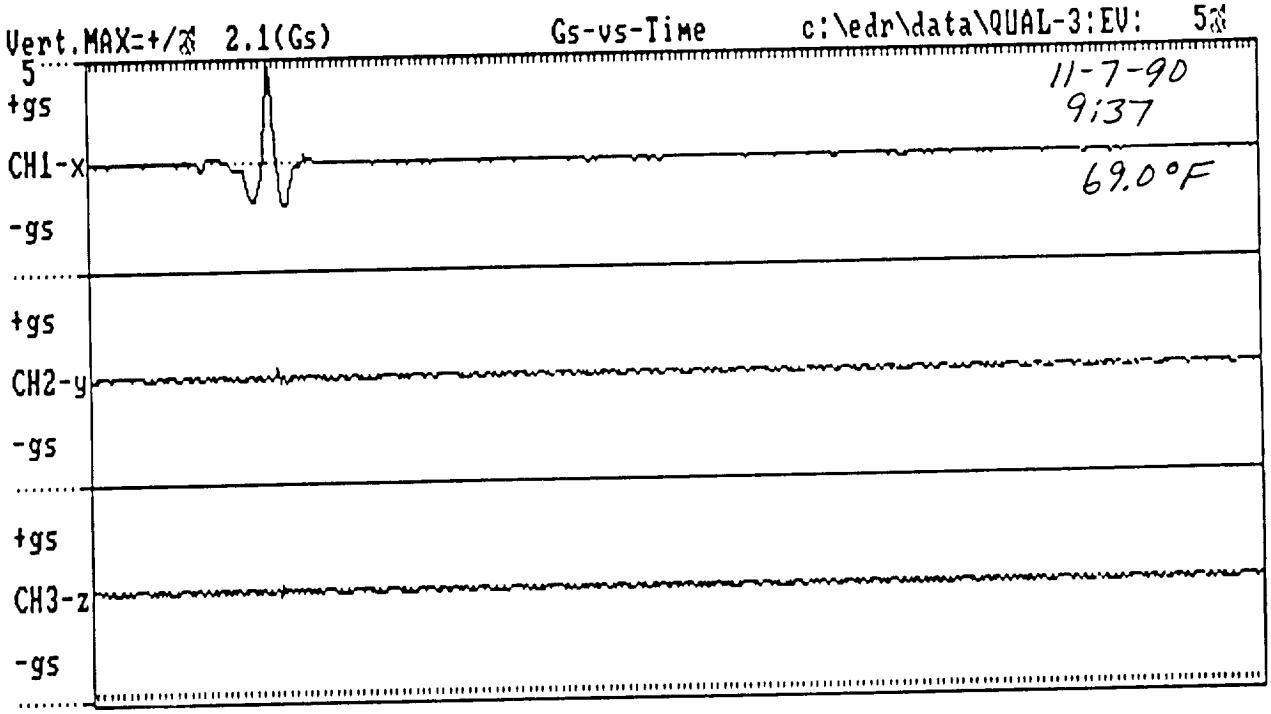
REQ2NG
12.00 HZ, 2.994 G ———————————— CONTROL

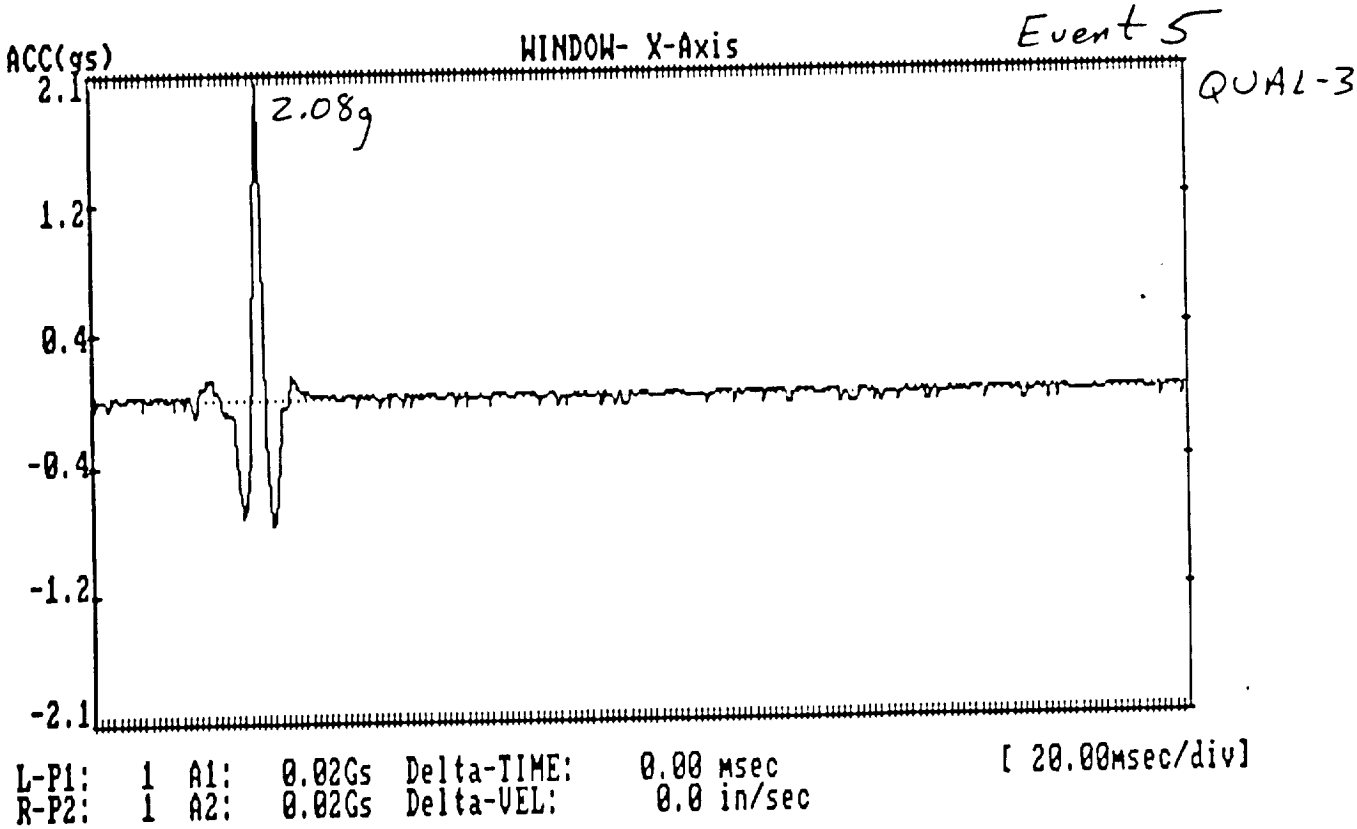

Vert.MAX=+/ 2.2(Gs)
Gs-vs-Time
c:\edr\data\qual-9:EV: 13
13
+gs
CH1-x
-gs
+gs
CH2-y
-gs
+gs
CH3-z
-gs
11-13-90
15:03:24
-30.2°F
0msec (----TIME(msec)----) 3500msec[20.00msec/div]
PNT/EXP: CH1-(F1/F4) 2-(F2/F5) 3-(F3/F6) DMP:F7/F8/F9 Quit-(Esc)

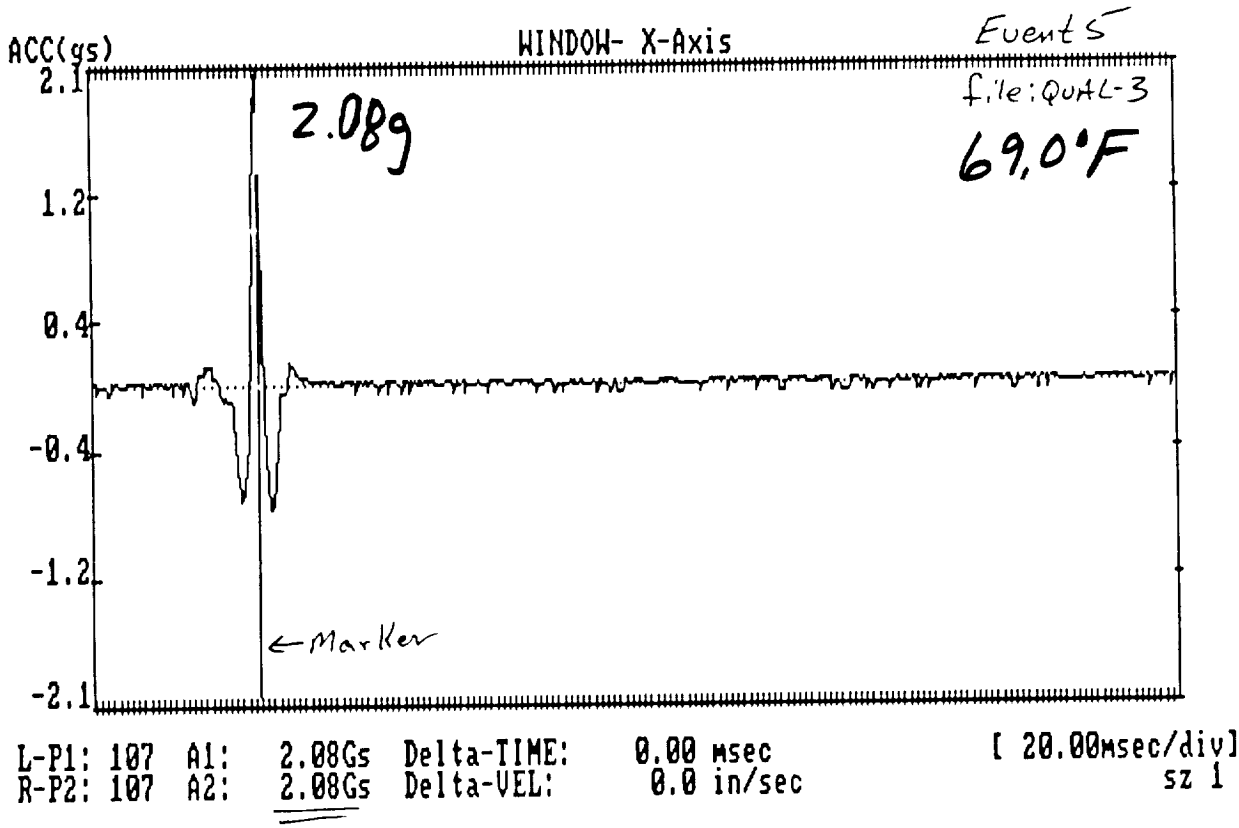

ACC(gs)
WINDOW- X-Axis
2.2
1.3
0.4
-0.4
-1.3
-2.2
2.20g
L-P1: 1 A1: 0.00Gs Delta-TIME: 0.00 msec
R-P2: 1 A2: 0.00Gs Delta-VEL: 0.0 in/sec
[20.00msec/div]

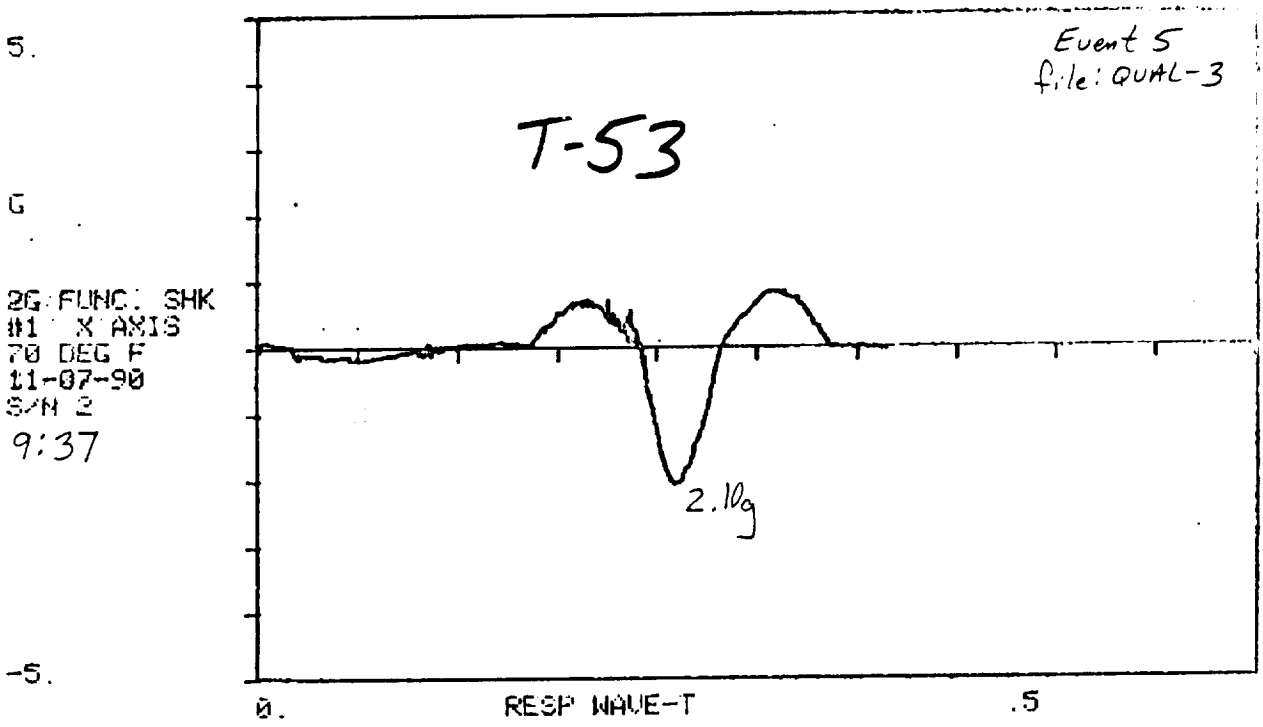

ACC(gs)
WINDOW- X-Axis
Event 13
11-13-90
15:03:24
-30.2 °F
file: QUAL-9
2.20g
2.2
1.3
0.4
-0.4
-1.3
-2.2
Marker
L-P1: 109 A1: 2.20Gs Delta-TIME: 0.00 msec
R-P2: 109 A2: 2.20Gs Delta-VEL: 0.0 in/sec
[20.00msec/div]
sz 1


Event 13
file: QUAL-9
T-53
5.
G
-5.
FUNC. SHK #4
2G: S/N 2
X AXIS
-35 DEG F
11-13-90
15:03:24
2.33g
0.
RESP WAVE-T
.5









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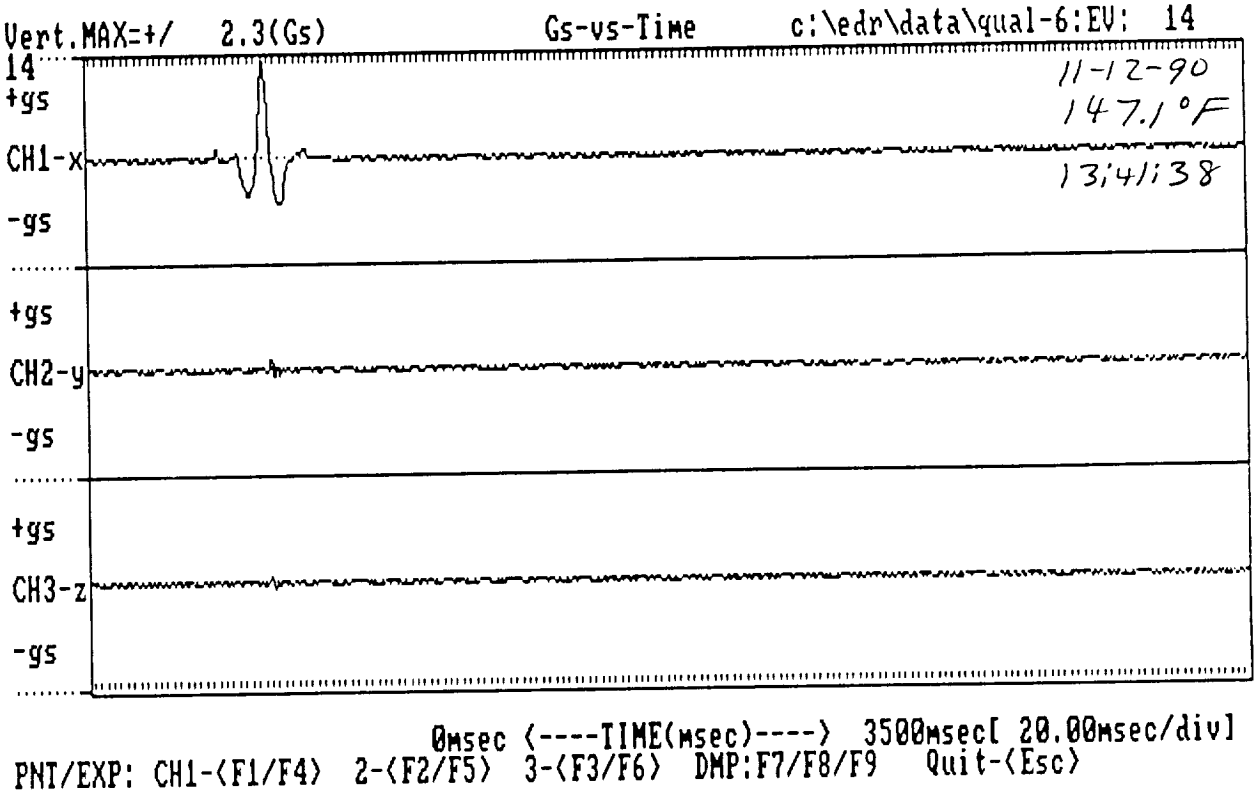
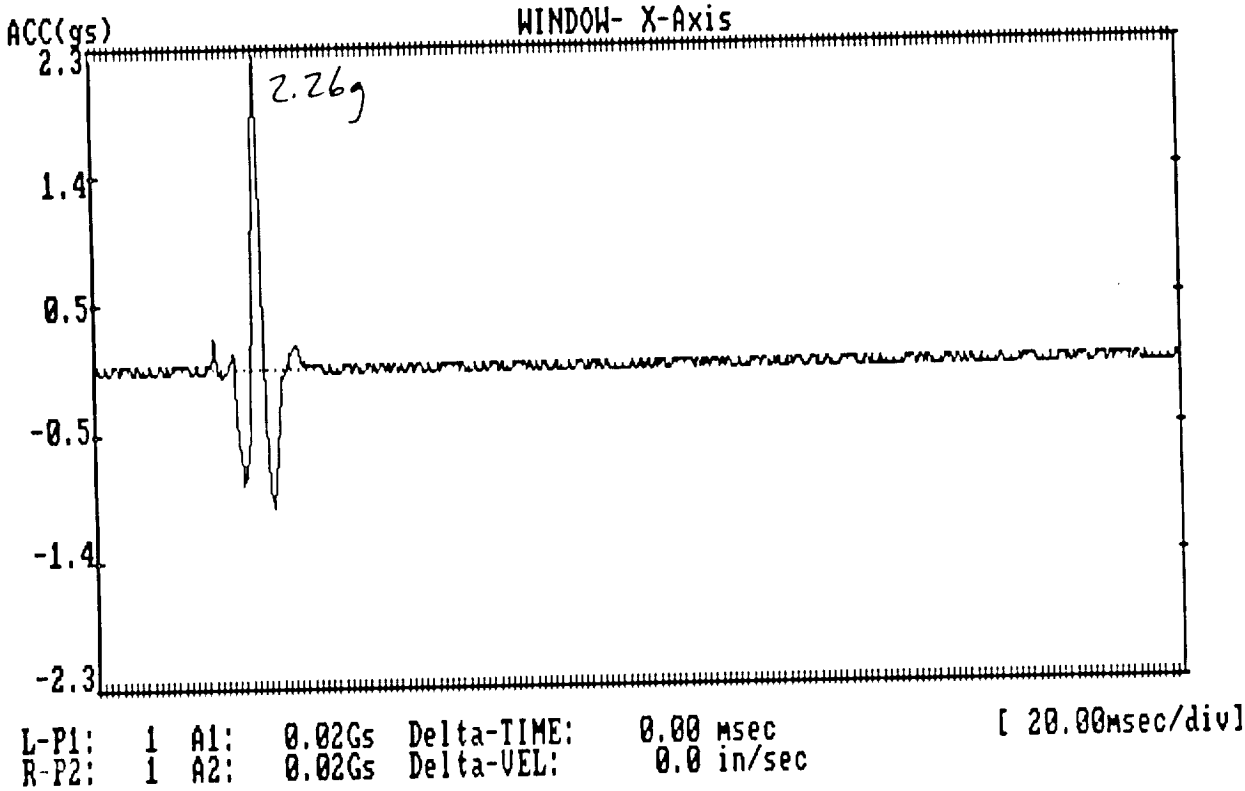
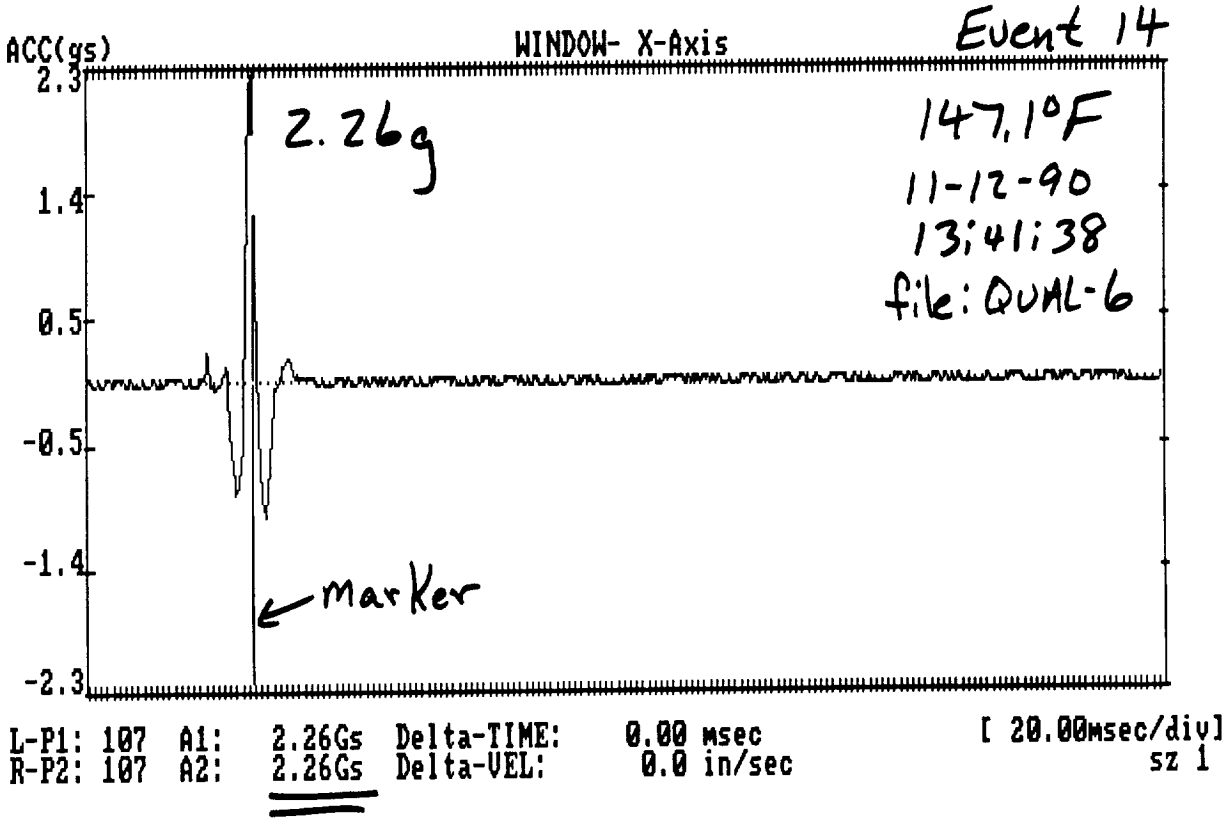
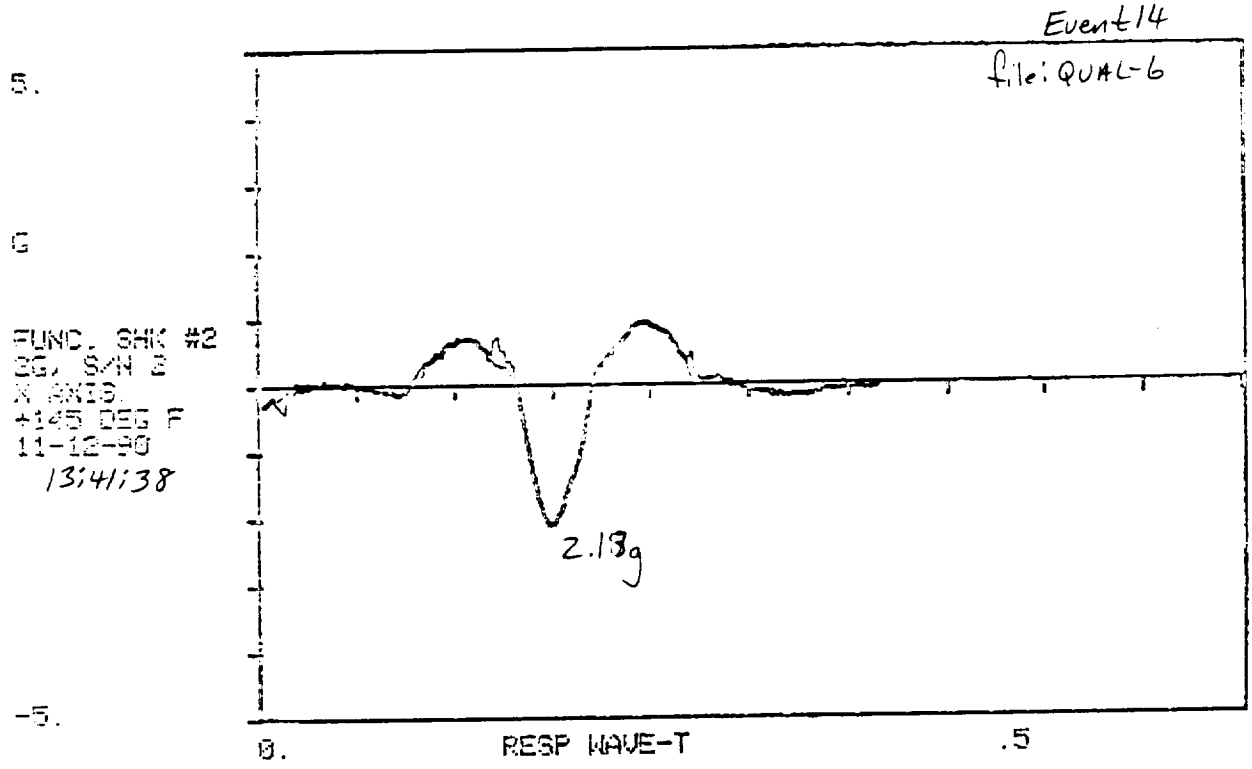

Vert.MAX=+/ 2.3(Gs)
Gs-vs-Time
c:\edr\data\qual-6:EV: 14
14
+gs
CH1-x
-gs
+gs
CH2-y
-gs
+gs
CH3-z
-gs
11-12-90
147.1 °F
13;41;38
0msec (----TIME(msec)----) 3500msec[20.00msec/div]
PNT/EXP: CH1-(F1/F4) 2-(F2/F5) 3-(F3/F6) DMP:F7/F8/F9 Quit-(Esc)


ACC(gs)
WINDOW- X-Axis
2.3
1.4
0.5
-0.5
-1.4
-2.3
2.26g
L-P1: 1 A1: 0.02Gs Delta-TIME: 0.00 msec
R-P2: 1 A2: 0.02Gs Delta-VEL: 0.0 in/sec
[20.00msec/div]





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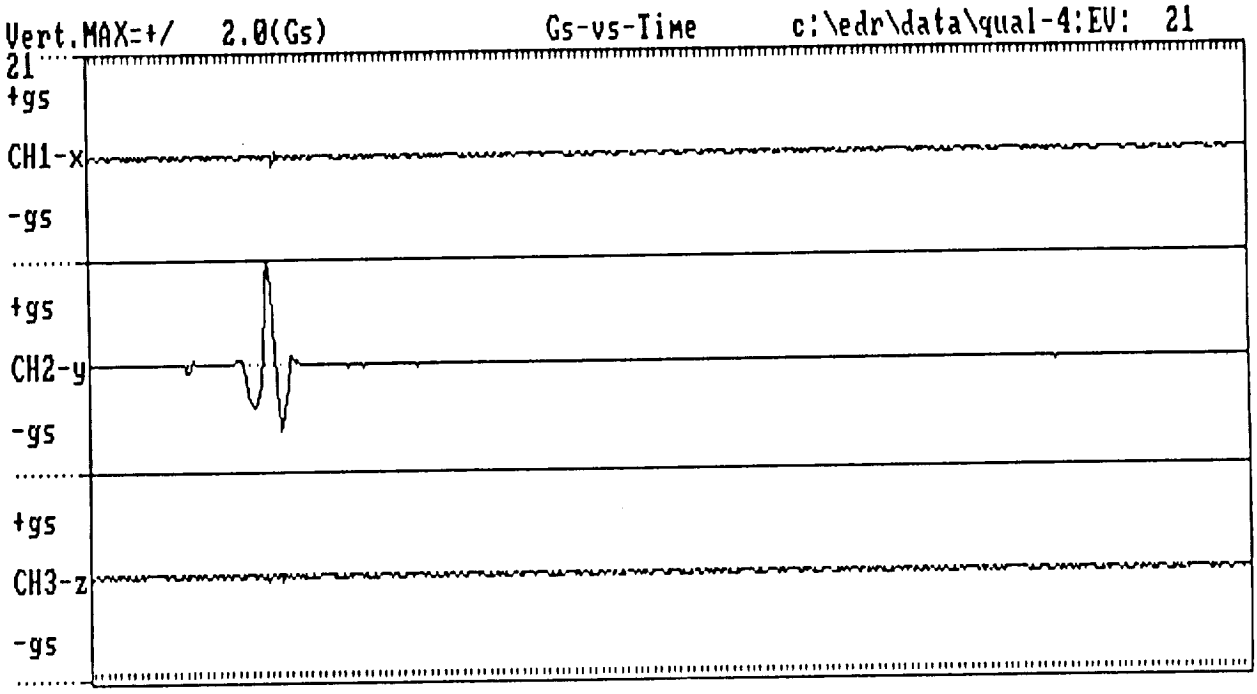
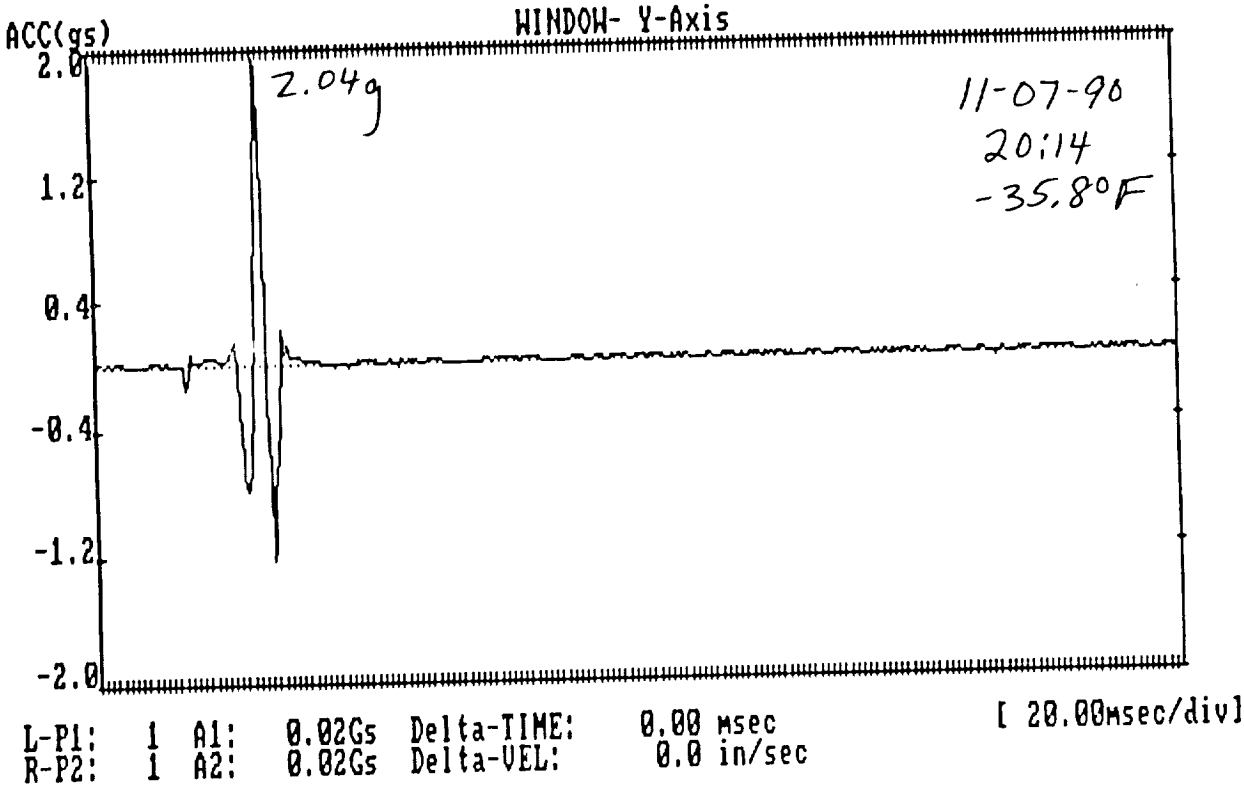
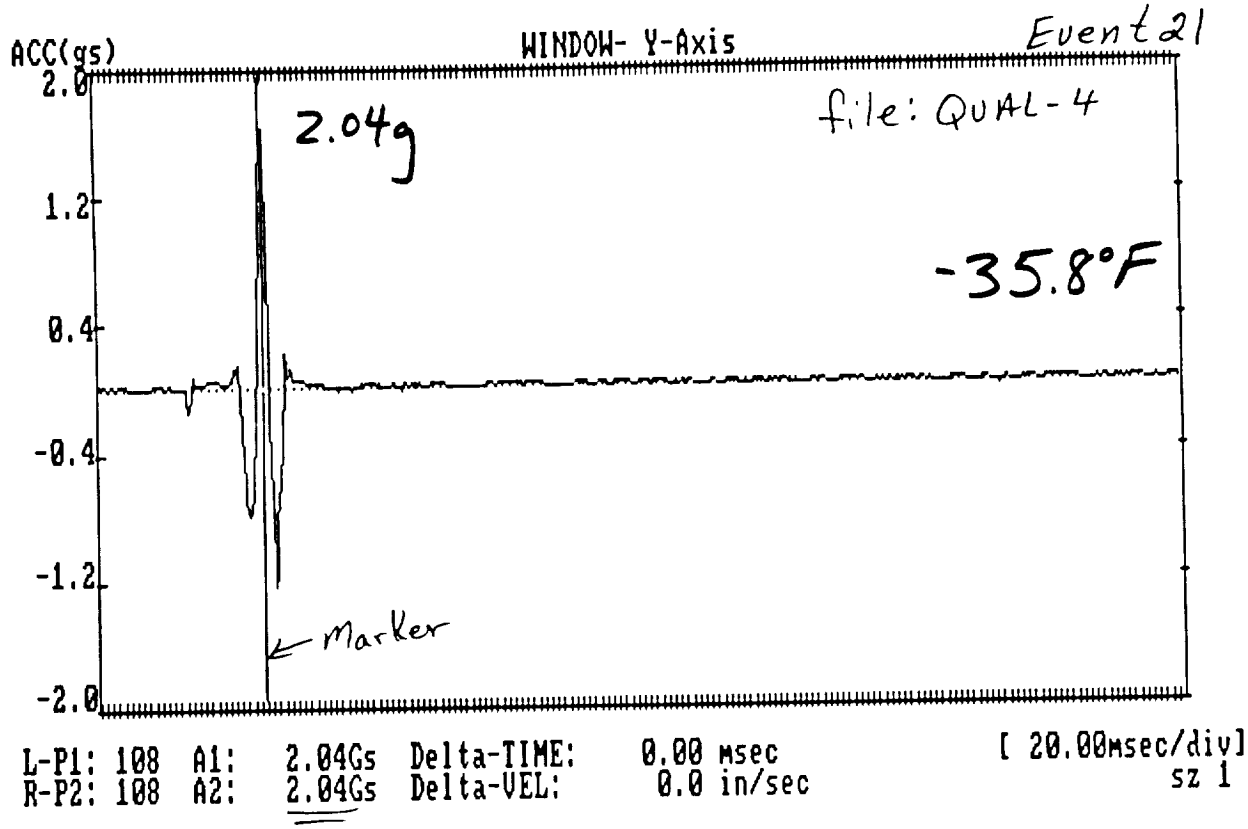
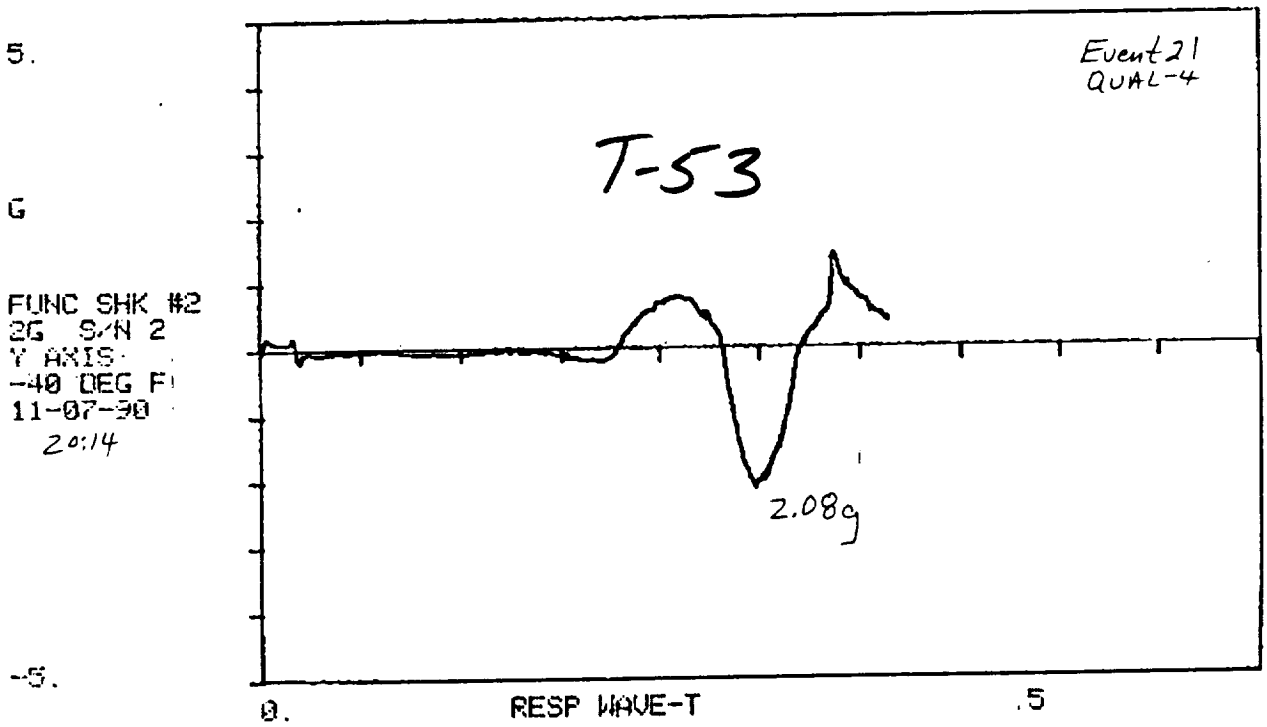
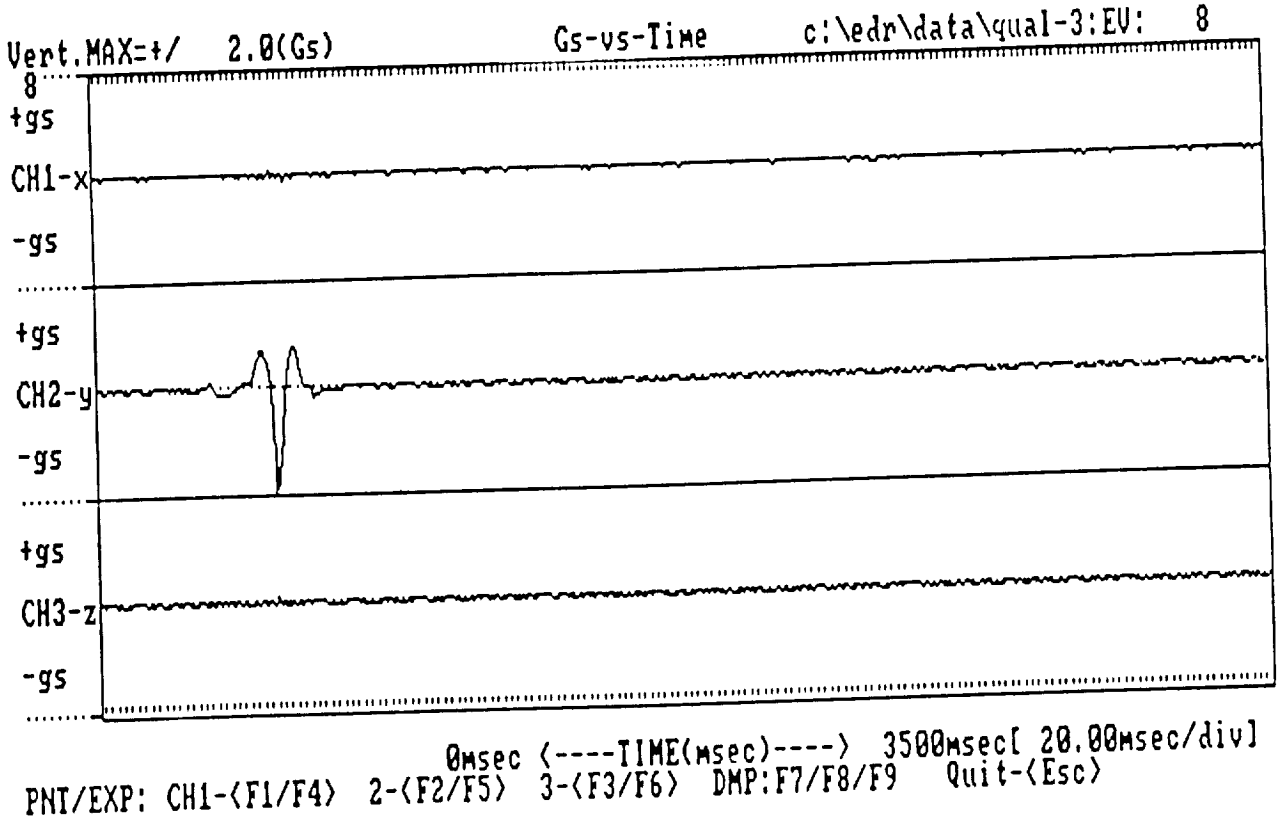
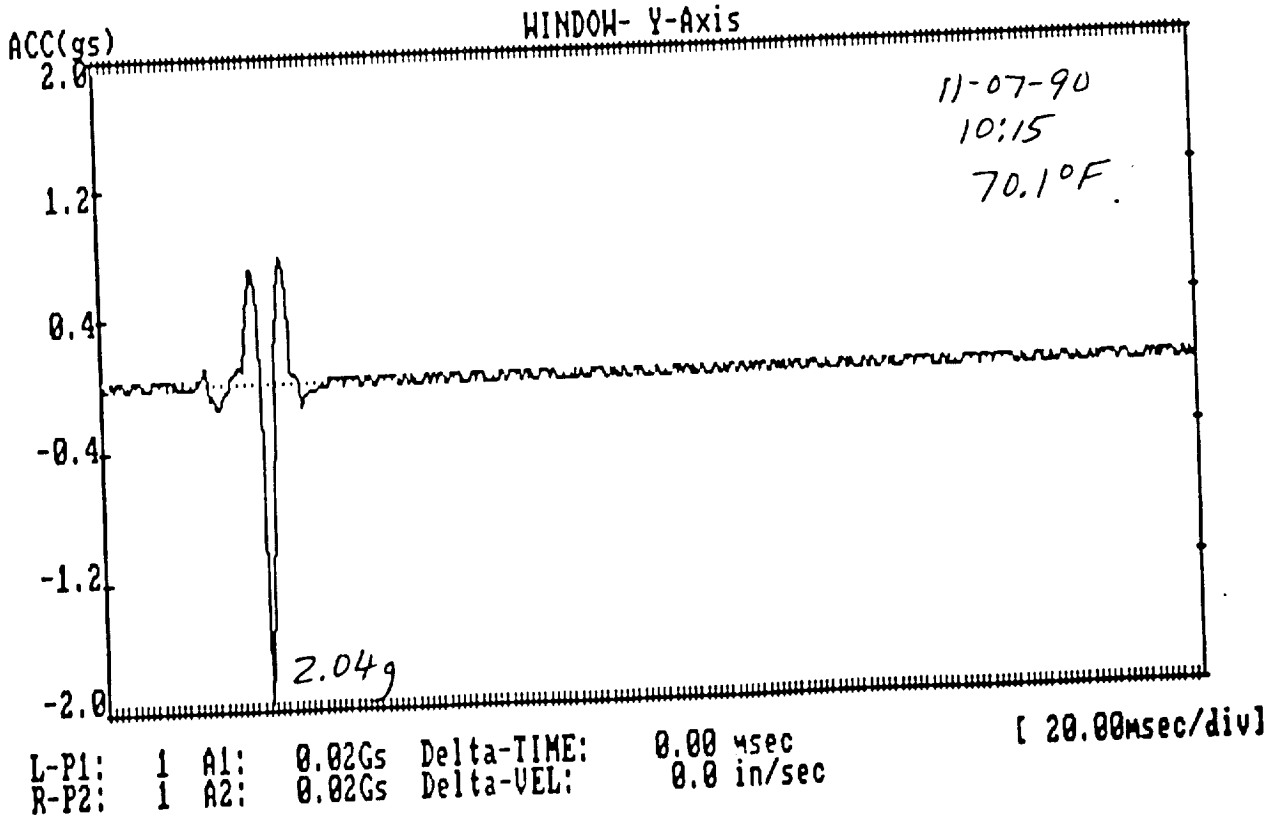

Vert.MAX=+/ 2.0(Gs)
Gs-vs-Time
c:\edr\data\qual-4:EV: 21
21
+gs
CH1-x
-gs
+gs
CH2-y
-gs
+gs
CH3-z
-gs
0msec (----TIME(msec)----) 3500msec[20.00msec/div]
PNT/EXP: CH1-(F1/F4) 2-(F2/F5) 3-(F3/F6) DMP:F7/F8/F9 Quit-(Esc)

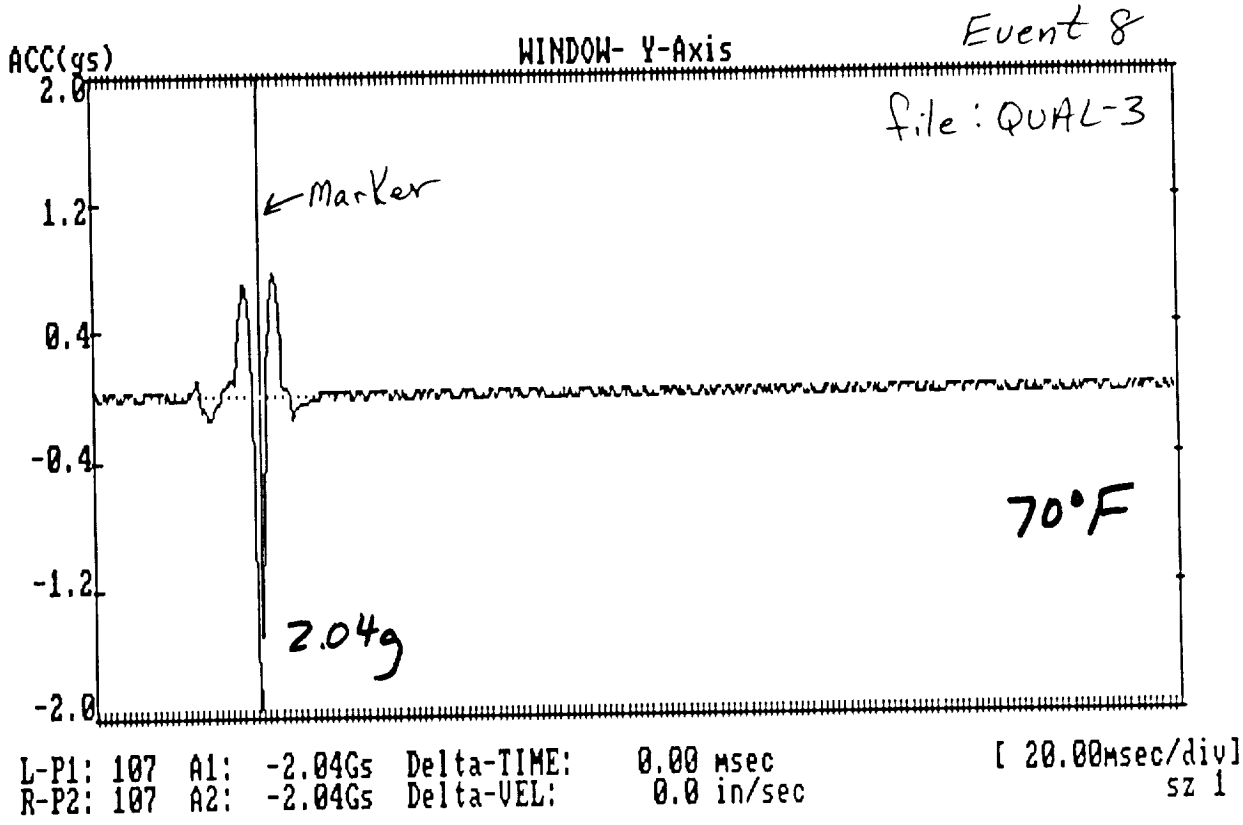

ACC(gs)
WINDOW- Y-Axis
2.0
1.2
0.4
-0.4
-1.2
-2.0
2.04g
11-07-90
20:14
-35.8°F
L-P1: 1 A1: 0.02Gs Delta-TIME: 0.00 msec
R-P2: 1 A2: 0.02Gs Delta-VEL: 0.0 in/sec
[20.00msec/div]

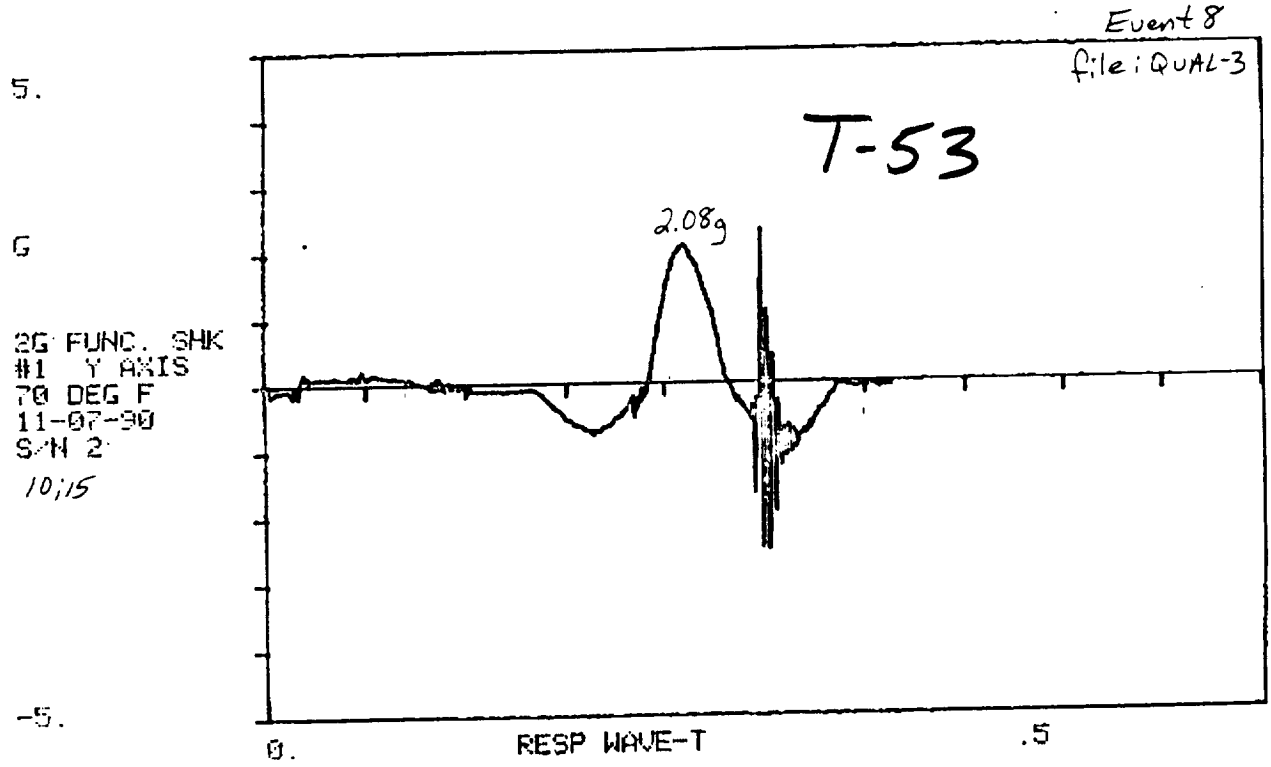


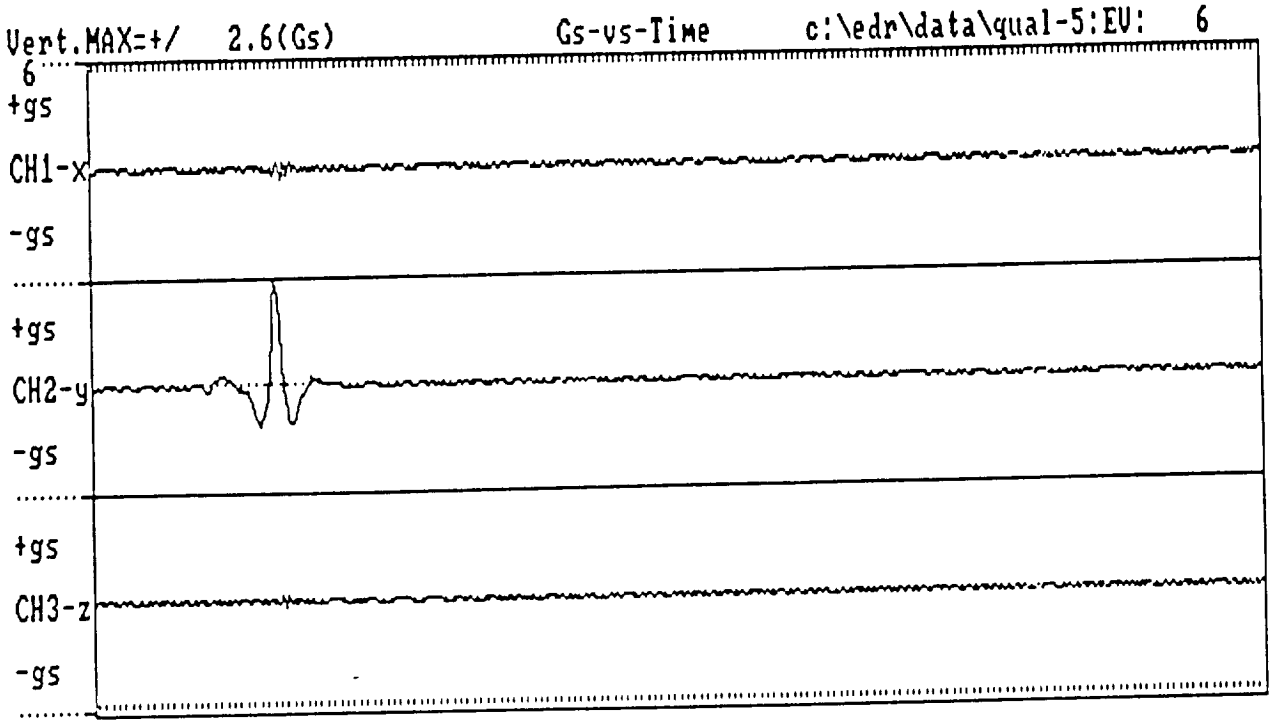


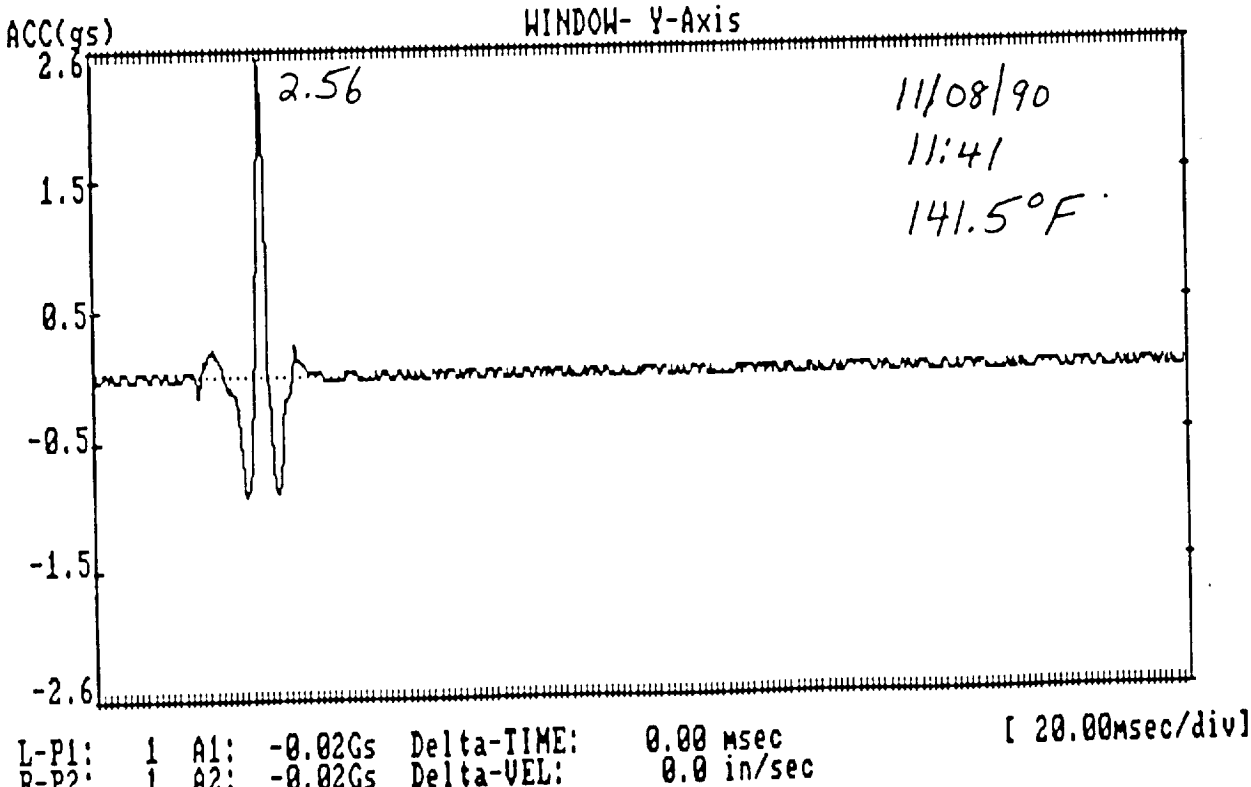

Vert.MAX=+/ 2.0(Gs)
Gs-vs-Time
c:\edr\data\qual-3:EV: 8
8
+gs
CH1-x
-gs
+gs
CH2-y
-gs
+gs
CH3-z
-gs
0msec <----TIME(msec)----> 3500msec[20.00msec/div]
PNT/EXP: CH1-<F1/F4> 2-<F2/F5> 3-<F3/F6> DMP:F7/F8/F9 Quit-<Esc>

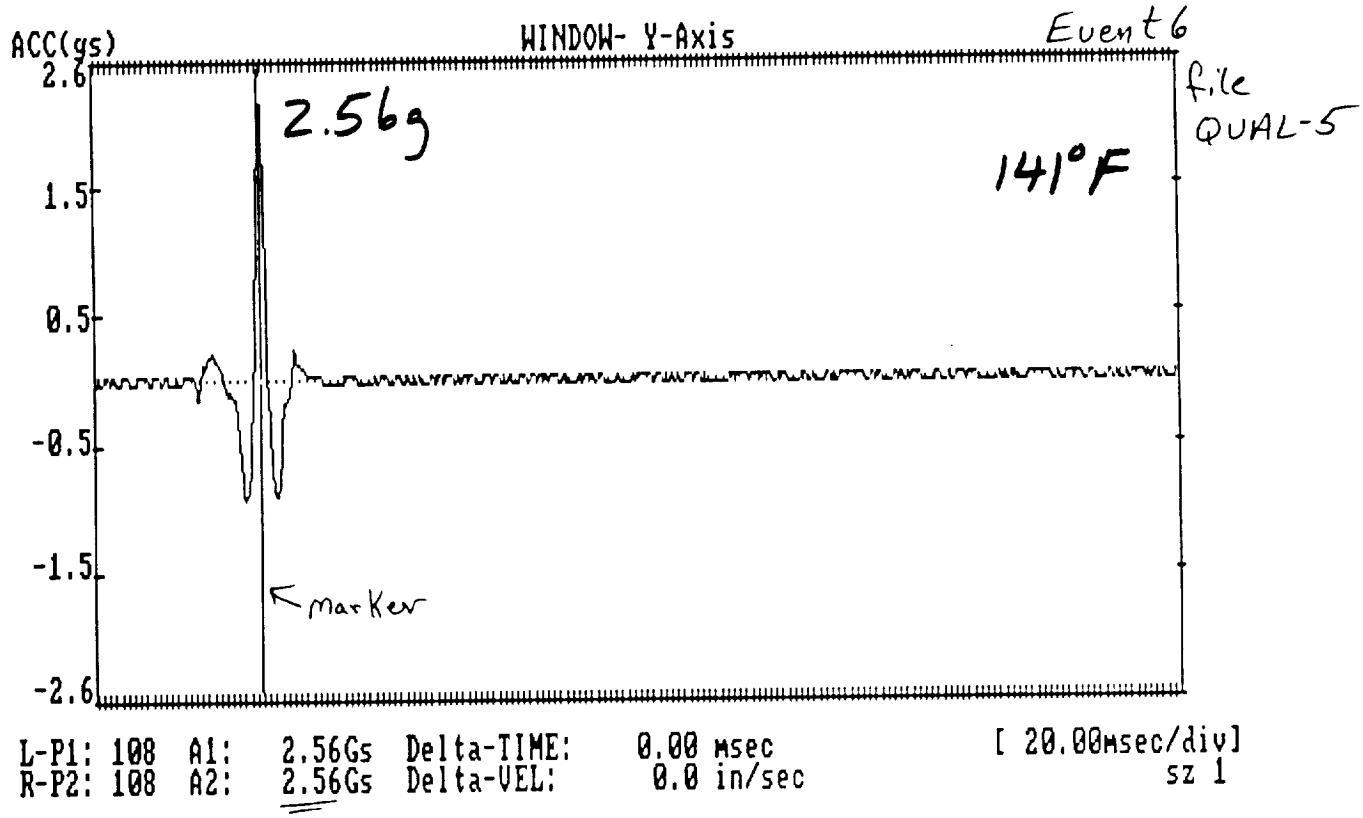

WINDOW- Y-Axis
ACC(gs)
2.0
1.2
0.4
-0.4
-1.2
-2.0
11-07-90
10:15
70.1°F.
2.04g
[20.00msec/div]
L-P1: 1 A1: 0.02Gs Delta-TIME: 0.00 msec
R-P2: 1 A2: 0.02Gs Delta-VEL: 0.0 in/sec

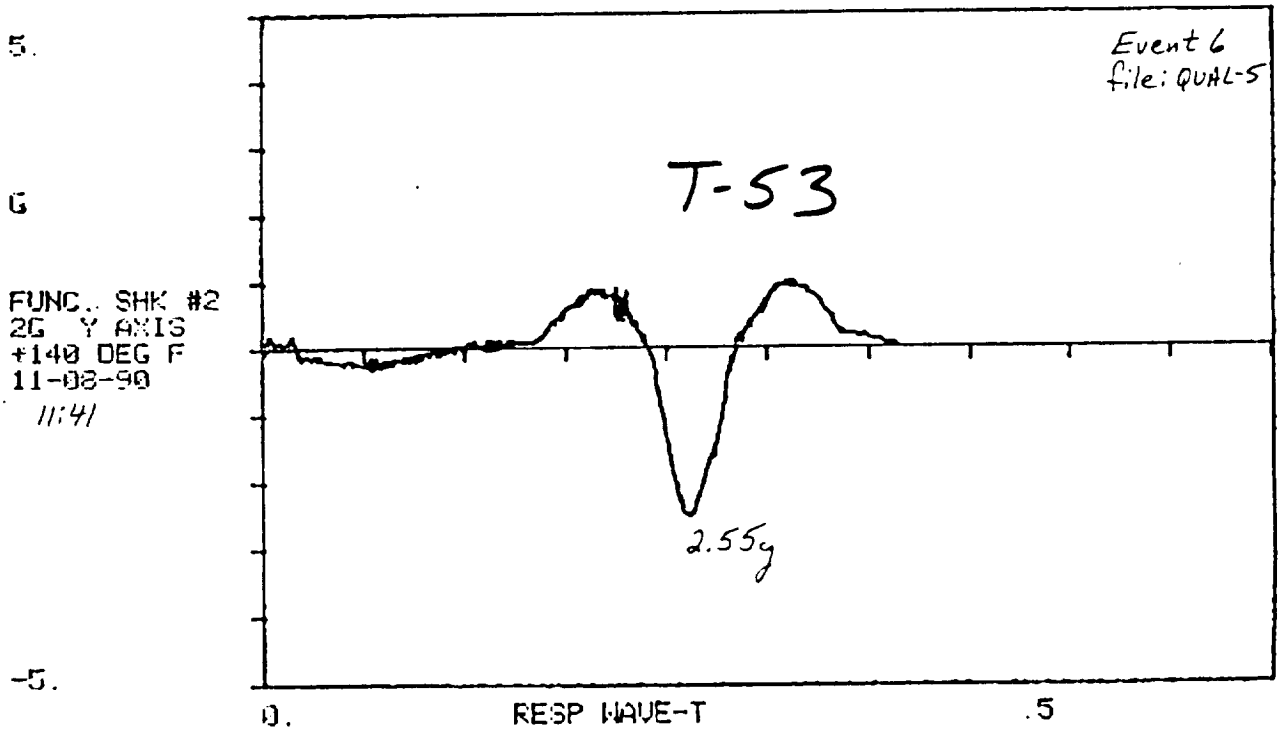


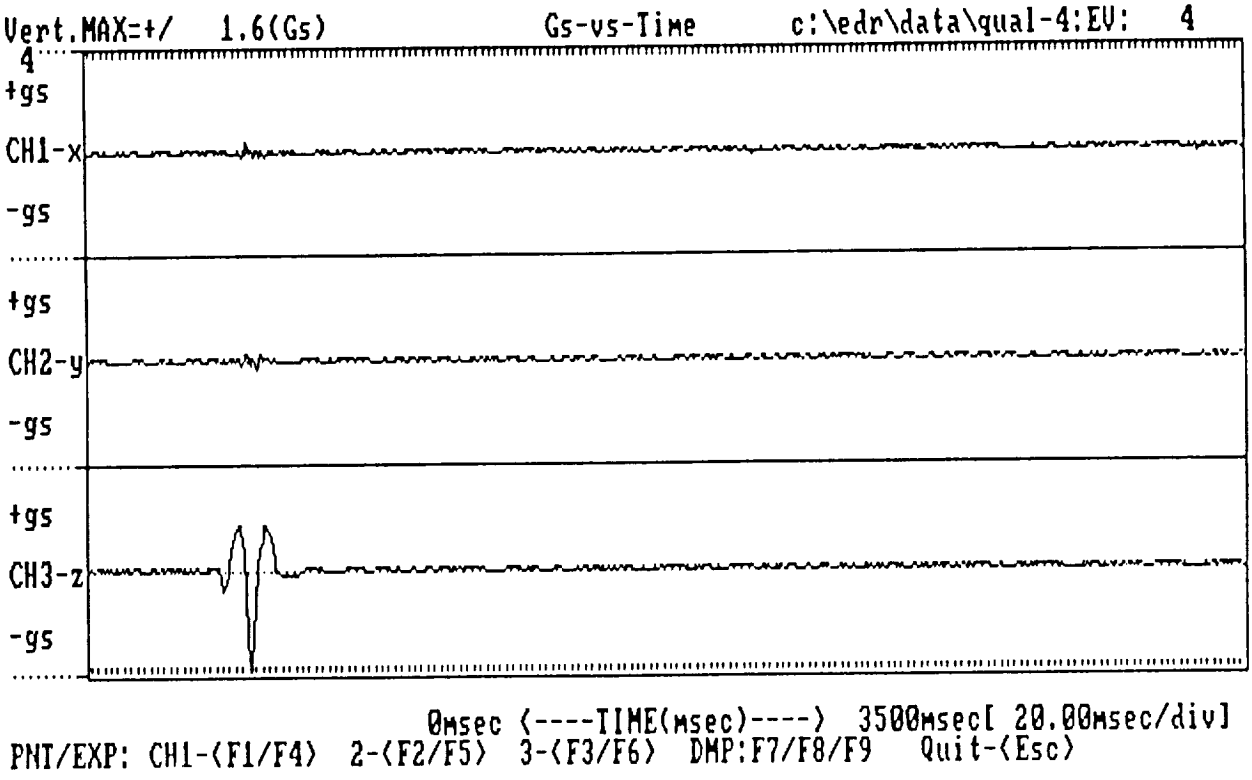


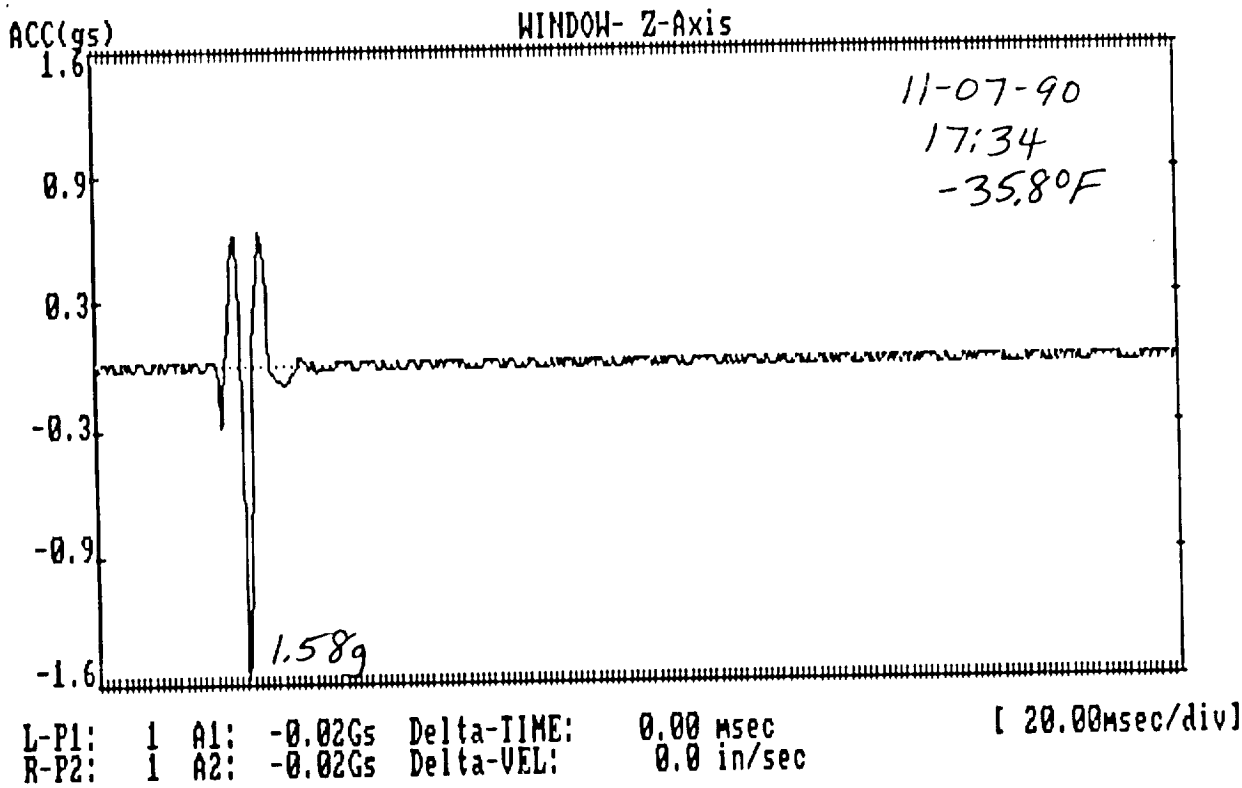












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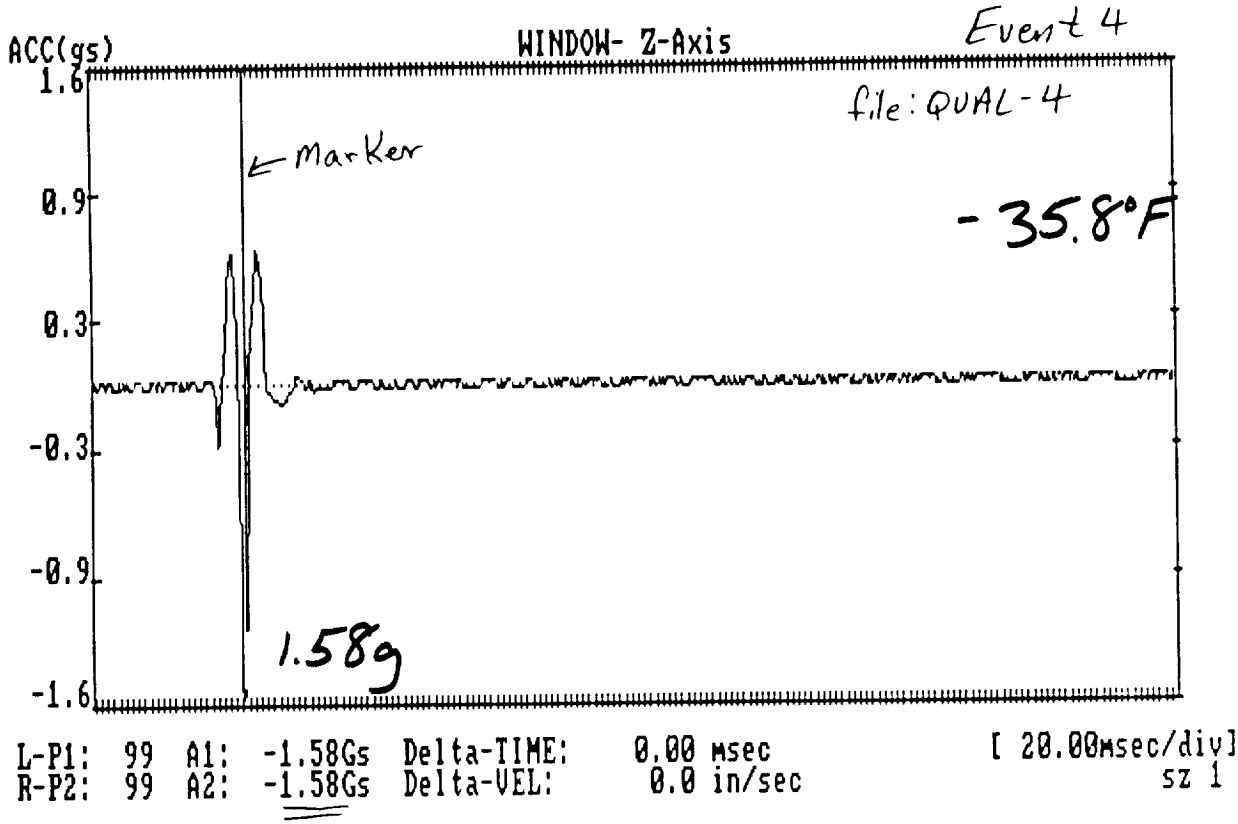
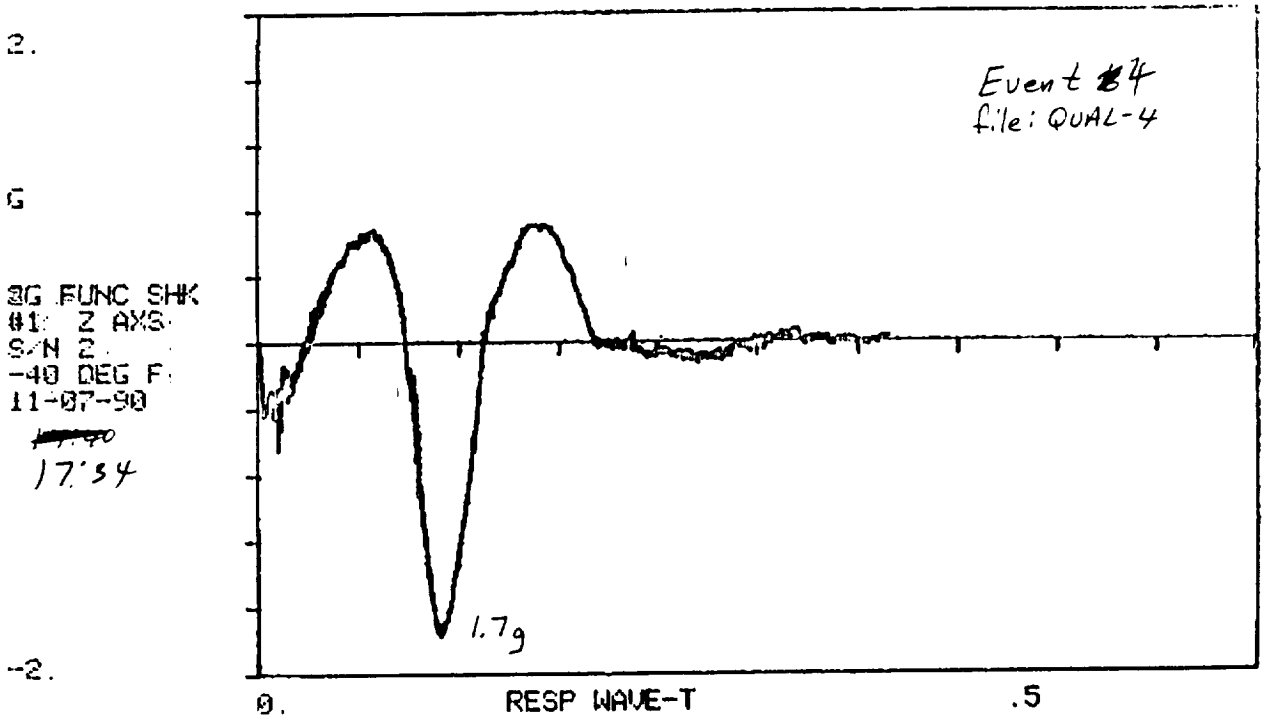
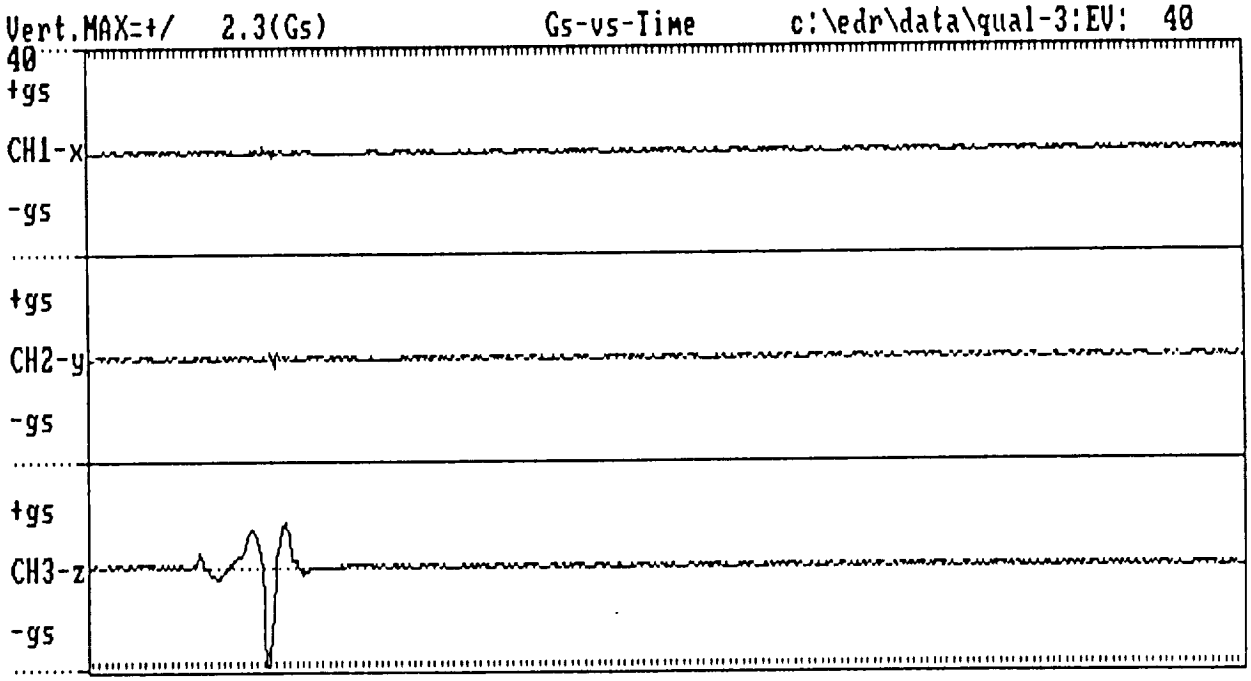
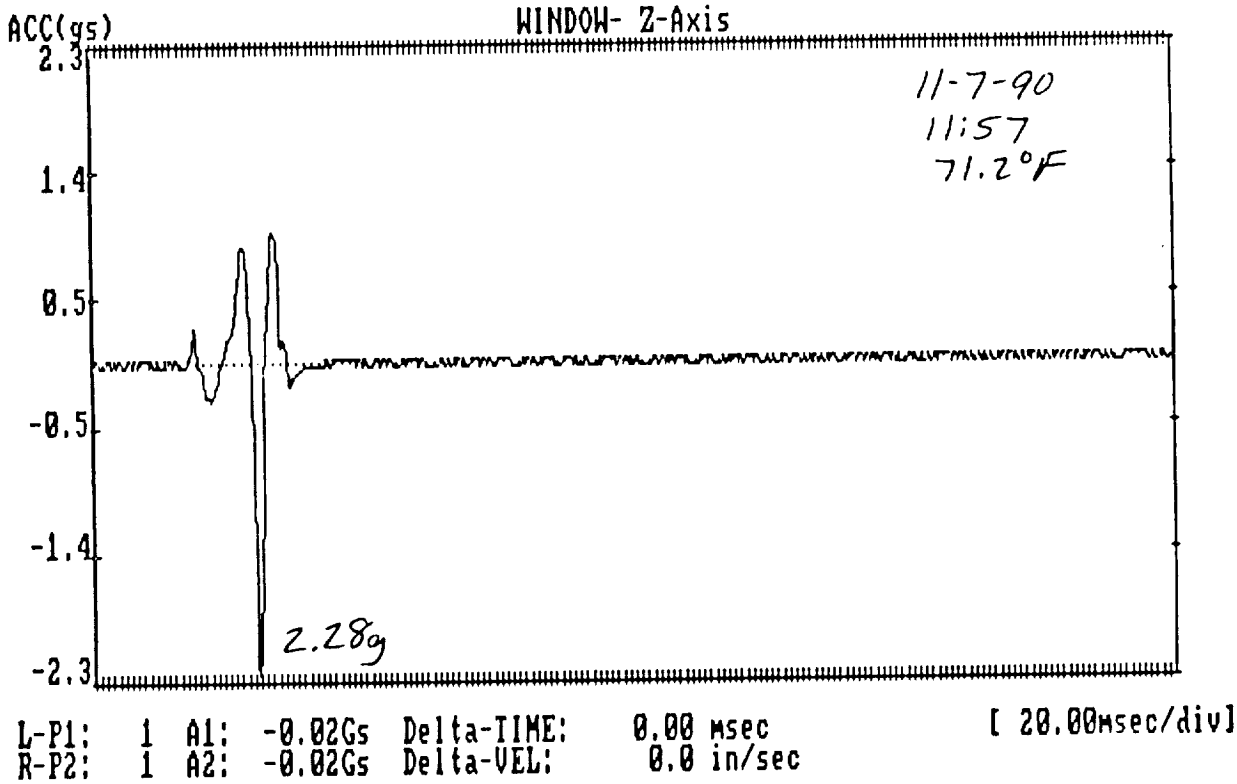
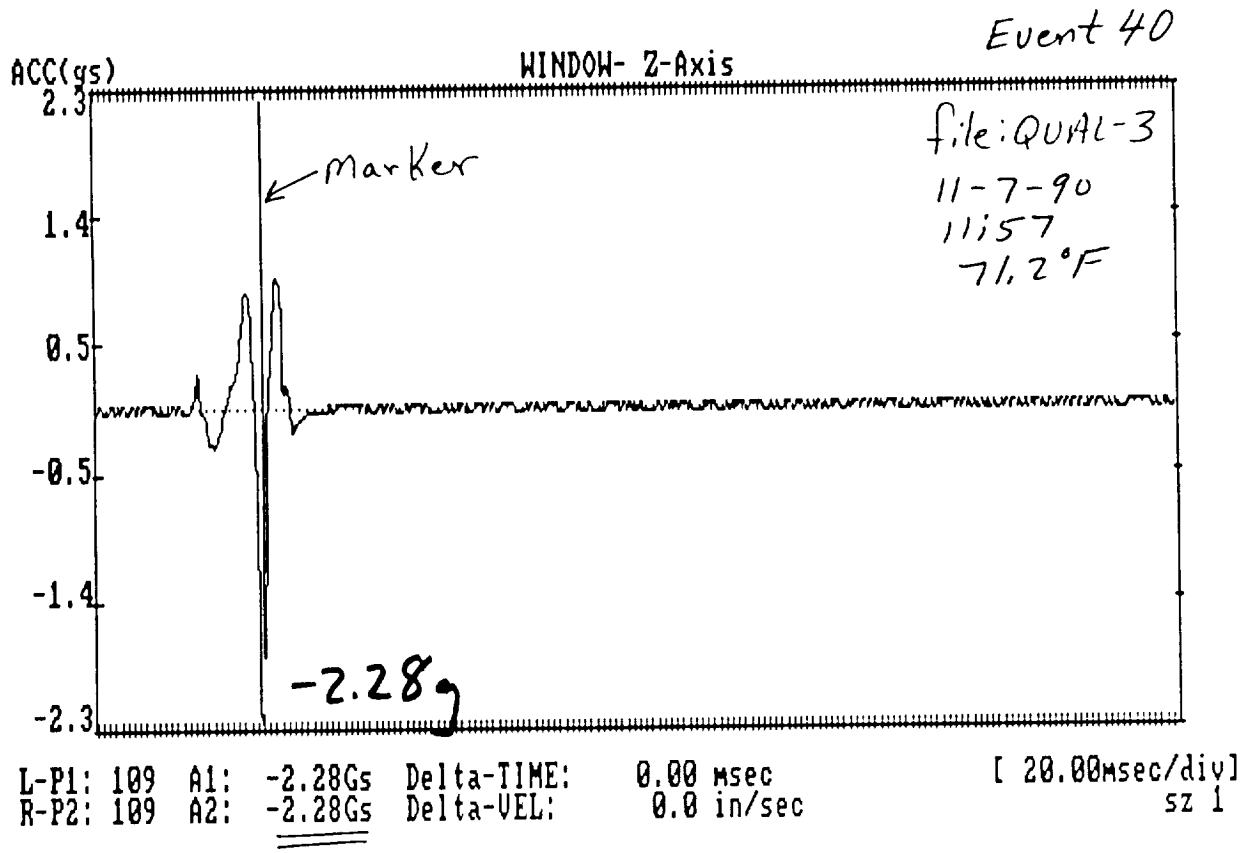
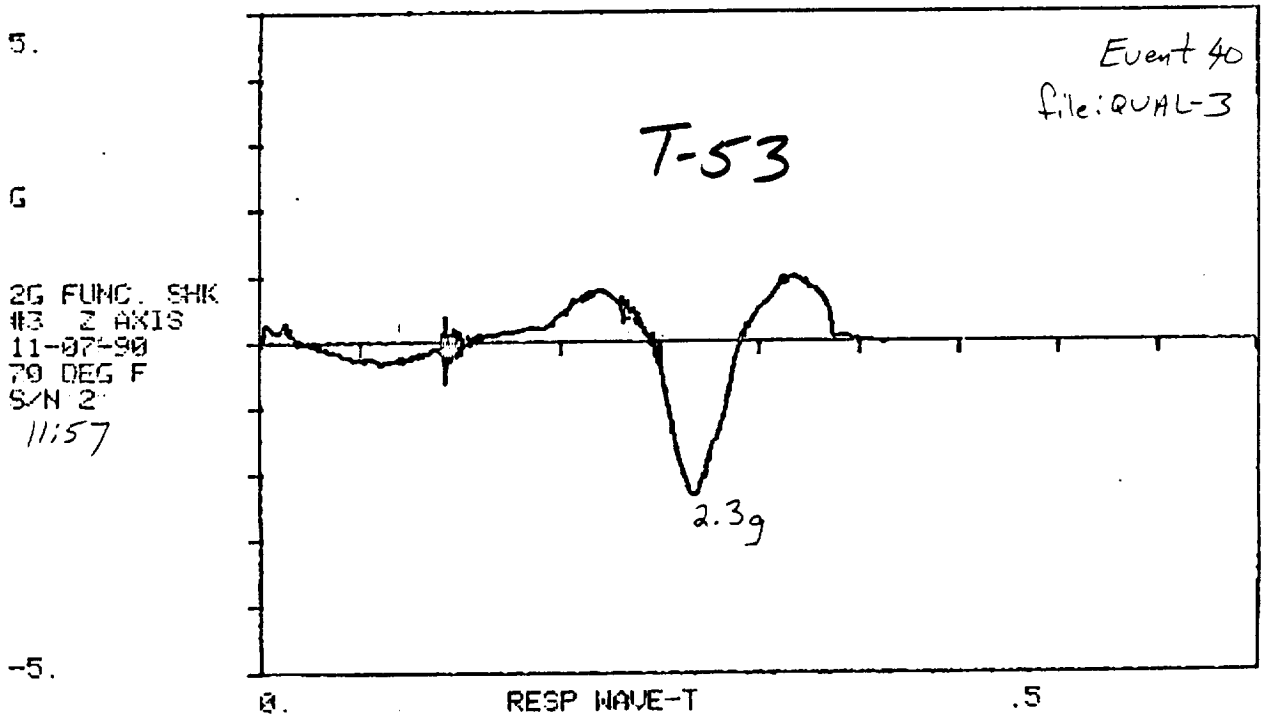


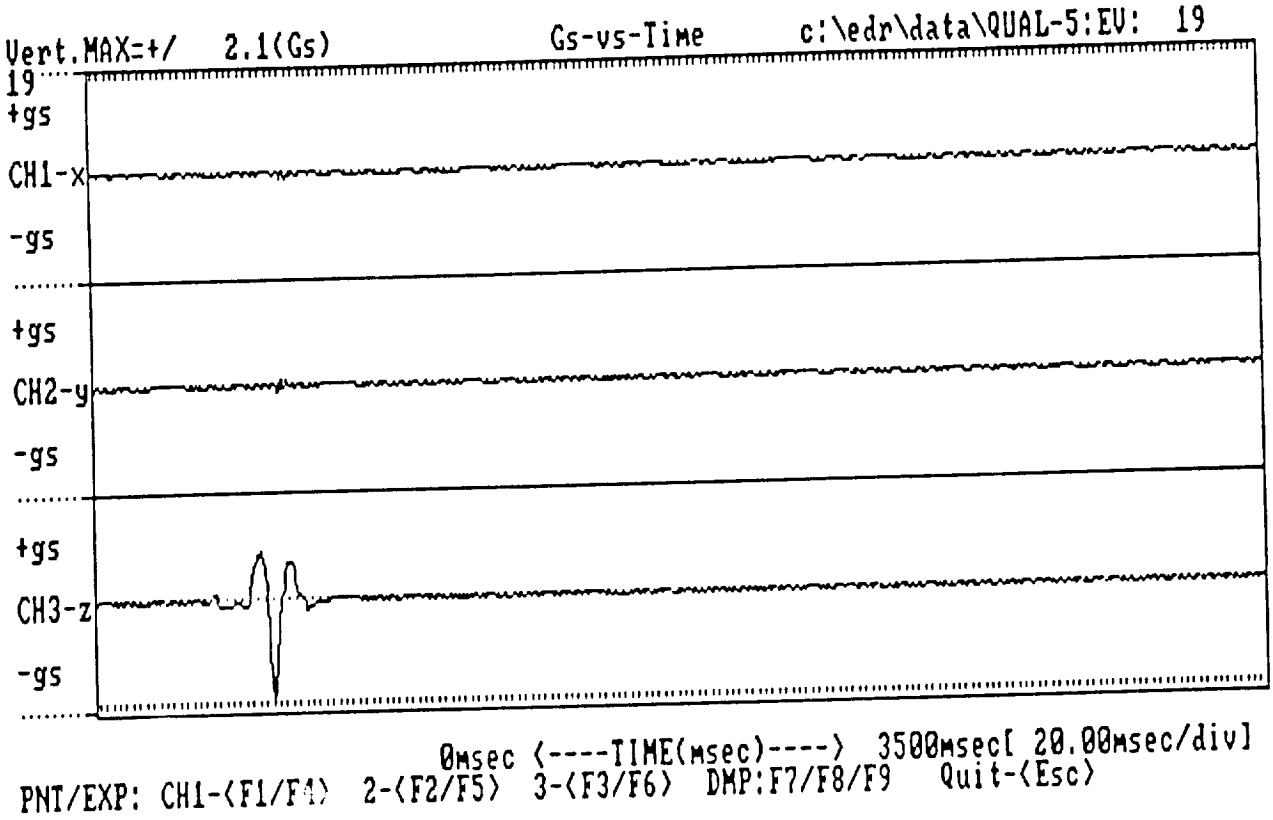


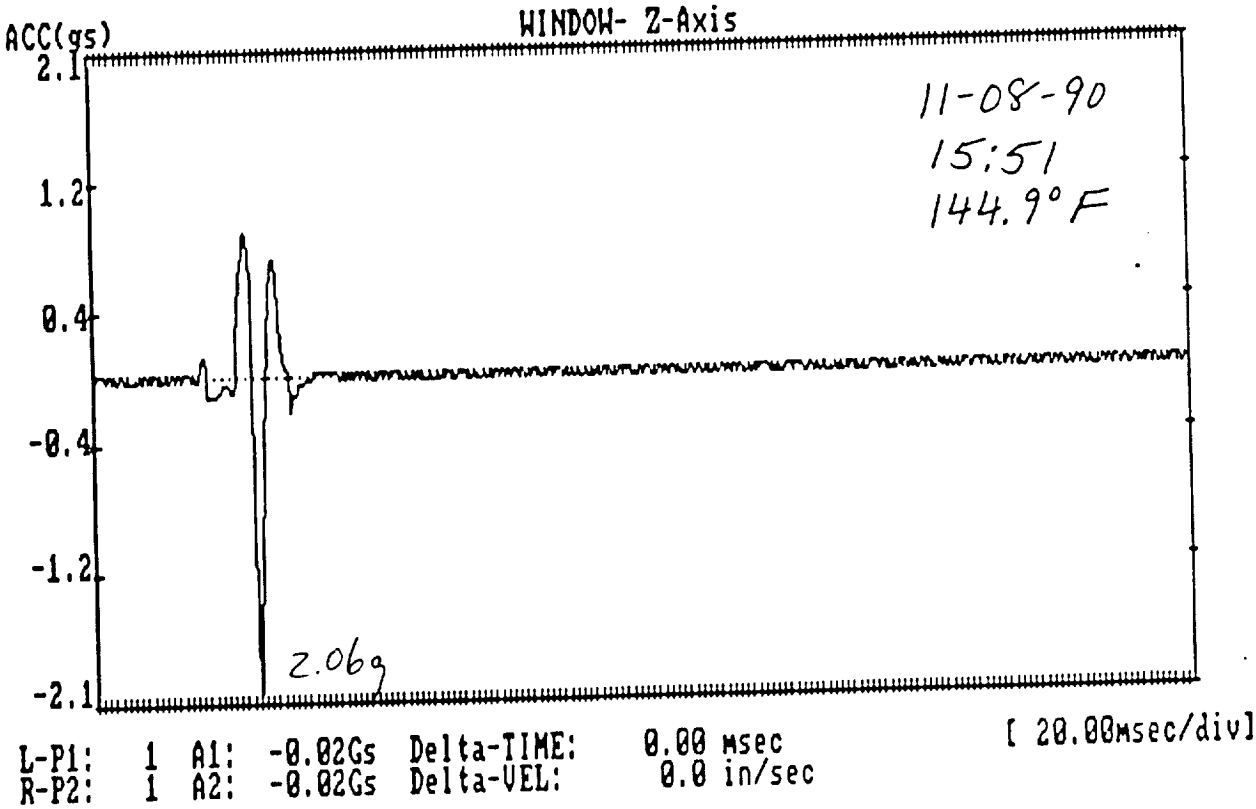

Vert.MAX=+/ 2.3(Gs)
Gs-vs-Time
c:\edr\data\qual-3:EV: 40
40
+gs
CH1-x
-gs
+gs
CH2-y
-gs
+gs
CH3-z
-gs
0msec (----TIME(msec)----) 3500msec[20.00msec/div]
PNI/EXP: CH1-(F1/F4) 2-(F2/F5) 3-(F3/F6) DMP:F7/F8/F9 Quit-(Esc)

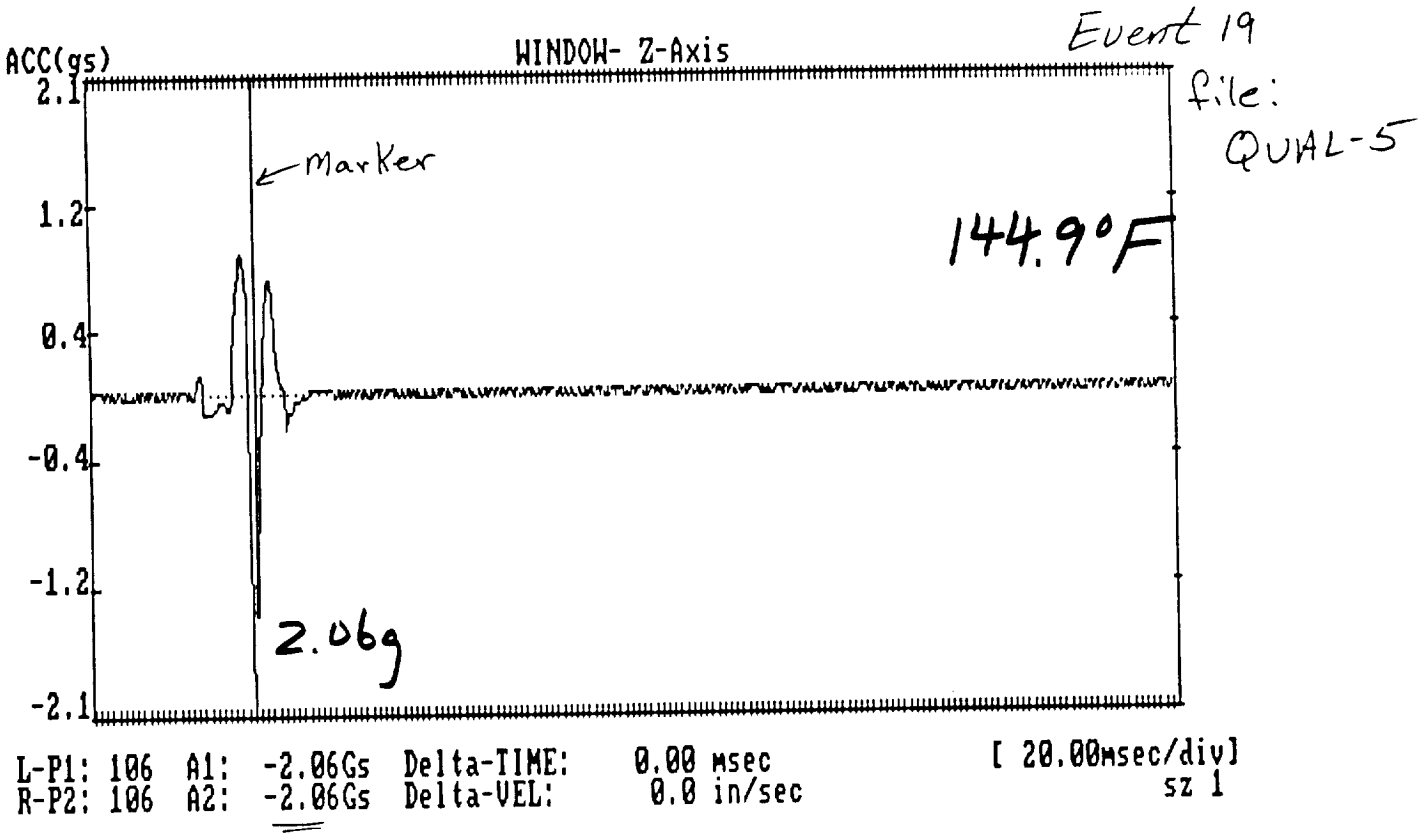

ACC(gs)
WINDOW- Z-Axis
2.3
1.4
0.5
-0.5
-1.4
-2.3
11-7-90
11:57
71.2°F
2.28g
L-P1: 1 A1: -0.02Gs Delta-TIME: 0.00 msec
R-P2: 1 A2: -0.02Gs Delta-VEL: 0.0 in/sec
[20.00msec/div]

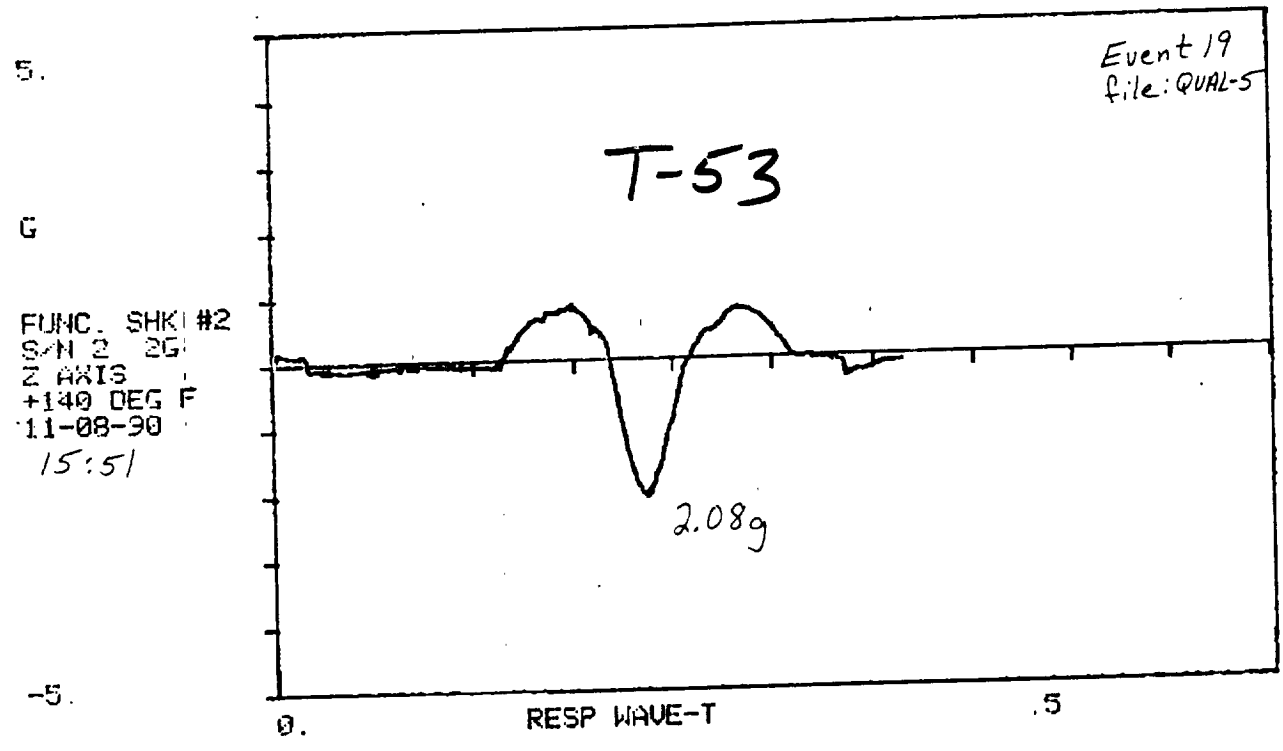


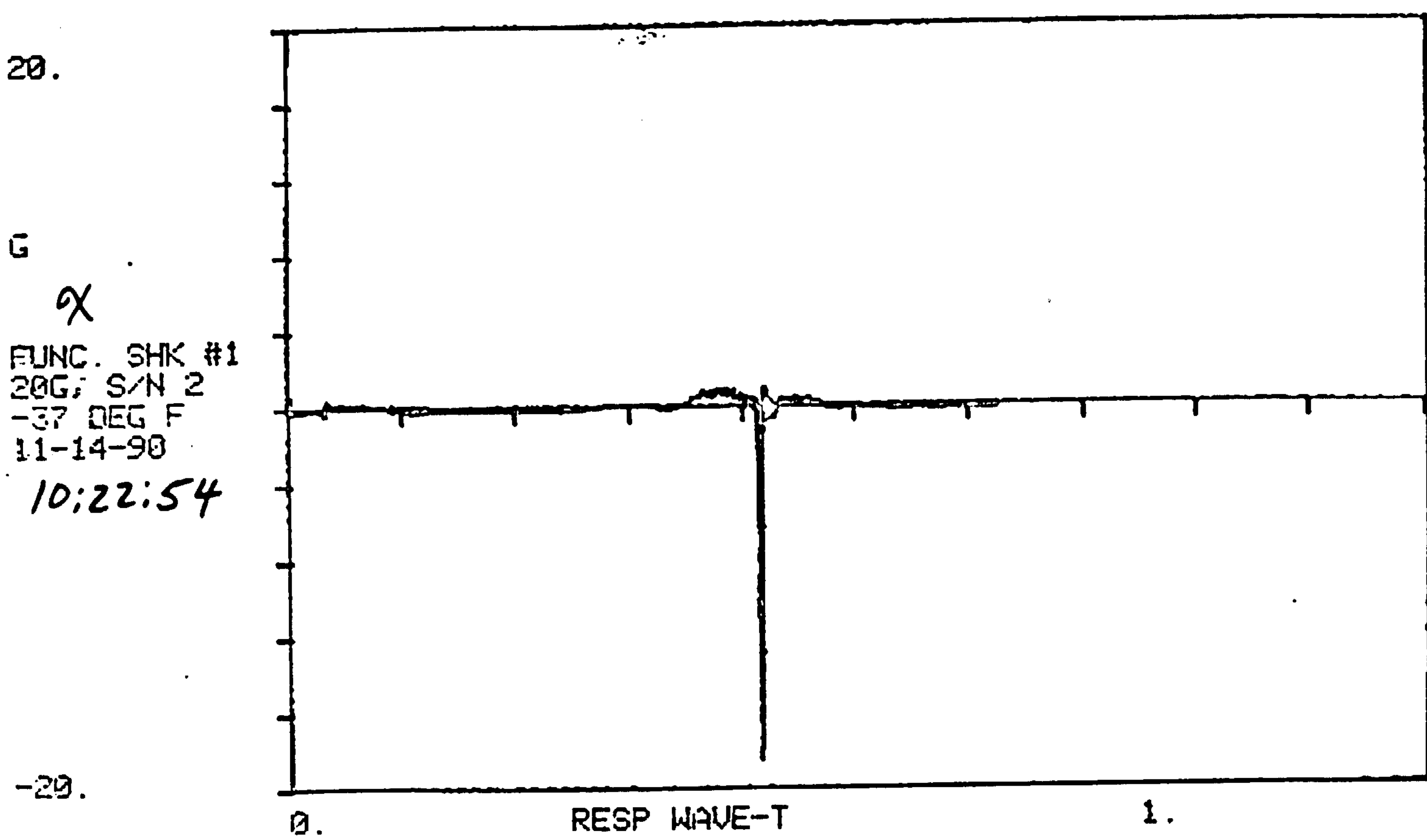







Event 19
file: QUAL-5
ACC(gs)
WINDOW- Z-Axis
2.1
1.2
0.4
-0.4
-1.2
-2.1
←Marker
144.9°F
2.06g
L-P1: 106 A1: -2.06Gs Delta-TIME: 0.00 msec
R-P2: 106 A2: -2.06Gs Delta-VEL: 0.0 in/sec
[20.00msec/div]
sz 1


Event 19
file: QUAL-5
T-53
5.
G
-5.
FUNC. SHK #2
S/N 2 2G
Z AXIS
+140 DEG F
11-08-90
15:51
2.08g
0.
RESP WAVE-T
.5



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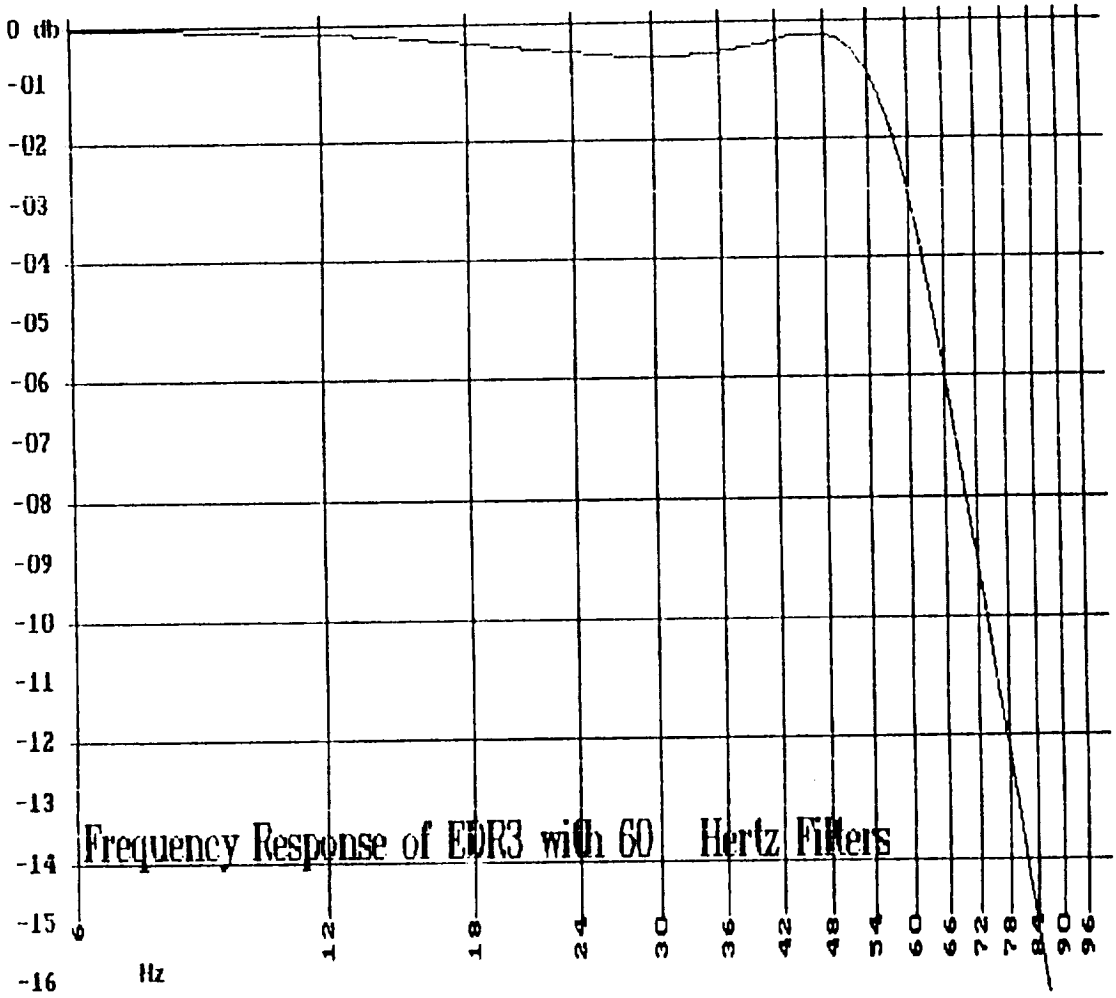

0 db
-01
-02
-03
-04
-05
-06
-07
-08
-09
-10
-11
-12
-13
-14
-15
-16
Hz
6
12
18
24
30
36
42
48
54
60
66
72
78
84
90
96
Frequency Response of EDR3 with 60 Hertz Filters

Appendix C

17- and 44- Day Test Data and Acceleration Event Test Data

Appendix C

17 & 44 Day Test Data and Acceleration Event Test Data

This appendix contains sample data from the EDR testing conducted per CTP-0223A. All data collected demonstrated full compliance to the test objectives.

Page	Description
C-3	Test results from the 17 and 44 day test. With the EDR mounted in the X-axis, the unit was subjected to four 2g shocks at three temperature ranges. The purpose of these test was to verify the power supply was capable of operating the unit for a minimum of 17 days. All percent error calculations indicate full compliance with acceleration accuracy test objectives.
C-4 to C-9	17 and 44 day shock sample plots. The top portion of each page is the EDR recorded shock plot. The bottom portion of each page is the T-53 test facility shock plot.
C-4	17 Day test at -35 +/- 5 Degree F.
C-5	17 Day test at 70 +/- 5 Degree F.
C-6	17 Day test at 145 +/- 5 Degree F.
C-7	44 Day test at -35 +/- 5 Degree F.
C-8	44 Day test at 70 +/- 5 Degree F.
C-9	44 Day test at 145 +/- 5 Degree F.
C-10 to C-11	EDR Vibration Frame Report for the Acceleration Event test indicating that fifty triggered events were recorded by the unit. During this portion of the test, the unit was subjected to a sinusoidal dwell for four minutes. This was conducted to demonstrate that the recording unit is capable of recording and storing fifty triggered events.
C-12	Expanded acceleration plots for Event #1 from the Acceleration Event test. The top portion is a plot of all axes. The bottom portion is an expanded plot of the X-axis.
C-13 to C-17	Condensed plots (10 per page) of all fifty triggered events recorded and stored by the EDR during the Acceleration Event test.

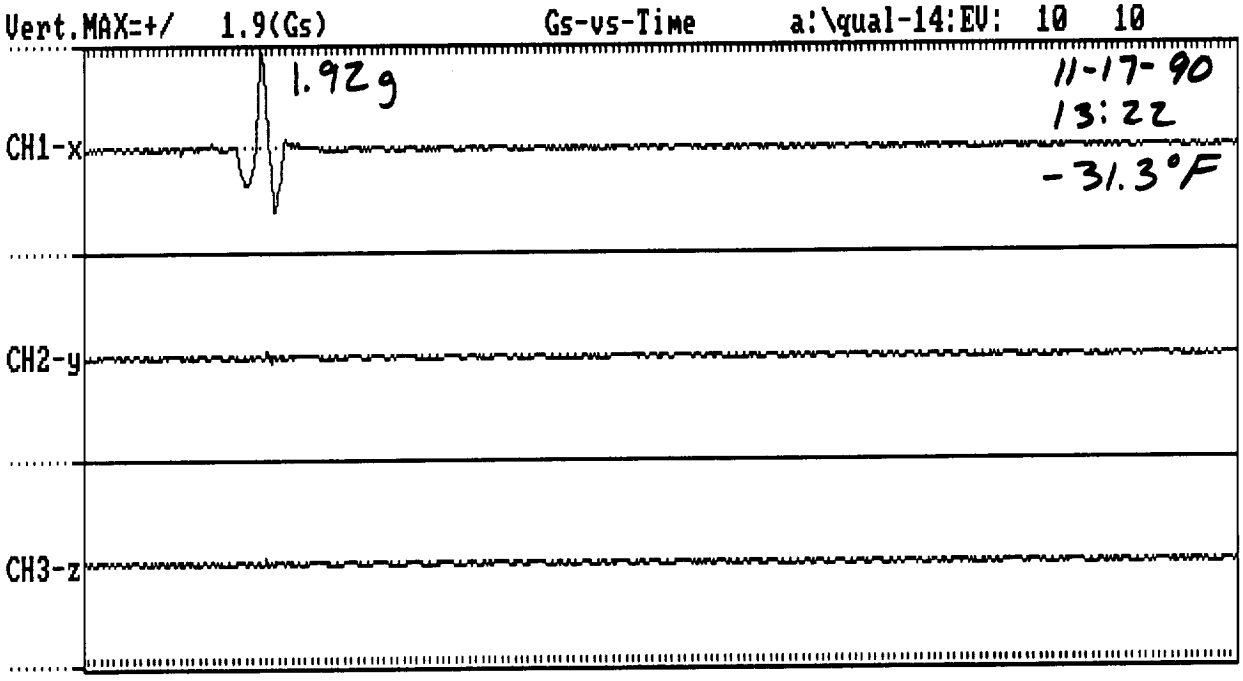
17 DAY TEST RESULTS

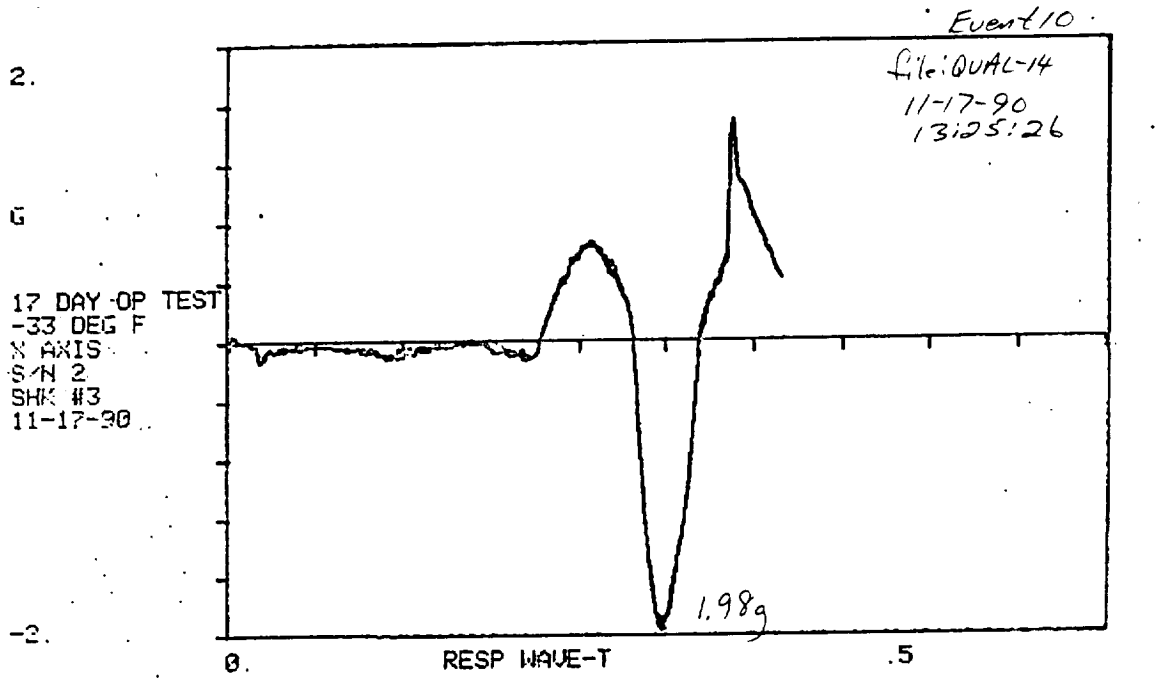
-35 Degree F			70 Degree F			145 Degree F		
EDR	T-53	%Error	EDR	T-53	%Error	EDR	T-53	%Error
2.72g	2.71g	0.4%	2.70g	2.71g	-0.4%	2.66g	2.68g	-0.7%
1.92g	2.04g	-5.9%	2.68g	2.73g	-1.8%	2.70g	2.62g	3.1%
*1.92g	1.98g	-3.0%	*2.70g	2.71g	-0.4%	*2.68g	2.60g	3.1%
1.88g	2.05g	-8.3%	2.72g	2.71g	0.4%	2.66g	2.60g	2.3%
1.94g	2.00g	-3.0%						

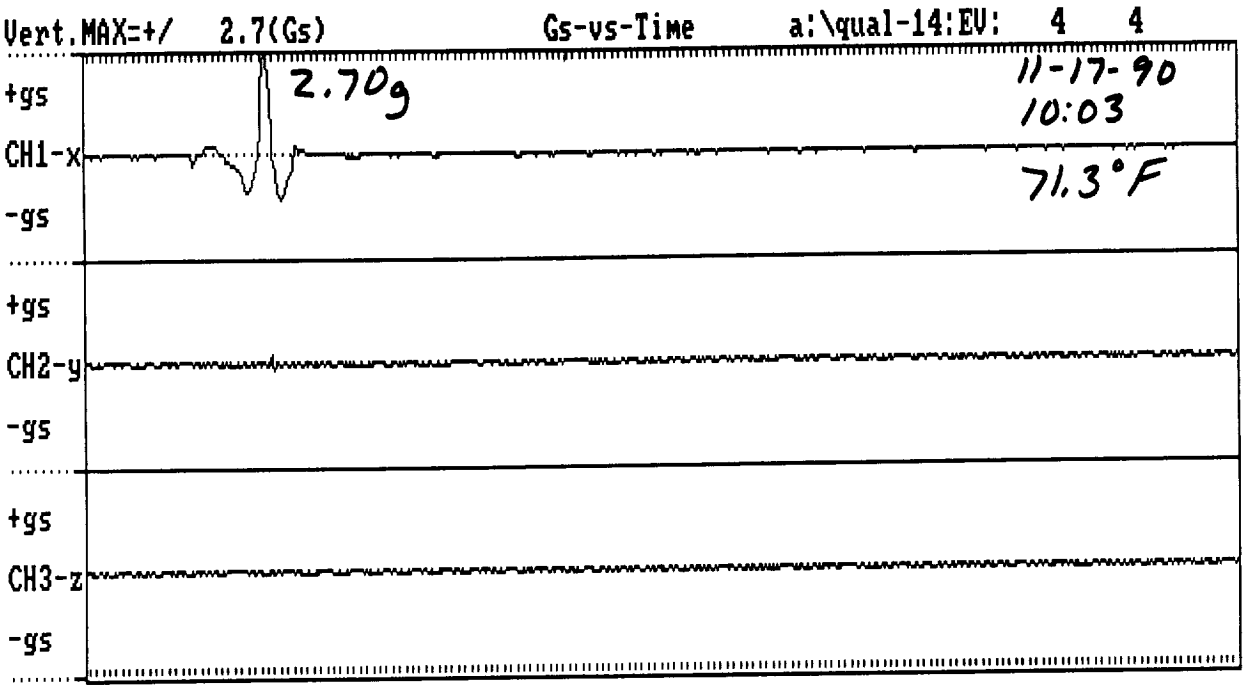
44 DAY TEST RESULTS

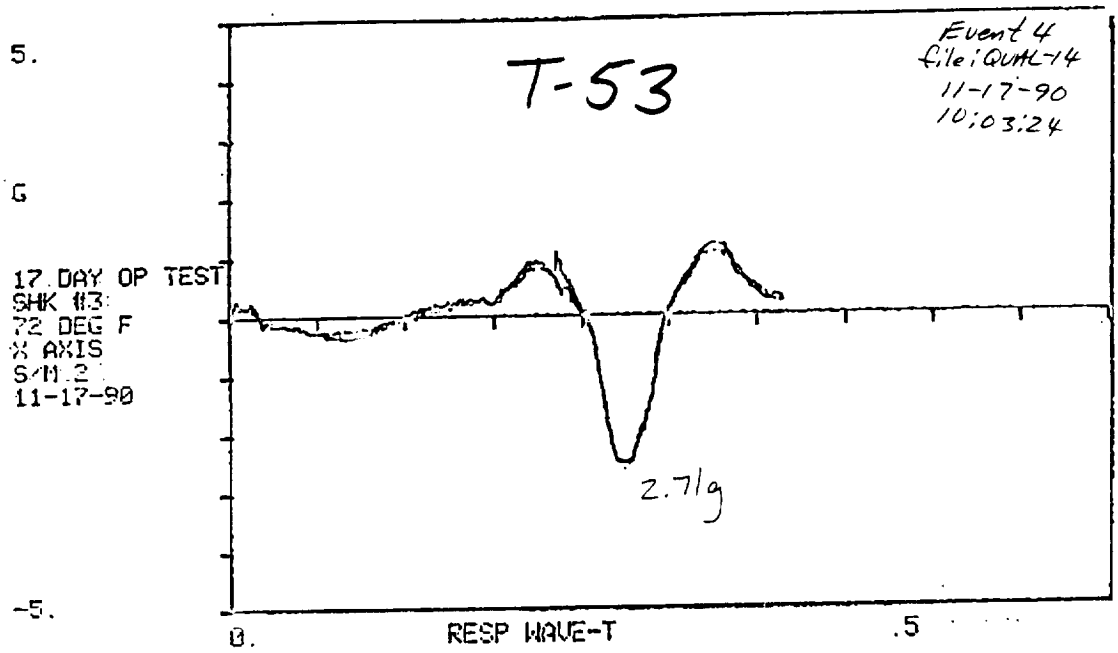
-35 Degree F			70 Degree F			145 Degree F		
EDR	T-53	%Error	EDR	T-53	%Error	EDR	T-53	%Error
2.38g	2.33g	-0.8%	*2.42g	2.44g	2.1%	2.46g	2.40g	2.5%
*2.30g	2.33g	0.8%	2.42g	2.40g	-1.3%	2.46g	2.33g	5.6%
2.40g	2.33g	-1.7%	2.36g	2.40g	3.0%	*2.50g	2.42g	3.3%
2.36g	2.33g	0.8%	2.42g	2.40g	1.3%	2.44g	2.37g	3.0%

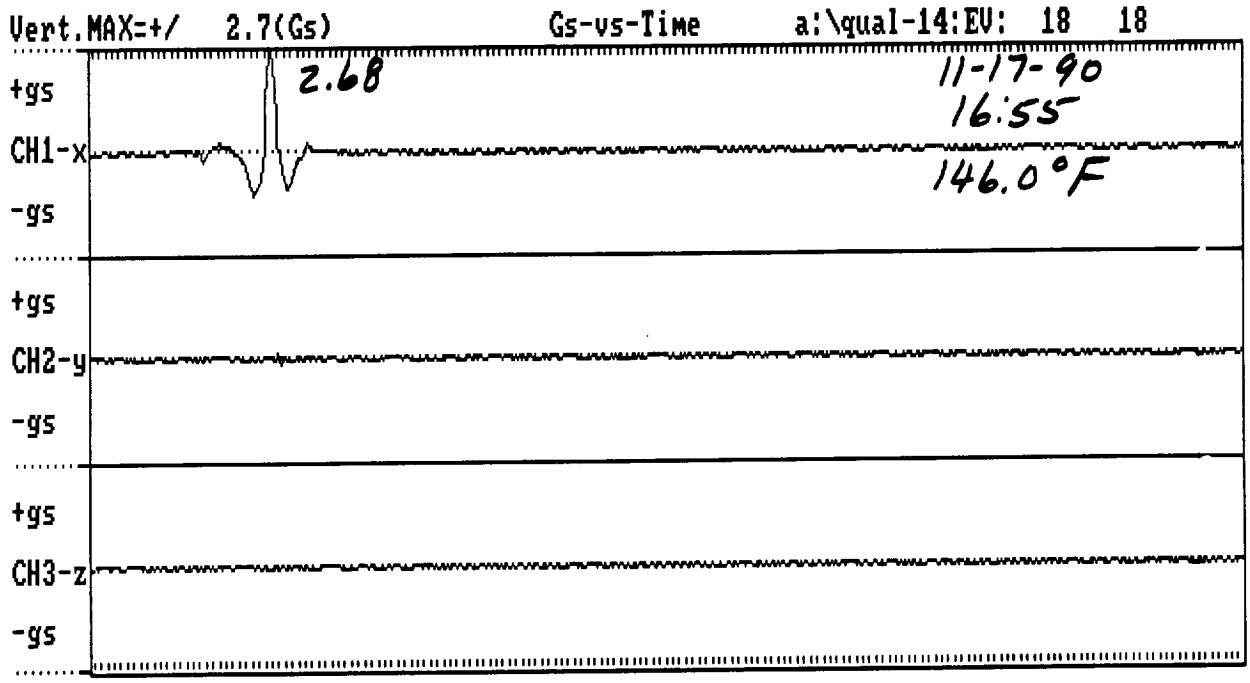
* Time vs acceleration plots available for review in this appendix pages C-4 through C-9.

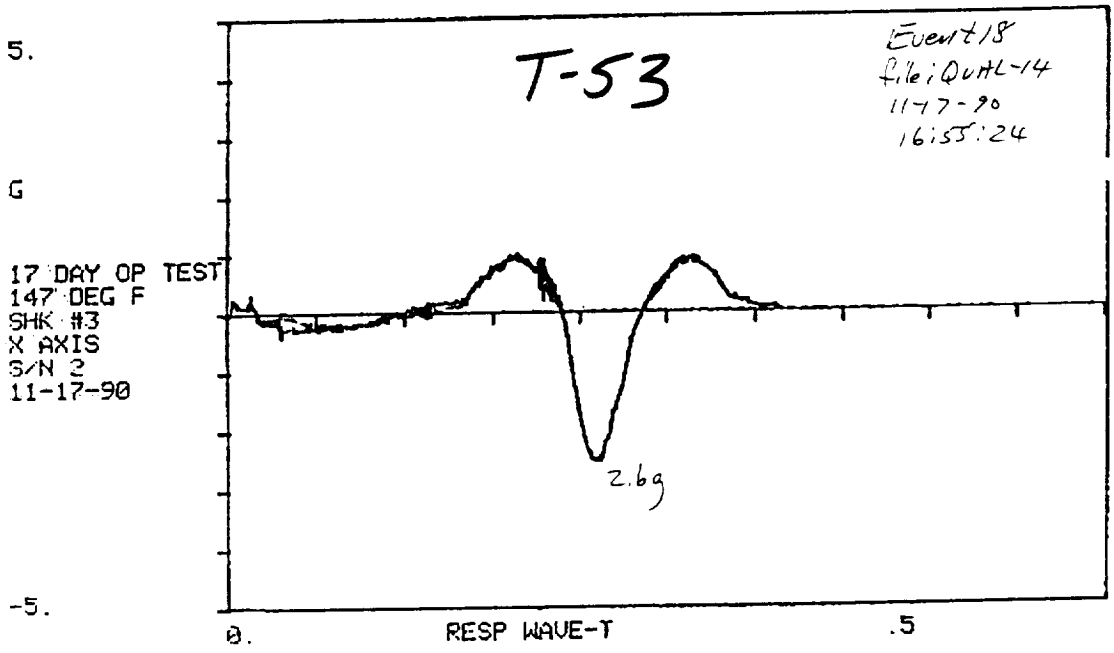


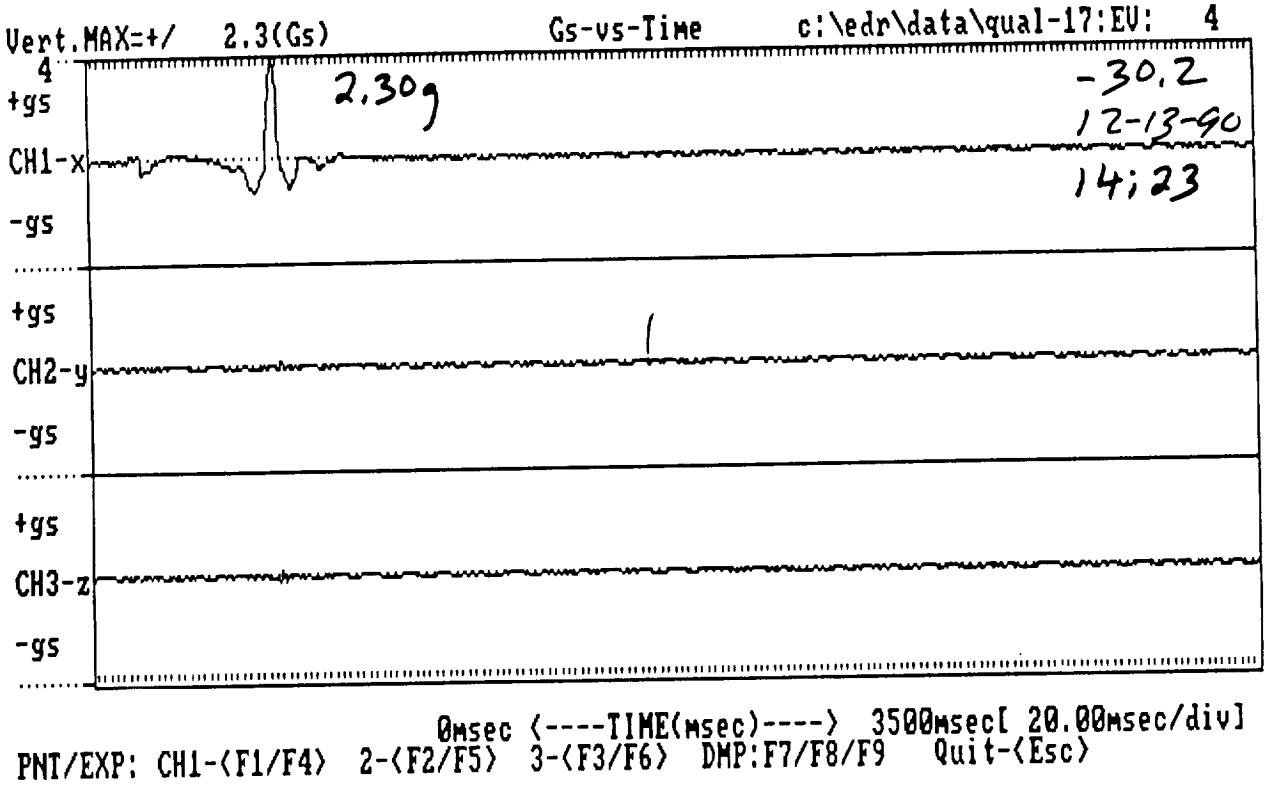


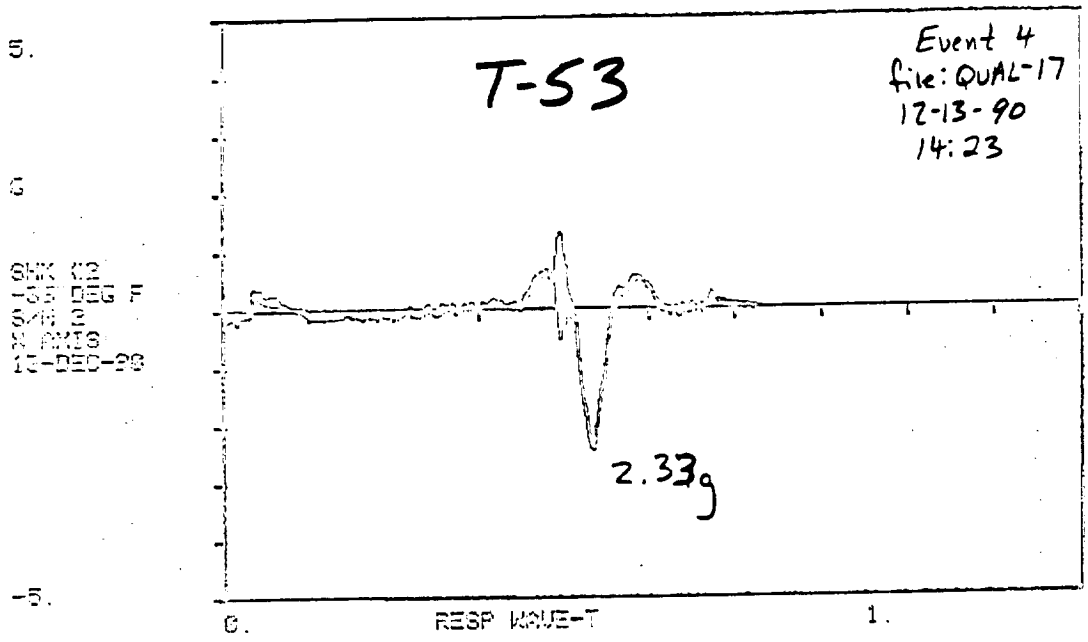

Vert.MAX=+/ 2.7(Gs)
Gs-vs-Time
a:\qual-14:EV: 4 4
2.70g
11-17-90
10:03
71.3°F
+gs
CH1-x
-gs
+gs
CH2-y
-gs
+gs
CH3-z
-gs
0msec <----TIME(msec)----> 3500msec[20.00msec/div]
PNT/EXP: CH1-<F1/F4> 2-<F2/F5> 3-<F3/F6> DMP:F7/F8/F9 Quit-<Esc>


T-53
Event 4
file: QUAL-14
11-17-90
10:03:24
5.
G
17 DAY OP TEST
SHK #3
72 DEG F
X AXIS
S/N 2
11-17-90
2.71g
-5.
0.
RESP WAVE-T
.5









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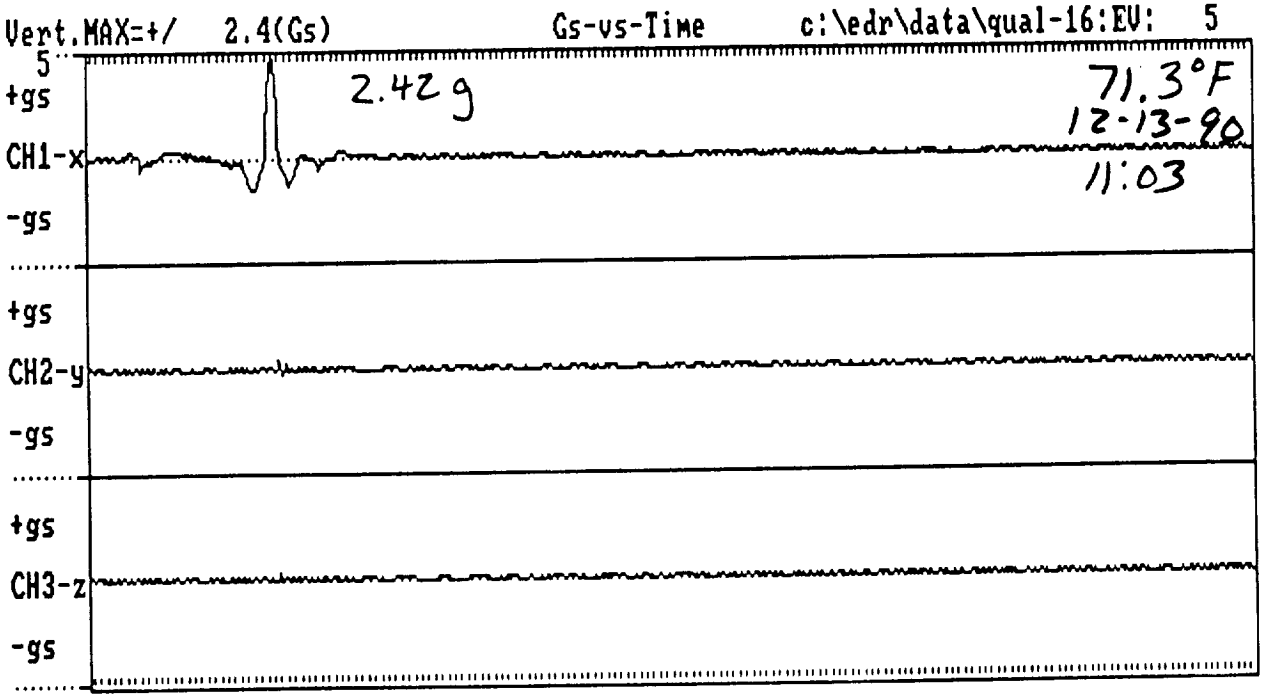

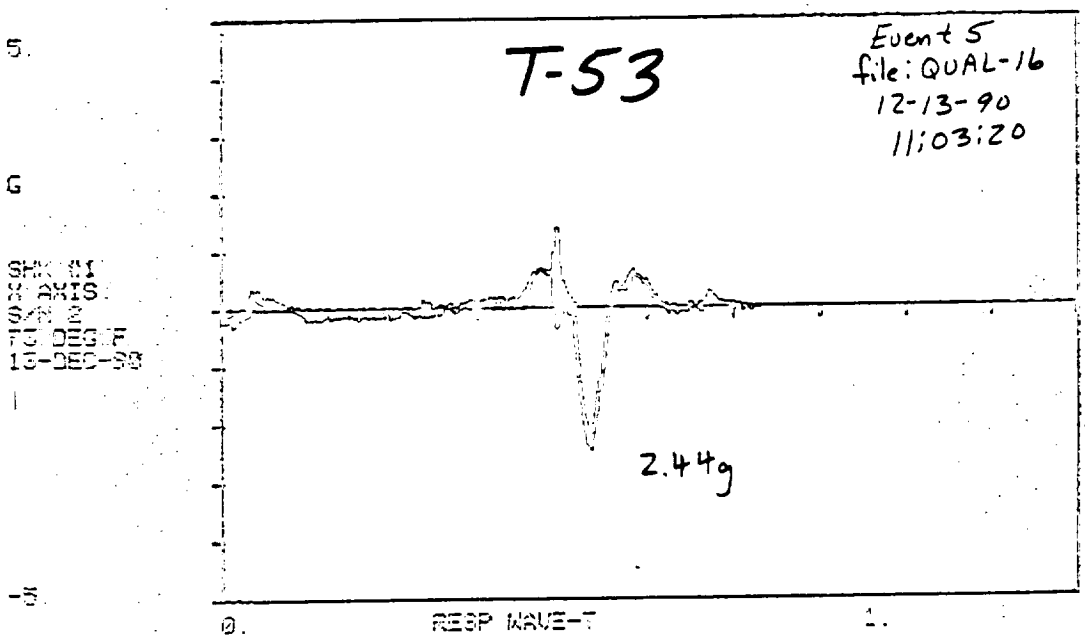

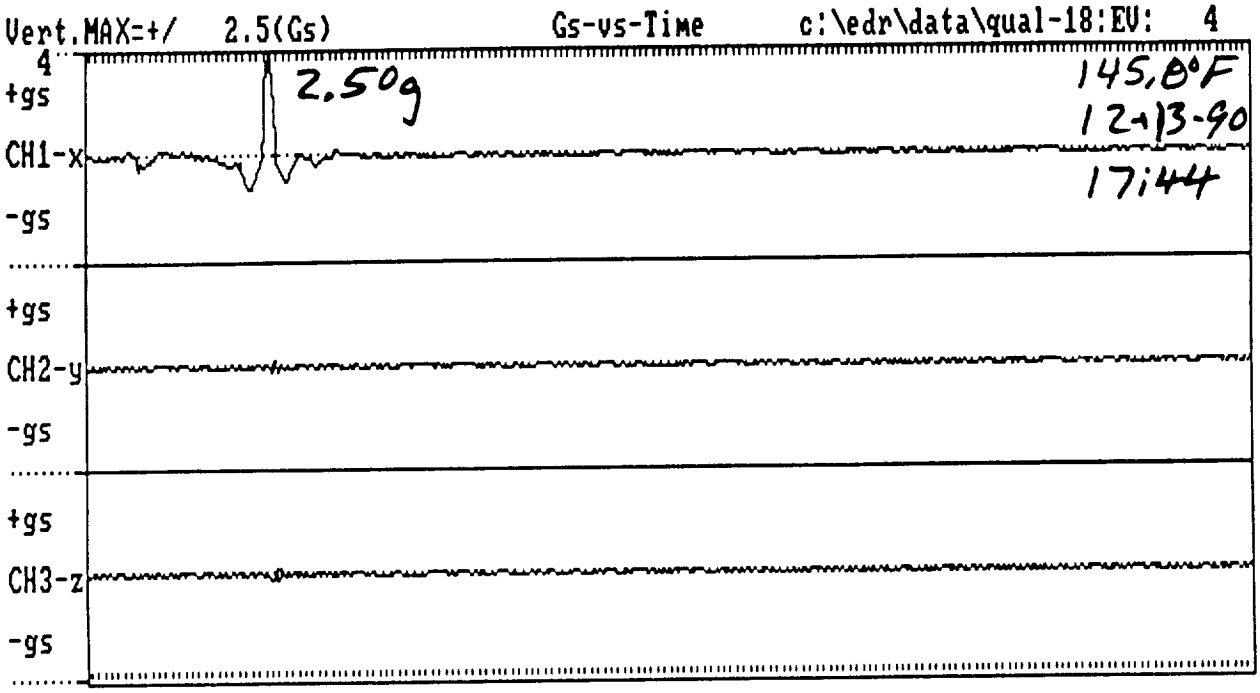

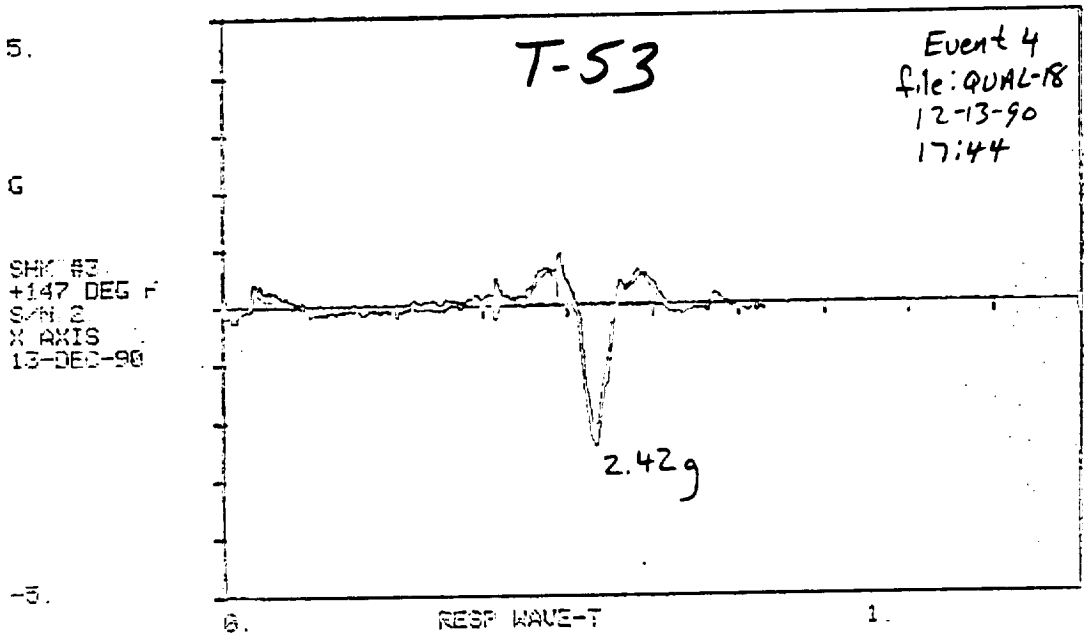

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VIBRATION FRAME REPORT
Report Date:12-18-1990
Report Ident: Acceleration Event Test for Qual

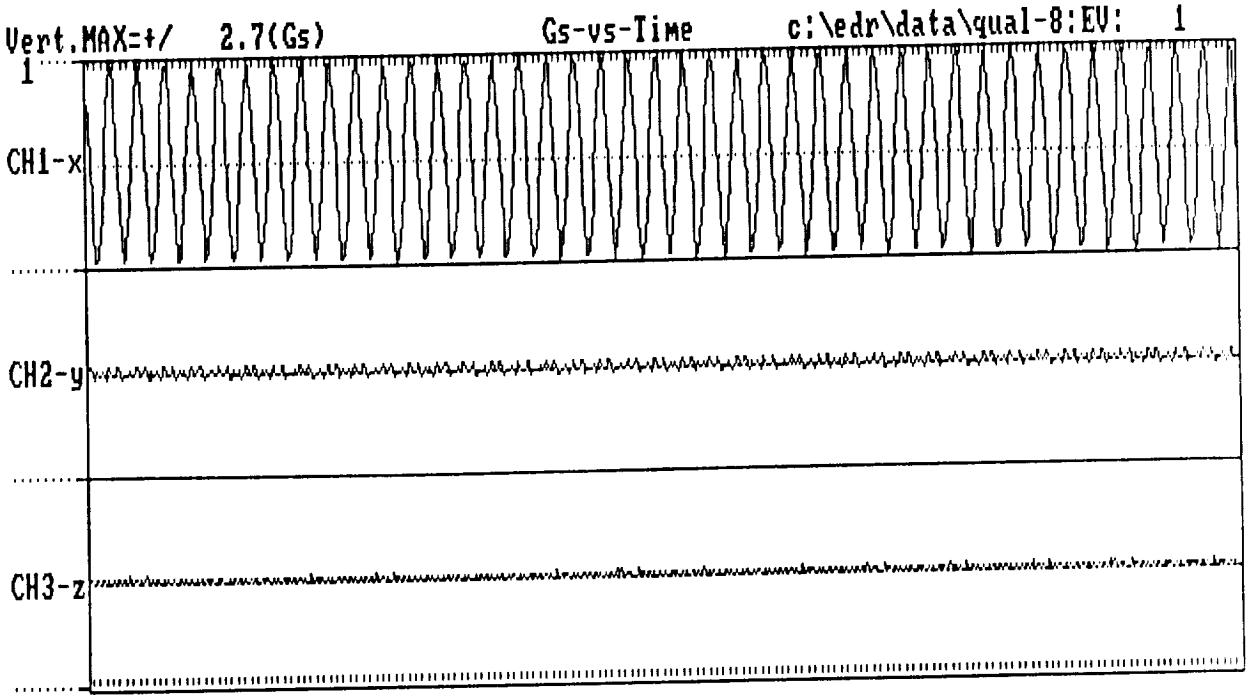
File: QUAL-8
(Peak Levels- Gs RMS levels- Gs Crest Factors Pk/RMS)
File Contains 50 Acceleration Frames

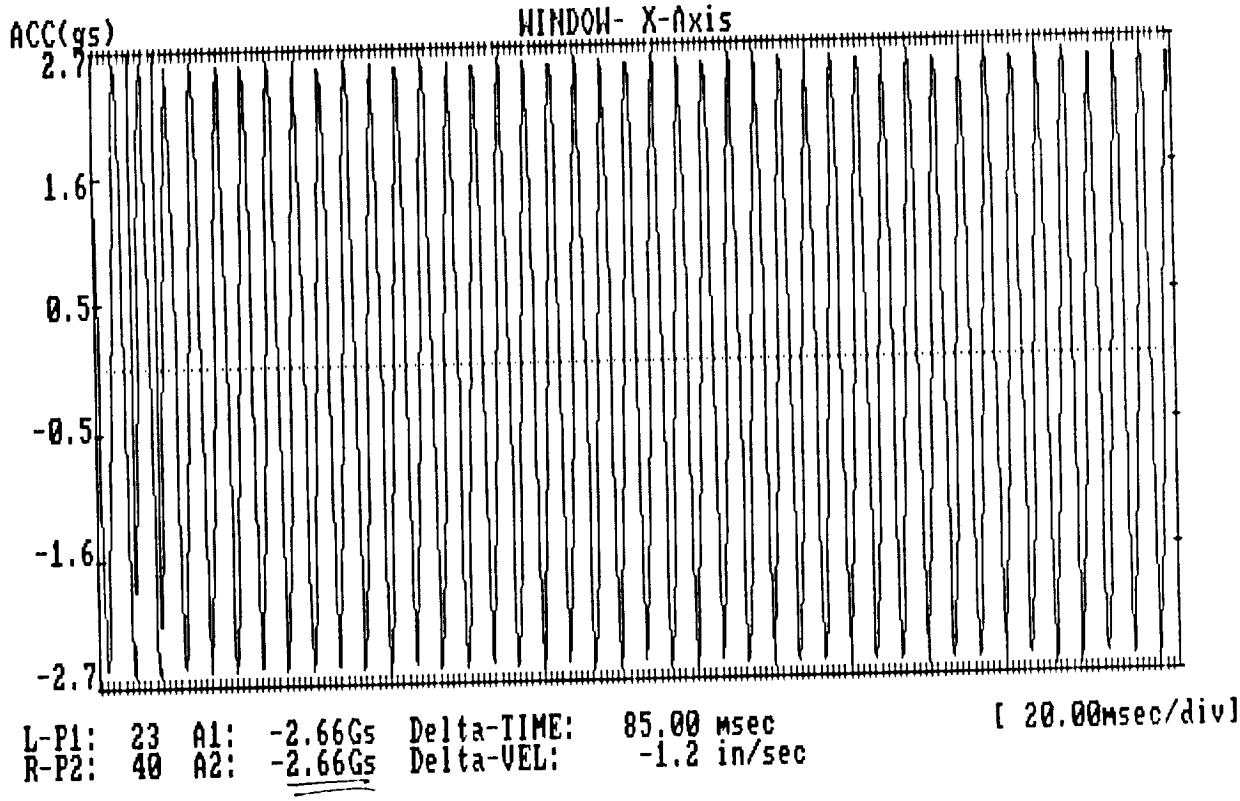
		Peak G levels			RMS levels			Crest Factors		
No.	Time	+ 1-x -	+ 2-y -	+ 3-z -	1-x	2-y	3-z	1-x	2-y	3-z
111/13/90	08:20:42	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
211/13/90	08:20:46	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
311/13/90	08:20:49	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
411/13/90	08:20:53	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
511/13/90	08:20:56	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
611/13/90	08:21:00	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
711/13/90	08:21:03	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
811/13/90	08:21:07	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
911/13/90	08:21:10	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
1011/13/90	08:21:14	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
1111/13/90	08:21:17	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
1211/13/90	08:21:21	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
1311/13/90	08:21:24	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
1411/13/90	08:21:28	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
1511/13/90	08:21:31	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
1611/13/90	08:21:35	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
1711/13/90	08:21:38	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
1811/13/90	08:21:42	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
1911/13/90	08:21:45	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
2011/13/90	08:21:49	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
2111/13/90	08:21:52	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
2211/13/90	08:21:56	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
2311/13/90	08:21:59	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
2411/13/90	08:22:03	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
2511/13/90	08:22:06	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
2611/13/90	08:22:10	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
2711/13/90	08:22:13	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
2811/13/90	08:22:17	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
2911/13/90	08:22:20	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
3011/13/90	08:22:24	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
3111/13/90	08:22:27	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
3211/13/90	08:22:31	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
3311/13/90	08:22:34	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
3411/13/90	08:22:38	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
3511/13/90	08:22:41	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
3611/13/90	08:22:45	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
3711/13/90	08:22:48	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
3811/13/90	08:22:52	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
3911/13/90	08:22:55	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
4011/13/90	08:22:59	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
4111/13/90	08:23:02	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
4211/13/90	08:23:06	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
4311/13/90	08:23:09	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
4411/13/90	08:23:13	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2

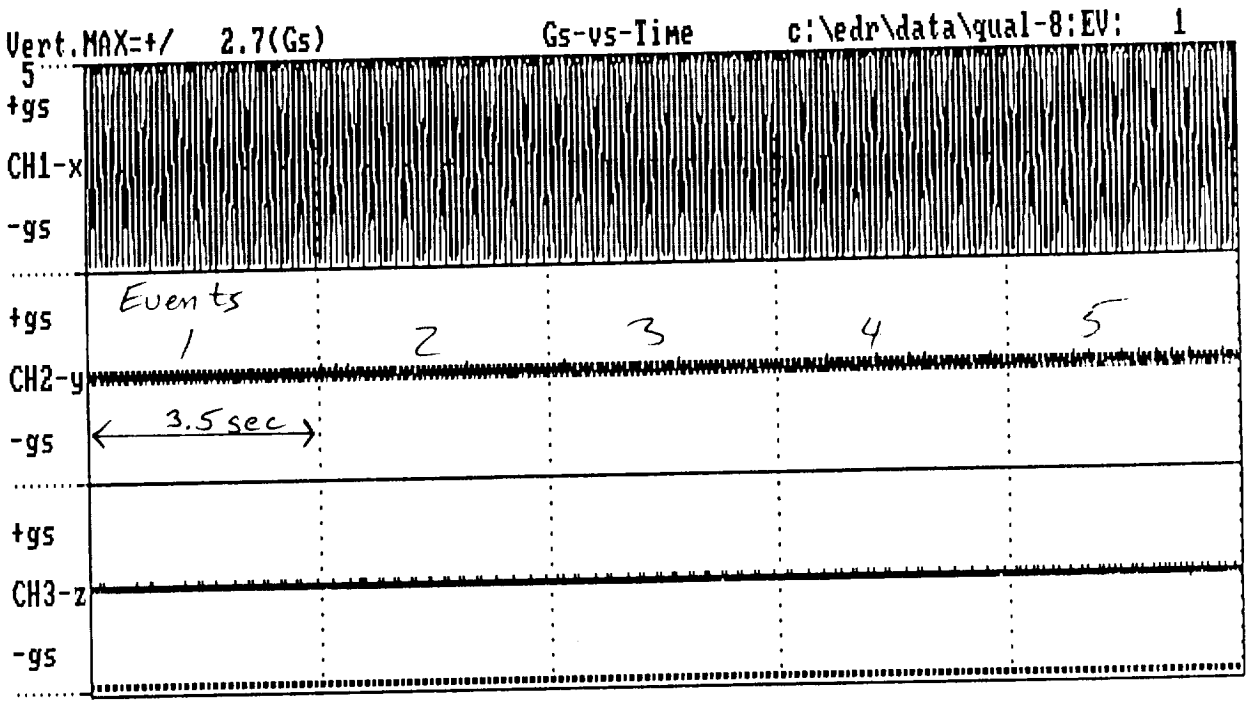
VIBRATION FRAME REPORT
Report Date:12-18-1990
Report Ident: Acceleration Event Test for Qual

File: QUAL-8
(Peak Levels- Gs RMS levels- Gs Crest Factors Pk/RMS)
File Contains 50 Acceleration Frames

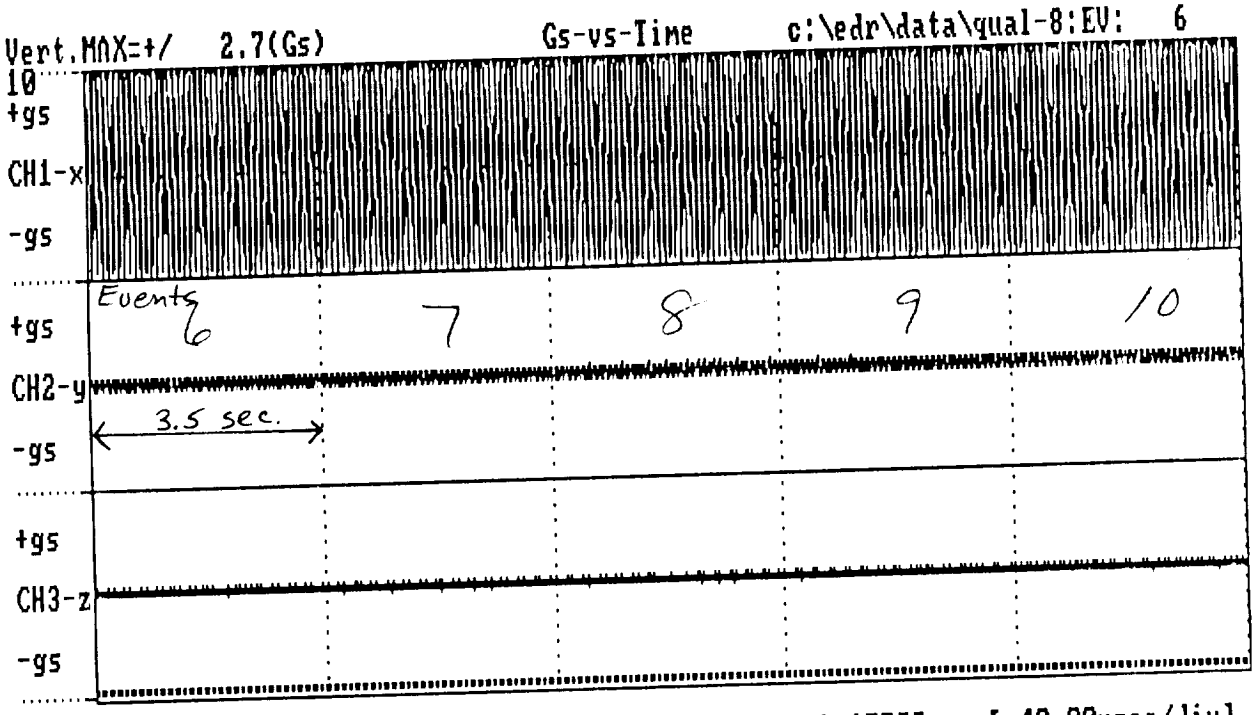
			Peak G levels					RMS levels			Crest Factors		
No.	Date	Time	+ 1-x -	+ 2-y -	+ 3-z -	1-x	2-y	3-z	1-x	2-y	3-z
45	11/13/90	08:23:16	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
46	11/13/90	08:23:20	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
47	11/13/90	08:23:23	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
48	11/13/90	08:23:27	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
49	11/13/90	08:23:30	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2
50	11/13/90	08:23:34	2.7/ 2.7	0.2/ 0.2	0.1/ 0.1	1.9	0.1	0.1	1	2	2







11-13-90



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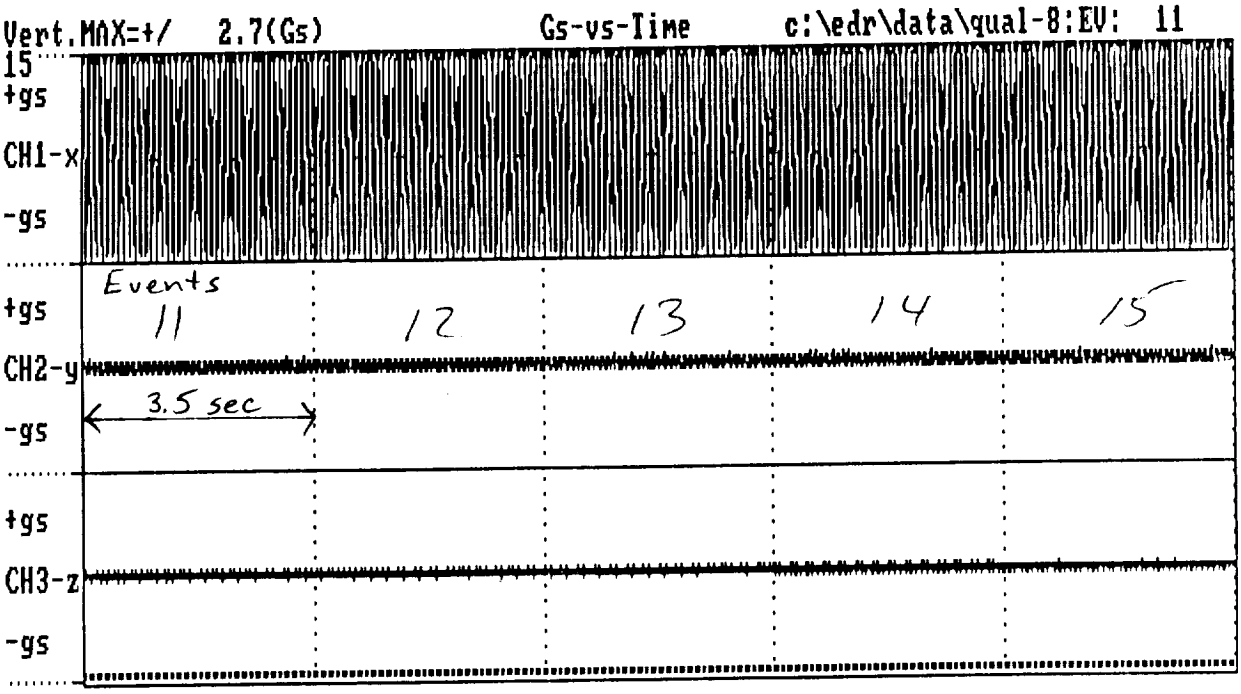
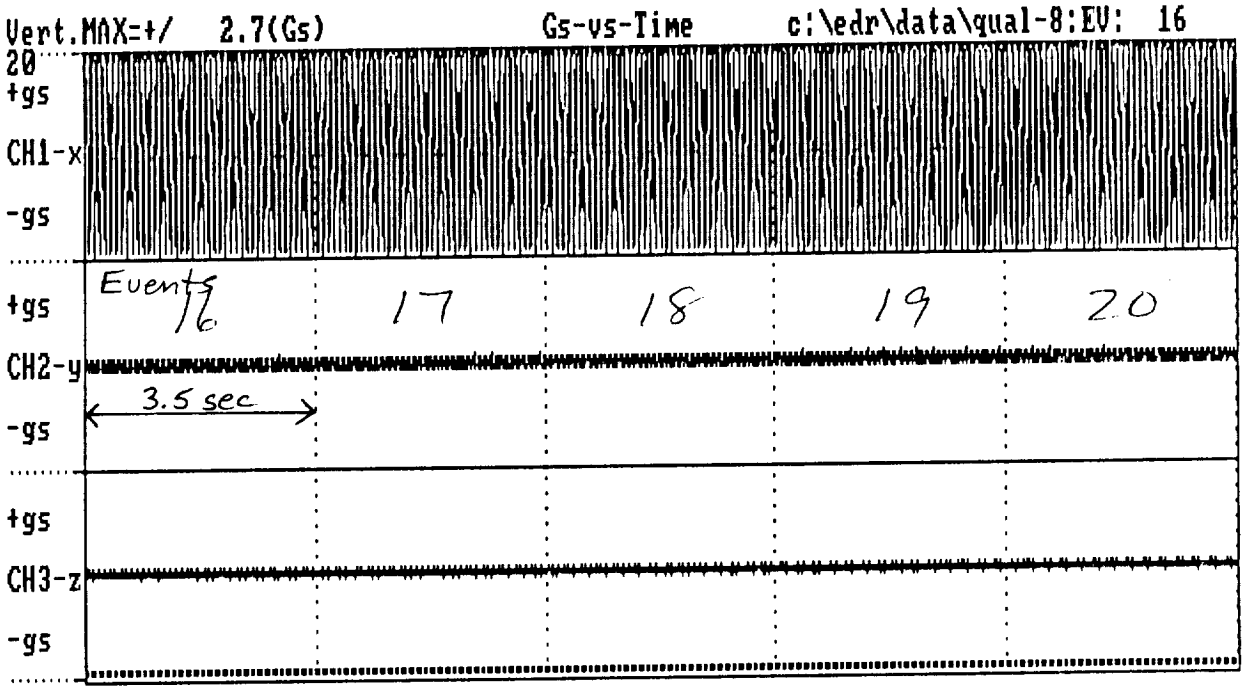
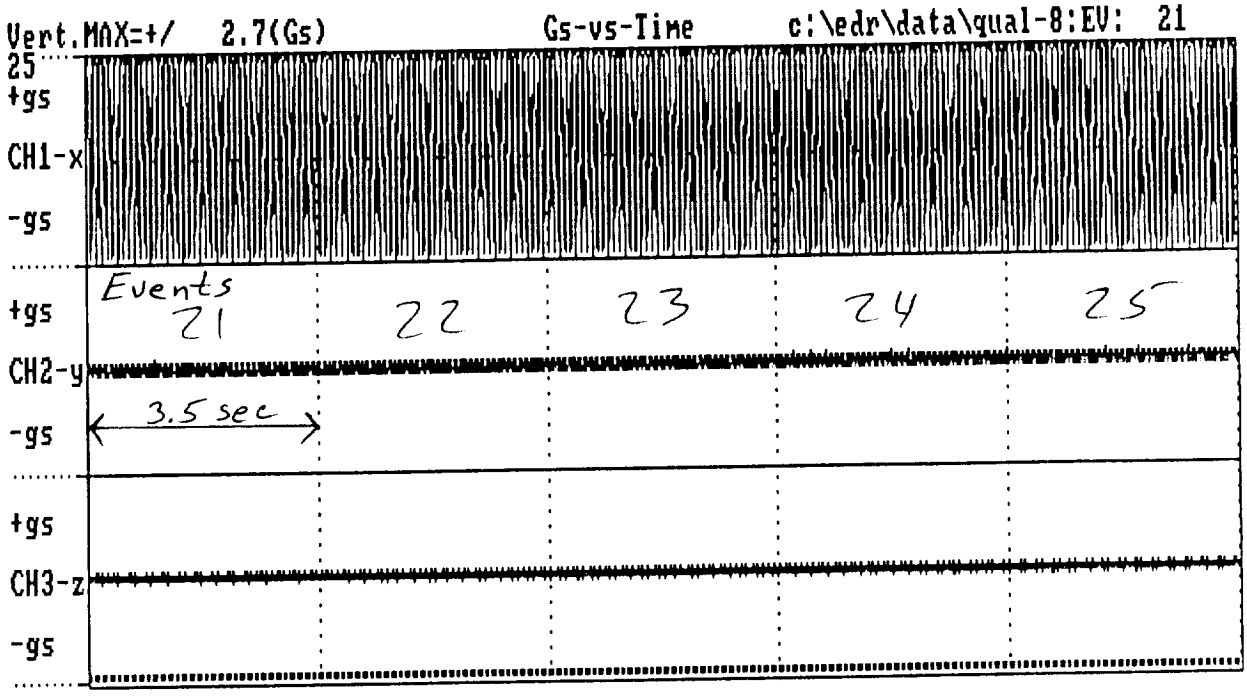
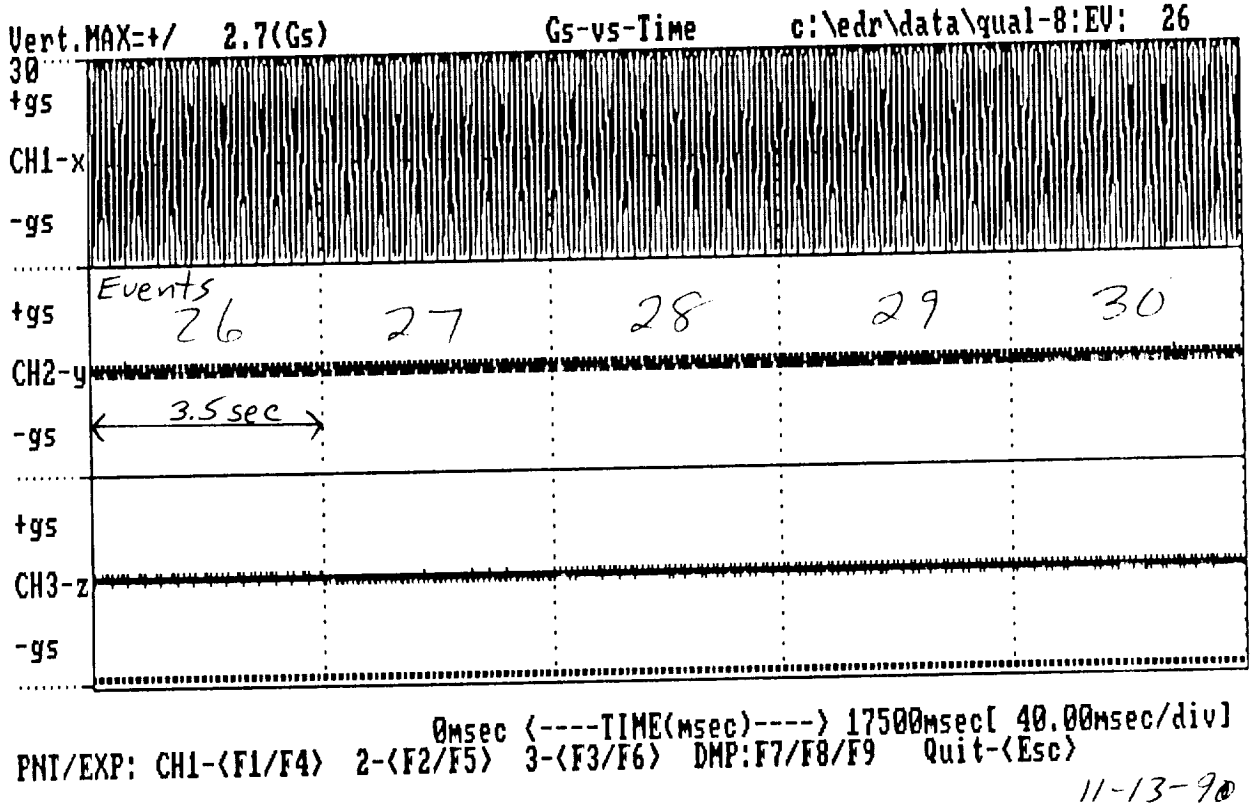
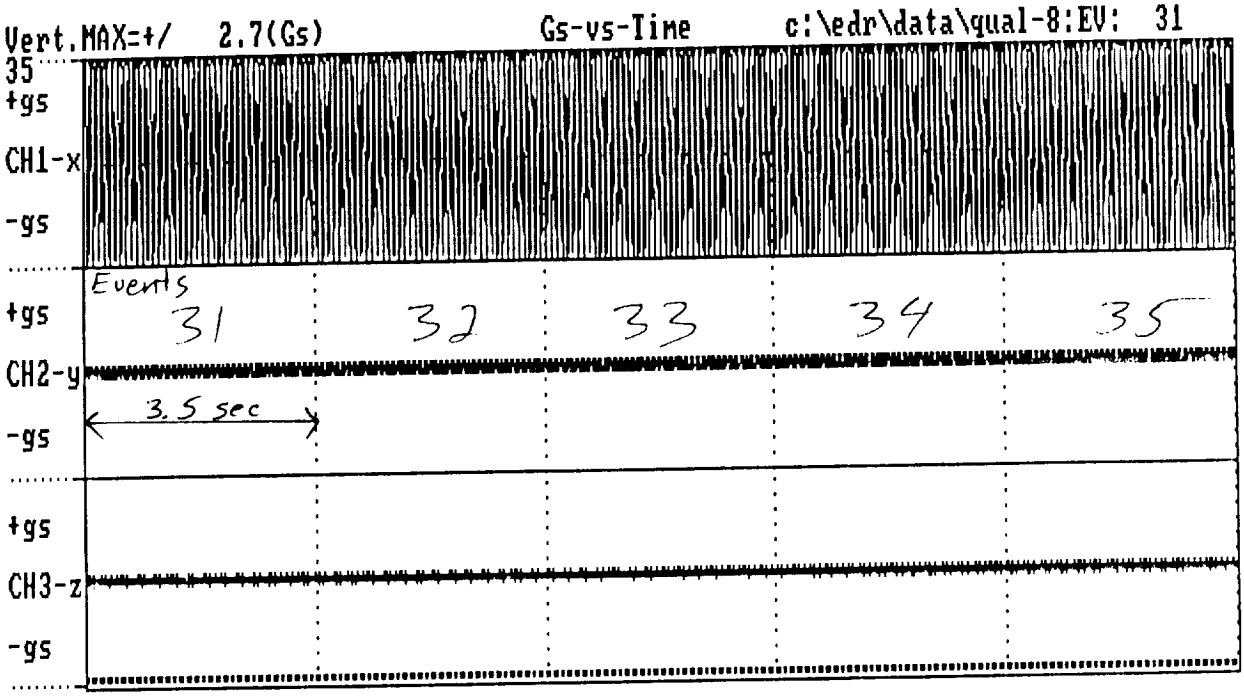
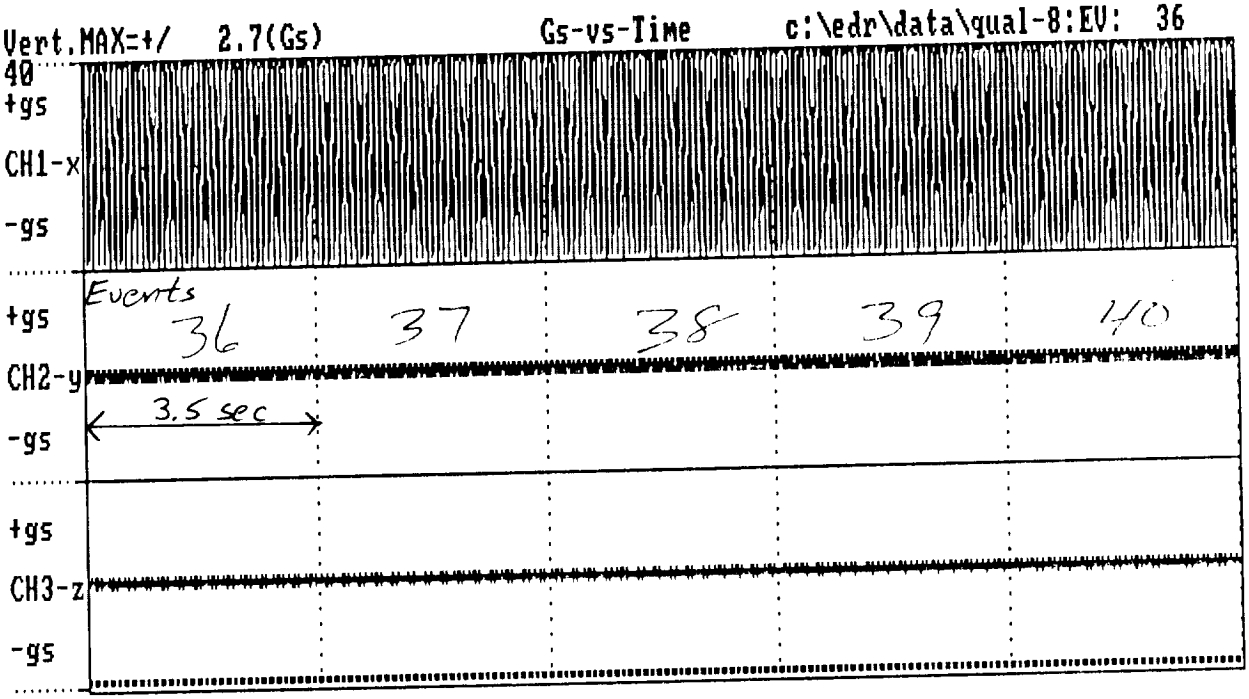


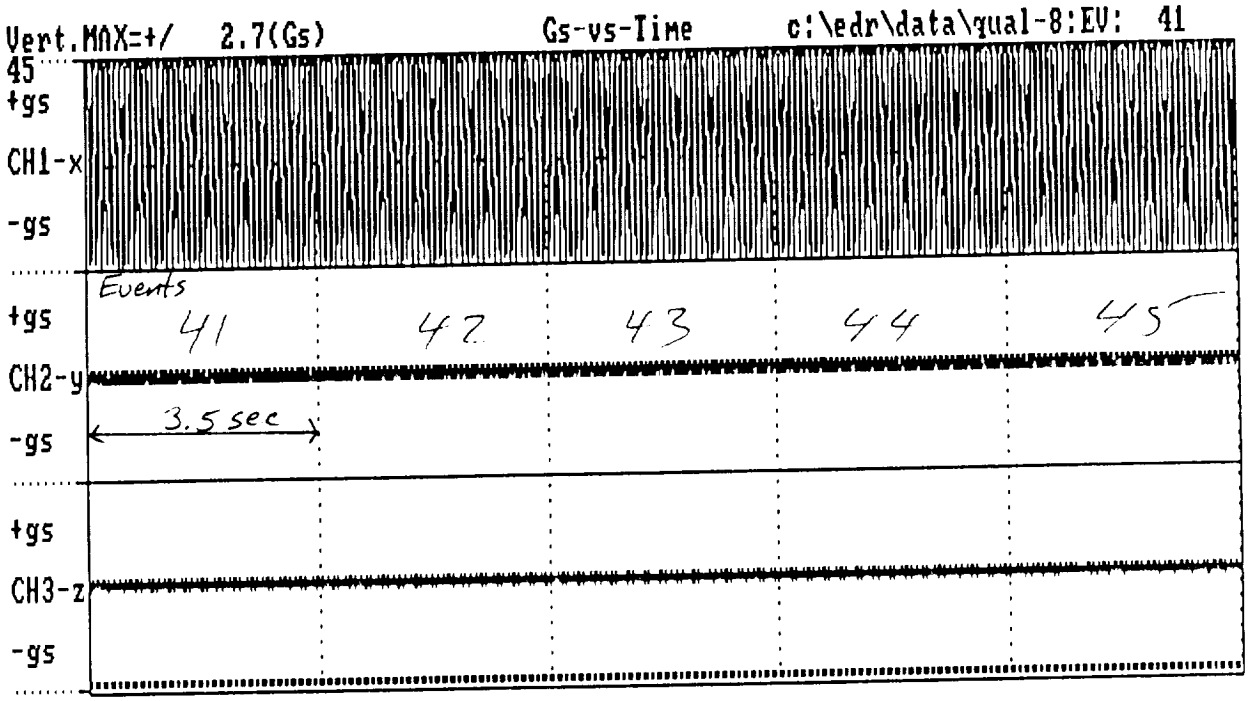



Vert.MAX=+/ 2.7(Gs)
Gs-vs-Time
c:\edr\data\qual-8:EV: 21
25
+gs
CH1-x
-gs
Events
21
22
23
24
25
+gs
CH2-y
3.5 sec
-gs
+gs
CH3-z
-gs
0msec <----TIME(msec)----> 17500msec[40.00msec/div]
PNT/EXP: CH1-<F1/F4> 2-<F2/F5> 3-<F3/F6> DMP:F7/F8/F9 Quit-<Esc>
11-13-90

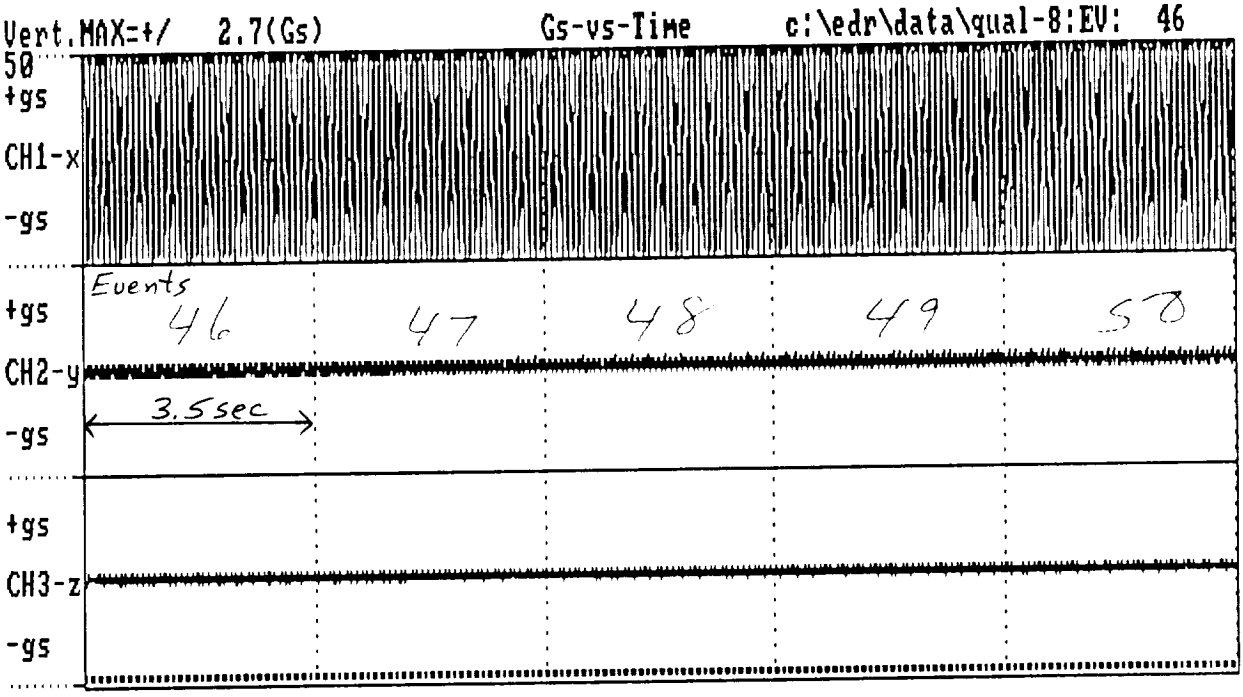

Vert.MAX=+/ 2.7(Gs)
Gs-vs-Time
c:\edr\data\qual-8:EV: 26
30
+gs
CH1-x
-gs
Events
26
27
28
29
30
+gs
CH2-y
3.5 sec
-gs
+gs
CH3-z
-gs
0msec <----TIME(msec)----> 17500msec[40.00msec/div]
PNT/EXP: CH1-<F1/F4> 2-<F2/F5> 3-<F3/F6> DMP:F7/F8/F9 Quit-<Esc>
11-13-90


Vert.MAX=+/ 2.7(Gs)
Gs-vs-Time
c:\edr\data\qual-8:EV: 31
35
+gs
CH1-x
-gs
Events
31
32
33
34
35
+gs
CH2-y
3.5 sec
-gs
+gs
CH3-z
-gs
0msec (----TIME(msec)----) 17500msec[40.00msec/div]
PNT/EXP: CH1-(F1/F4) 2-(F2/F5) 3-(F3/F6) DMP:F7/F8/F9 Quit-(Esc)
11-13-90


Vert.MAX=+/ 2.7(Gs)
Gs-vs-Time
c:\edr\data\qual-8:EV: 36
40
+gs
CH1-x
-gs
Events
36
37
38
39
40
+gs
CH2-y
3.5 sec
-gs
+gs
CH3-z
-gs
0msec (----TIME(msec)----) 17500msec[40.00msec/div]
PNT/EXP: CH1-(F1/F4) 2-(F2/F5) 3-(F3/F6) DMP:F7/F8/F9 Quit-(Esc)
11-13-90



11-13-90



11-13-90

Appendix D

Metrology Lab Report Memo, 7316-FY91-M494
Environmental Data Recording Unit, 8U77299-01, S/N 0000002

Thiokol CORPORATION
STRATEGIC OPERATIONS

14 December 1990
7316-FY91-M494

TO: K. G. Rees, Engineer
Ignition, Instrumentation & Electrical Design

FROM: D. L. McEwan, Sr. Engineer
Metrology Laboratory

SUBJECT: Calibration Results, TRANSPORTATION RECORDING UNIT, 8U77299-01, S/N 0000002.

Per your request, the following information is provided relative to the Transportation Recording Unit subject.

This is the initial calibration on the S/N 2 Transportation Recording Unit. Two series of tests were performed: temperature and vibration. Tests were completed on 19 September 1990. The calibration control number assigned is SL-36200. The unit is due for recalibration on 18 March 1991.

TEMPERATURE
The unit was exposed to five temperatures: -36.5, +3.1, +47.6, +90.9, and +139.3 Degree F. The temperature data was then down-loaded and compared to the standard data. All temperature readings were within the 5 Degree F. tolerance.

VIBRATION
The unit was exposed to five peak to peak g's at 15 Hz: 1, 3, 5, 7, and 9 g's. The g readings were then down-loaded, and compared to the standard data. All g readings were within the 10% tolerance.

DLMcEwan
David L. McEwan

DLM/dmi

Appendix E

Temperature Test Data

Appendix E

Temperature Test Data

This appendix contains sample temperature data from the EDR functional test conducted per CTP-0223A. All data collected demonstrated full compliance to the test objectives.

Page	Description
E-3 to E-6	EDR temperature report from 14 Nov 90 to 17 Nov 90.
E-7	Sample temperature data. EDR measured temperature vs. T-53 test facility.
E-8	Temperature Plot of EDR measured temperatures.

Environmental Data Recorder: TEMPERATURE/HUMIDITY REPORT
Report Date:01-07-1991
Report Ident:

File: QUAL-14
Temperatures (F)
File Contains 165 Temperature/Humidity Samples

SAMPLE NO.	DATE	TIME	TEMPERATURE	%REL.HUMIDITY
1	11/14/90	10:49:27	-30	26
2	11/14/90	10:49:42	-30	26
3	11/14/90	11:19:31	53	98
4	11/14/90	11:49:19	70	35
5	11/14/90	12:19:08	71	23
6	11/14/90	12:48:57	77	19
7	11/14/90	13:18:45	79	17
8	11/14/90	13:48:34	79	16
9	11/14/90	14:18:22	80	16
10	11/14/90	14:48:11	82	15
11	11/14/90	15:18:00	81	15
12	11/14/90	15:47:48	79	16
13	11/14/90	16:17:37	79	17
14	11/14/90	16:47:25	77	18
15	11/14/90	17:17:14	76	18
16	11/14/90	17:47:02	76	18
17	11/14/90	18:16:51	75	18
18	11/14/90	18:46:40	74	18
19	11/14/90	19:16:28	74	19
20	11/14/90	19:46:17	71	19
21	11/14/90	20:16:05	74	19
22	11/14/90	20:45:54	74	19
23	11/14/90	21:15:43	71	19
24	11/14/90	21:45:31	71	19
25	11/14/90	22:15:20	72	19
26	11/14/90	22:45:08	72	19
27	11/14/90	23:14:57	71	19
28	11/14/90	23:44:46	70	19
29	11/15/90	00:14:34	71	19
30	11/15/90	00:44:23	71	19
31	11/15/90	01:14:11	70	19
32	11/15/90	01:44:00	72	19
33	11/15/90	02:13:48	69	19
34	11/15/90	02:43:37	72	20
35	11/15/90	03:13:26	69	20
36	11/15/90	03:43:14	70	20
37	11/15/90	04:13:03	71	20
38	11/15/90	04:42:51	70	20
39	11/15/90	05:12:40	70	20
40	11/15/90	05:42:29	68	20
41	11/15/90	06:12:17	69	20
42	11/15/90	06:42:06	70	20
43	11/15/90	07:11:54	71	20
44	11/15/90	07:41:43	70	20

Environmental Data Recorder: TEMPERATURE/HUMIDITY REPORT
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Report Ident:

File: QUAL-14
Temperatures (F)
File Contains 165 Temperature/Humidity Samples

SAMPLE NO.	DATE	TIME	TEMPERATURE	%REL.HUMIDITY
45	11/15/90	08:11:31	70	19
46	11/15/90	08:41:20	68	19
47	11/15/90	09:11:09	70	19
48	11/15/90	09:26:31	69	19
49	11/15/90	09:27:55	70	19
50	11/15/90	09:30:57	69	18
51	11/15/90	09:31:13	69	19
52	11/15/90	10:01:02	71	18
53	11/15/90	10:30:51	70	19
54	11/15/90	11:00:39	71	19
55	11/15/90	11:30:28	70	18
56	11/15/90	12:00:16	71	18
57	11/15/90	12:30:05	72	18
58	11/15/90	12:59:54	74	18
59	11/15/90	13:29:42	71	18
60	11/15/90	13:59:31	72	18
61	11/15/90	14:29:19	74	18
62	11/15/90	14:59:08	72	18
63	11/15/90	15:28:56	74	18
64	11/15/90	15:58:45	75	17
65	11/15/90	16:28:34	74	18
66	11/15/90	16:58:22	74	18
67	11/15/90	17:28:11	71	18
68	11/15/90	17:57:59	72	17
69	11/15/90	18:27:48	74	18
70	11/15/90	18:57:37	74	17
71	11/15/90	19:27:25	72	17
72	11/15/90	19:57:14	71	17
73	11/15/90	20:27:02	71	17
74	11/15/90	20:56:51	70	17
75	11/15/90	21:26:39	71	17
76	11/15/90	21:56:28	71	17
77	11/15/90	22:26:17	71	17
78	11/15/90	22:56:05	71	16
79	11/15/90	23:25:54	71	16
80	11/15/90	23:55:42	70	16
81	11/16/90	00:25:31	69	16
82	11/16/90	00:55:20	69	16
83	11/16/90	01:25:08	70	16
84	11/16/90	01:54:57	70	16
85	11/16/90	02:24:45	70	16
86	11/16/90	02:54:34	70	16
87	11/16/90	03:24:23	70	16
88	11/16/90	03:54:11	70	16

Environmental Data Recorder: TEMPERATURE/HUMIDITY REPORT
Report Date:01-07-1991
Report Ident:

File: QUAL-14
Temperatures (F)
File Contains 165 Temperature/Humidity Samples

SAMPLE NO.	DATE	TIME	TEMPERATURE	%REL.HUMIDITY
89	11/16/90	04:24:00	69	16
90	11/16/90	04:53:48	70	16
91	11/16/90	05:23:37	70	16
92	11/16/90	05:53:25	70	16
93	11/16/90	06:23:14	71	16
94	11/16/90	06:53:03	70	16
95	11/16/90	07:22:51	69	16
96	11/16/90	07:52:40	69	16
97	11/16/90	08:22:28	72	16
98	11/16/90	08:52:17	70	16
99	11/16/90	09:22:06	70	17
100	11/16/90	09:51:54	71	17
101	11/16/90	10:21:43	71	16
102	11/16/90	10:51:31	70	16
103	11/16/90	11:21:20	72	17
104	11/16/90	11:51:09	70	17
105	11/16/90	12:20:57	70	16
106	11/16/90	12:50:46	70	17
107	11/16/90	13:20:34	70	17
108	11/16/90	13:50:23	72	17
109	11/16/90	14:20:11	70	17
110	11/16/90	14:50:00	70	17
111	11/16/90	15:19:49	71	17
112	11/16/90	15:49:37	70	17
113	11/16/90	16:19:26	70	17
114	11/16/90	16:49:14	74	16
115	11/16/90	17:19:03	76	15
116	11/16/90	17:48:52	74	15
117	11/16/90	18:18:40	75	15
118	11/16/90	18:48:29	76	15
119	11/16/90	19:18:17	75	15
120	11/16/90	19:48:06	77	14
121	11/16/90	20:17:54	78	13
122	11/16/90	20:47:43	79	13
123	11/16/90	21:17:32	78	13
124	11/16/90	21:47:20	80	13
125	11/16/90	22:17:09	79	13
126	11/16/90	22:46:57	80	13
127	11/16/90	23:16:46	80	12
128	11/16/90	23:46:35	79	13
129	11/17/90	00:16:23	79	13
130	11/17/90	00:46:12	79	13
131	11/17/90	01:16:00	80	13
132	11/17/90	01:45:49	78	13

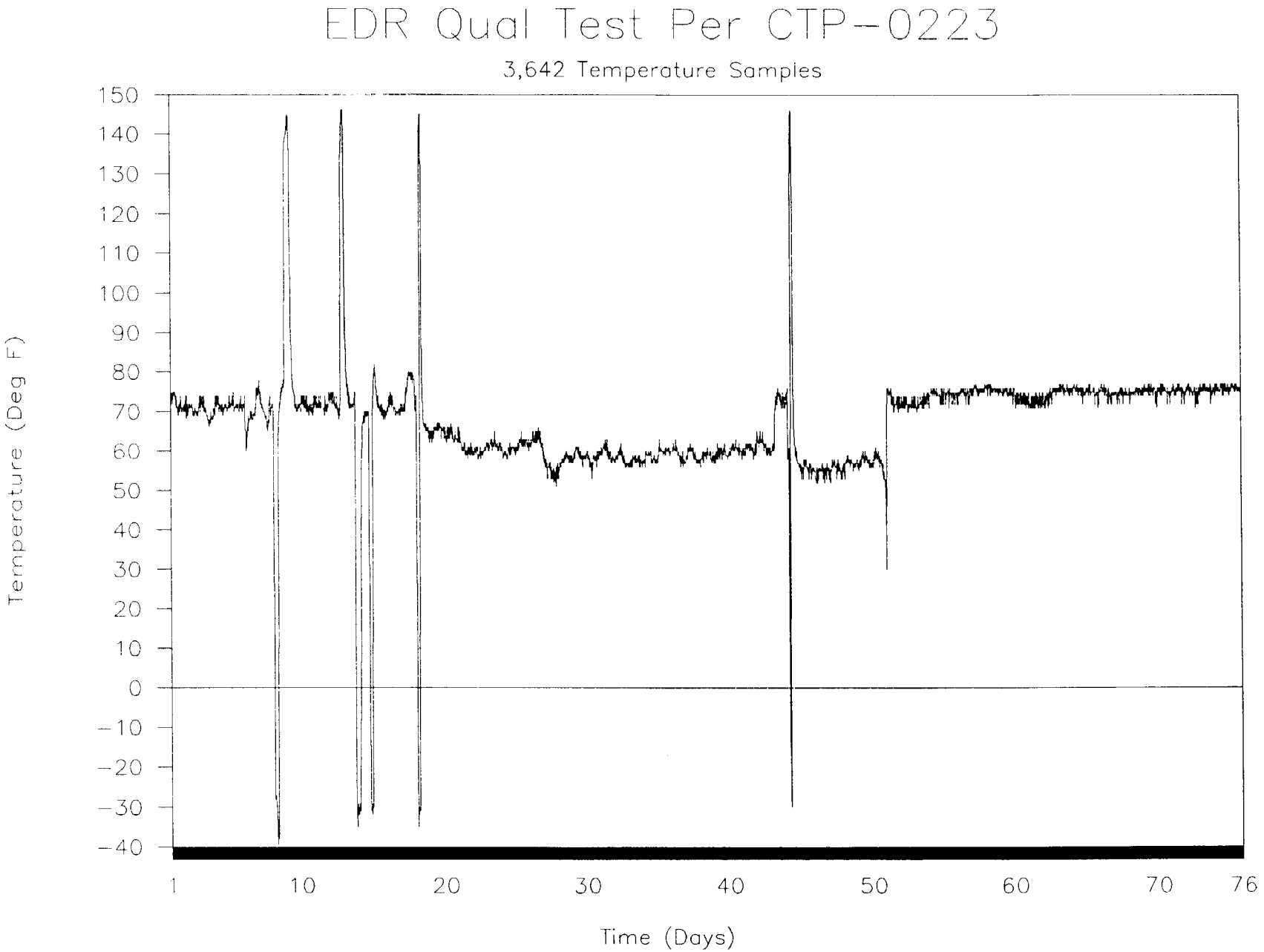
Environmental Data Recorder: TEMPERATURE/HUMIDITY REPORT
Report Date:01-07-1991
Report Ident:

File: QUAL-14
Temperatures (F)
File Contains 165 Temperature/Humidity Samples

SAMPLE NO.	DATE	TIME	TEMPERATURE	%REL.HUMIDITY
133	11/17/90	02:15:38	80	13
134	11/17/90	02:45:26	78	13
135	11/17/90	03:15:15	79	13
136	11/17/90	03:45:03	77	13
137	11/17/90	04:14:52	80	13
138	11/17/90	04:44:40	80	13
139	11/17/90	05:14:29	79	13
140	11/17/90	05:44:18	79	13
141	11/17/90	06:14:06	79	14
142	11/17/90	06:43:55	78	14
143	11/17/90	07:13:43	78	15
144	11/17/90	07:43:32	77	15
145	11/17/90	08:13:21	71	17
146	11/17/90	08:43:09	70	17
147	11/17/90	09:12:58	70	17
148	11/17/90	09:42:46	71	17
149	11/17/90	10:18:50	71	17
150	11/17/90	10:19:28	74	17
151	11/17/90	10:19:44	72	17
152	11/17/90	10:49:33	-19	16
153	11/17/90	11:19:21	-35	23
154	11/17/90	11:49:10	-34	25
155	11/17/90	12:18:58	-30	26
156	11/17/90	12:48:47	-31	26
157	11/17/90	13:18:36	-30	26
158	11/17/90	13:35:08	-30	26
159	11/17/90	13:43:27	-31	26
160	11/17/90	14:13:15	58	98
161	11/17/90	14:43:04	114	13
162	11/17/90	15:12:52	140	6
163	11/17/90	15:42:41	143	5
164	11/17/90	16:12:30	145	5
165	11/17/90	16:42:18	145	5

Functional Test Temperature Data

Date	Time	EDR (Deg. F)	T-53 (Deg. F)	Delta Temp
11/07/90	17:53:22	-35.80	-38.60	-2.8
11/07/90	19:55:53	-36.91	-39.20	-2.3
11/07/90	19:56:07	-38.03	-39.20	-1.2
11/07/90	20:06:03	-36.91	-39.60	-2.7
11/17/90	09:58:05	71.29	72.4	1.1
11/17/90	10:01:06	72.40	72.4	-0.0
11/17/90	10:03:24	71.29	72.3	1.0
11/17/90	10:05:31	72.40	72.3	-0.1
11/17/90	16:48:29	144.91	147.2	2.3
11/17/90	16:48:46	144.91	147.2	2.3
11/17/90	16:50:29	147.14	147.2	0.1
11/17/90	16:53:04	144.91	147.5	2.6


EDR Qual Test Per CTP-0223
3,642 Temperature Samples
Temperature (Deg F)
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
1
10
20
30
40
50
60
70
76
Time (Days)

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